How and Why to Manage Organic Matter on Putting Greens

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Turfgrass Science
University of Nebraska

NEW ENGLAND REGIONAL TURFGRASS FOUNDATION
ESTABLISHED 1996

2023 Conference March 7th - 9th
Providence, RI

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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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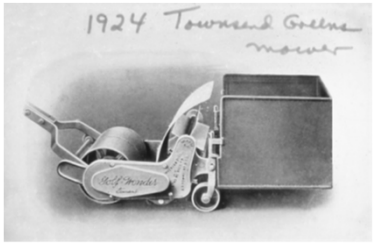
Closer cut mowers



As low as 0.25”

7

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

8

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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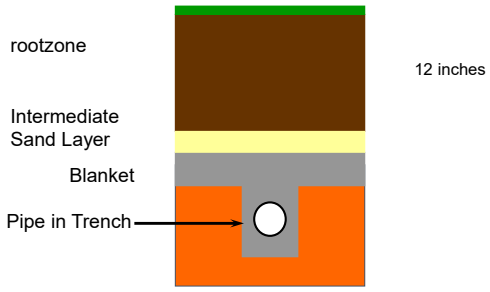
Three Tier (USGA) System



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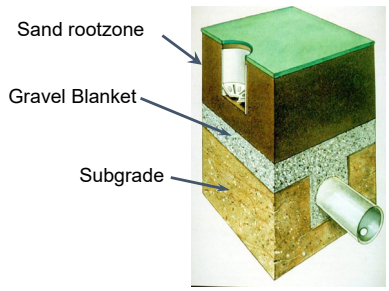
Two Tier System (USGA)



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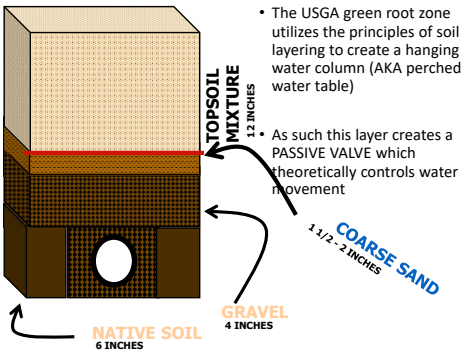

- The USGA green root zone utilizes the principles of soil layering to create a hanging water column (AKA perched water table)
- As such this layer creates a PASSIVE VALVE which theoretically controls water movement

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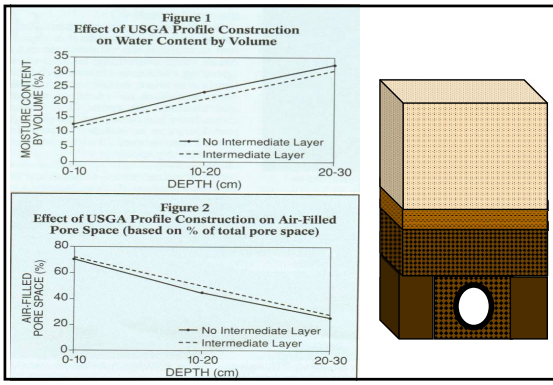

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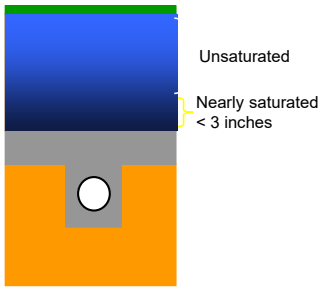
Displacement of Saturated Zone



Sand-based System at Field Capacity

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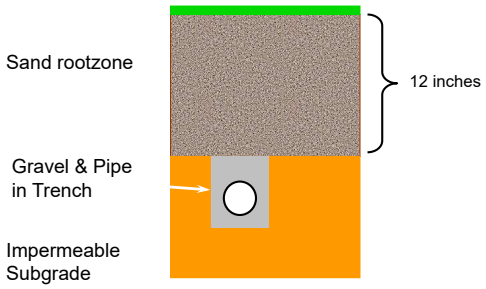
One Tier System (California)



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Root Zone Properties

Before 2004

USGA K_{sat} guidelines

Normal:	6-12 inches per hour
Accelerated:	12-24 inches per hour

Account for substantial climatic differences

Normal:	temperate to dry climates
Accelerated:	high rain subtropical and tropical climates or regions with frequent dust storms

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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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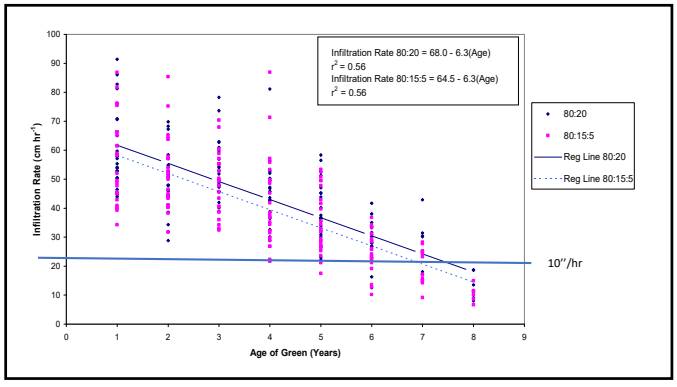

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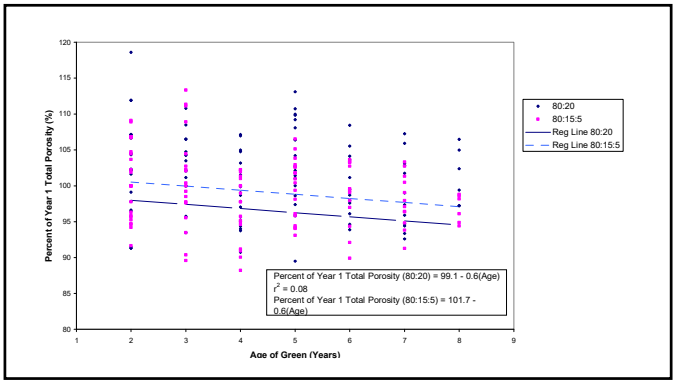

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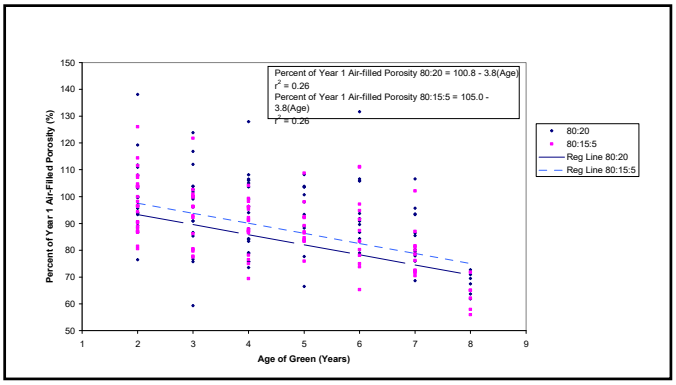

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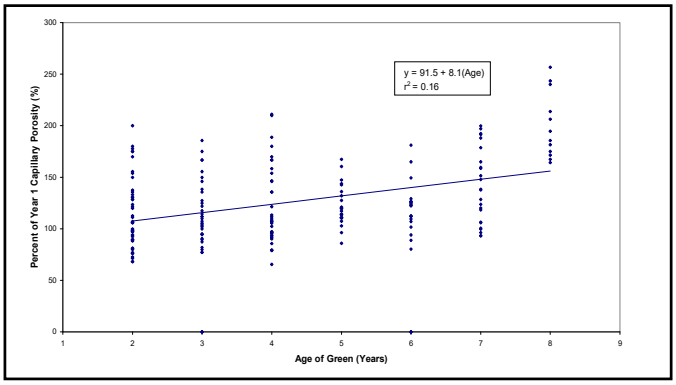

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Microbial Properties

(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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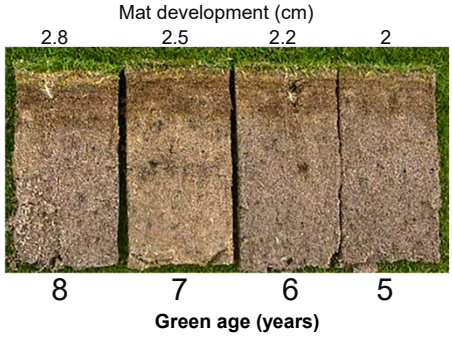

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Formation of Mat

- 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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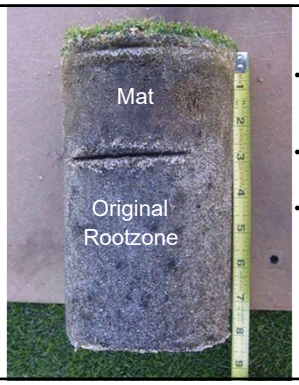

- 2004 USGA research committee site visit
- original rootzone
- mat development

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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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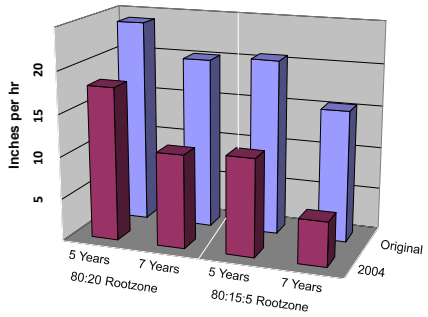

Comparison of preconstruction K_{sat} values to K_{sat} values taken 10/04.

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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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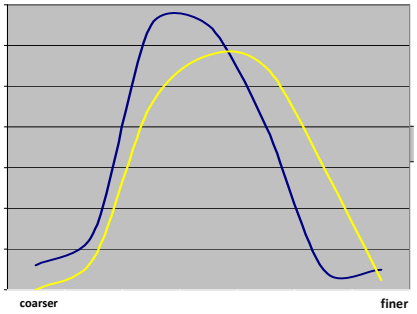

USGA sand size compared to sand used in topdressing program for USGA plots at Mead, NE.

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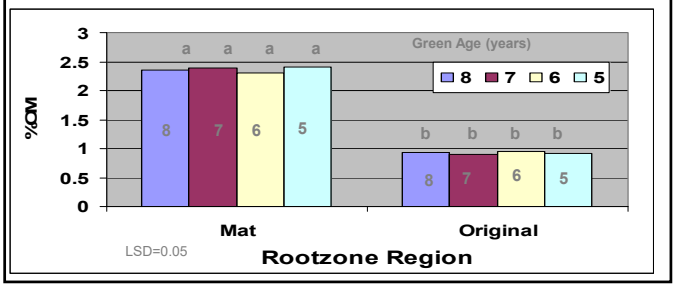
Rootzone vs Mat: Organic Matter



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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.**

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Research Need (2004)

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

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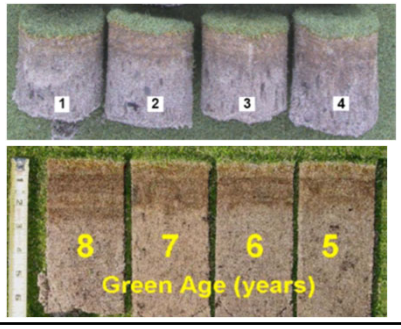
OM accumulates as sand greens age



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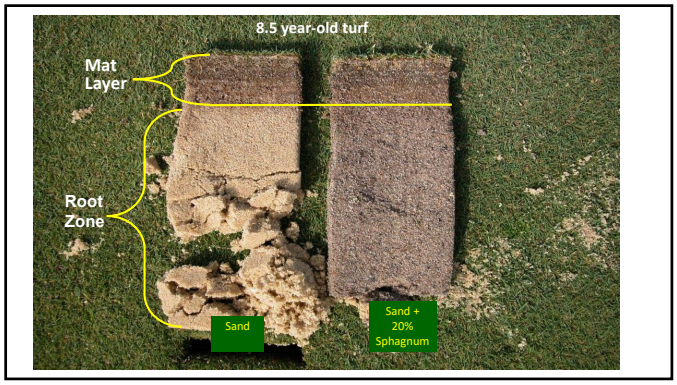

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Organic Matter Management Study

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

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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 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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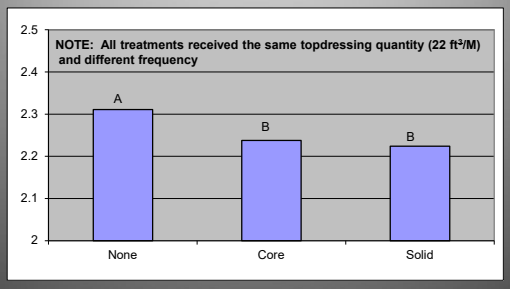
Effect of Tines on OM after 1 yr



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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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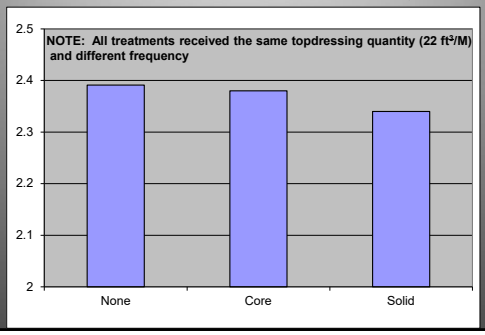
Effect of Tines on OM after 2 yrs



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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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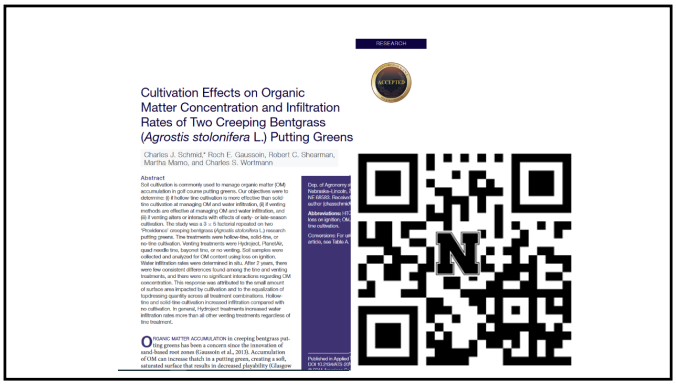

RESEARCH

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

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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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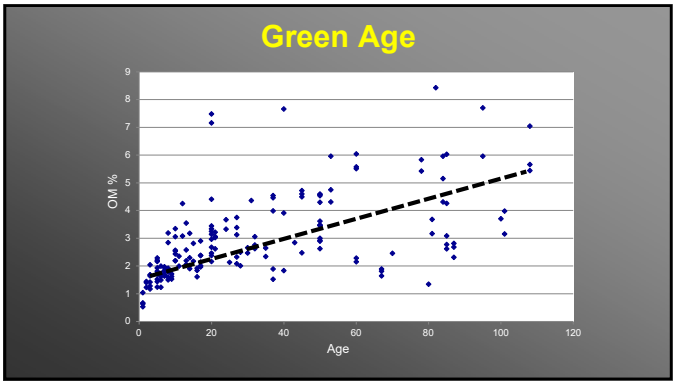

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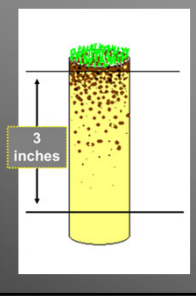
Is the age effect misleading?

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



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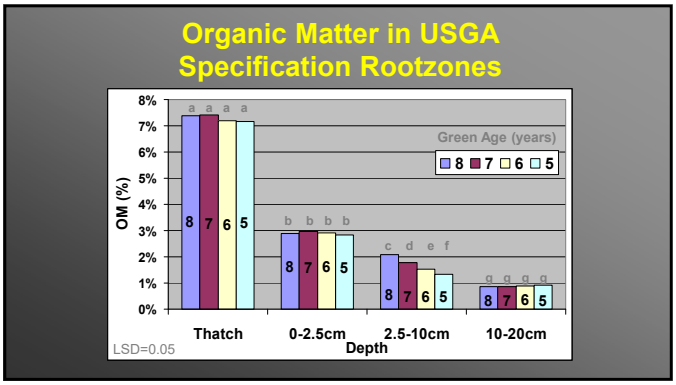

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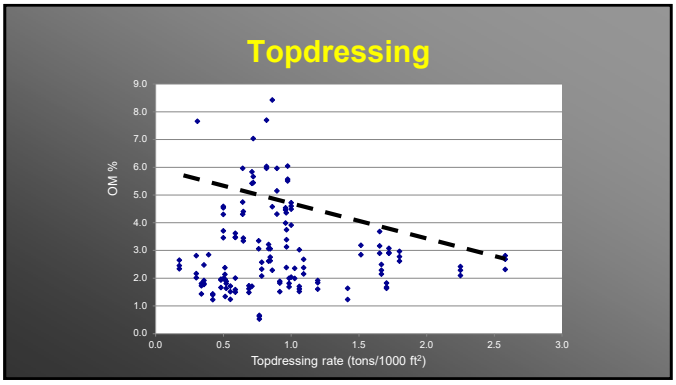

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Survey Summary

- 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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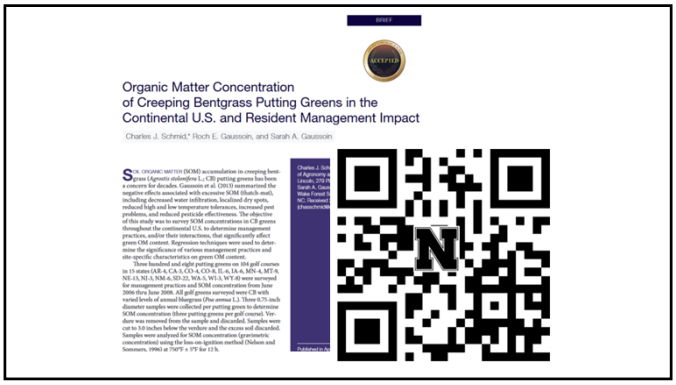

Organic Matter Concentration of Creeping Bentgrass Putting Greens in the Continental U.S. and Resident Management Impact

Charles J. Schmid,* Roch E. Gaussoin, and Sarah A. Gaussoin

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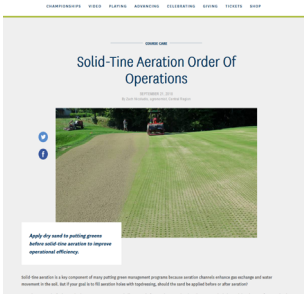
https://www.usga.org/content/usga/home-page/course-care/regional-updates/central-region/2018/solid-tine-aeration-order-of-operations.html



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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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AER-AIDER

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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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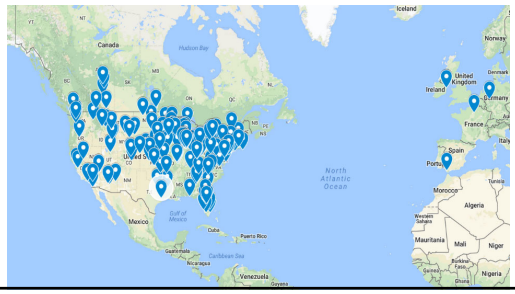
2016 Survey Respondents via Greenkeeper



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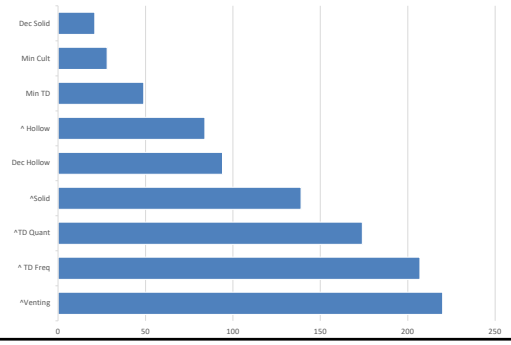
303 Responses



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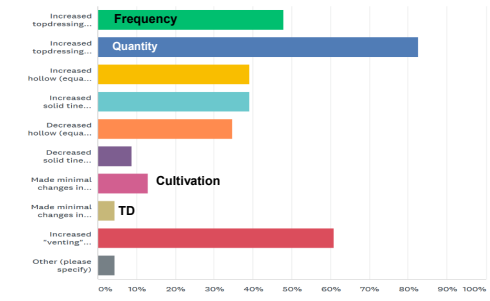
(Please mark all that apply.) In the last 5-10 years, on our greens, our facility has:

Answered: 23 Skipped: 0 2019 GIS seminar attendees



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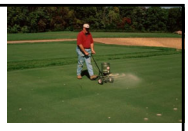
Managing for Drier Mat Layer



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 and very fine
- Cost and interference with play and mowing are the limiting factors

Core Cultivation

- Very effective at producing a drier surface
- Time for healing is greatest limitation
  - ***Solid Tine Cultivation?****

Gaussoin adds

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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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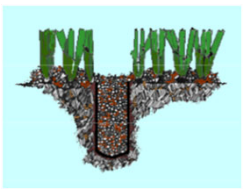
Layering

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



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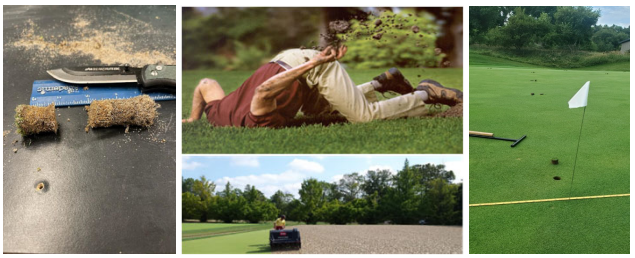

Dos and Don'ts of Organic Matter Sampling

N EXTENSION

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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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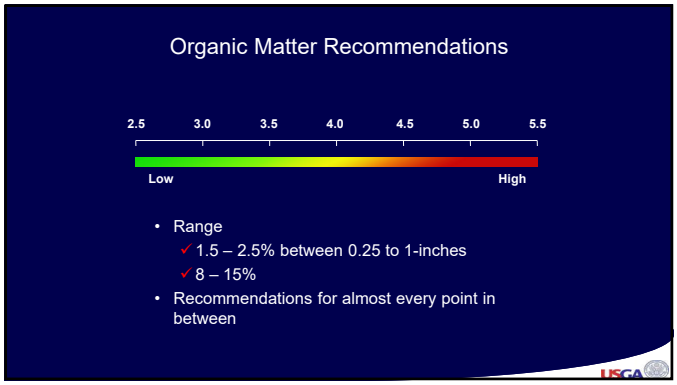

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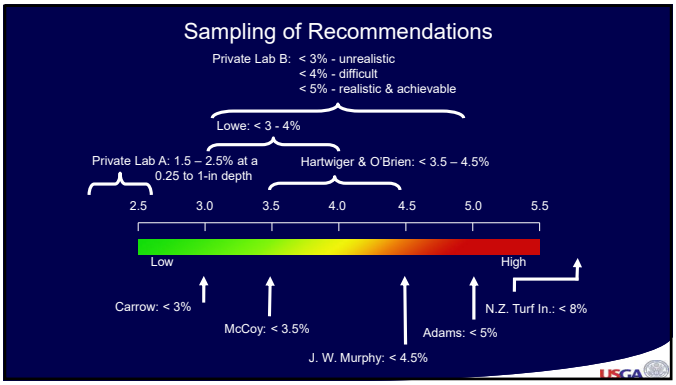

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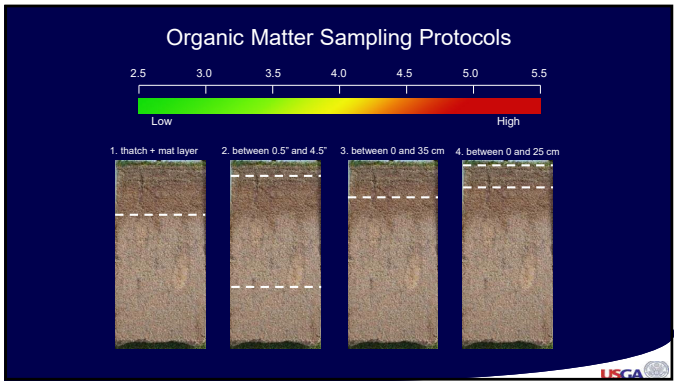

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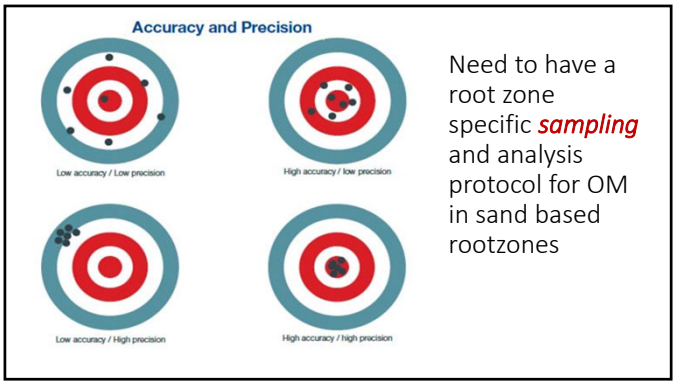

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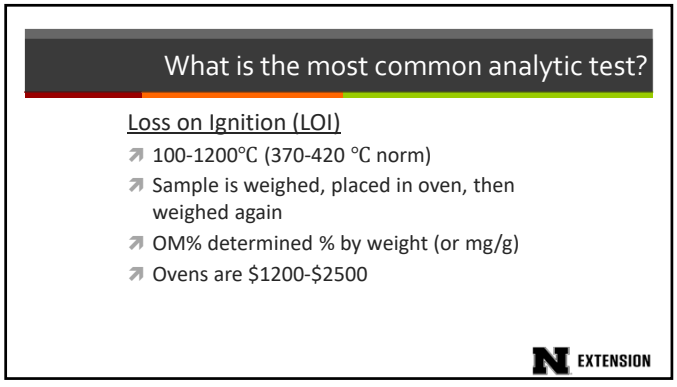

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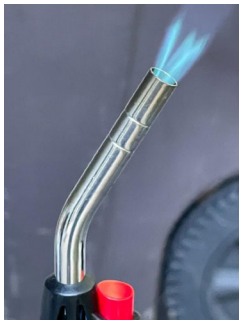
Can the superintendent do this?



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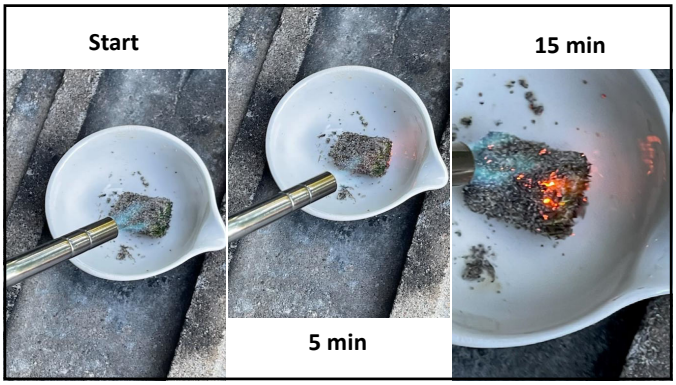

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Developing a simple, practical method for organic matter content determination by superintendents

Leifeld and Kogel-Knabner (2001)

Funded by

USGA®

Mike Davis Program for Advancing Golf Course Management

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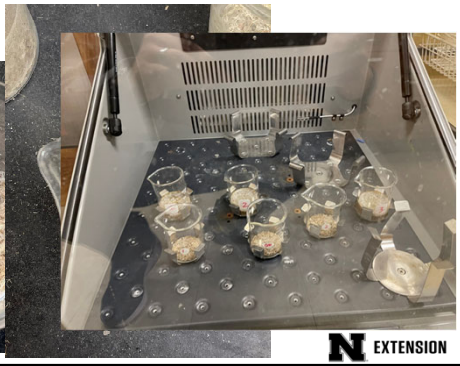

EXTENSION

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Don' try this at home.....

- Methods using hydrogen peroxide adapted from Leifeld and Kogel-Knabner (2001) were time-consuming and step intensive for practical use.
- *Attempts to find a correction factor were also not discovered.*
- Regression models based on data of the best attempt showed a high level of variation measuring OM percentages of pre-determined lab mixed samples.
- *A rapid, practical, inexpensive, and reliable method to test OM content on golf using equipment available on a typical golf course is not feasible.*
- Like the torch fiasco, you still need an analytic balance and other lab equipment

EXTENSION

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Taking a representative sample

- Sample depth(s)
- Number of samples
- Sample location
- Sample size
- Time of year
- Verdure on or off?

EXTENSION

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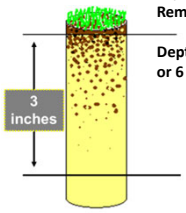
Historic Sampling Depth (as approved by the SSSA)

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



EXTENSION

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Develop an accurate and efficient method for characterizing OM in sand root zones

Questions that need to be answered:

1. How does sample preparation affect mean SOM?
2. How does core diameter affect mean SOM?
3. How many samples are required to adequately characterize the mean SOM on a single putting green?
4. How far apart should samples be taken?

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How does sample preparation affect mean SOM?

- Some researches leave verdure on, some remove, how does this impact mean SOM?
- Most labs grind and sieve samples, how does this impact the mean SOM when verdure is left on?
- Does increased core diameter size affect the mean SOM?

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Site Characteristics

Samples were taken at the OJ Noer Turf Research Facility and University Ridge Golf Course in Verona, WI

50 samples were taken from five different root zones on a 10'X10' grid
- 3 from research plots
- 2 from putting greens

	Mean OM %
Putting Green 1	5.82
Putting Green 2	5.39
Research Green 2	5.23
Research Green 3	5.07
Research Green 1	4.74

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Sample Preparation

- Core diameter evaluation
  - 0.75 inch or 1.5 inch
- Verdure evaluation
  - removed above the thatch layer to remove all green material
  - left on
- Grinding/sieving evaluation
  - analyzed intact
  - ground with mortar and pestle and sieved with no. 10 sieve
- All samples were dried for 24 hr. at 105 C before weighing and burned and 360 C for 2 hours

Diameter (cm)	Verdure	Sieve
3.8	Yes	No
1.9	Yes	No
1.9	Yes	Yes
1.9	No	Yes
1.9	No	No

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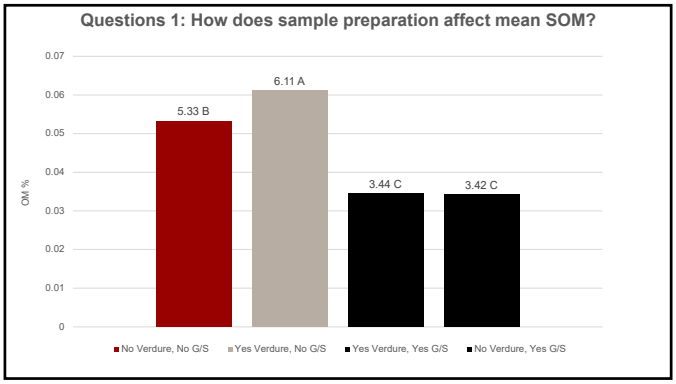

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Sample size

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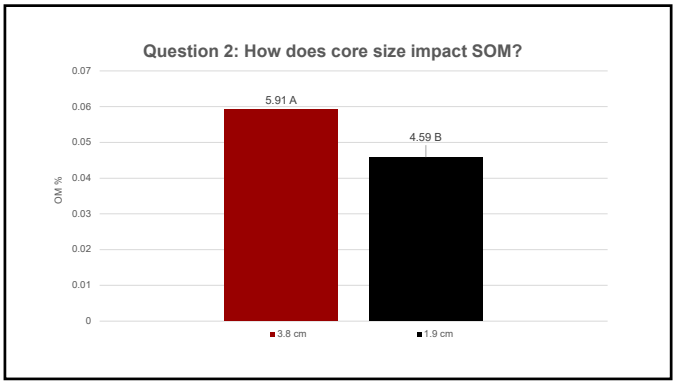

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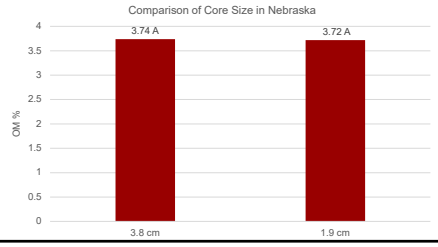
Core diameter difference not found in Nebraska

- Additional samples were taken on a Nebraska golf course on a 3*3m grid with both 1.5- and 0.75-inch cores



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Question 3: How many samples do we need to take?

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of samples and location

- 3 golf courses at different geographic locations
- 5 holes at each course
- Samples from N to and E to W on 10 ft centers

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Loc	N	E
1	1	B
2	1	C
3	1	D
4	1	E
5	2	A
6	2	B
7	2	C

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With standard 0.75 inch probes most greens need only 5 samples to characterize the mean OM

Wisconsin		
Green	# Samples	Average OM
Chip	5	4.59
12	5	7.21
8	5	7.23
4	5	7.06
1	5	6.69

Pennsylvania		
Green	# Samples	Average OM
6	7	17.14
2	5	10.83
3	8	15.66
4	5	11.72
7	5	13.2

Nebraska		
Green	# Samples	Average OM
9	5	4.01
8	5	4.09
7	5	3.95
6	5	3.60
5	5	3.09

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With the 1.5 inch probe need between 4-5 samples to achieve the same precision

Nebraska Standard		
Green	# Samples	Average OM
9	5	4.01
8	5	4.09
7	5	3.95
6	5	3.60
5	5	3.09

Nebraska Large		
Green	# Samples	Average OM
9	4	3.96
8	5	4.09
7	5	3.90
6	4	3.62
5	4	3.20

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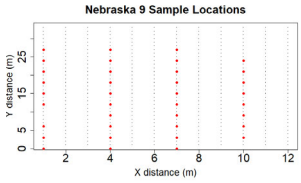
Question 4: How far apart should samples be taken?

- What we did
  - Same sampling technique, 3*3m grids, 0.75 inch probe on 5 greens at 3 courses
  - Analyzed the data using spatial variograms to determine sampling distance



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Initial findings for how 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

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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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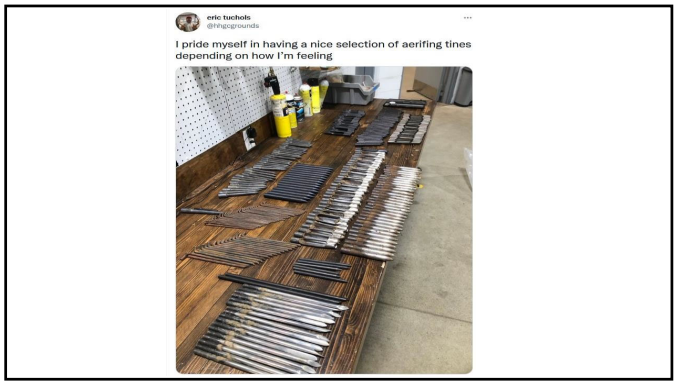

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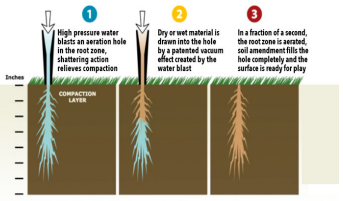
DryJect



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Dryject Trial Fall 2021

- Check
- Hollow ½" ID
- Solid ½"OD
- DryJect 1 (3x3)
- Needle
- DryJect 2 (3x2)
- Needle + Solid
- Needle + Hollow

Procore - 3" target depth on all tines except Dryject = 5"

Sampled day after treatment in 1' depth increments to 4 "

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Treatment	% OM	
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
- Hollow tine response was unexpected
- ***Data is preliminary***

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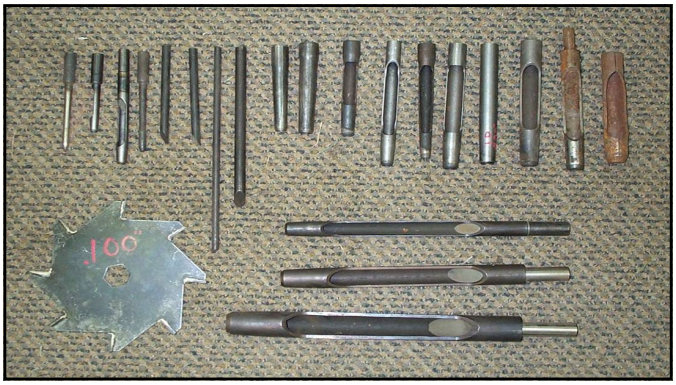

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Spring 2023 Tine Trial

- ~~8~~ 26 tine types/configurations
- 2 devices (ProCore and DryJect)
- Timing (spring/fall)
- OM by depth
- Surface and firmness using the USGA GS3 digital golf ball

Equipment and Tine Support Provided by

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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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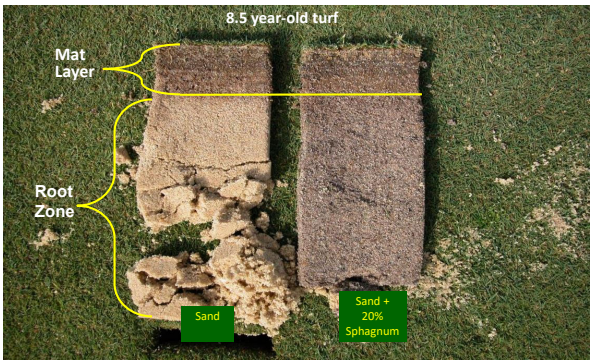

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It matters how you manage the accumulating thatch/mat layer

- 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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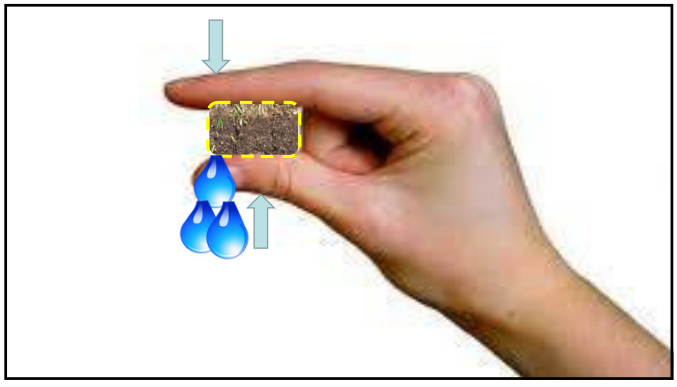

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Key is matching your growth rate to optimize topdressing + …….

How much sand to use for topdressing?

- Generic recommendation is 20-40 ft^3 per 1000 sq. feet/yr (about 0.5 inch/M/yr)
  - ***UNL worked showed 20-24 ft^3 for OM management***
- Varies by amount of:
  - Traffic
  - Grass species or cultivar
  - Nitrogen Applied
  - Water Applied
  - Microclimate/Location

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#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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Acknowledgement (Rutgers)

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- Nebraska Turfgrass Association

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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 and best wishes for 2023!

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