Understanding and Managing Organic Matter Accumulation in Cool-Season Putting Greens

Roch Gaussoin
University of Nebraska-Lincoln
rgaussoin1@unl.edu
@rockinsince57

What do we want to learn today?

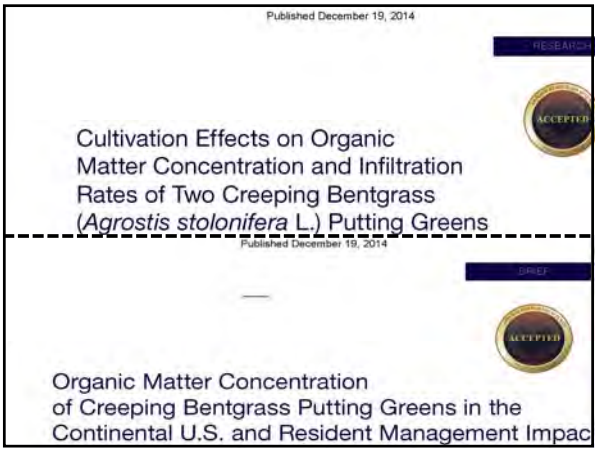
https://turf.unl.edu/

Then scroll down

ASA Monograph (3RD Edition)

Chapter 12
Characterization, Development, and Management of Organic Matter in Turfgrass Systems

R.E. Gaussoin, Dep. of Agronomy and Horticulture, Univ. of Nebraska
W.L. Berndt, Dep. of Resort and Hospitality Management, Florida Gulf Coast University
C.A. Dockrell, Teagasc College of Amenity Horticulture Dublin, Ireland
R.A. Drijber, Dep. of Agronomy and Horticulture, Univ. of Nebraska



Organic matter development: ***Are We the Problem?***

Or:

is organic matter % the green speed of the new millennium?

How does organic matter accumulate?

- Organic matter; defined
  - dead or near dead plant residue which accumulates in the grass ecosystem

How does organic matter accumulate?

- As grasses mature there is a continual senescence of non or limited function parts (roots, shoots and leaves)
- Senescence also happens when damage or injury occurs

How much OM is produced annually?

- Roots = 3500 lbs/acre
- Leaves = 2000 lbs/acre
- Other = 2500 lbs/acre

- TOTAL = ***8000 lbs/acre*** ***8967 kg/ha***

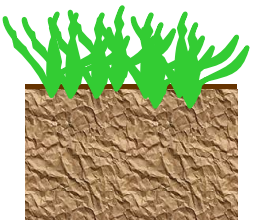
Fairway height blue/rye estimated annual production

Where does organic matter accumulate?

- Above ground
  - Thatch/Mat
  - clipping residue
    - relatively short term
    - "pseudo" thatch
- Below ground
  - root zone
  - rhizosphere

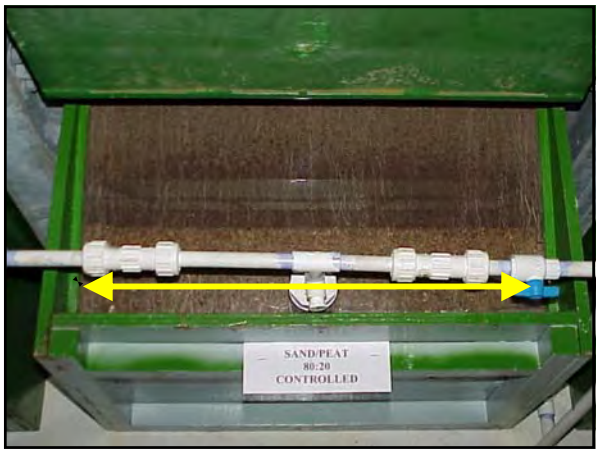
Importance of (P)OM in the rhizosphere

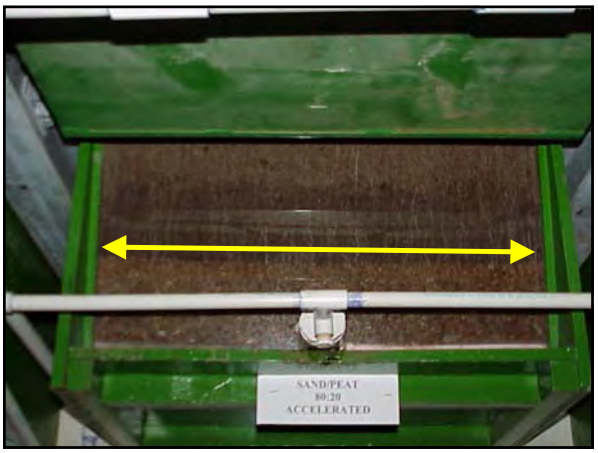
- deposition of particulate OM
- microbial niches
- nutrient uptake
- pathogen competition



Factors influencing rootzone (P)OM accumulation

- Mowing
  - increase height=increase rooting
- Irrigation
  - root growth restricted in waterlogged soils
- Cultivation
  - increase or decrease
- Fertility
  - increase or decrease
- Stress



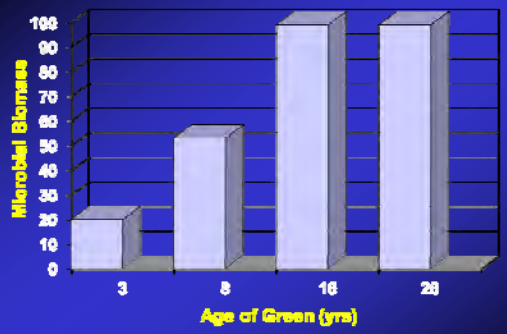


Rootzone accumulation yearly in sand green

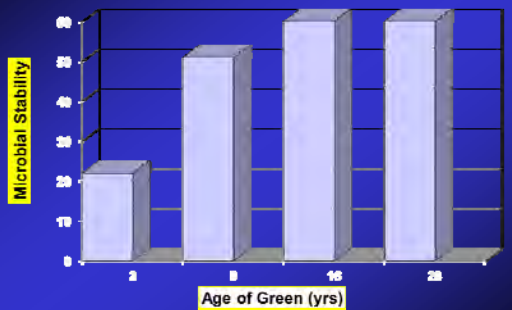
1997	1998	1999
0.65%	6.0%	3.0%

USGA spec. green constructed in 1997 with 20% (by volume) organic matter

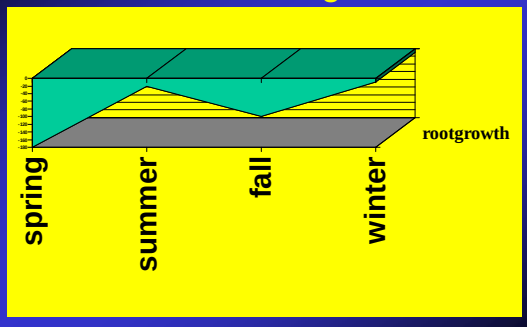
Green Age Effects on Microbial Biomass



Green Age Effects on Microbial Stability

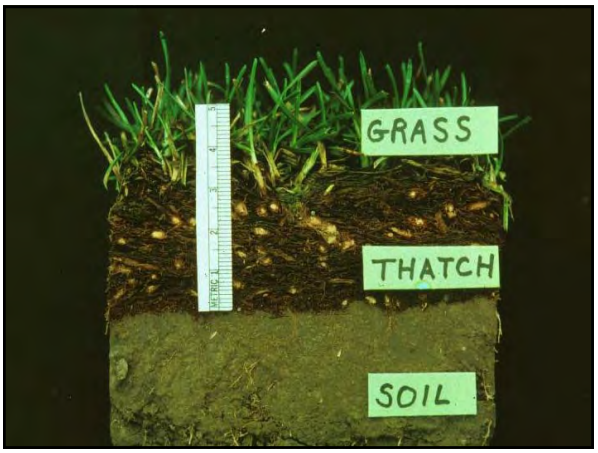


Rootzone accumulation seasonal root growth

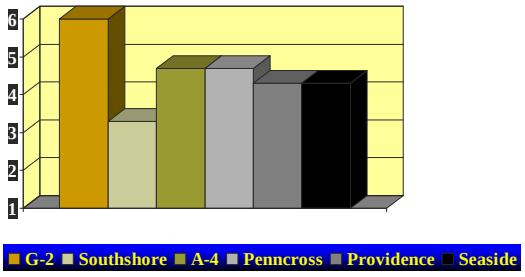


Thatch

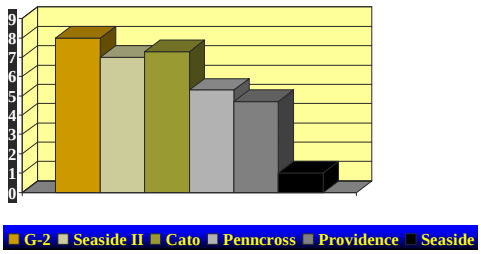
A loose, intermingled, organic, layer of dead and living shoots, stems, and roots that develops between the zone of green vegetation and the soil



Greens Height Bentgrass Thatch Thickness (mm)



Fairway Height Bentgrass Thatch Thickness (mm)



Benefits of “Moderate” Thatch

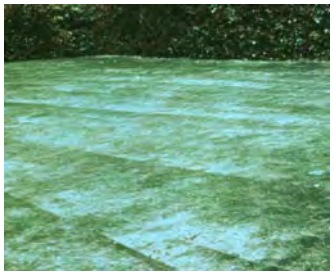
- Improved resilience and cushion
- improved wear tolerance
- insulate soil/crown to temperature extremes

Problems with excessive thatch

- Footprinting

Problems with excessive thatch

- Scalping



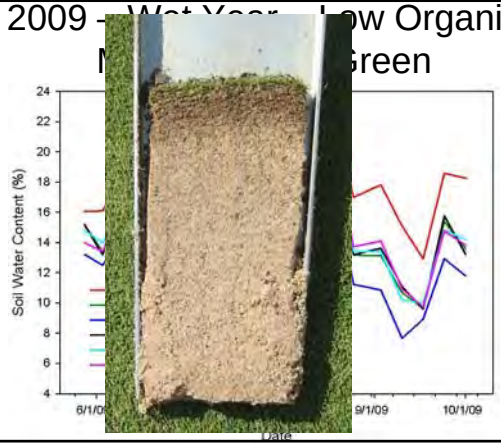
Problems with excessive thatch

- LDS

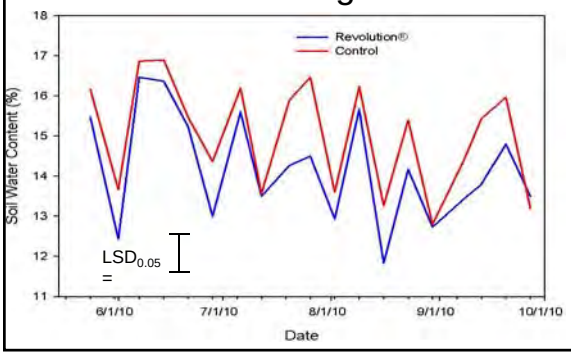
Doug Soldat's work at UW

- Next 3 slides
- Wetting agents, year differences and low and high OM greens

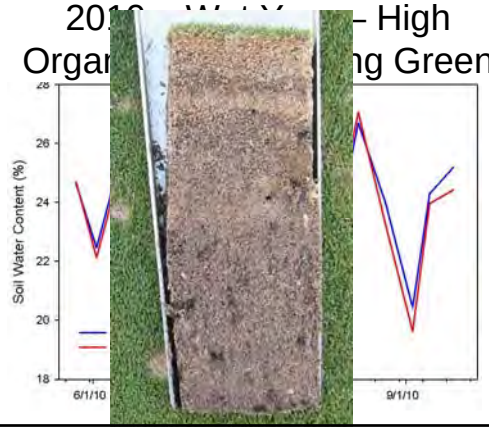
2009 – Wet Year – Low Organic Matter Putting Green



2010 – Wet Year – Low Organic Matter Putting Green



201[illegible] – High Organ[illegible]ng Green



Problems with excessive thatch

- Reduced Stress Tolerance

Problems with excessive thatch

- Overseeding Failure

Mat

Thatch that has been intermixed with mineral (soil) matter

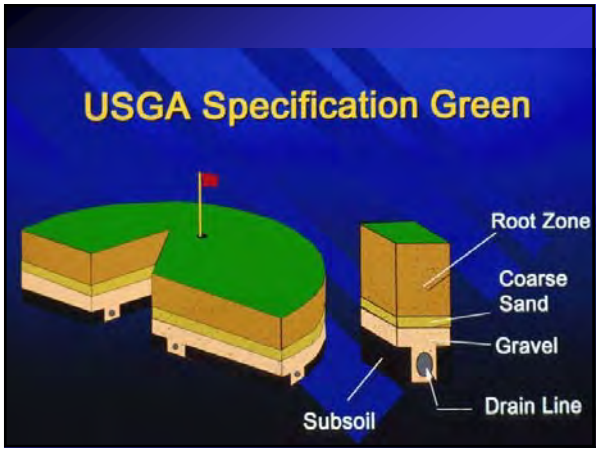
Because of inherent ambiguity in terminology and sampling techniques, the term "thatch-mat" has appeared frequently since the late 2000's (McCarty et al., 2007; Barton et al., 2009; Fu et al., 2009).

and yet one more definition……

SOM- Soil Organic Matter

Physical And Chemical Characteristics Of Aging Golf Greens

Roch Gaussoin, PhD
Jason Lewis
Ty McClellan
Chas Schmid
Bob Shearman, PhD



Treatments

- rootzone Mix
  - 80:20 (sand/peat)
  - 80:15:5 (sand/peat/soil)
- Grow-In Procedure
  - Accelerated
  - Controlled

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 rootzone materials and grow-in procedures.

Project Schedule (Phase II)

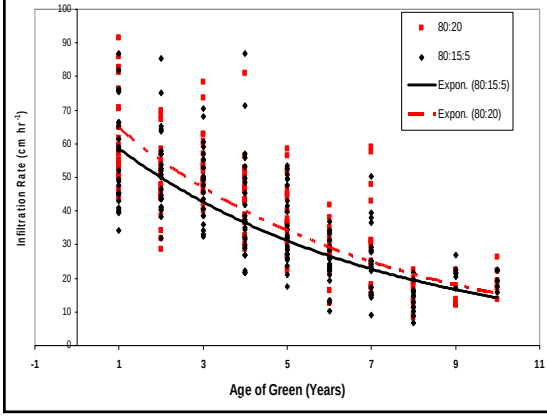
2002 | 2003 | 2004 | 2005

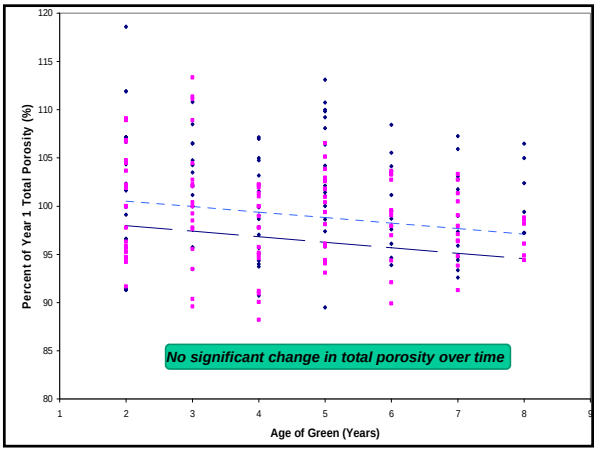
Data collection on soil physical and chemical characteristics as influenced by age, rootzone materials and grow-in procedures.

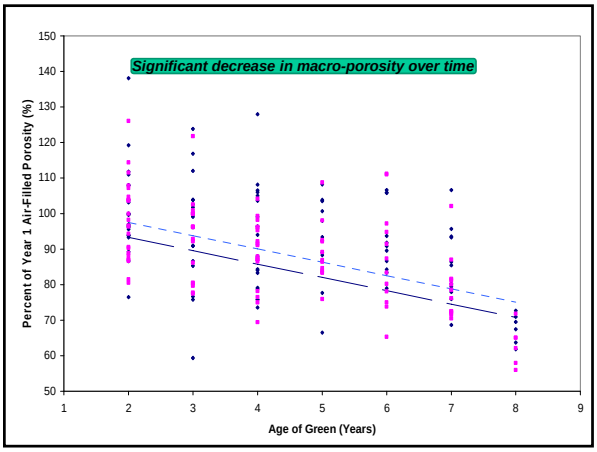
Materials and Methods

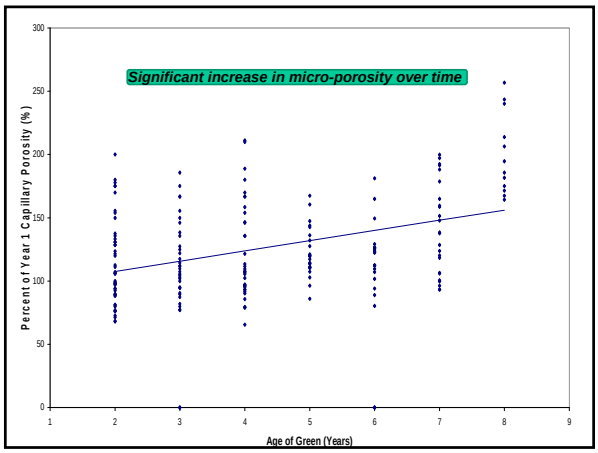
9 yr old green	10 yr old green	12 yr old green	13 yr old green

As of 2009



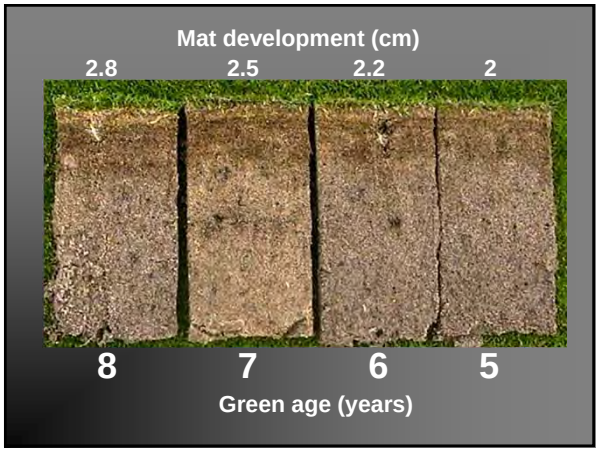






Formation of Mat

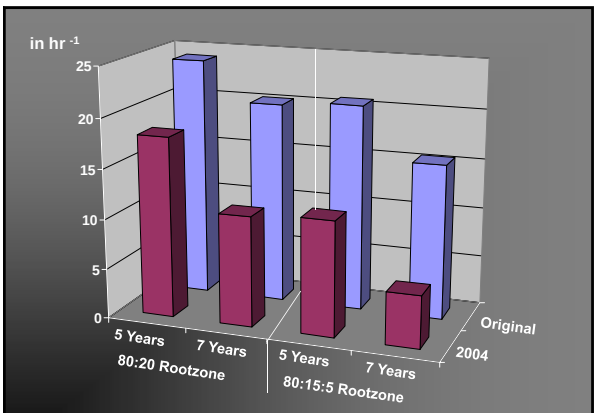
- Formation of mat layer increased approximately 0.65 cm annually (following establishment year).
- No visible layering, only a transition is evident between mat and original rootzone.
- Topdressing program
  - Light, Frequent
    - every 10-14 days (depending on growth) and combined with verticutting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



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

Materials and Methods

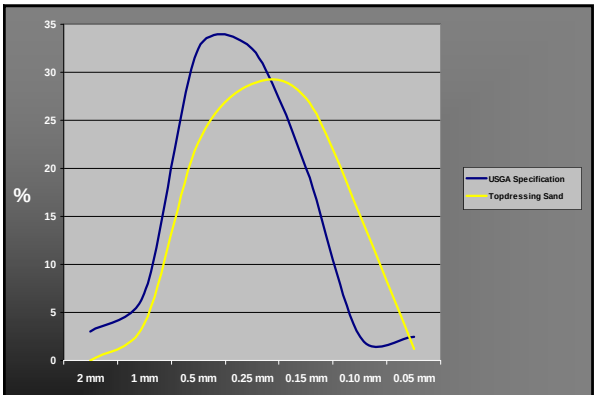
- **2004 rootzone samples taken below mat layer from each soil treatment and sent to Hummel labs for Quality Control Test (24 total samples) & tested against original quality control test (z-score).**
- **Other analysis also completed**



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

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).
- 5 of 8 rootzones were significant (z-score) for increased fine sand content.



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

Conclusions

- The K_{SAT} decrease over time ***may*** be due to organic matter accumulation above and in the original rootzone and/or the increased fine sand content originating from topdressing sand

Root Zone: Mat vs. Original

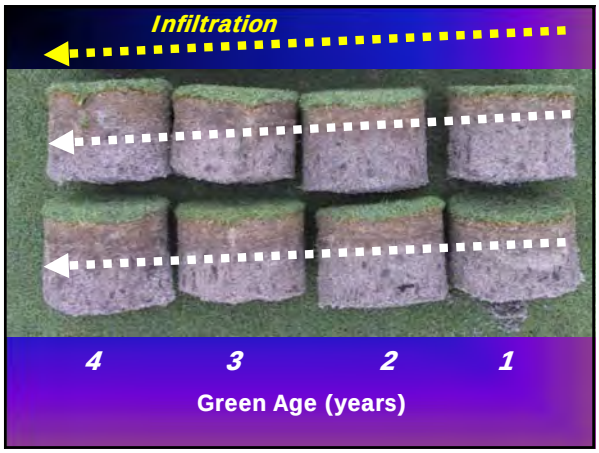
- pH:
  - Mat < Original for all USGA and California Greens.
- CEC, OM, and all Nutrients tested:
  - Mat > Original for all USGA and California Greens.

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.

Why is high OM considered to be "bad"?

- Loss of infiltration
- Decreased aeration
- Traps "toxic" gases
- Are these concerns real or imagined?
- Why the confusion?



all slides with the USGA logo in the corner are courtesy of Paul Vermeulen. Director, Competitions Agronomy at PGA TOUR, former USGA Agronomist

Organic Matter Recommendations

2.5 3.0 3.5 4.0 4.5 5.0 5.5

Low High

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

Sampling of Recommendations

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

Lowe: < 3 - 4%

Private Lab A: 1.5 – 2.5% at a 0.25 to 1-in depth

Hartwiger & O'Brien: < 3.5 – 4.5%

2.5 3.0 3.5 4.0 4.5 5.0 5.5

Low High

Carrow: < 3%

McCoy: < 3.5%

Adams: < 5%

N.Z. Turf In.: < 8%

J. W. Murphy: < 4.5%

Analysis Methods

- **Many exist, but the most relevant is "combustion" or "loss on ignition"**
- **The sample represents both dead and *living* organic matter**
  - **Food for thought……**

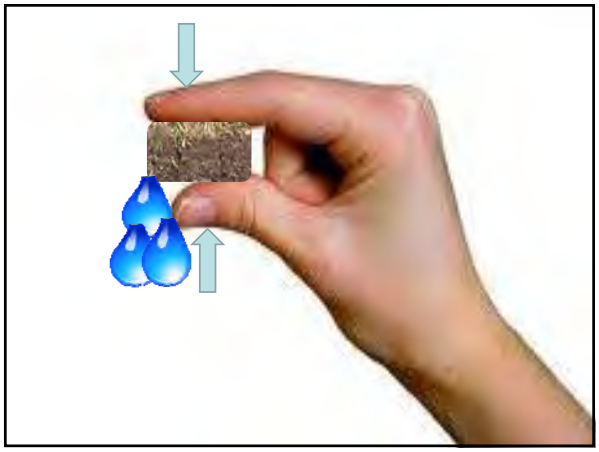
Organic Matter Sampling Protocols

2.5 3.0 3.5 4.0 4.5 5.0 5.5

Low High

1. thatch + mat layer
2. between 0.5" and 4.5"
3. between 0 and 35 cm
4. between 0 and 25 cm

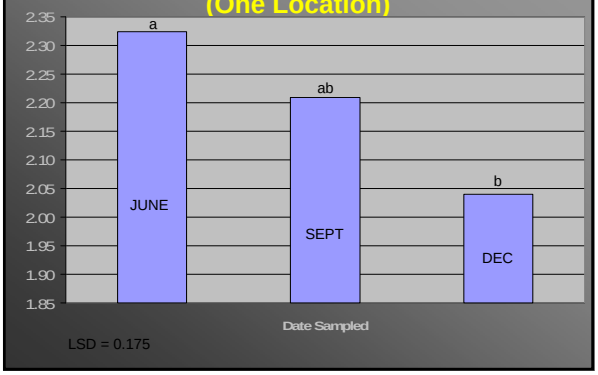
There is no "magic" number



OM Testing

- Know how your sample was taken and compare notes with others that use the same protocol
- Take annual tests to determine long-term trend
  - Same time of year
  - Same location and green
- Correlate your test results with turf quality and performance during stressful environmental conditions to determine need for changes in management program
- Threshold/critical levels likely vary across the United States and from course to course

Seasonal Variation
(One Location)



LSD = 0.175

How do you get rid of OM?

?????

Organic Matter Degradation Study

2007

Treatments

- Aerator (Granular)
- Aerator (Liquid)
- EXP072
- EXP074
- EXP076
- Carbo-Plex
- Bio-Blend
- ***Carbo-Plex + Bio-Blend***
- Bio-Groundskeeper (Granular)
- ***Bio-Groundskeeper (Liquid)***
- ***Thatch X***
- EXPO70M
- EcoChem Lawn Thatch Reducer
- Untreated Control

Locations

- **KY Bluegrass Tee Box**
  - **Native Soil**
- **Bentgrass Green**
  - **California Green**
- **KY Bluegrass Sports Turf**
  - **Sand based**
  - **2.5" Mowing**

Plot Set-Up
14 Treatments, 3 Reps

Each Plot Aerified before Application of products

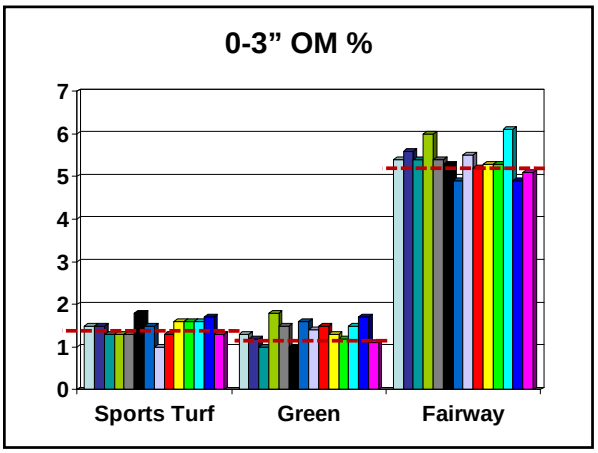



Data Collection

- **Infiltration**
- **Penotrometer**
- **Thatch**
- **Organic Matter**
  - **Thatch, 0-3", 3-6"**

Analysis Summary

Source	Thatch (mm)	Clegg (g)	Infiltrat (in/hr)	Thatch (OM %)	0-3" (OM %)	3-6" (OM %)
Site	**	*	**	**	**	**
Trtmnt	NS	NS	NS	NS	NS	NS
Site X Trtmnt	NS	*(0.10)*	NS	NS	*	NS

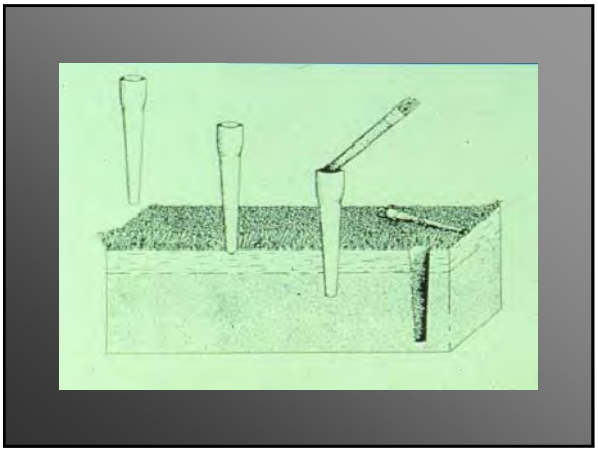


Summary

- No product increased degradation of OM

How effective is removal?

- **Surface disruptive, short and long term**
- **Core aeration is the most widespread practice recommended for OM management**



Tine Size and Surface Area Chart

Tine Size (in.)	Spacing (in.)	Holes/ft^2	Surface Area of One Tine	Percent Surface Area Affected
1/4	1.25^2	100	0.049	3.4%
1/4	2.5^2	25	0.049	0.9%
1/2	1.25^2	100	0.196	13.6%
1/2	2.5^2	25	0.196	3.4%
5/8	2.5^2	25	3.07	5.3%

Organic Matter Management

- Funded by:
  - USGA (2006)
  - Nebraska Golf Course Superintendents Assoc. (2007-2009)
  - Golf Course Superintendents Assoc. of South Dakota (2006-2009)
  - Peaks & Prairies GCSA (2007-2009)

Project Objective

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

Sampling Procedures

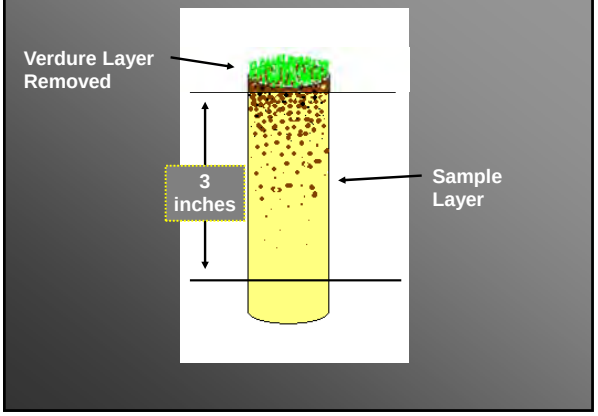
Years 1, 2, & 3

- At least 3 different greens per golf course sampled
- Soil samples taken from 3 different area per green
- Samples are evaluated for OM levels using LOI
- GPS location

- *Management & Site survey*

Sampling Methods

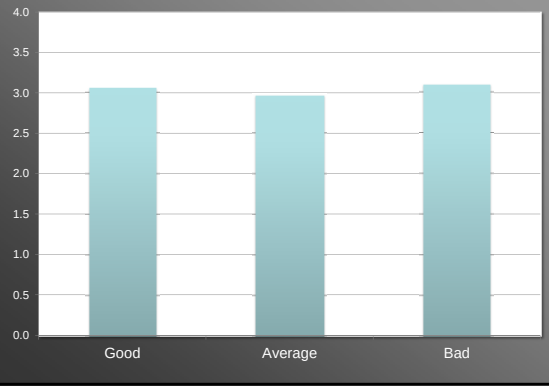
- Samples from at least 3 greens per course
  - (1) Problematic, (1) Non-problematic plus rebuilt or varied age/management
- 3 samples from each green
- Samples taken with ¾ inch soil probe



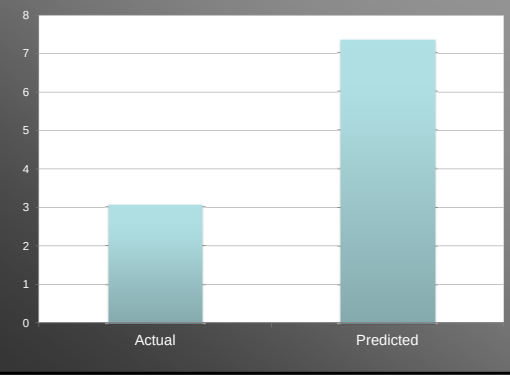
2006/07/08 Samples

- 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

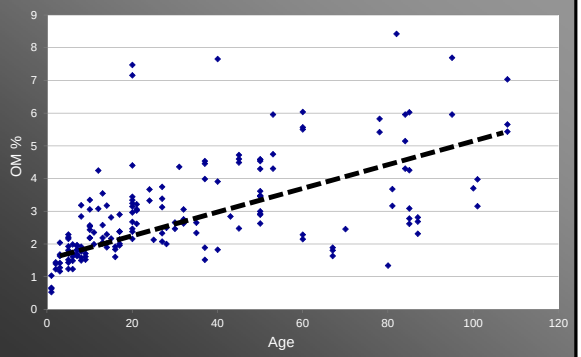
Problematic vs Non-problematic



Superintendent predicted vs actual

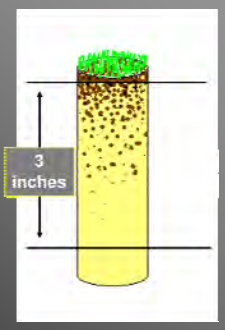


Green Age

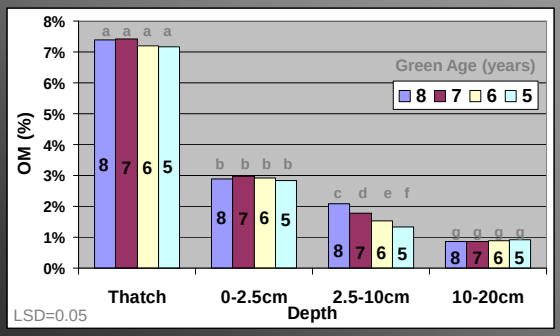


Is the age effect misleading?

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

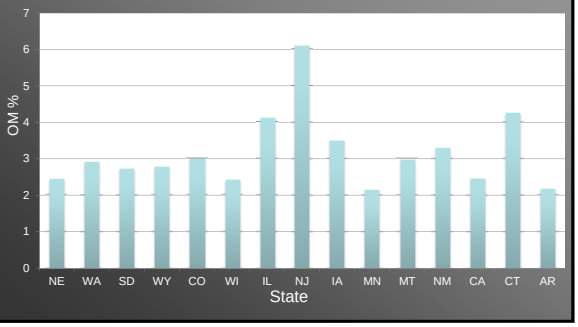


Organic Matter in USGA Specification Rootzones

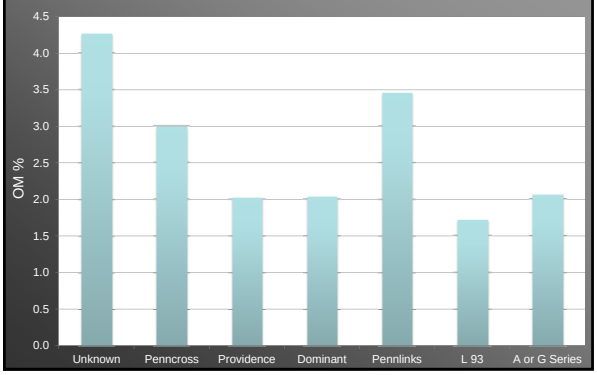


Mat Development with Age

State Differences (highly correlated with age)



Cultivar



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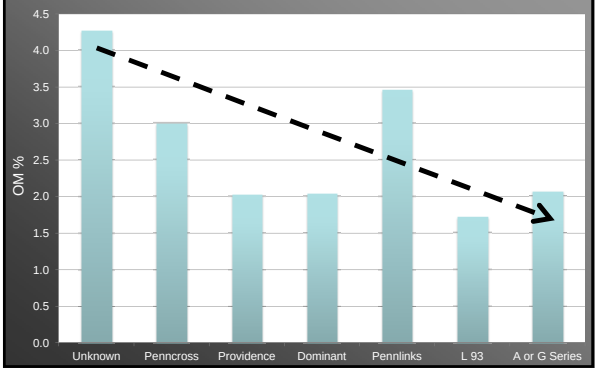
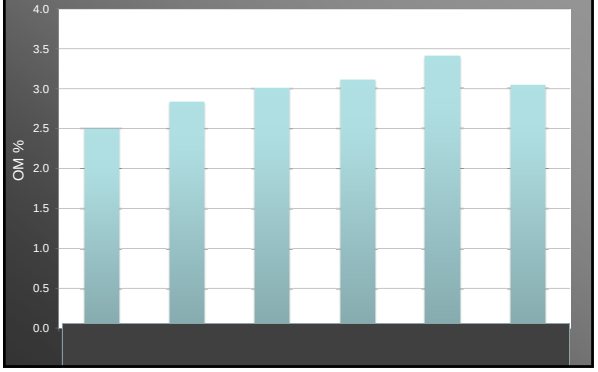
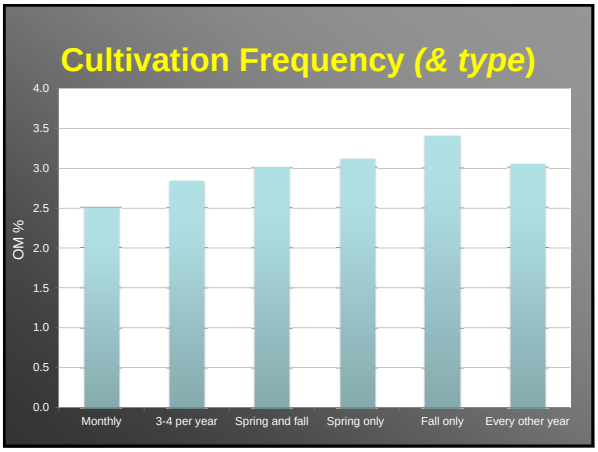


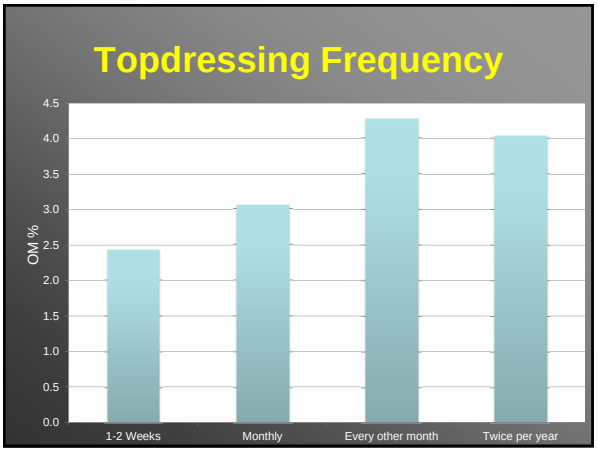
Cultivation Frequency *(& type)*



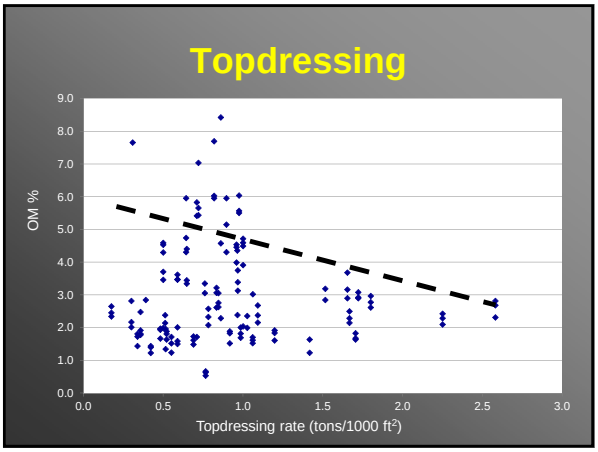
Cultivation Frequency *(& type)*



Topdressing Frequency



Topdressing



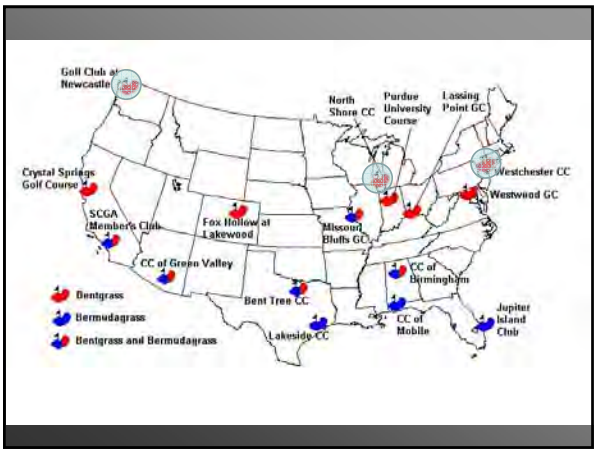
Survey Summary

- 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" consistently had the lowest OM
- Of the ***known*** cultivars, no differences in OM were evident

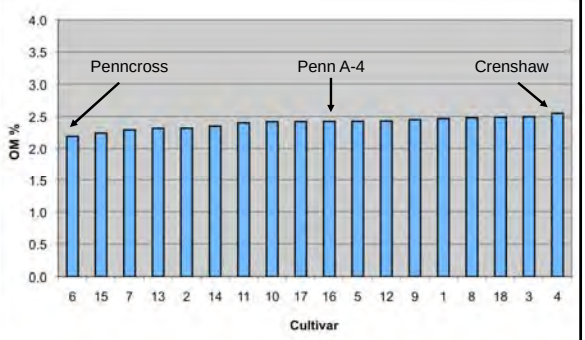
**1 ft³ = 100 lbs of dry sand; yd³ = 2700 lbs*

Onsite NTEP Cultivar Evaluation

1	L-93	10	SR 1020
2	Putter	11	SR 1119
3	Cato	12	Viper
4	Crenshaw	13	Century
5	LCB-103	14	Imperial
6	Penncross	15	Penn A-1
7	Backspin	16	Penn A-4
8	Trueline	17	Penn G-6
9	Providence	18	Penn G-1



Onsite NTEP Bentgrass Evaluation

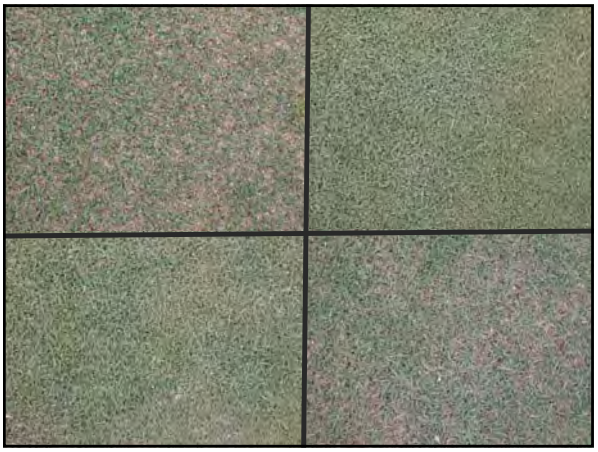


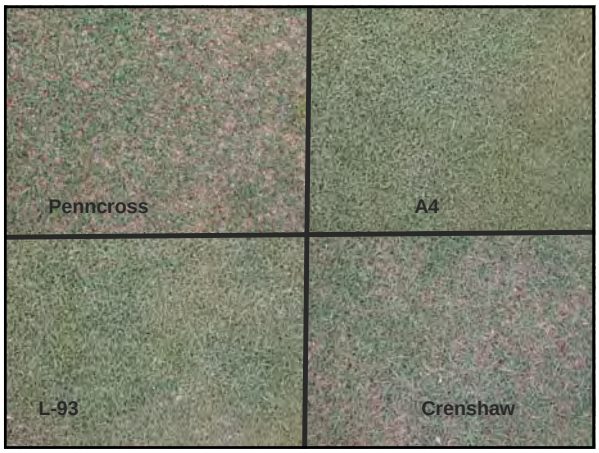
"New ultra-dense varieties of bentgrass and bermudagrass are especially susceptible to excessive organic matter accumulation due to high shoot density and the ability to grow a deep, dense root system in sand-based rootzone material. Working topdressing into a tight canopy of turf is a challenge, and much of the sand can be removed with the clippings."

Vavrek, 2006

Topdressing and the new bents

Easy or hard???





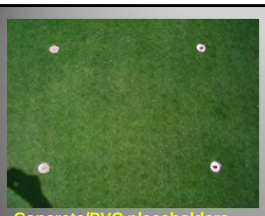
New bents = denser and more upright

Pulling cores or poking holes?

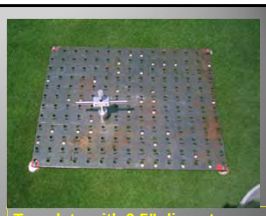
- In 2005, 45 of 141 courses surveyed* planned no core removal
  - Many had not pulled cores for 2-20 years
- 75 planned to pull cores
  - 35 of the 75 had no agronomic reason to pull a core (based on USGA Agronomist evaluation) while 40 "needed" to pull cores
- With current and evolving cultivation/topdressing/ rootzone technologies is pulling a core ***always*** necessary?
- Finally, is core cultivation an effective way to manage OM ?

** Mid-continent region USGA*

Let's take a quick look at that…

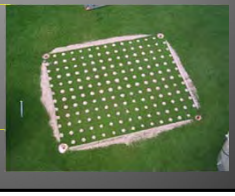


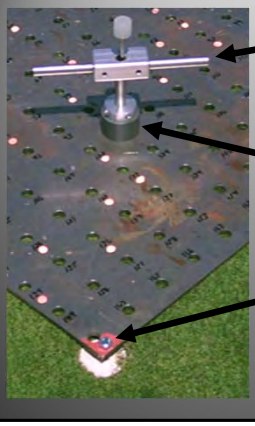
Concrete/PVC placeholders



Template with 0.5" diameter cores at 2.5" spacing

Cores removed to 5" depth; cores filled with sand topdressing





Modified soil probe simulates 0.5" diameter hollow-tine core aeration

Stabilizer block to ensure vertical probe entry

Bolts insert into placeholders to ensure exact location for resampling

- Study initiated 22 June 2005; concluded 11 Nov. 2005
- 2 USGA Putting Greens
  - Constructed in 1997 and 2000
- Sample every 2 weeks for 20 weeks
- 2 depths of interest
  - 3 & 6”

		Time after core creation (weeks)							
		2	4	6	8	10	12	14	16
Putting Green	Depth	Organic Matter Reduction (%)							
9 yr	3”	*79*	73	70	71	69	66	67	*66*
	6”	*71*	64	60	63	59	56	57	*56*
5 yr	3”	*73*	66	61	62	62	62	61	*59*
	6”	*66*	56	51	51	52	52	51	*49*

Organic Matter Management Study

Objectives

1. Determine if conventional hollow tine is more effective than solid tine aerification at managing organic matter accumulation

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 (less invasive cultivation) methods are effective at managing OM accumulation

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

All treatments received the same topdressing quantity (22 ft^3/M) but different frequency

Regional Survey

- Annual topdressing rate for 10 well maintained courses in each region
  - Stable maintenance program during past 5 growing seasons
  - Same general turf conditions
- Surveys are not research!
  - Fertility
  - Traffic
  - Green construction
  - Etc.

Survey Anticipated Results

- Cool-season - gradual increase in annual topdressing rate from north to south and east to west corresponding to length of growing season
- Warm-season – changes in annual topdressing rate corresponding to overseeding practices, length of growing season, annual rainfall
- Surveys are not research!
  - ✓ fertility
  - ✓ traffic
  - ✓ green construction
  - ✓ etc.

Survey Expectations

- Cool-season - gradual increase in annual topdressing rate from north to south and east to west corresponding to length of growing season
- Warm-season – changes in annual topdressing rate corresponding to overseeding practices, length of growing season, annual rainfall
- Surveys are not research!
  - ✓ fertility
  - ✓ traffic
  - ✓ green construction
  - ✓ etc.

Central United States – Cool-season

North-Central, Elm Grove, WI

Topdressing (ft3/1,000ft2/yr)	
Mean:	20.7
Range:	8.4 – 34.5
Standard Deviation:	8.2

Mid-Continent, White Heath, IL

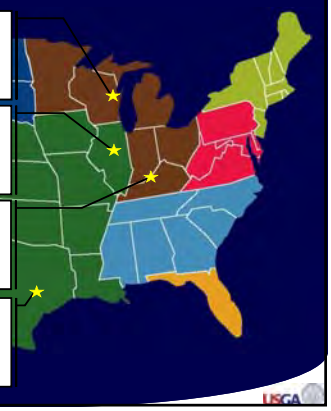
Topdressing (ft3/1,000ft2/yr)	
Mean:	20.7
Range:	15.8 – 30.6
Standard Deviation:	4.5

North-Central, Covington, KY

Topdressing (ft3/1,000ft2/yr)	
Mean:	18.5
Range:	8.3 – 25.4
Standard Deviation:	7.6

Mid-Continent, Carrollton, TX

Topdressing (ft3/1,000ft2/yr)	
Mean:	0
Range:	0
Standard Deviation:	0



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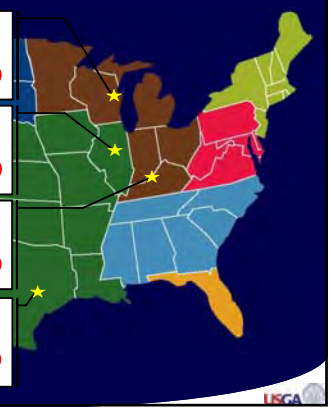
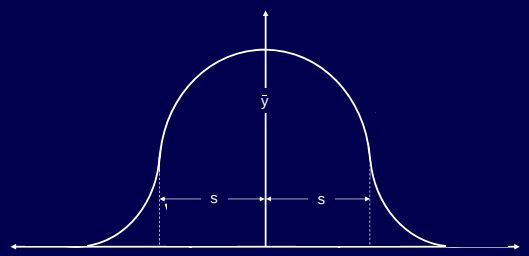
Standard Deviation:	0



Empirical Rule



68% of measurements are within plus or minus one standard deviation (s) of the mean (ȳ)

Central United States – Cool-season

North-Central, Elm Grove, WI

Topdressing (ft3/1,000ft2/yr)	
Mean:	~~20.7~~
Range:	8.4 – 34.5
Standard Deviation:	8.2

Mid-Continent, White Heath, IL

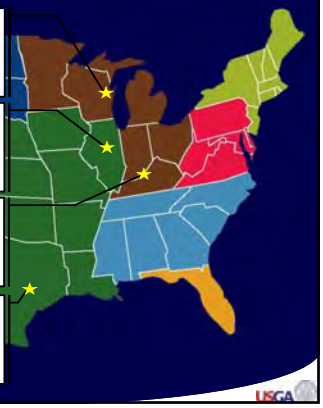
Topdressing (ft3/1,000ft2/yr)	
Mean:	~~20.7~~
Range:	15.8 – 30.6
Standard Deviation:	4.5

North-Central, Covington, KY

Topdressing (ft3/1,000ft2/yr)	
Mean:	~~18.5~~
Range:	8.3 – 25.4
Standard Deviation:	7.6

Mid-Continent, Carrollton, TX

Topdressing (ft3/1,000ft2/yr)	
Mean:	~~0~~
Range:	0
Standard Deviation:	0



Eastern United States – Cool-season

Northeast, Palmer, MA & Easton, PA

Topdressing (ft3/1,000ft2/yr)	
Mean:	20.3
Range:	12.0 – 51.7
Standard Deviation:	8.8

Mid-Atlantic, Glen Mills, PA

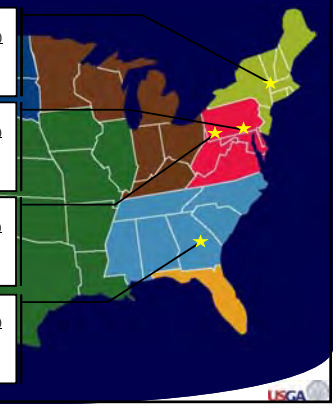
Topdressing (ft3/1,000ft2/yr)	
Mean:	16.0
Range:	7.5 – 26.3
Standard Deviation:	6.7

Mid-Atlantic, Pittsburgh, PA

Topdressing (ft3/1,000ft2/yr)	
Mean:	27.1
Range:	14.5 – 51.1
Standard Deviation:	11.1

Southeast, Griffin, GA

Topdressing (ft3/1,000ft2/yr)	
Mean:	0
Range:	0
Standard Deviation:	0



Western United States – Cool-season

Northwest, Gig Harbor, WA

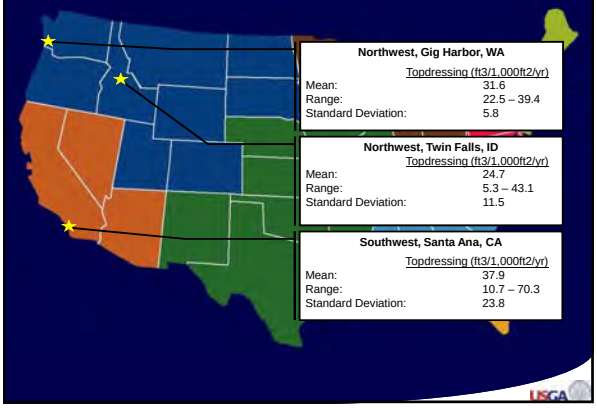
Topdressing (ft3/1,000ft2/yr)	
Mean:	31.6
Range:	22.5 – 39.4
Standard Deviation:	5.8

Northwest, Twin Falls, ID

Topdressing (ft3/1,000ft2/yr)	
Mean:	24.7
Range:	5.3 – 43.1
Standard Deviation:	11.5

Southwest, Santa Ana, CA

Topdressing (ft3/1,000ft2/yr)	
Mean:	37.9
Range:	10.7 – 70.3
Standard Deviation:	23.8



Southern United States – Warm-season

Southwest, Santa Ana, CA

Topdressing (ft3/1,000 ft2/yr)	
Mean:	24.1
Range:	11.4 – 33.7
Standard Deviation	12.0

Southeast, Birmingham, AL

Topdressing (ft3/1,000 ft2/yr)	
Mean:	0
Range:	0
Standard Deviation	0

Mid-Continent, Carrollton, TX

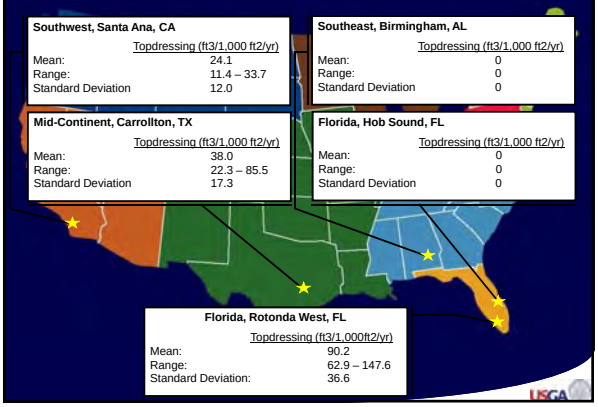
Topdressing (ft3/1,000 ft2/yr)	
Mean:	38.0
Range:	22.3 – 85.5
Standard Deviation	17.3

Florida, Hob Sound, FL

Topdressing (ft3/1,000 ft2/yr)	
Mean:	0
Range:	0
Standard Deviation	0

Florida, Rotonda West, FL

Topdressing (ft3/1,000ft2/yr)	
Mean:	90.2
Range:	62.9 – 147.6
Standard Deviation:	36.6



Regional Topdressing Survey Summary

Region/Turf	Ave. Rate ft³/1,000ft²/yr	Range ft³/1,000ft²/yr	Sample Standard Deviation
Florida – Upper / ultradwarf, overseeded			
Florida – Lower / ultradwarf, non-overseeded	90.2	62.9 – 147.6	36.6
Mid-Atlantic - Eastern / cool-season	15.8	7.5 – 26.3	6.7
Mid-Atlantic – Western / cool-season	27.1	16.2 – 51.1	11.1
Mid-Continent – Lower / cool-season			
Mid-Continent – Lower / ultradwarf, non-overseeded	38.1	22.3 – 85.5	17.3
Mid-Continent – Upper / cool-season	20.8	15.8 – 30.6	4.5
North-Central – Upper / cool-season	20.7	8.4 – 34.5	8.2
North-Central– Lower / cool-season	18.5	8.3 – 25.4	7.62
Northeast / cool-season	20.3	12.0 – 51.7	8.8
Northwest - Coastal / cool-season	31.6	22.5 – 39.4	5.8
Northwest - Inland Northern Rockies / cool-season	24.7	5.3 – 43.1	11.5
Southeast – Lower / ultradwarf, non-overseeded			
Southeast – Upper / cool-season			
Southwest - Coastal California / cool-season	38.0	10.7 – 70.3	23.8
Southwest - Desert / warm-season, overseeded	24.1	11.4 – 33.7	12.0

Survey Review

- Regional differences were found, however not exactly as predicted
- Some differences did not appear to have a basis in agronomy or climatic conditions
- Survey results generate multiple questions regarding current industry practices and suggest need to conduct further research in the area of organic matter management
- It is premature to conclude that the survey provides guidance for establishing sound topdressing recommendations due to the broad range of the data and the very high standard deviation found in most regions

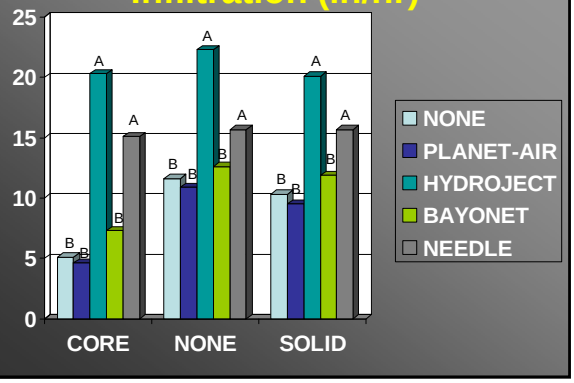
All treatments received the same topdressing quantity (22 ft^3/M) but different frequency

Equilibrated to identify differences of the practices in question

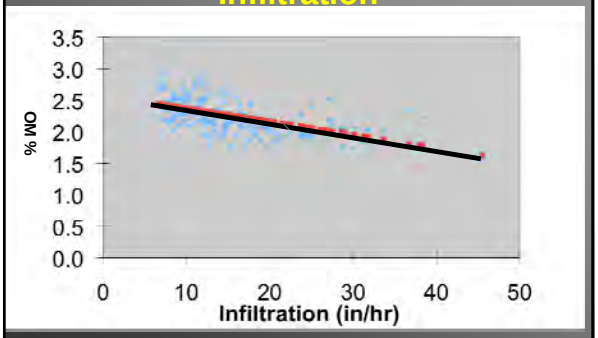
Materials and Methods

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

Infiltration (in/hr)



Relationship between OM and Infiltration



*Significant at α = 0.01

OM Data Analysis Year 1

- **No differences between green age except for higher % in older green**

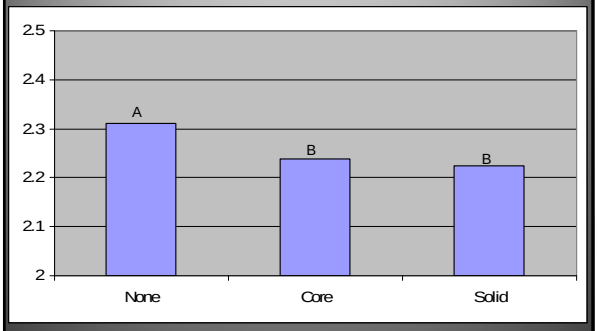
OM Data Analysis Year 1

- No differences between green age except for higher % in older green
- No differences among venting methods

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

Effect of Aerification on OM



OM Data Analysis Year 2

- No differences between green age except for higher % in older green

OM Data Analysis Year 2

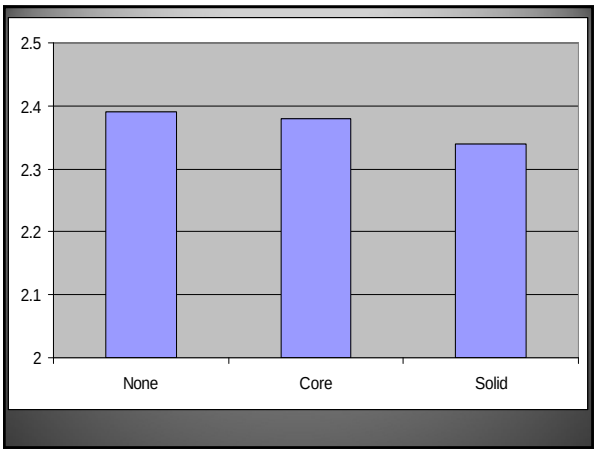
- No differences between green age except for higher % in older green
- No differences among venting methods

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

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**



What these data do/don't suggest

- Topdressing is the most consistent and repeatable factor in OM management
- Cultivation was insignificant as a means to control OM
- However, a superintendent must use whatever tools they have at their disposal to insure sand is making it into the profile and not the mower buckets

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

- **NONE/NONE**
  - **5-10 days**
- **Solid & Hollow/NONE**
  - **7-14 days**
- **Solid & Hollow/LIC**
  - **14-18 days**

*Observed and calculated based on displacement and surface area opened

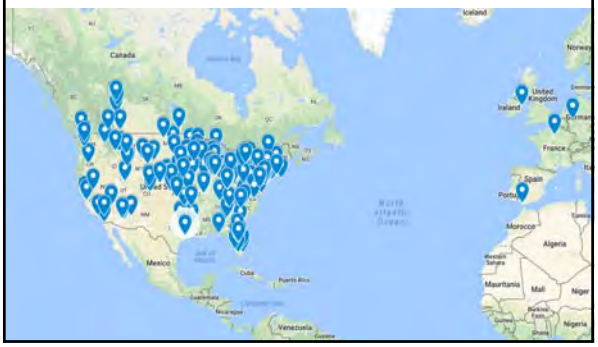
GreenKeeper Survey

cool season only, mark all that apply

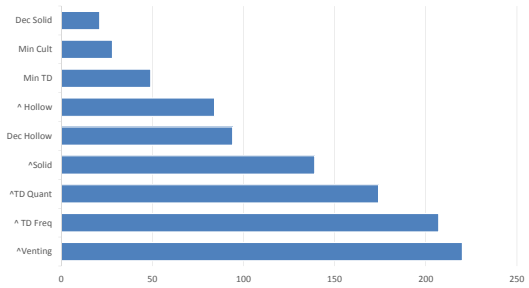
In the last 5-10 years, on our greens, our facility has:

- ❑ Increased topdressing quantity.
- ❑ Increased topdressing frequency.
- ❑ Increased hollow (equal or greater than 0.5") tine 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.

Survey Respondents via Greenkeeper



303 Responses



"the solution to pollution is dilution"

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"

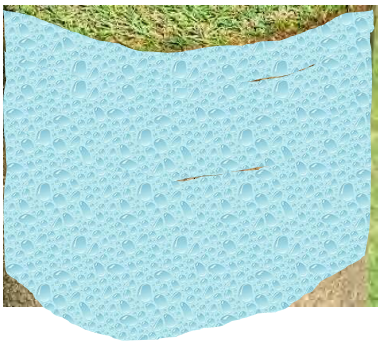
What is the "best" way to get sand into the profile?

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

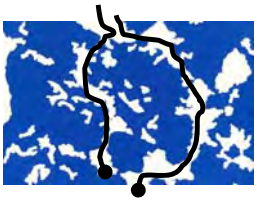


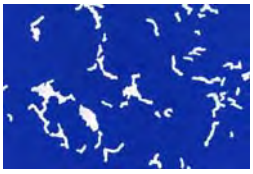
Layering

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

"the solution to pollution is dilution"

Soil Macropores





Compacted

How do you get rid of OM?

- Decomposition (microbial)
  - Increase surface area and aeration
  - Inoculation
- Removal
  - Power raking, dethatching, core aerification
- Dilution
  - Topdressing

Acknowledgements

- USGA
- Environmental Institute for Golf
- Nebraska GCSA
- GCSA of South Dakota
- Peaks & Prairies GCSA
- Jacobsen, Toro, JRM & PlanetAir
- Nebraska Turfgrass Association