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Topdressing 101: Organic Matter Management for Cool-Season Putting Greens

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Outline

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

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THE FIFTH GREEN AT THE ESSEX COUNTY COUNTRY CLUB

1930 Advertisement

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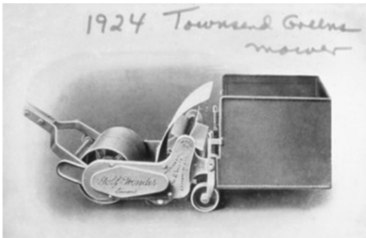
Closer cut mowers



As low as 0.25”

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

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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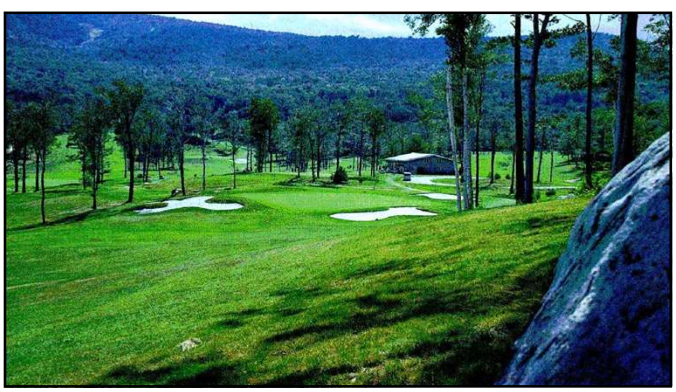

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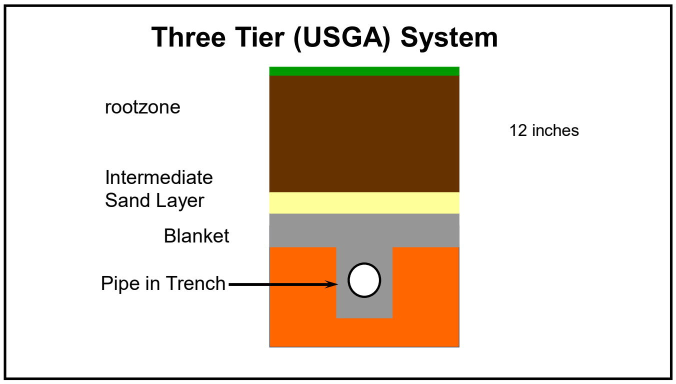

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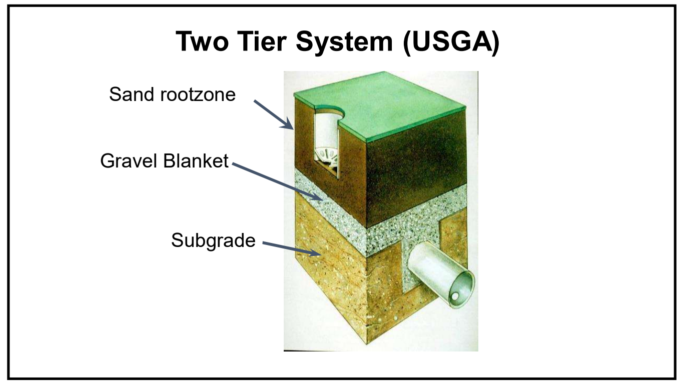

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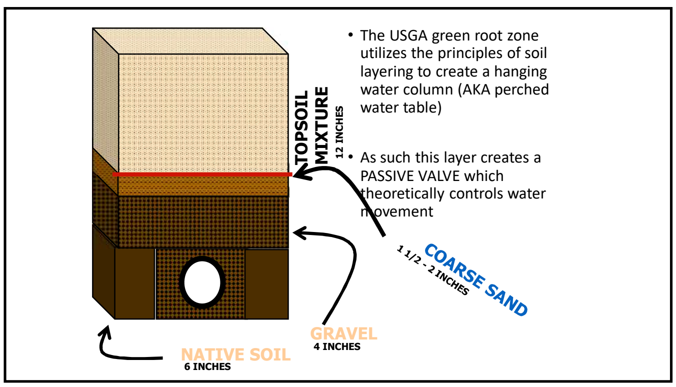

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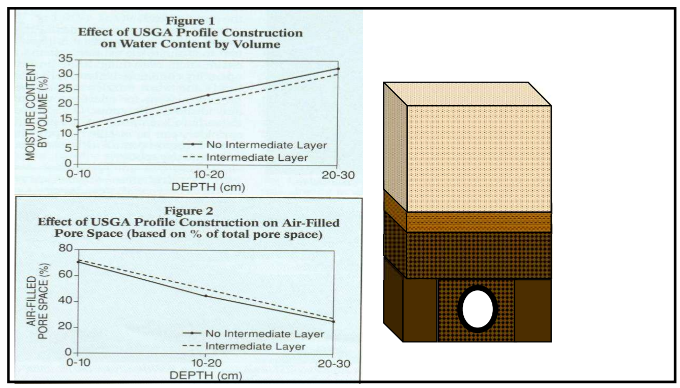

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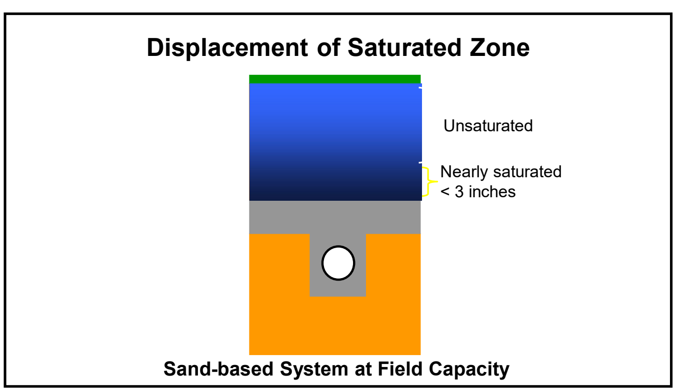

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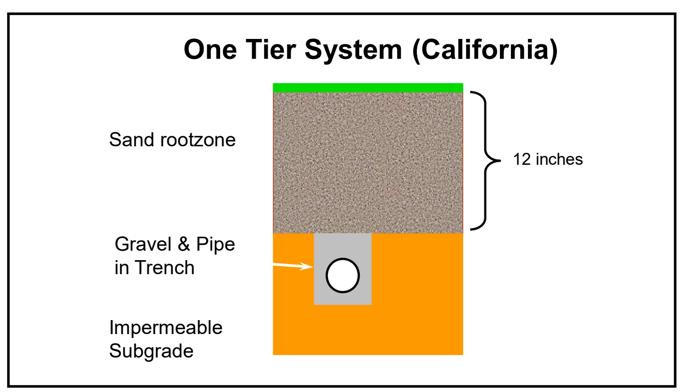

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Root Zone Properties

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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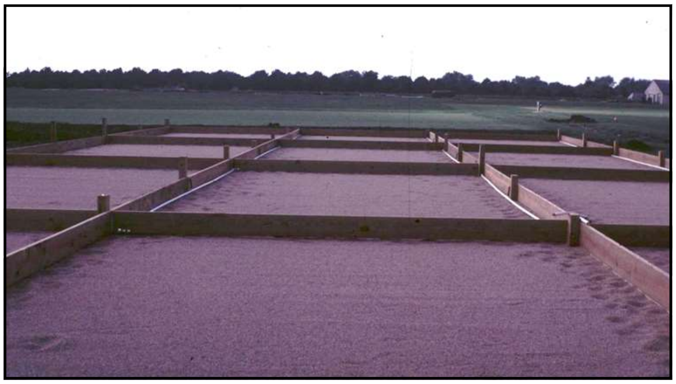

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Project Schedule (Phase I)

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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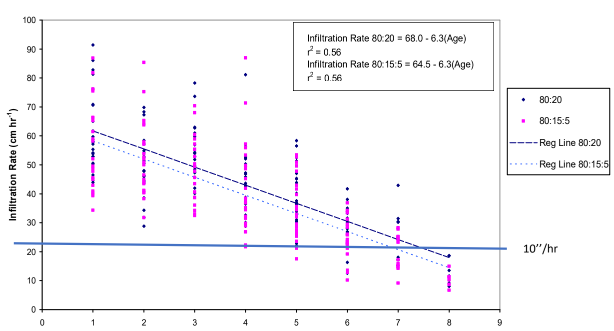

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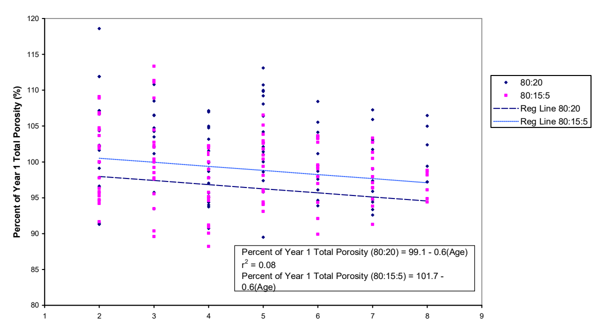

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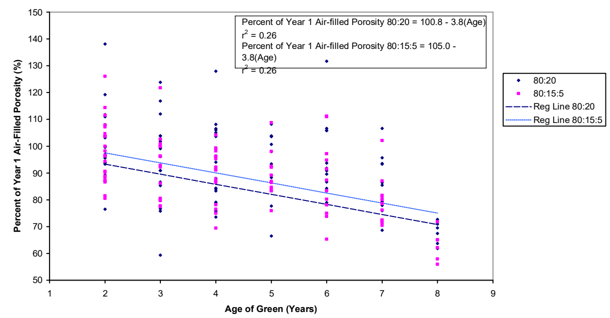

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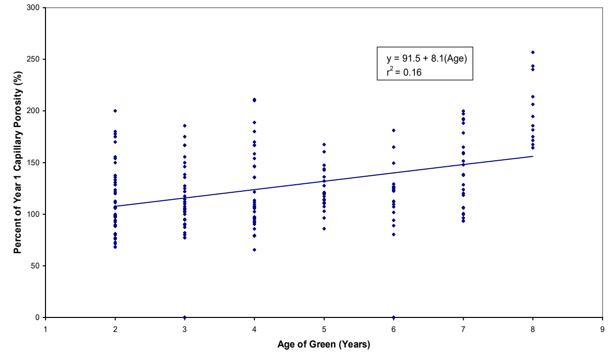

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Microbial Properties

(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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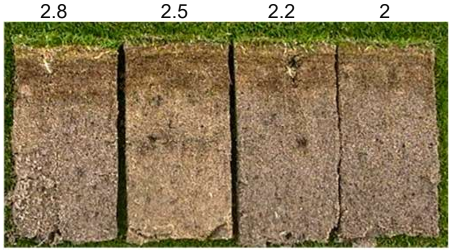
Mat development (cm)

2.8 2.5 2.2 2



8 7 6 5

Green age (years)

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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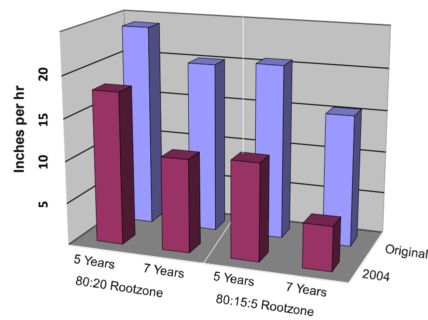

Comparison of preconstruction K_{sat} values to K_{sat} values taken 10/04.

40

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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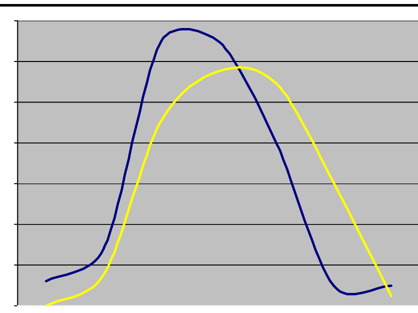

USGA sand size compared to sand used in topdressing program for USGA plots at Mead, NE.

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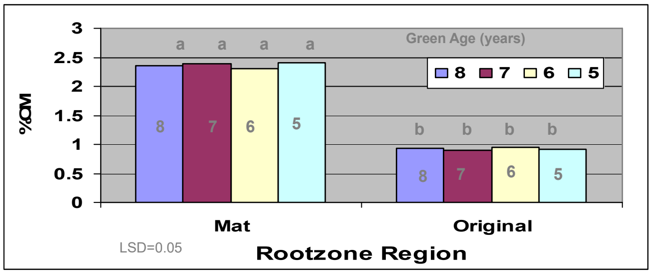
Rootzone vs Mat: Organic Matter



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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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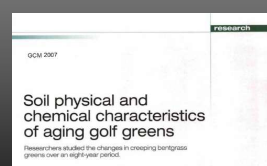
Want to know more?

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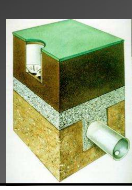
10+ Years of Research on Putting Green Root Zones at Rutgers University



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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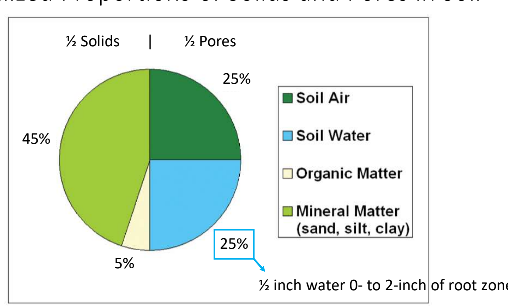
Idealized Proportions of Solids and Pores in Soil



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

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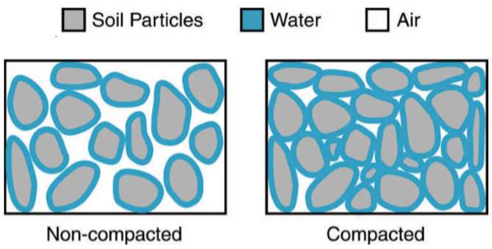

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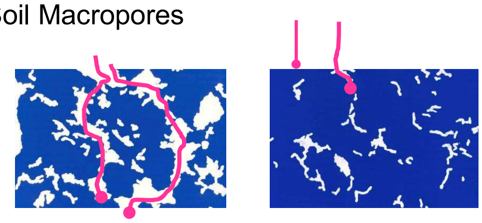
Soil Macropores



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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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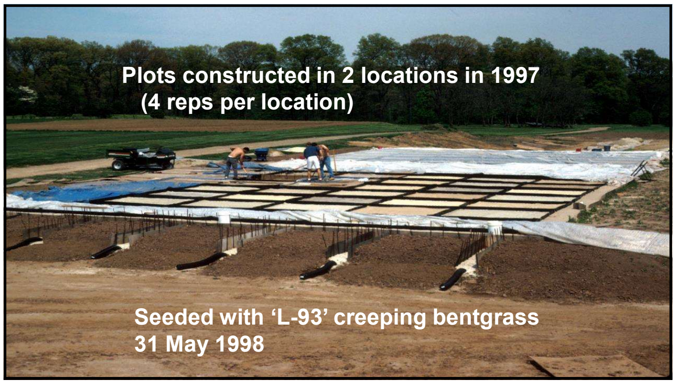

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Open Location

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Enclosed Location

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Topdressed with Construction Mix

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Mircoenvironment effect on annual mean turf quality averaged over root zone amendment treatments.

	1999	2000	2001	2002	2003	2004	2005
	9 = best, 5 = least acceptable turf quality						
Open	6.9	6.7	7.6	6.0	6.6	7.5	7.6
Enclosed	6.7	6.9	7.0	5.3	5.5	6.7	6.2
F test	*	NS	***	***	**	***	***

- As expected, turf quality poorest in the enclosed microenvironment (ME).
- More importantly, relative differences among treatment was similar across MEs; no evidence to justify building differently based on ME.

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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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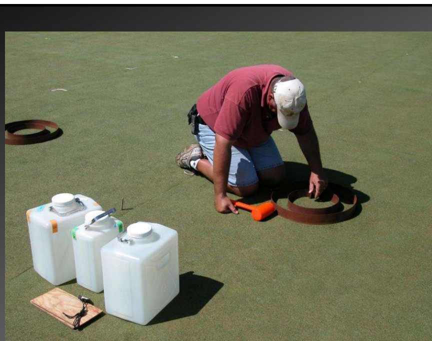

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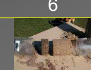
K_{sat} and Field Water Infiltration in 2004

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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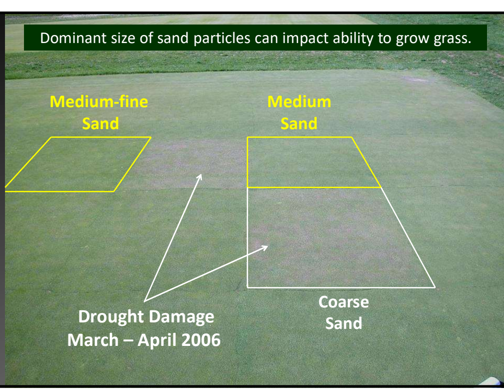

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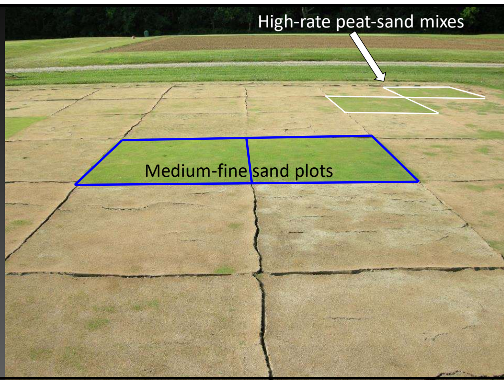

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Algae forms when plots are not allowed to dry sufficiently between irrigations (i.e., plot specific irrigation discontinued)

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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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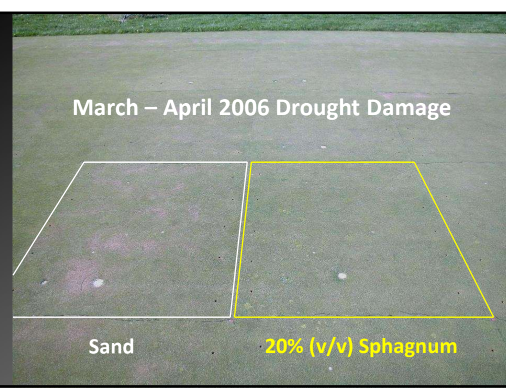

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Compost

- 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/ US Composting Council

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Inorganic amendments

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

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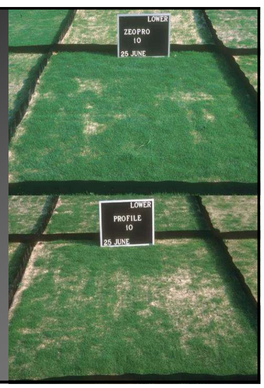
Inorganic Amendments

- 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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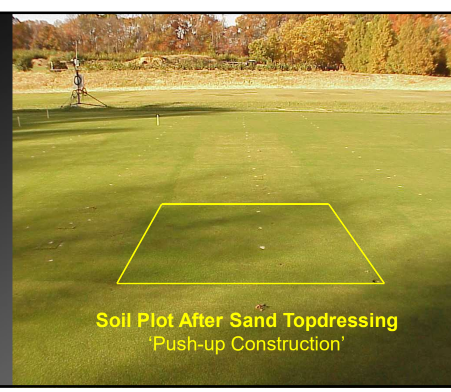

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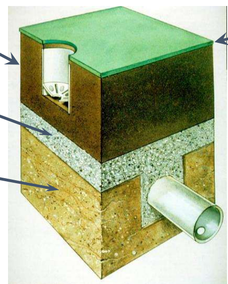
USGA Sand-based Rootzone



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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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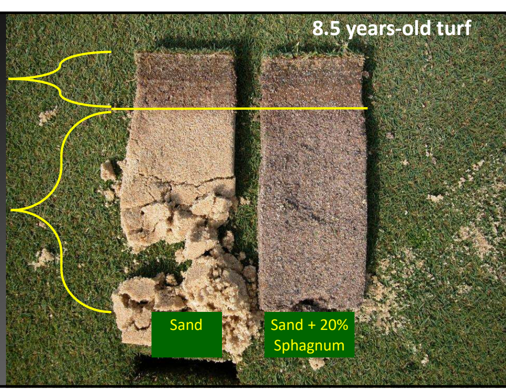

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Sand

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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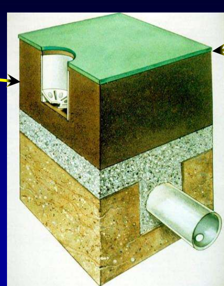
USGA Sand-based Rootzone



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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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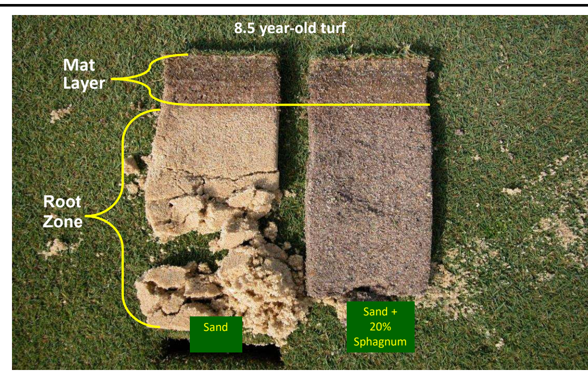

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Organic Matter Management Study

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

100

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

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

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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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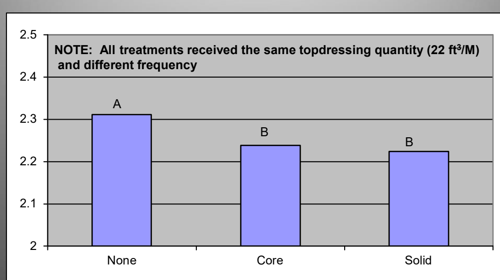
Effect of Tines on OM after 1 yr



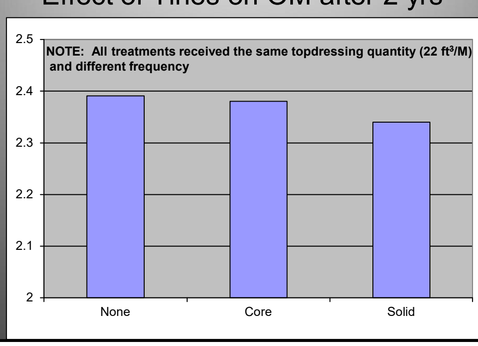
105

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



107

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

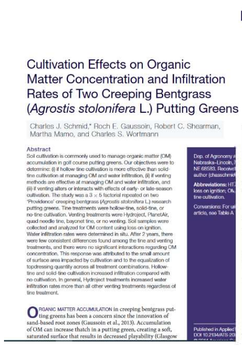
109

*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

111

Project Objective

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

112

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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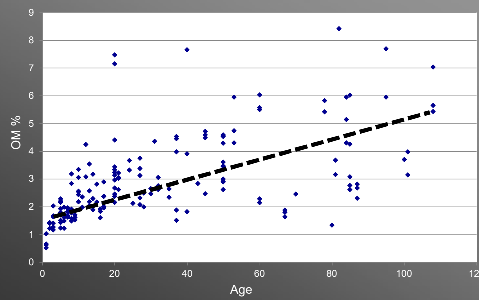
114

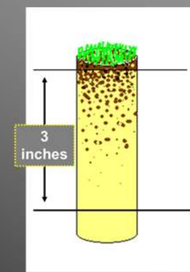
Green Age



115

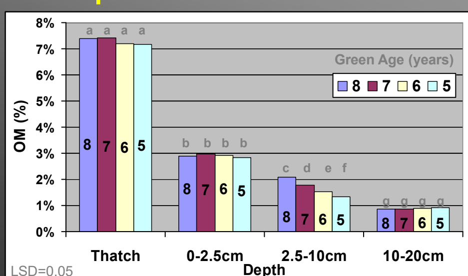
Is the age effect misleading?

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



116

Organic Matter in USGA Specification Rootzones



117

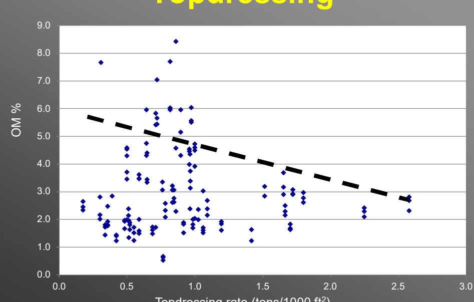
Mat Development with Age

8 7 6 5

Green Age (years)

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***

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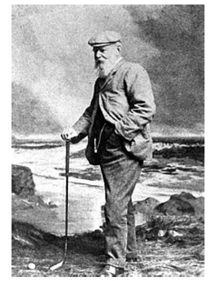
Topdressing

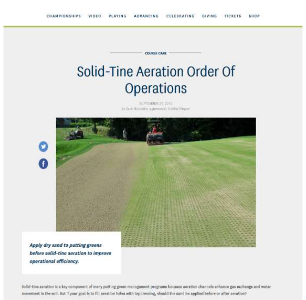
Old Tom Morris (1821–1908) is thought to have discovered the benefits of topdressing accidentally when he spilled a wheelbarrow of sand on a putting green and noted how the turf thrived shortly afterward (Hurdzan, 2004).

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

124

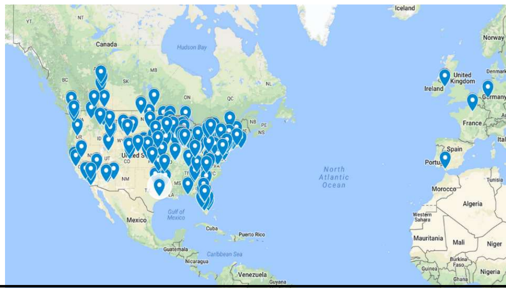
125

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.

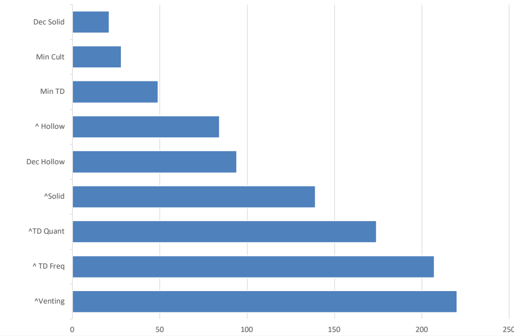
126

2016 Survey Respondents via Greenkeeper



127

303 Responses

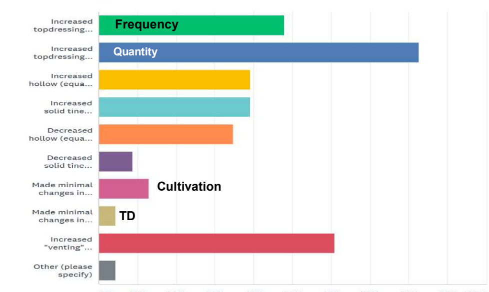


128

(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

130

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

131

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?

133

	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

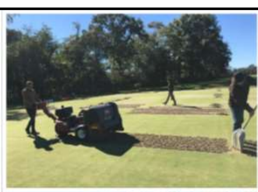
134

	Factors in the Experiment				
Treatment No.	Sand Size	Topdressing Rate during Growing Season	Cultivation (twice/year; May & Oct) Hollow Tine	Backfill / Topdress	Annual Quantity of Sand Applied
		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

135

	Factors in the Experiment				
Treatment No.	Sand Size	Topdressing Rate during Growing Season	Cultivation (twice/year; May & Oct) Solid Tine ⅝-inch	Backfill / Topdressing	Annual Quantity of Sand Applied
		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

136



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

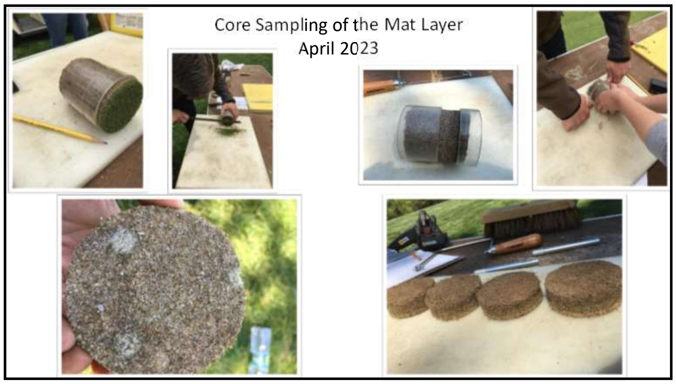
137

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

138



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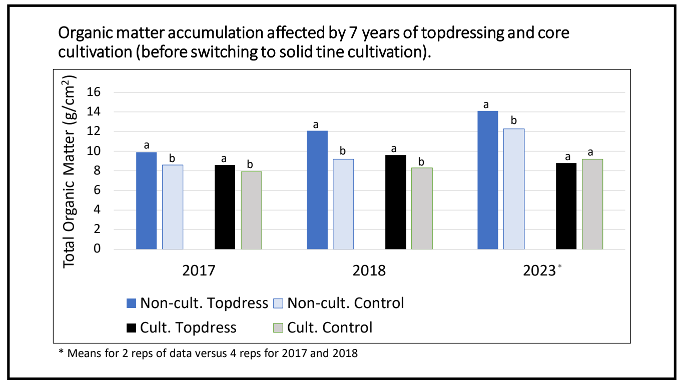

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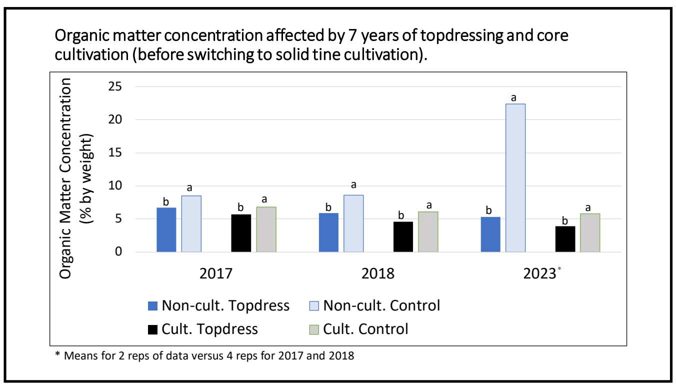

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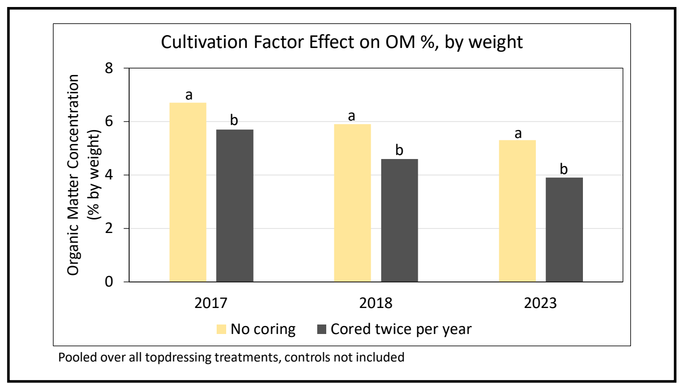

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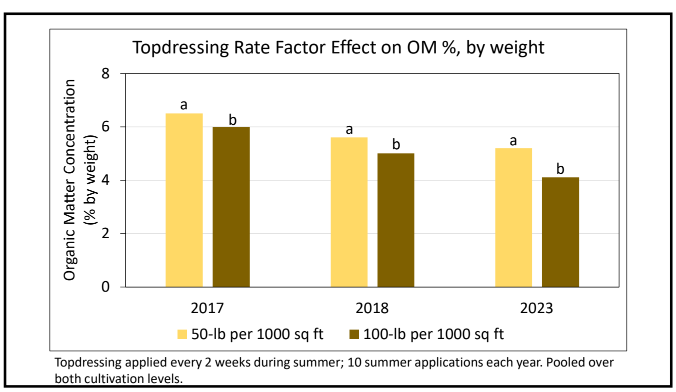

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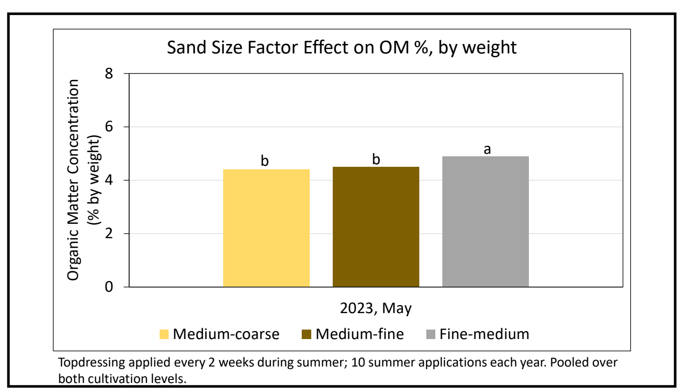


144

Double-ring Infiltration Test (August 2019)

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

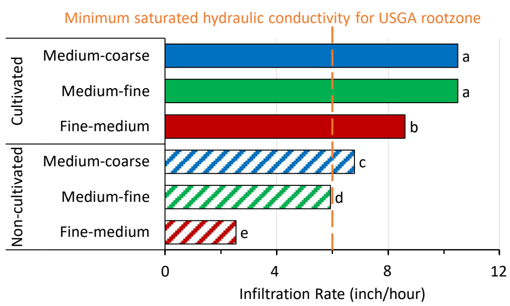
145

ANOVA of Water Infiltration Rate (August 2019)

	------- Infiltration Rate -------		
Source of Variation	1st round	2nd round	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

146

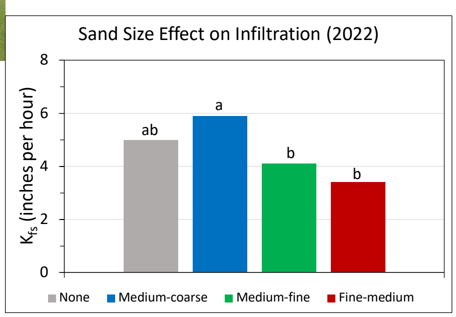
Sand Size x Core Cultivation Interaction
3rd round of 1-inch of water



147

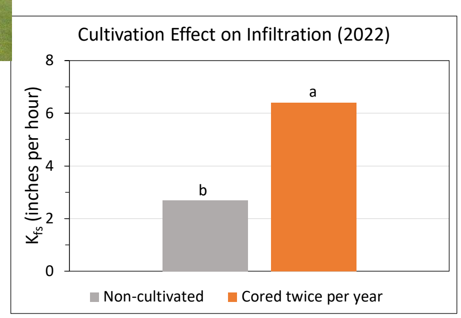
Field Saturated Hydraylic Conductivity, K_{fs} (2022)

148



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

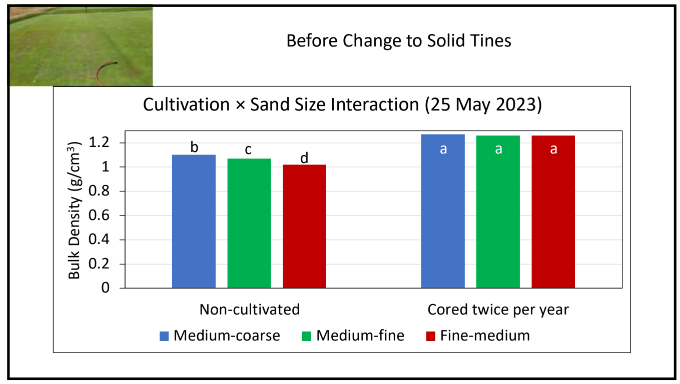
149



Pooled across all levels of topdressing sand size.

150

151



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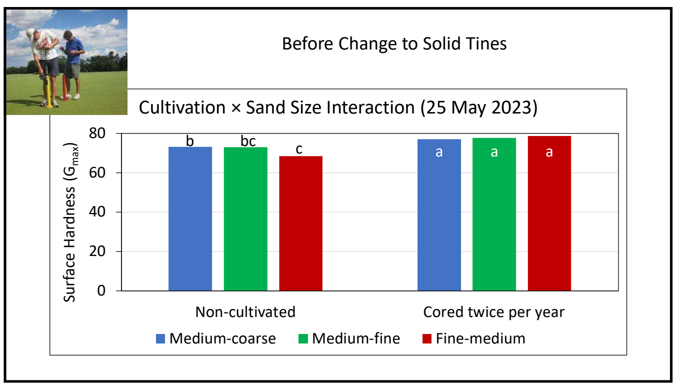

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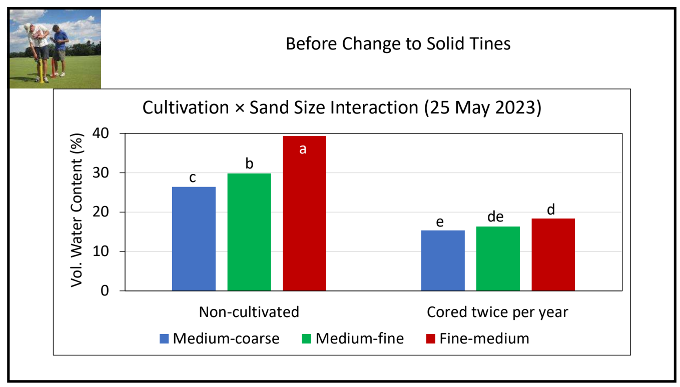

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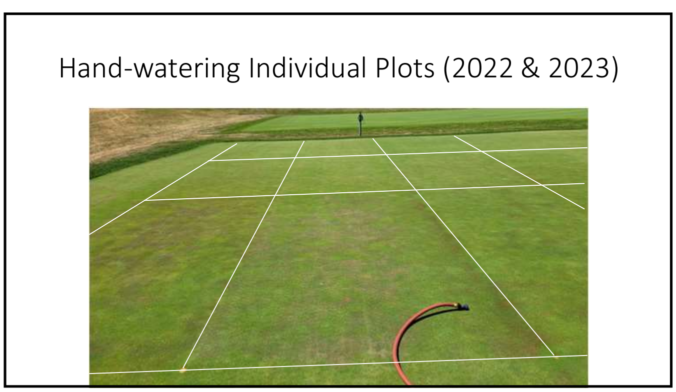

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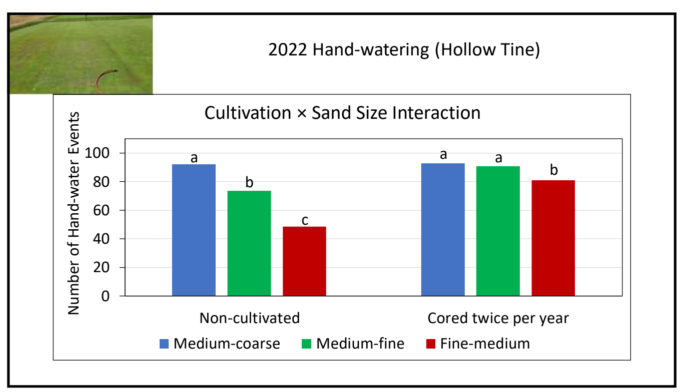
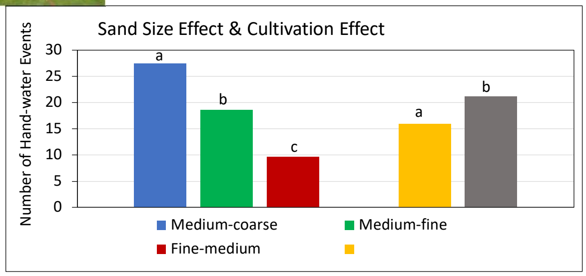


156

2023 Hand-watering (Solid Tine on 25 May 2023)



157

Mat-layer Physical Properties

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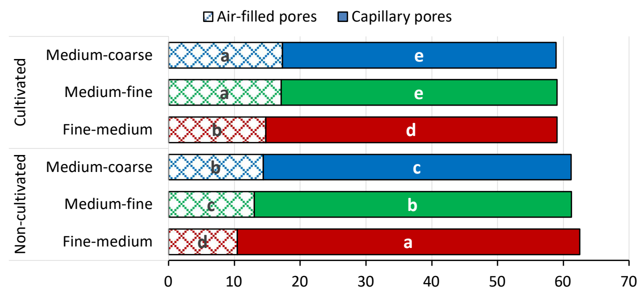
ANOVA of Mat-layer Physical Properties

	---Pore Size Distribution----			------Sand Particle Size Fraction------			
Source of Variation	Total	Air-filled	Capillary	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

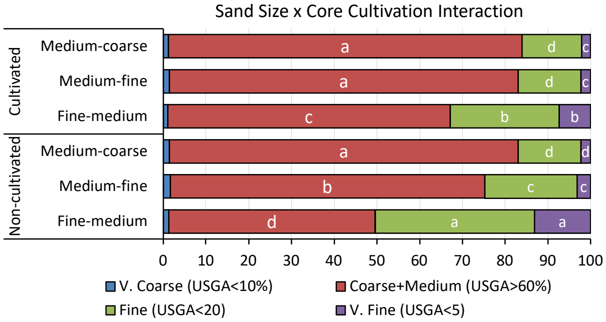
159

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



160

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



161

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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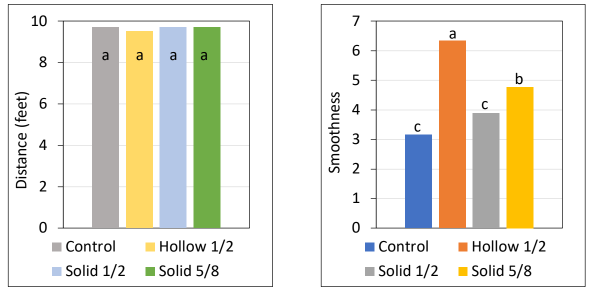
USGA GS3 Device for Playability

- Distance
- Trueness
- Smoothness
- Firmness

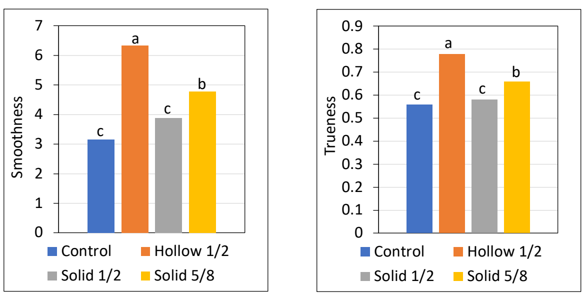
163

Ball roll characteristics on 20 Nov. 2023, 40 days after cultivation in Trial 8A.



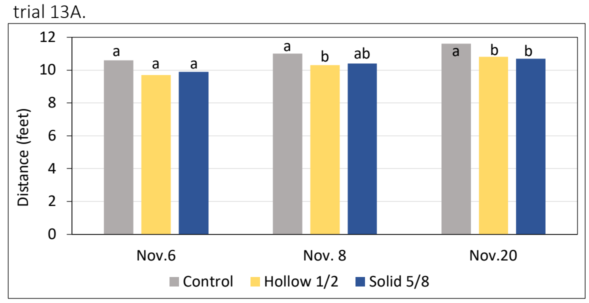
164

Ball roll characteristics on 20 Nov. 2023, 40 days after cultivation in Trial 8A.



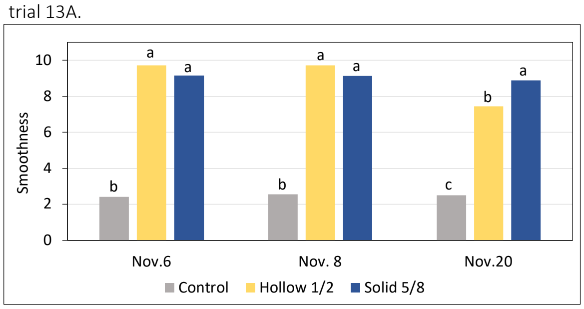
165

Ball roll distance 19 to 33 days after cultivation on 18 Oct. 2023 in trial 13A.



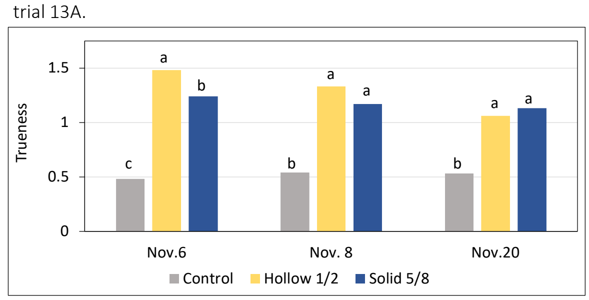
166

Ball roll smoothness 19 to 33 days after cultivation on 18 Oct. 2023 in trial 13A.



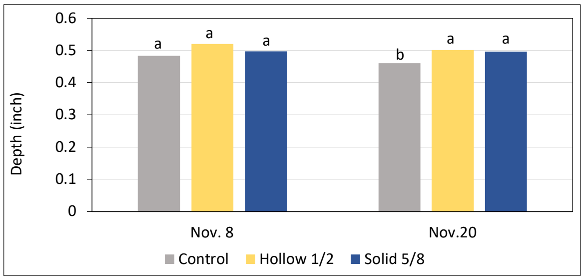
167

Ball roll trueness 19 to 33 days after cultivation on 18 Oct. 2023 in trial 13A.



168

Ball drop test 21 to 33 days after cultivation on 18 Oct. 2023 in trial 13A.



169

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

170

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

171

Acknowledgments

RUTGERS
New Jersey Agricultural Experiment Station
Center for Turfgrass Science

Golf Course Superintendents Association New Jersey 1926

New Jersey Turfgrass Association

USGA®
Mike Davis Program for Advancing Golf Course Management

172

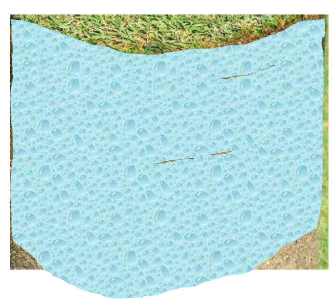
Layering

- 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

173



174

175

Layering

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

176

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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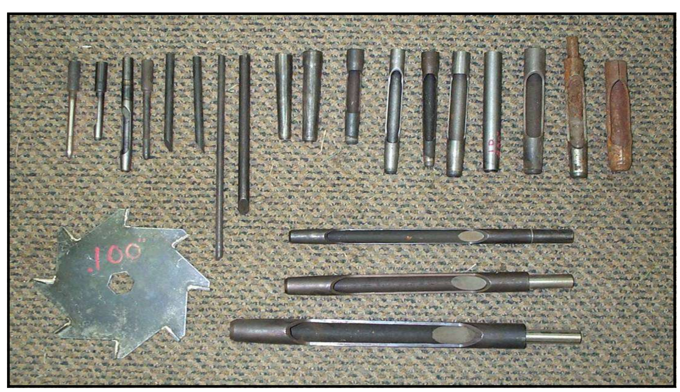
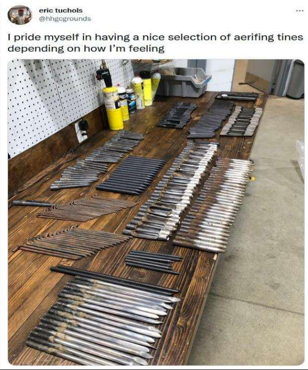
179



180



181

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 “

182

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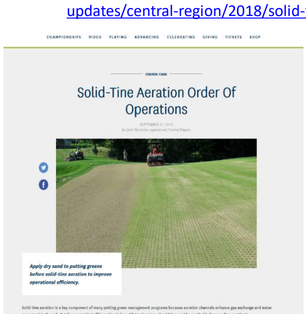
https://www.usga.org/content/usga/home-page/course-care/regional-updates/central-region/2018/solid-tine-aeration-order-of-operations.html



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

- Main Plots (42' X 60' with a 6' border between)
  - 1. Topdress before tines with 0.25"(0.125" on October 2023) on surface (equates to 1 (1/2 fall) ton/1000 ft^2 or 20 ft^3/1000ft^2)
  - 2. Topdress after tines
- Sub-plots (tine treatments) set at 3" depth
  - ***1. 5/8' Viper Nose™***
  - ***2. 1/2" Viper Nose™***
  - 3. 3/8" solid
  - ***4.*** ½" solid cross
  - 5. Untined control
  - 6. ¼ " solid
  - 7. .50" solid
  - ***8. 3/8" hollow, side eject***
  - 9. 1/2" solid cross
  - 10. .75" solid slicing
  - **11. 1/2" hollow, tapered**
  - **12. 1/2" hollow side eject**
  - **13. DryJect 3X3**
  - 14. Untined Control
  - 15. **DryJect 2X3**

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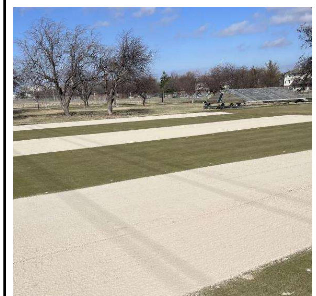


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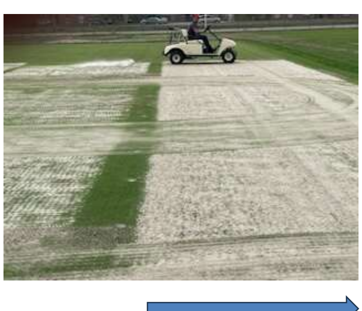


Plot after dragging and several mowings and irrigation

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

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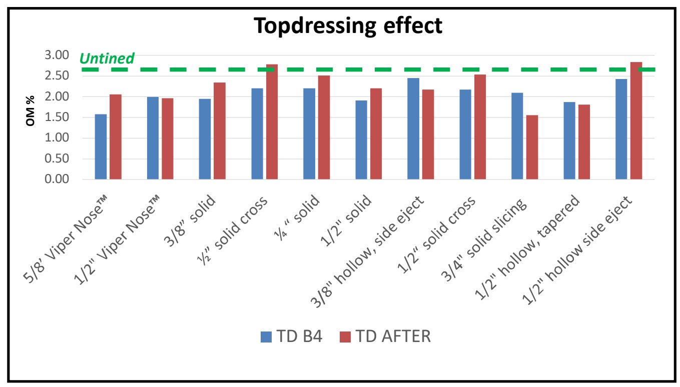

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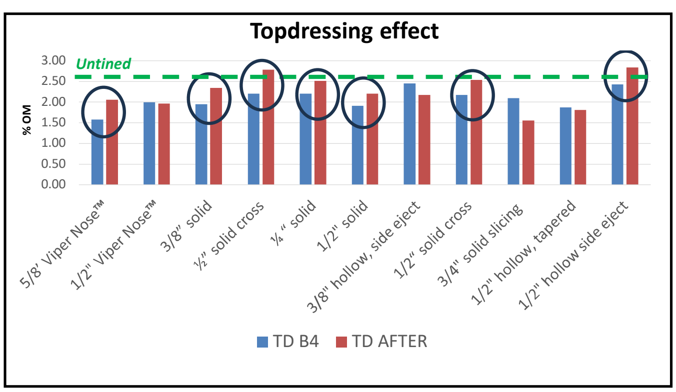

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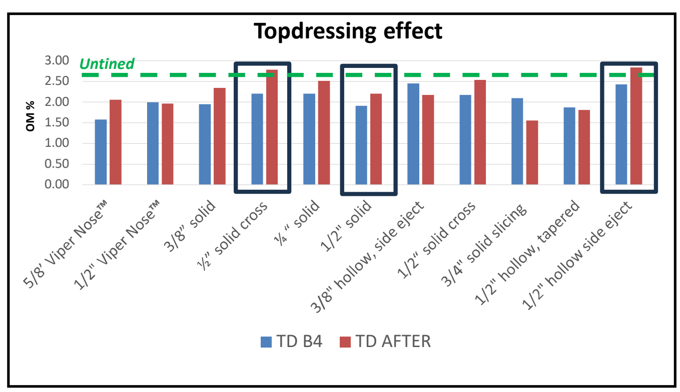

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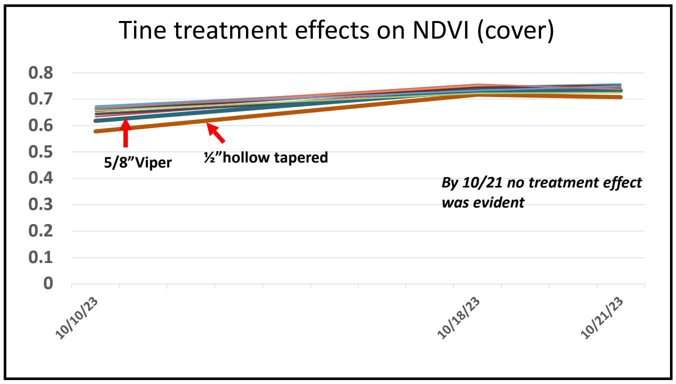

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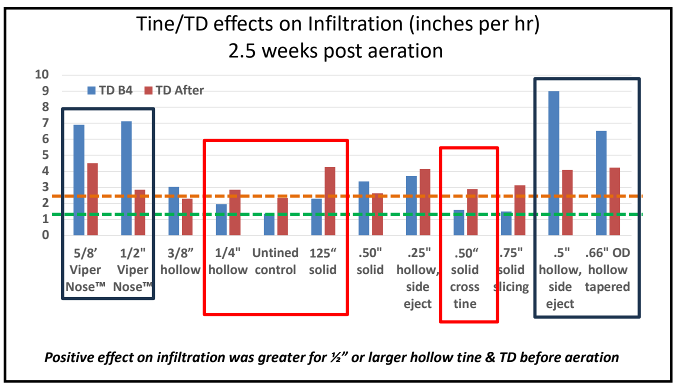

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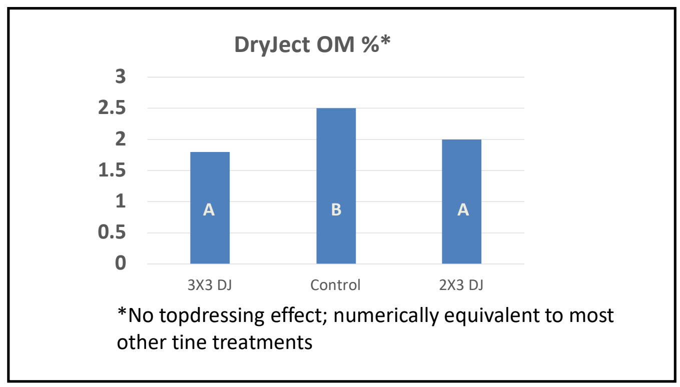

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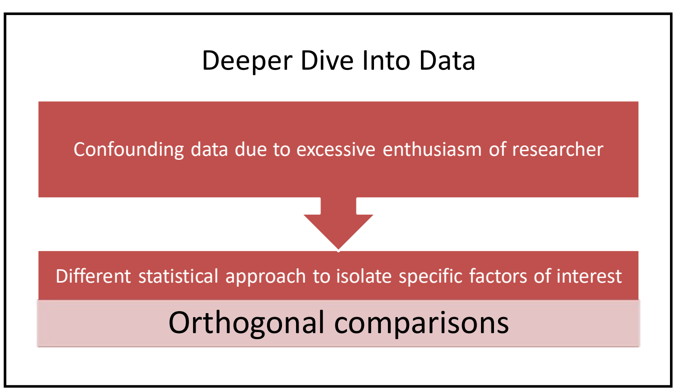

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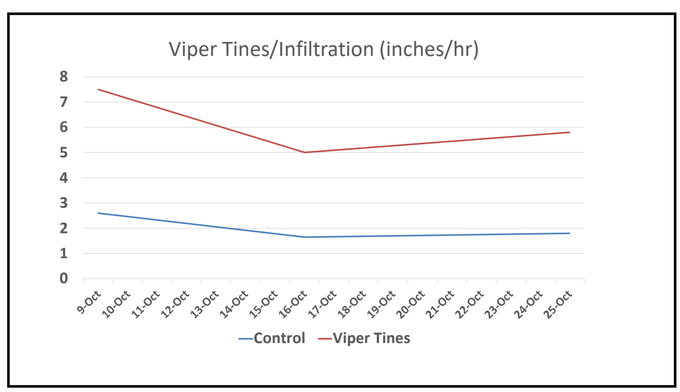

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1/2 Solid	1/2 Hollow
% OM	
1.8	2.4

**

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

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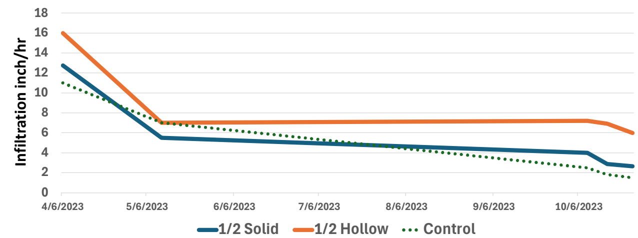
2023 infiltration/tine effect over time



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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Early Results

- Lots of stuff going on
- Topdressing before aeration, even with *some* hollow tines will incorporate more sand and increase infiltration
- 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***
- Study will continue into 2024..........maybe longer

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PROCORE 648 VS 648S

- Is there a difference in solid tine displacement and sand reception?

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Champions Run, Omaha, NE

Aerated on separate areas of the sand-based nursery putting green at 0.125" HOC, with ½" solid tines set at 3" with a 648S and 648. Each area was 60 ft².

Sampled with a 1" probe above aeration hole; 0-3" and 3-6" with 10 random locations per aerator

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Results

	648	648S
OM % 0-3"	2.2a	1.6b
OM % 3-6"	1.6a	1.4a

Different letters within a row indicate statistically significant differences at P < .01 based on a paired t-test with 18df

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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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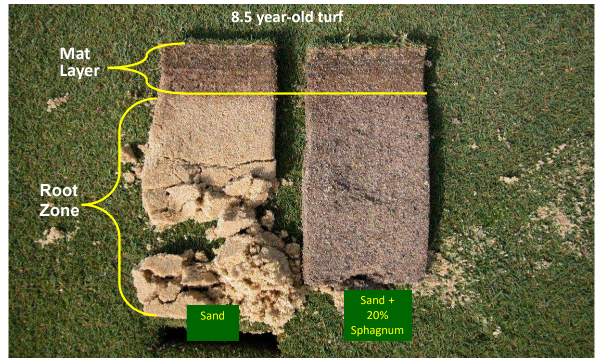

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It matters how you manage the accumulating thatch/mat layer

- 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 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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Dos and Don'ts of Organic Matter Sampling

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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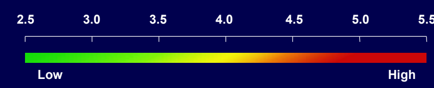
Organic Matter Recommendations



- Range
  - ✓ 1.5 – 2.5% between 0.25 to 1-inches
  - ✓ 8 – 15%
- Recommendations for almost every point in between

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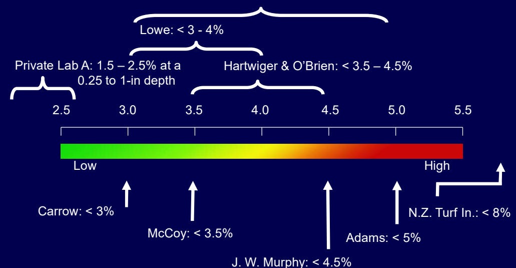
Sampling of Recommendations

Private Lab B: < 3% - unrealistic
< 4% - difficult
< 5% - realistic & achievable



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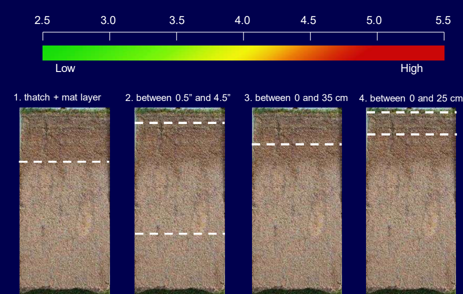
Organic Matter Sampling Protocols



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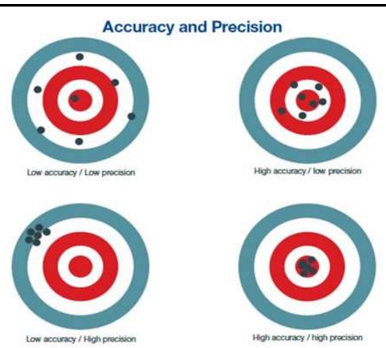

Need to have a root zone specific *sampling* and analysis protocol for OM in sand based rootzones

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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 360̊ C for measuring organic matter. Ensure the lab you choose measures organic matter of the entire intact sample using 440̊ 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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Acknowledgement (Rutgers)

United States Golf Association
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New Jersey Turfgrass Foundation
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AT Sales
Koonz Sprinkler
New Jersey State Golf Association
Rutgers Center for Turfgrass Science

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- **GCSA of South Dakota**
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- **Toro, DryJect, Ceres Turf, Inc**
- **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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