2024 CAROLINAS GCSA
CONFERENCE & TRADE SHOW

Aging Putting Green Root Zones & Organic Matter Management

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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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Donald Ross 1927

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THE FIFTH GREEN AT THE ESSEX COUNTY COUNTRY CLUB

1930 Advertisement

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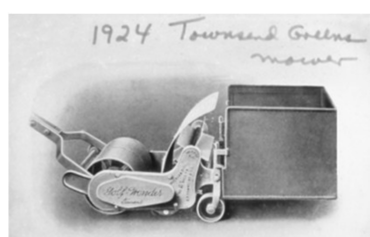
Closer cut mowers



As low as 0.25"

7

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

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USGA Method of Putting Green Construction

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

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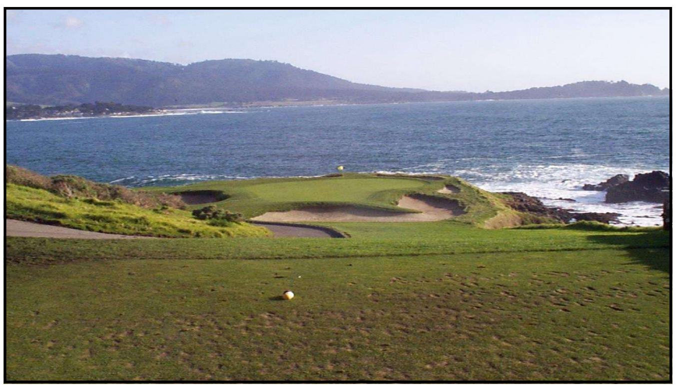

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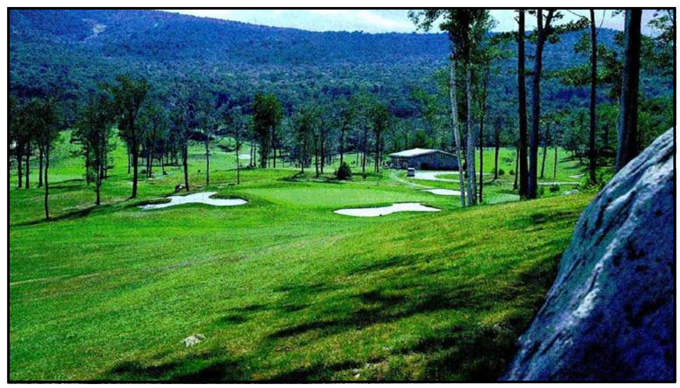

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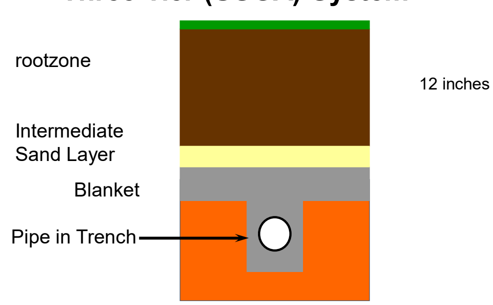
Three Tier (USGA) System



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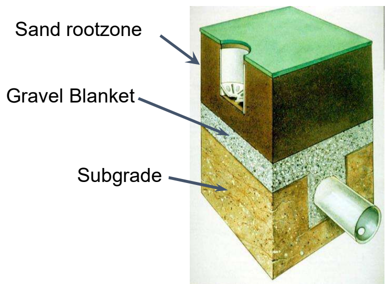
Two Tier System (USGA)



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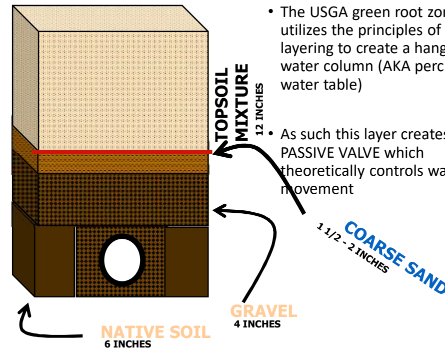

- The USGA green root zone utilizes the principles of soil layering to create a hanging water column (AKA perched water table)
- As such this layer creates a PASSIVE VALVE which theoretically controls water movement

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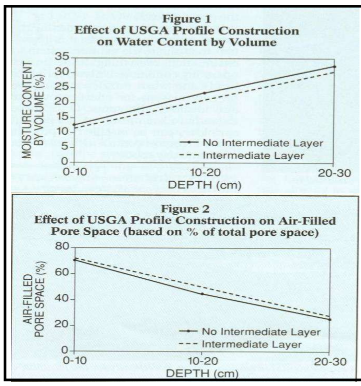

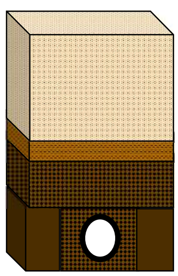

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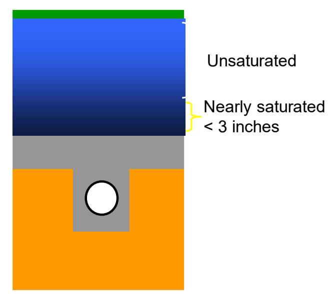
Displacement of Saturated Zone



Sand-based System at Field Capacity

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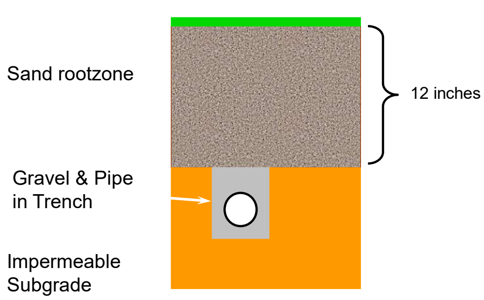
One Tier System (California)



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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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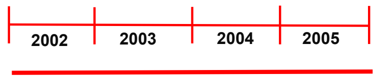
Project Schedule (Phase II)



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

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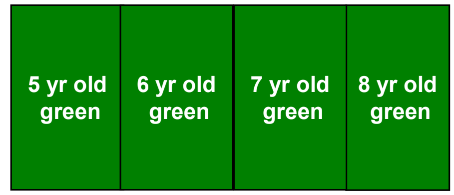
Materials and Methods



As of 2004

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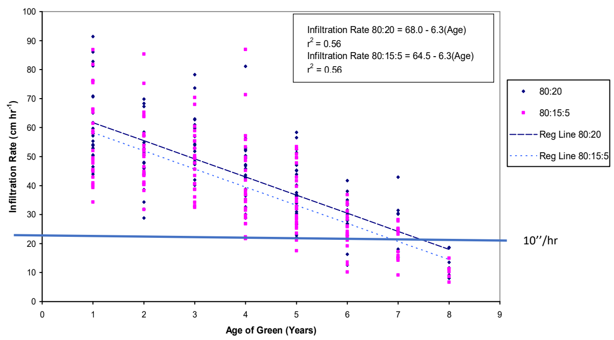

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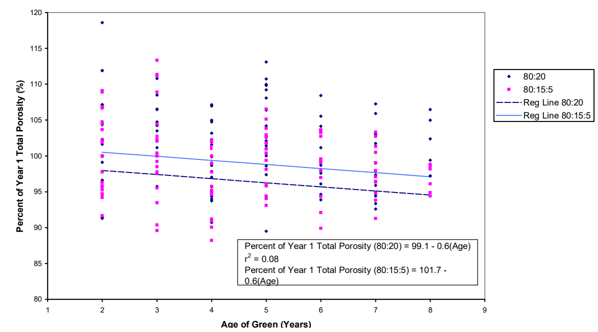

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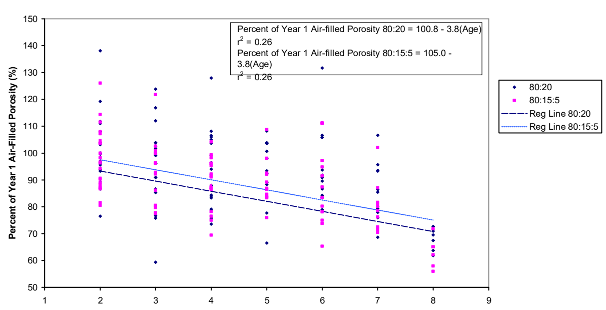

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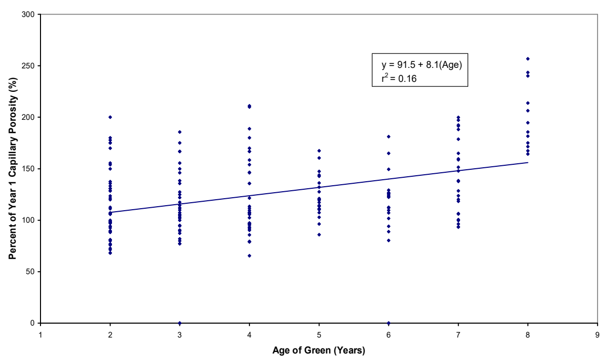

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Microbial Properties

(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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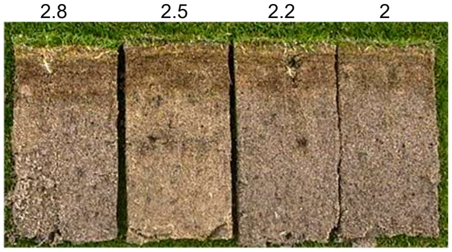
Mat development (cm)

2.8 2.5 2.2 2



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Green age (years)

35

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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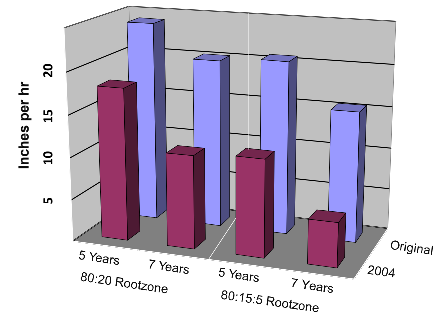

Comparison of preconstruction K_{sat} values to K_{sat} values taken 10/04.

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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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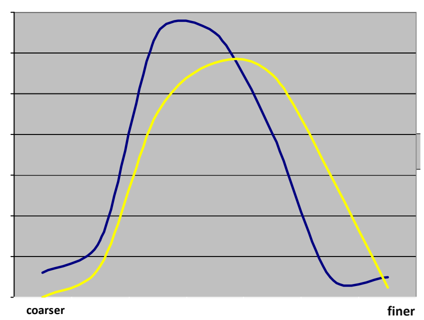

USGA sand size compared to sand used in topdressing program for USGA plots at Mead, NE.

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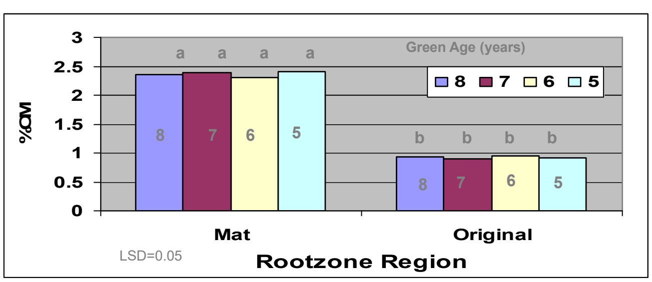
Rootzone vs Mat: Organic Matter



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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.


research
GCM 2007
Soil physical and chemical characteristics of aging golf greens

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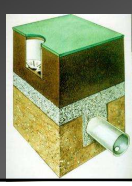
10+ Years of Research on Putting Green Root Zones at Rutgers University



T.J. Lawson, H. Samaranayake, J.A. Honig
B. Wolverton, B. Cashel, J. Devaney,
D. Gimenez, S.L. Murphy, M. Koch,
and numerous other undergraduate
and short course students

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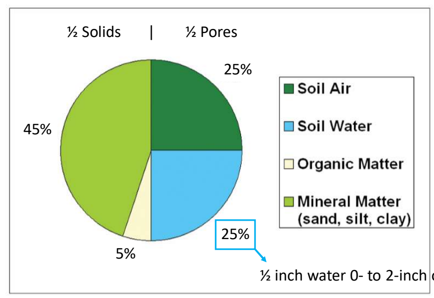
Idealized Proportions of Solids and Pores in Soil



Source: https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052836.pdf

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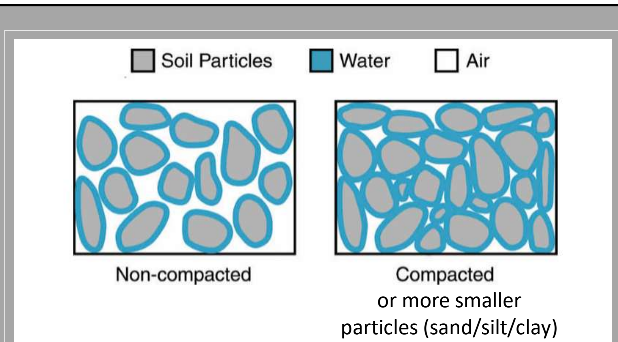

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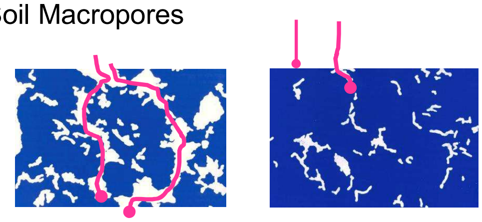
Soil Macropores



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Sand – particle size

Size
- Medium (0.5 – 0.25 mm) sand has very rapid drainage
- Very Fine Sand, Silt and Clay
  - increase water retention and stability of sand
  - but slow water flow (drainage)
  - Maximum 10% fines, less is usually preferable if drainage is critical

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Particle Size Distribution for Drainage (USGA)

Particle Name	Diameter (mm)	Recommendation (by weight)
Fine Gravel	2 – 3.4	Not more than 10% total, maximum of 3% fine gravel
Very Coarse Sand	1 – 2	
Coarse Sand	0.5 – 1	Minimum of 60%
Medium Sand	0.25 – 0.5	
Fine Sand	0.15 – 0.25	Not more than 20%
Very Fine Sand	0.05 – 0.15	Not more than 5%
Silt	0.002 – 0.05	Not more than 5%
Clay	< 0.002	Not more than 3%
Total Fines	very fine sand + silt + clay	Less than or equal to 10%

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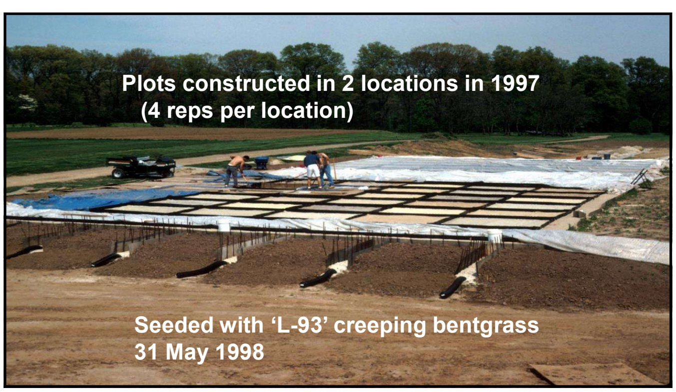

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Open Location

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Enclosed Location

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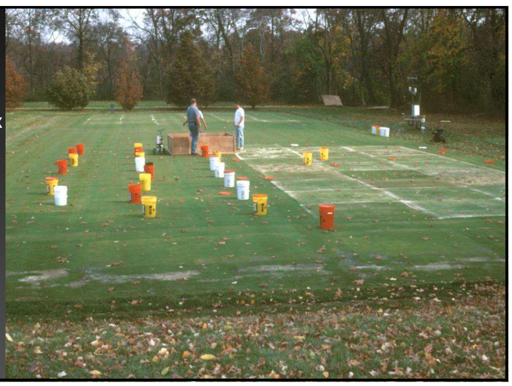
Topdressed with Construction Mix



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Sand size distributions of five root zones.

Root Zone Mixes	Very Coarse	Coarse	Medium	Fine	Very Fine
			%		
Coarse	6	61	32	1	0
Coarse-medium	5	48	38	7	1
Medium	6	26	49	17	2
Medium-fine-1	4	11	53	26	6
Medium-fine-2	0	7	56	30	7
USGA rec	*≤ 10*	*≥ 60*		*≤ 20*	*≤ 5*

All sands mixed with sphagnum peat at 10% by volume

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Pre-construction Properties of Root Zone Materials

Root Zone Sand	K_{sat}	Air-filled Porosity	Capillary Porosity
	in / hr	----- %	------
Coarse	37	35	7
Coarse-Medium	30	27	13
Medium	25	20	20
Medium-Fine-1	16	17	25
Medium-Fine-2	24	14	29
$LSD_{0.05}$	3	1.6	1.2

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Intact Core Sampling

Physical Property Tests

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K_{sat} of Root Zone Mixes

Root Zone Sand	Pre-Construction	1999	2001	2004
	inches per hour			
Coarse	37	32	56	96
Coarse-Medium	30	32	43	48
Medium	25	27	31	35
Medium-Fine-1	16	24	22	22
Medium-Fine-2	24	24	22	24
$LSD_{0.05}$	3	4	4	6

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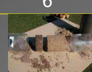
K_{sat} and Field Water Infiltration in 2004

Root Zone Sand	Field Core K_{sat}	Field Infiltration
	inches per hour	
Coarse	96	7
Coarse-Medium	48	5
Medium	35	4
Medium-Fine-1	22	2
Medium-Fine-2	24	2
$LSD_{0.05}$	6	2



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Plot Specific Irrigation

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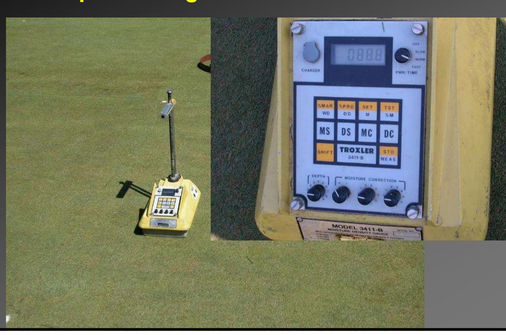
Plot Specific Irrigation



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Total Hand Water from May to October 2001

Root Zone Sand	Hand Water	Air-filled Porosity	Capillary Porosity
	inches	----- %	------
Coarse	8.8	34.5	7.3
Coarse-Medium	7.4	26.8	13.3
Medium	5.4	19.5	20.4
Medium-Fine-1	3.1	17.1	25.0
Medium-Fine-2	3.4	14.2	28.5
$LSD_{0.05}$	1.6	1.6	1.2

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Total Hand Water from May to October 2001

Root Zone Sand	Hand Water	Turf Quality 1999	Turf Quality 2000
	inches	9 = best	
Coarse	8.8	5.7	5.6
Coarse-Medium	7.4	6.7	6.8
Medium	5.4	7.0	7.0
Medium-Fine-1	3.1	7.9	8.0
Medium-Fine-2	3.4	7.8	7.5
$LSD_{0.05}$	1.6	0.4	0.4

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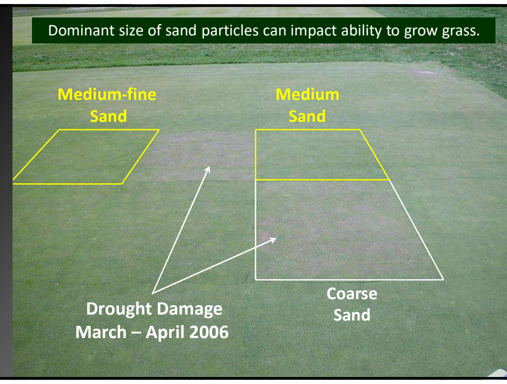

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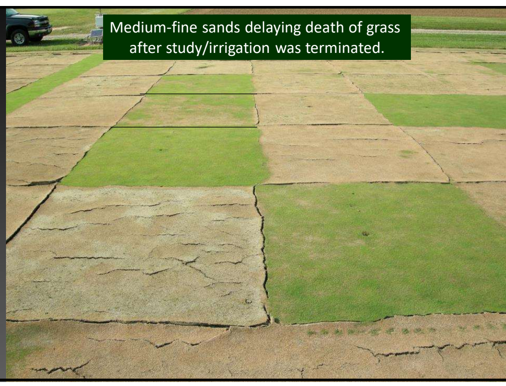

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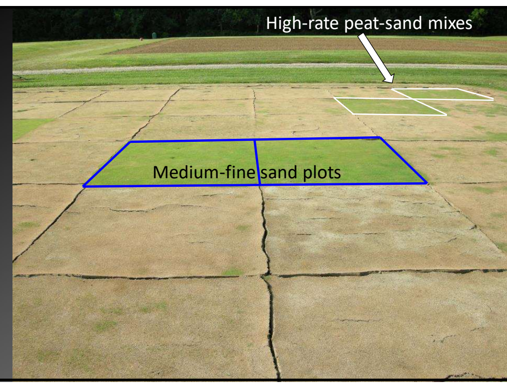

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Algae forms when plots are not allowed to dry sufficiently between irrigations (i.e., plot specific irrigation discontinued)

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Amendments for Sand

- Materials vary based on individual preference/bias
- Peat successful for many decades
- Numerous replacements for peat proposed and used
  - Native soil
  - Composts
  - Inorganic materials

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Amendment Treatments (rate - % by volume)

Sand

Soil 2.5, 5 and 20%
Soil 5% subgrade
Soil 100%

Sphagnum 5, 10 and 20%
Reed Sedge 5 and 10%
Irish peat 10 and 20%

Fertl-soil compost 5%
AllGro compost 10%
AT Sales sand + AllGro compost 20%

Axis 10%
Greenschoice 10%
Isolite 10%
Profile 10 and 20%
ZeoPro 10%
ZeoPro 10% surface 4"
ZeoPro + micros 10%
surface 4"

Kaofin 10%

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Straight Sand (un-amended) Root Zones

- OM remains very low (probably too low) over time
- Results in more frequent and intensive inputs to maintain proper plant nutrition and avoid drought stress.

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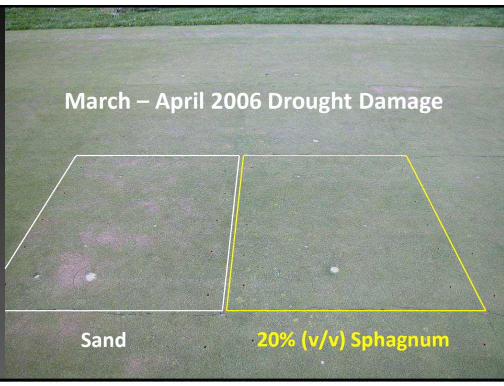

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Compost

- Provided good to excellent turf performance (as good or better than peat)
- … but identification of a high quality compost can be difficult and is critical to success
- http://www.compostingcouncil.org/programs/

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Inorganic amendments

Internally porous granules
- ✓ ceramics (kiln-fired clays)
- ✓ natural minerals (zeolite, diatomaceous earth)

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Inorganic Amendments

- Greater nutrient retention than 100% sand
- Greater water availability but not a dramatic improvement in carrying capacity (days between irrigations)
- Subtle improvement in turf quality
- Cost of these materials is significant, cost-benefit?

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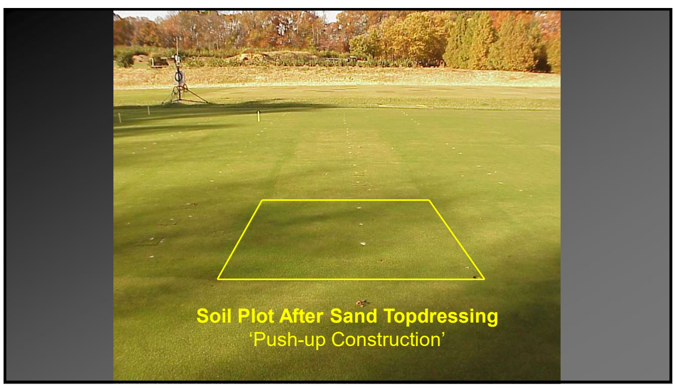

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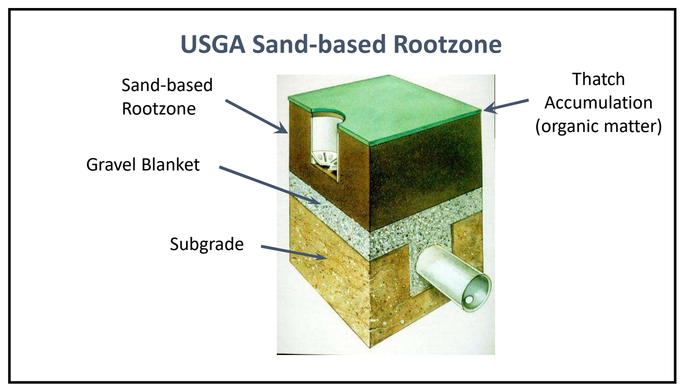

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Straight Sand (un-ameneded) Root Zones

Popular with some architects, builders and superintendents.

- Ease of construction
- Initial cost savings - no blending and less testing
- Reputed to be useful in managing the accumulation of organic matter

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Straight Sand (un-ameneded) Root Zones

Advocates suggest organic matter (OM) accumulation will "amend" the sand over time

i.e., do not need to amend the sand it will happen anyway.

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Mat Layer versus Root Zone Physical Properties

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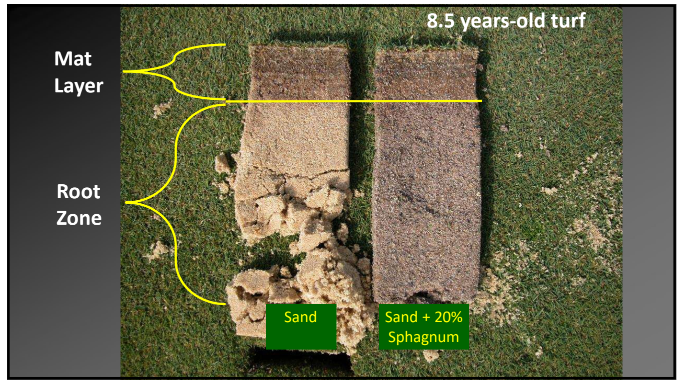

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Sand	
Layer	OM
	%
Mat	4.5
Root Zone	0.3

20% Sphagnum	
Layer	OM
	%
Mat	5.4
Root Zone	0.7

90

Sand	
Layer	K_{sat}
	in/hr
Mat	8
Root Zone	26

20% Sphagnum	
Layer	K_{sat}
	in/hr
Mat	11
Root Zone	23

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Profile	Total Porosity	Air-filled Porosity	Capillary Porosity
	---------------	% (by volume)	---------------
Mat Layer	51	11	40
Rootzone	40	20	20

2” deep mat layer stores 0.8” of water

2” deep root zone stores 0.4” of water

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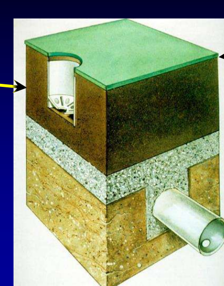
USGA Sand-based Rootzone



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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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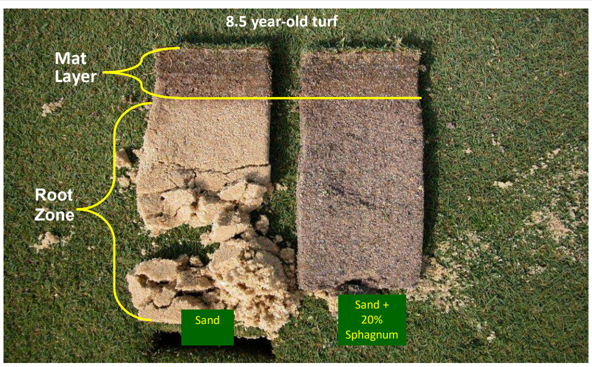

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Practices to change thatch into mat include topdressing and …

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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
None
2X Hollow tine
2x Solid tine

Venting Treatment
None
PlanetAir
Hydroject
Bayonet tine
Needle tine

100

Treatments

Tine Treatment
None
2X Hollow tine
2x Solid tine

Venting Treatment
None
PlanetAir
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

101

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***

102

Materials and Methods

- **Green Age:**
  - **12 years**
  - **9 years**
- **Data collected:**
  - **OM% (pre-cultivation/monthly)**
  - **Single wall infiltration (monthly)**

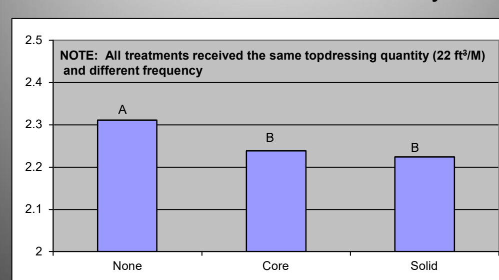
103

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**

104

Effect of Tines on OM after 1 yr



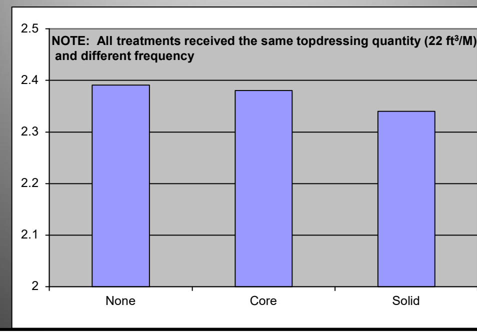
105

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

106

Effect of Tines on OM after 2 yrs



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108

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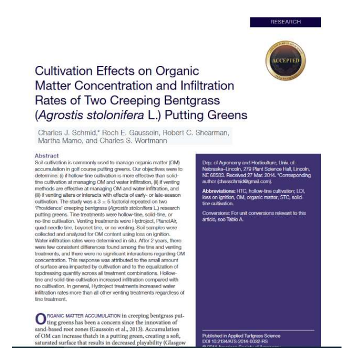
*Topdressing interval relative to Tine/Venting combinations (22 cu ft/M)**

- 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

110



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
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

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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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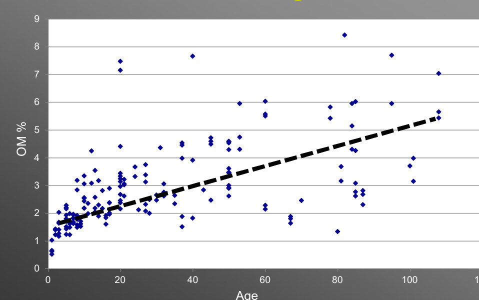
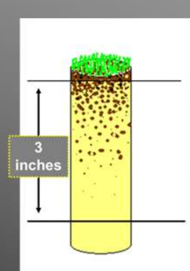
Green Age



115

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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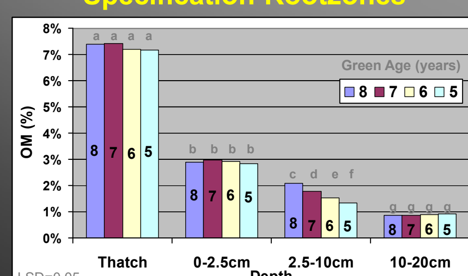
Organic Matter in USGA Specification Rootzones



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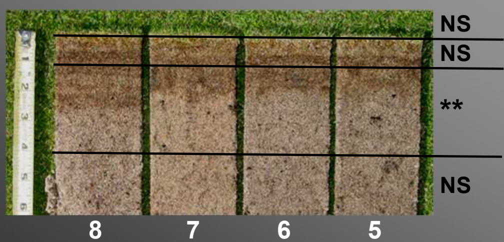
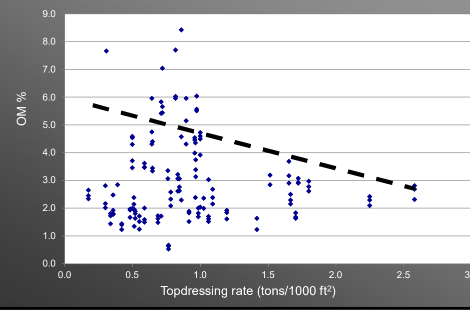
Mat Development with Age



118

Topdressing



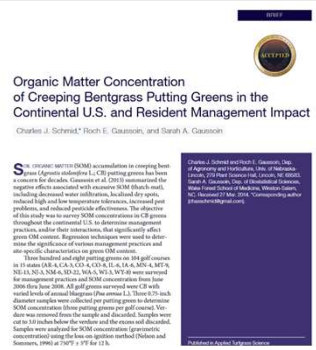
119

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***

120


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

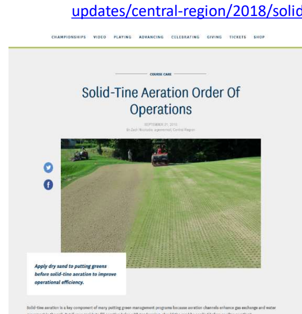
Old Tom Morris (1821–1908) is thought to have discovered the benefits of topdressing accidentally when he spilled a wheelbarrow of sand on a putting green and noted how the turf thrived shortly afterward (Hurdzan, 2004).

J.B. Beard is his classic textbook "Turfgrass Science & Culture, 1973 writes:

"The most important management practice for OM management is topdressing"

122

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



123

"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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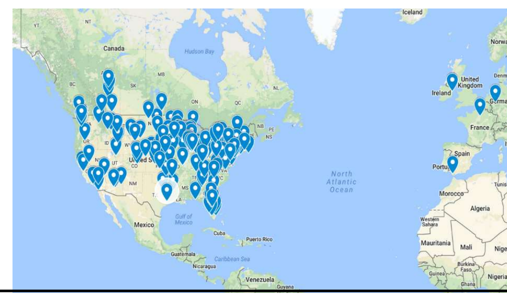
2016 Survey Respondents via Greenkeeper



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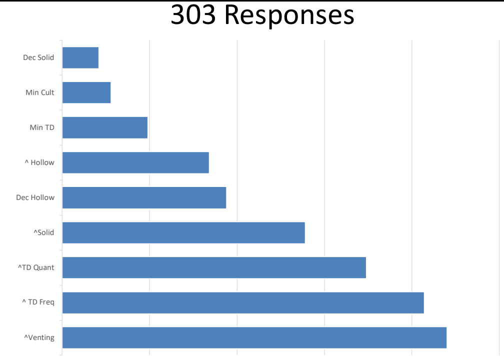
303 Responses



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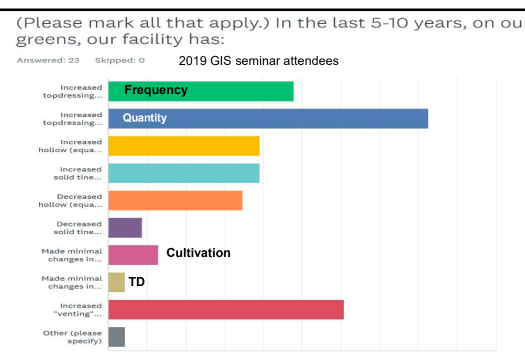

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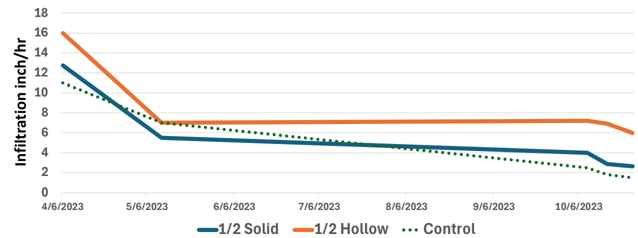
1/2 Solid	1/2 Hollow
% OM	
1.8	2.4

**

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

130



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 18"/hr.

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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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	2-1 mm	1-0.5 mm	0.5-0.25 mm	0.25-0.15 mm	0.15-0.05 mm
Sand Size	Very Coarse	Coarse	Medium	Fine	Very Fine
	----------------------- % (by weight) retained ----------------------				
Medium-coarse (1-mm)	0	30	60	10	< 1
Medium-fine (0.5-mm)	0	0	74	24	2
Fine-medium	0	4	27	48	21

136

Treatment No.	Factors in the Experiment				Annual Quantity of Sand Applied
	Sand Size	Topdressing Rate during Growing Season	Cultivation (twice/year; May & Oct)		
			Hollow Tine	Backfill / Topdress	
		lbs. / 1,000-sq.-ft.		lbs. / 1,000-sq.-ft.	lbs. / 1,000-sq.-ft.
1	Medium-coarse	50	None	400	1,300
2	Medium-coarse	50	Core + Backfill	600	1,700
3	Medium-coarse	100	None	400	1,800
4	Medium-coarse	100	Core + Backfill	600	2,200
5	Medium-fine	50	None	400	1,300
6	Medium-fine	50	Core + Backfill	600	1,700
7	Medium-fine	100	None	400	1,800
8	Medium-fine	100	Core + Backfill	600	2,200
9	Fine-medium	50	None	400	1,300
10	Fine-medium	50	Core + Backfill	600	1,700
11	Fine-medium	100	None	400	1,800
12	Fine-medium	100	Core + Backfill	600	2,200
13	None	0	None	0	0
14	None	0	Core + Backfill	600	1,200

137

Treatment No.	Factors in the Experiment				Annual Quantity of Sand Applied
	Sand Size	Topdressing Rate during Growing Season	Cultivation (twice/year; May & Oct)		
			Solid Tine ⅝-inch	Backfill / Topdressing	
		lb / 1,000 sq ft		lb / 1,000 sq ft	lb / 1,000 sq ft
1	Medium-coarse	50	None	400	1,300
2	Medium-coarse	50	Solid Tine	600	1,700
3	Medium-coarse	100	None	400	1,800
4	Medium-coarse	100	Solid Tine	600	2,200
5	Medium-fine	50	None	400	1,300
6	Medium-fine	50	Solid Tine	600	1,700
7	Medium-fine	100	None	400	1,800
8	Medium-fine	100	Solid Tine	600	2,200
9	Fine-medium	50	None	400	1,300
10	Fine-medium	50	Solid Tine	600	1,700
11	Fine-medium	100	None	400	1,800
12	Fine-medium	100	Solid Tine	600	2,200
13	None	0	None	0	0
14	None	0	Solid Tine	600	1,200

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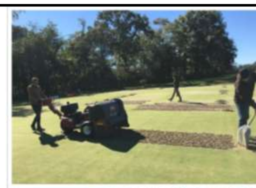

Cultivation Factor

- Solid tine twice/year (May and Oct)
- Holes backfilled with medium-coarse sand at 600 lb / 1,000 sq ft
- At same time, non-cored plots topdressed with respective sand size at 400 lb / 1,000 sq ft

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Managing for Drier Mat Layer

Topdressing
- As much and as often as feasible (~1 ton / 1,000 sq ft / 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 factors limiting

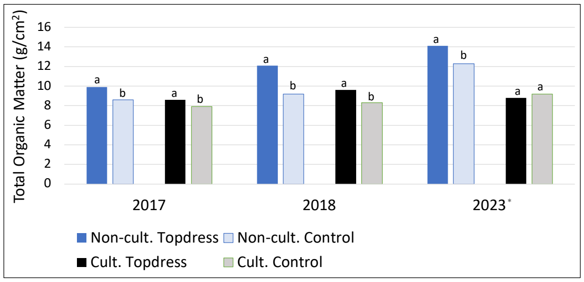
Core Cultivation & Backfilling
- Very effective at producing a drier surface
- Time for healing is greatest limitation

140

Core Sampling of the Mat Layer
April 2023

141

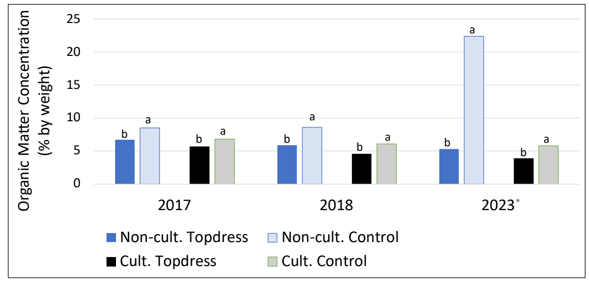
Organic matter accumulation affected by 7 years of topdressing and core cultivation (before switching to solid tine cultivation).



* Means for 2 reps of data versus 4 reps for 2017 and 2018

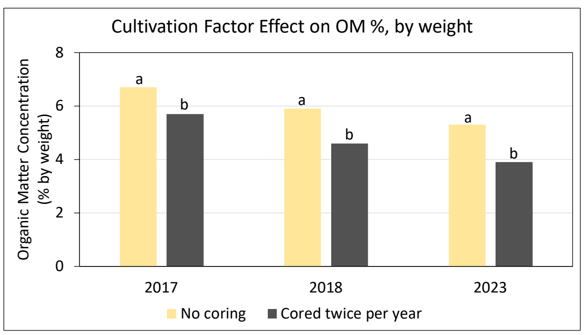
142

Organic matter concentration affected by 7 years of topdressing and core cultivation (before switching to solid tine cultivation).



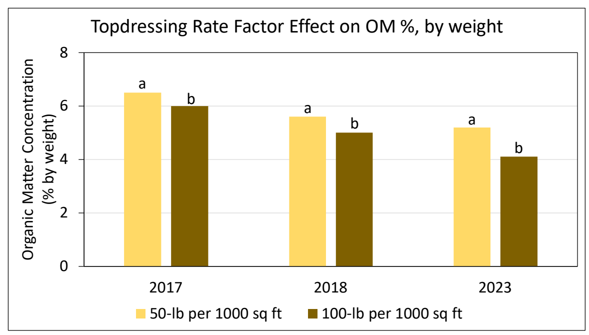
* Means for 2 reps of data versus 4 reps for 2017 and 2018

143



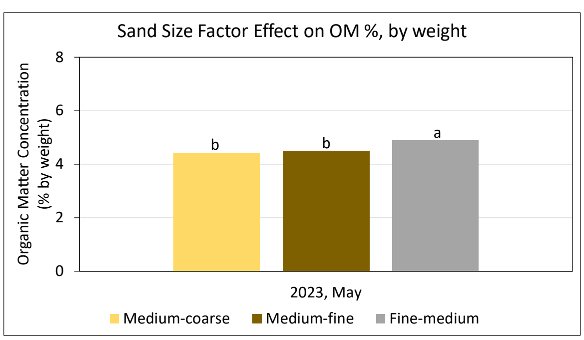
Pooled over all topdressing treatments, controls not included

144



Topdressing applied every 2 weeks during summer; 10 summer applications each year. Pooled over both cultivation levels.

145



Topdressing applied every 2 weeks during summer; 10 summer applications each year. Pooled over both cultivation levels.

146

Double-ring Infiltration Test (August 2019)

- Measured 3 consecutive infiltration tests of 1-inch of water per double-ring
- One double-ring per plot

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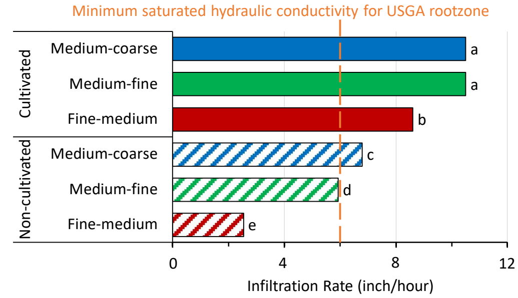
ANOVA of Water Infiltration Rate (August 2019)

Source of Variation	Infiltration Rate: 1st round	Infiltration Rate: 2nd round	Infiltration Rate: 3rd round
Sand Size (SS)	***	***	***
Topdress Rate (TR)	ns	ns	ns
SS*TR	ns	ns	ns
Core Cultivation (CC)	***	***	***
SS*CC	ns	ns	*
TR*CC	ns	ns	ns
SS*TR*CC	ns	ns	ns

148

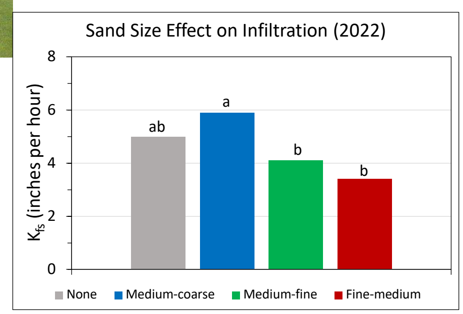
Sand Size x Core Cultivation Interaction
3rd round of 1-inch of water



149

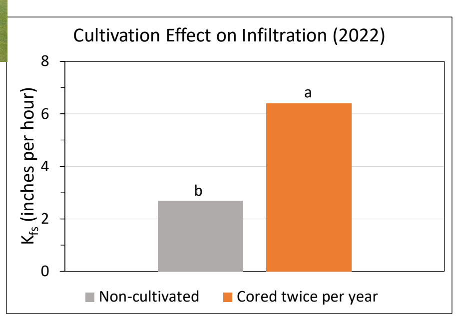
Field Saturated Hydraylic Conductivity, K_{fs} (2022)

150



Topdressing sands applied at 100-lb per 1,000 sq ft every 2 weeks during summer. Pooled over both levels of cultivation.

151

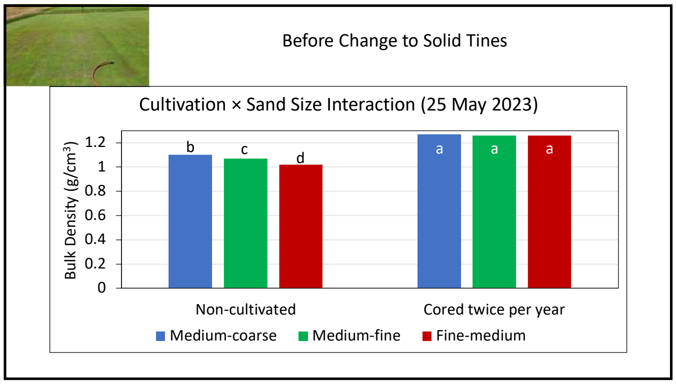


Pooled across all levels of topdressing sand size.

152

Bulk Density
Surface Hardness
Volumetric Water Content

153



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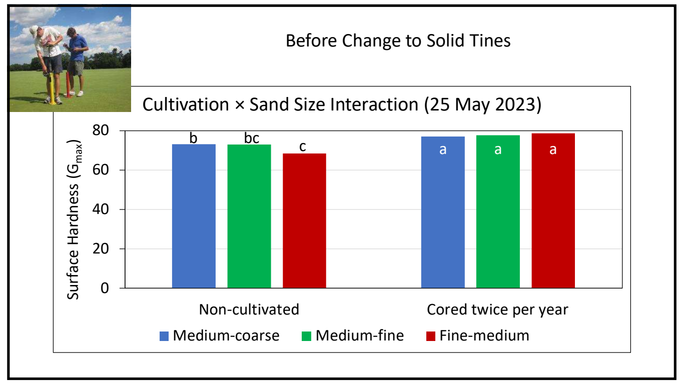

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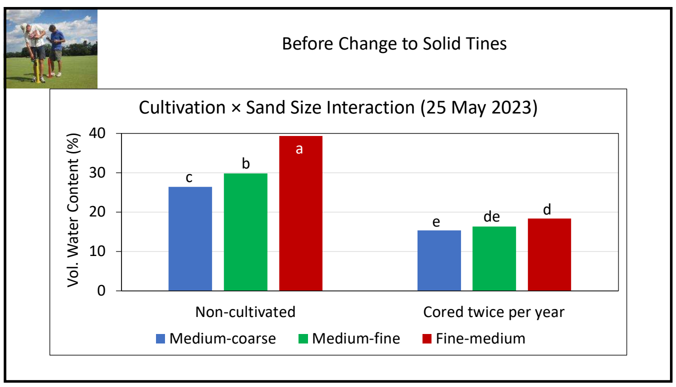

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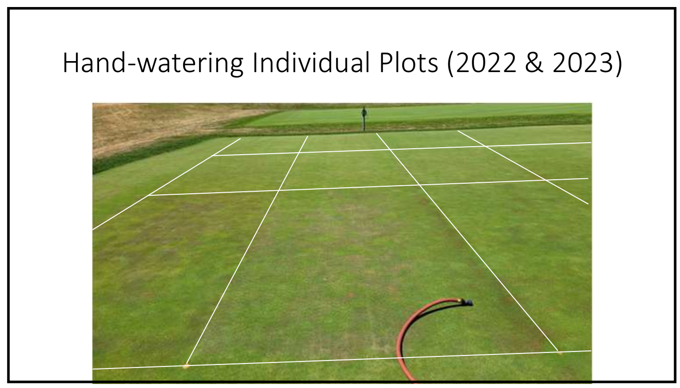

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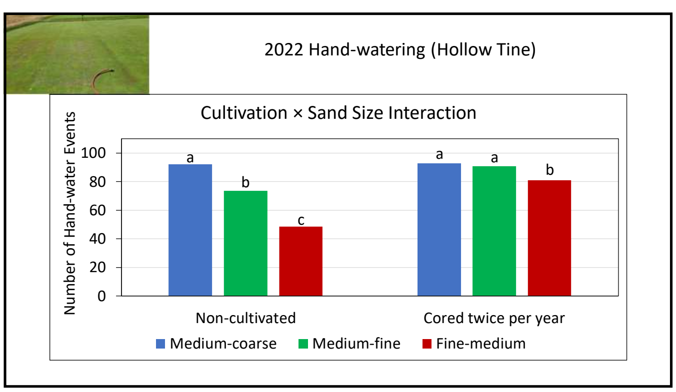

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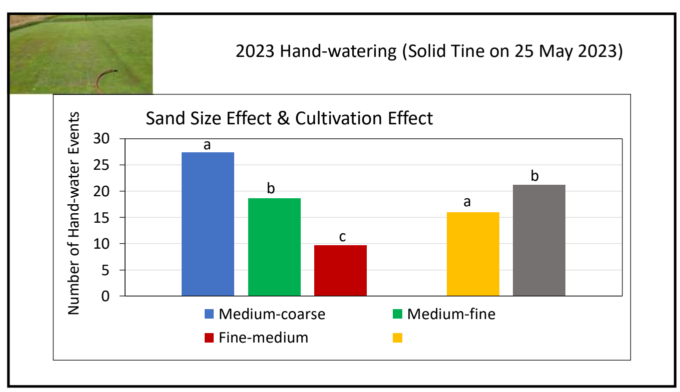


159

Mat-layer Physical Properties

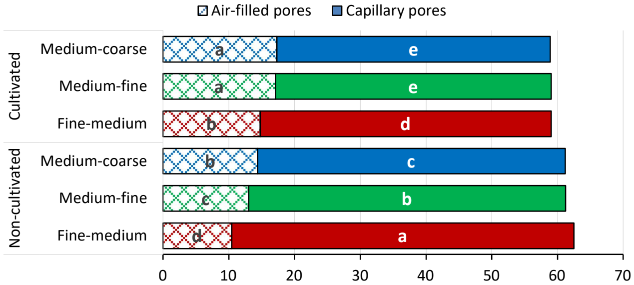
160

ANOVA of Mat-layer Physical Properties

Source of Variation	---Pore Size Distribution---- Total	Air-filled	Capillary	------Sand Particle Size Fraction------ Very Coarse	Coarse + Medium	Fine	Very Fine
Sand Size (SS)	*	***	***	ns	***	***	***
Topdress Rate (TR)	***	ns	***	**	ns	ns	ns
SS*TR	ns	ns	ns	ns	ns	ns	ns
Core Cultivation (CC)	***	***	***	**	***	***	***
SS*CC	ns	*	*	*	***	***	***
TR*CC	*	ns	ns	ns	ns	ns	ns
SS*TR*CC	ns	ns	ns	ns	ns	ns	ns

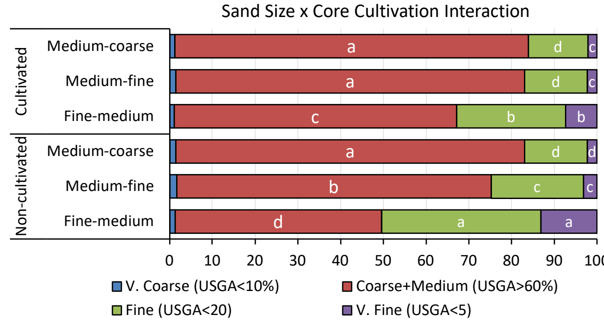
161

Pore Size Distribution as Affected by Sand Size x Core Cultivation Interaction



162

Sand Particle Size Fraction as Affected by Sand Size x Core Cultivation Interaction



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New Trials

Two cultivation trials initiated on creeping bentgrass in 2023 to compare hollow tine and solid tine cultivation.

Evaluating:

1. Turf quality
2. Healing of tine holes
3. Residual sand after topdressing
4. Volumetric water content at the 0- to 3-inch depth zone
5. Dual-head infiltrometers
6. Clegg soil hardness
7. Ball roll distance – GS3
8. Trueness of ball roll – GS3
9. Smoothness of ball roll – GS3
10. Firmness – drop test with GS3

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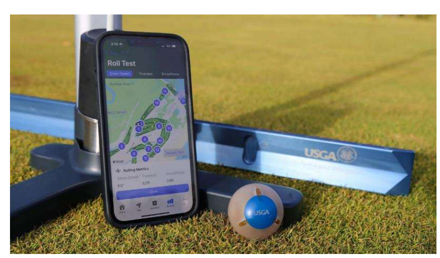
USGA GS3 Device for Playability

- Distance
- Trueness
- Smoothness
- Firmness



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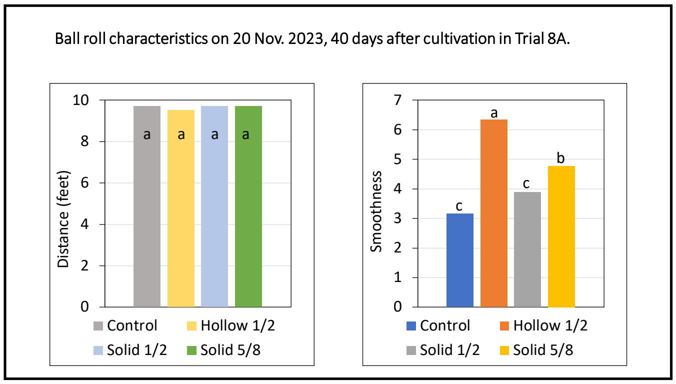

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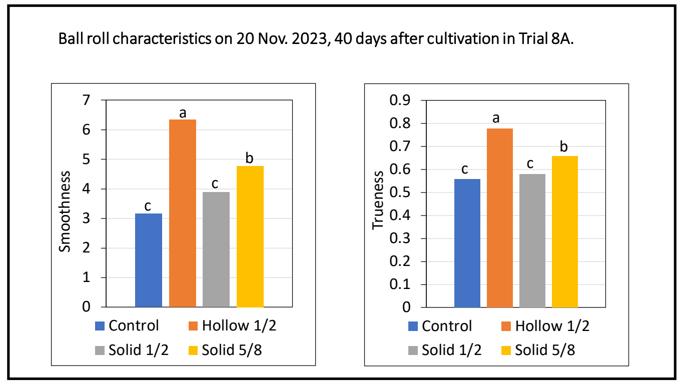

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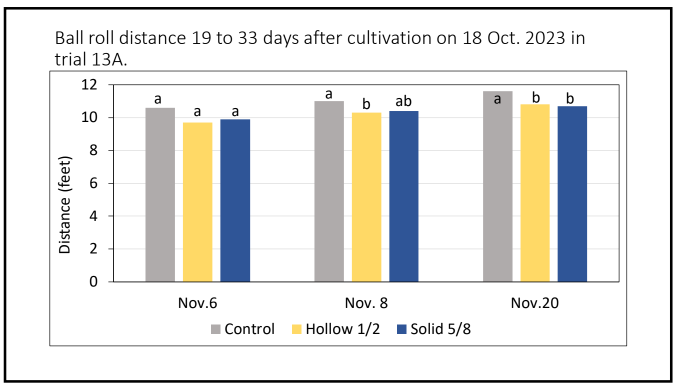

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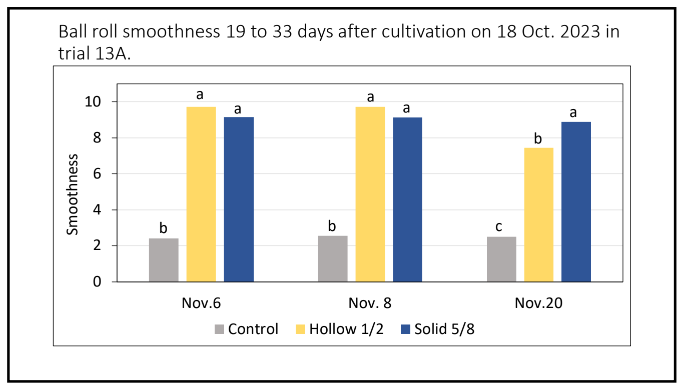

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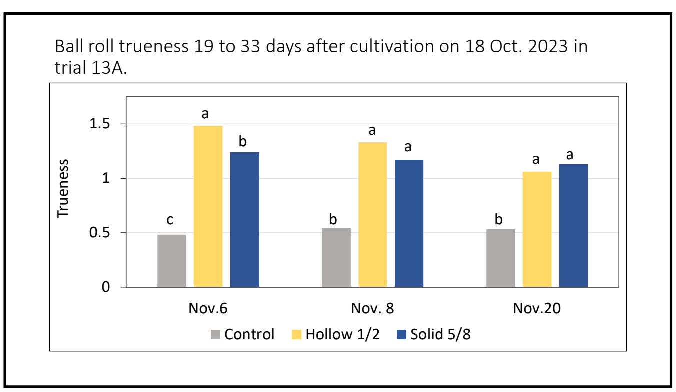

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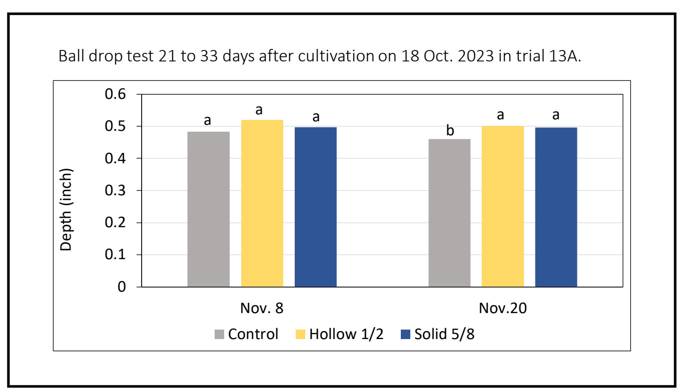

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Conclusions

Strong impact of core cultivation 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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Managing for Drier Mat Layer

Topdressing

- As much and as often as feasible — ~1 ton / 1,000 sq ft / yr; **18-22 ft^3 / 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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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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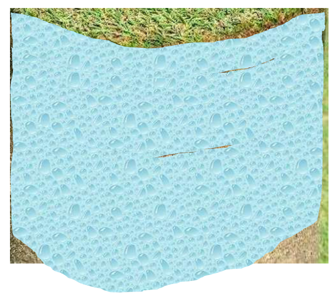

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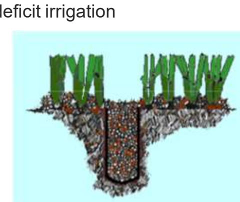
Layering

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



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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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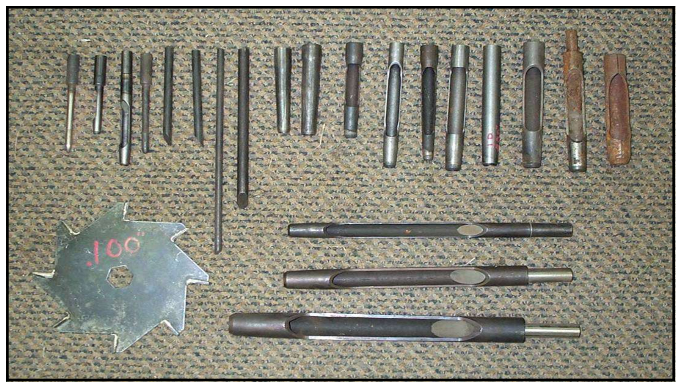

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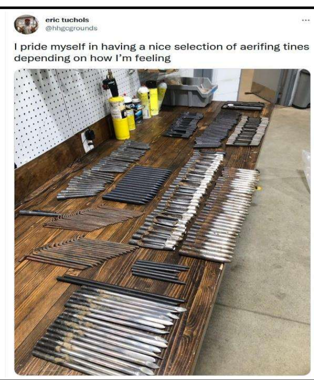

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What have we learned?

- 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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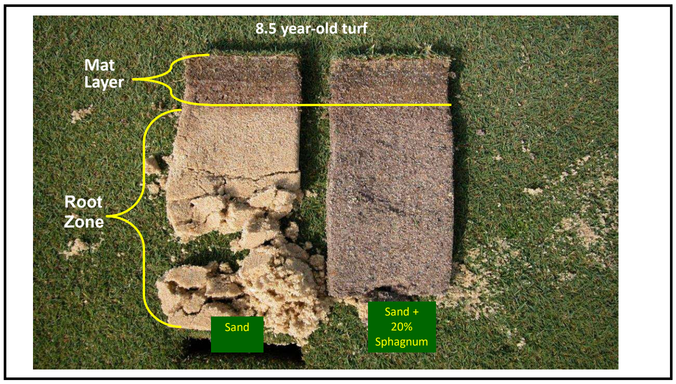

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It matters how you manage the accumulating thatch/mat layer

- 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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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

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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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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:
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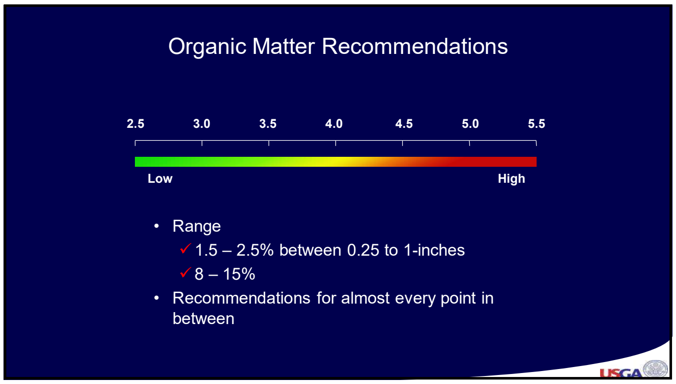

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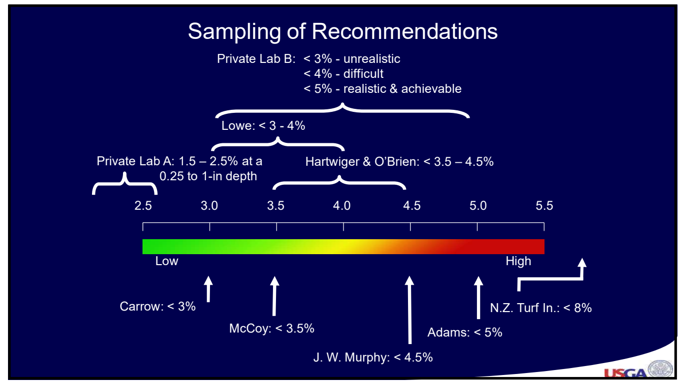

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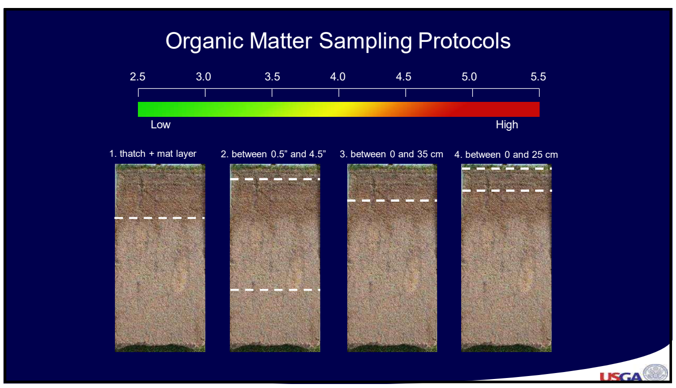

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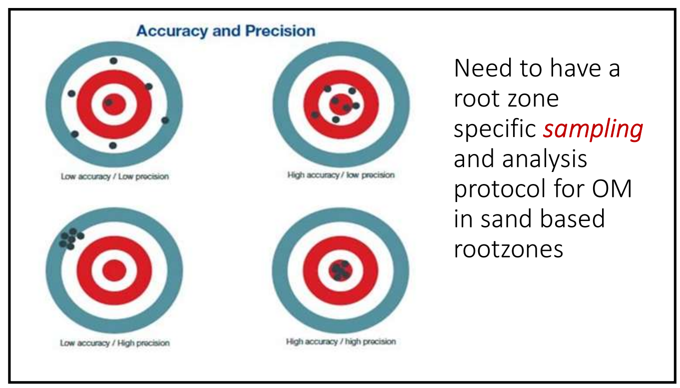

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How and when to take samples

- 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 360°C for measuring organic matter. Ensure the lab you choose measures organic matter of the entire intact sample using 440°C 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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- **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 2024!

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