Cultural & mechanical practices that have an impact on turfgrass health. Part I

Thomas A. Nikolai, Ph.D.
Michigan State University

Cultural & mechanical practices that have an impact on turfgrass health. Part II

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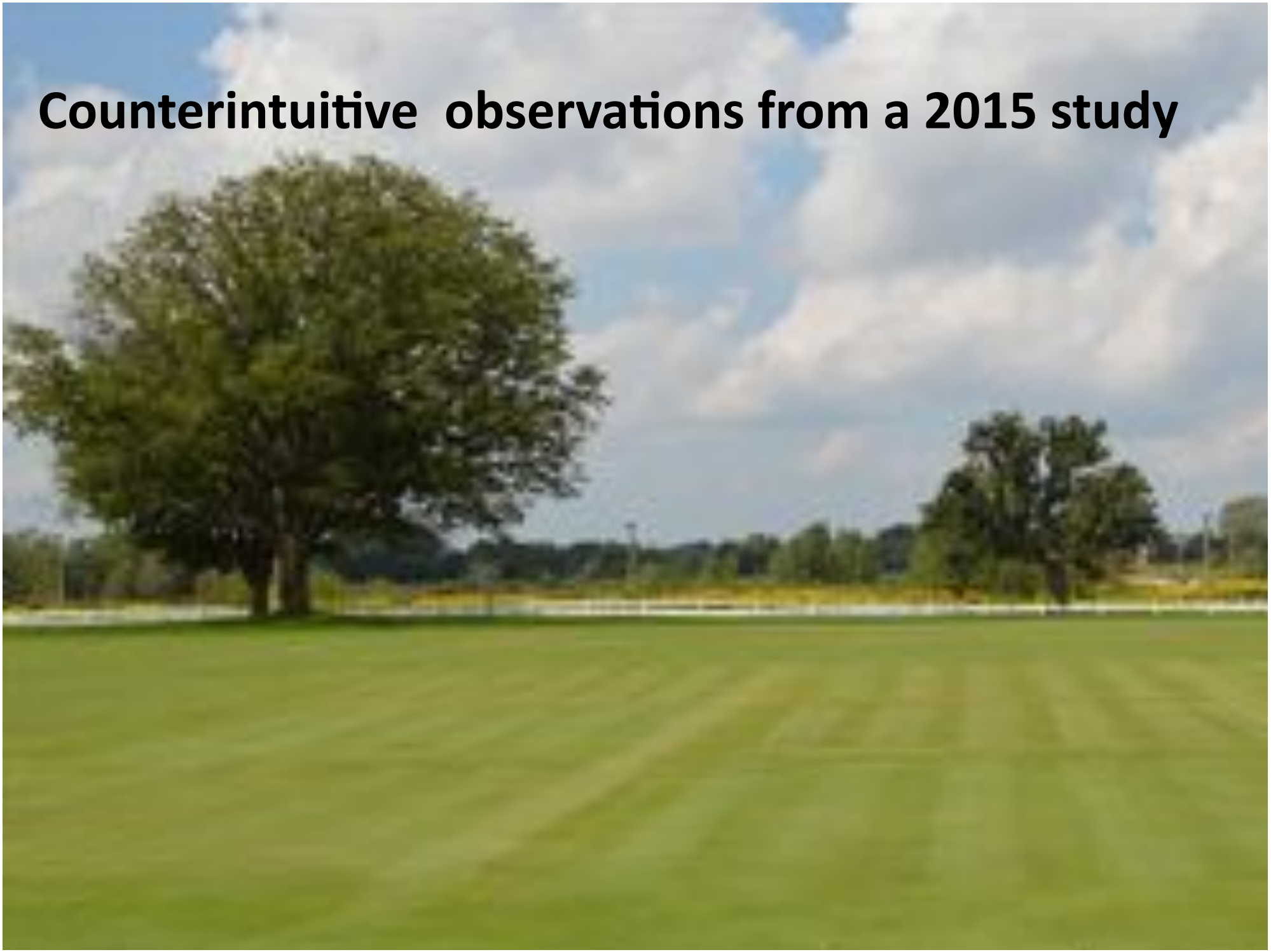
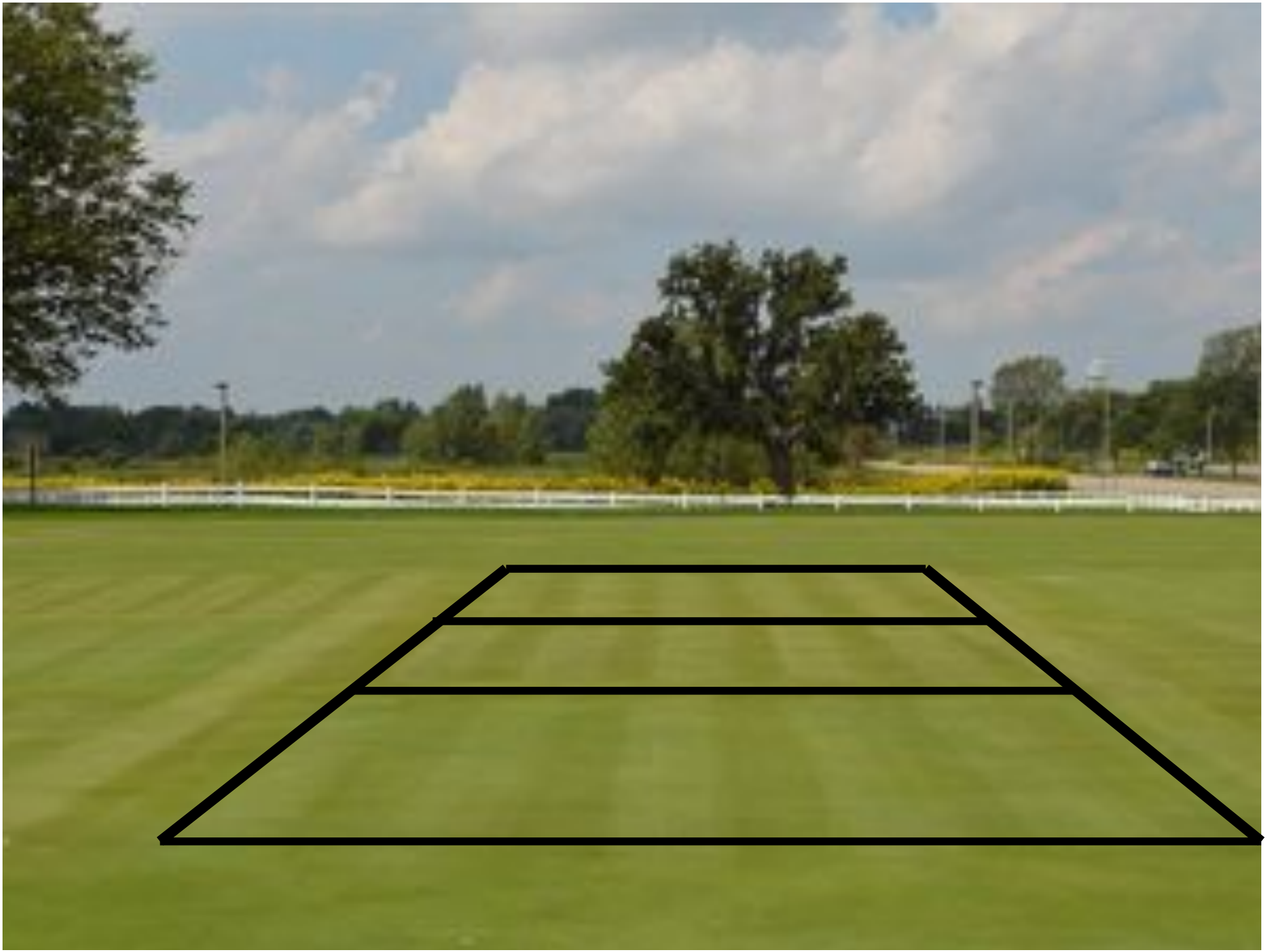
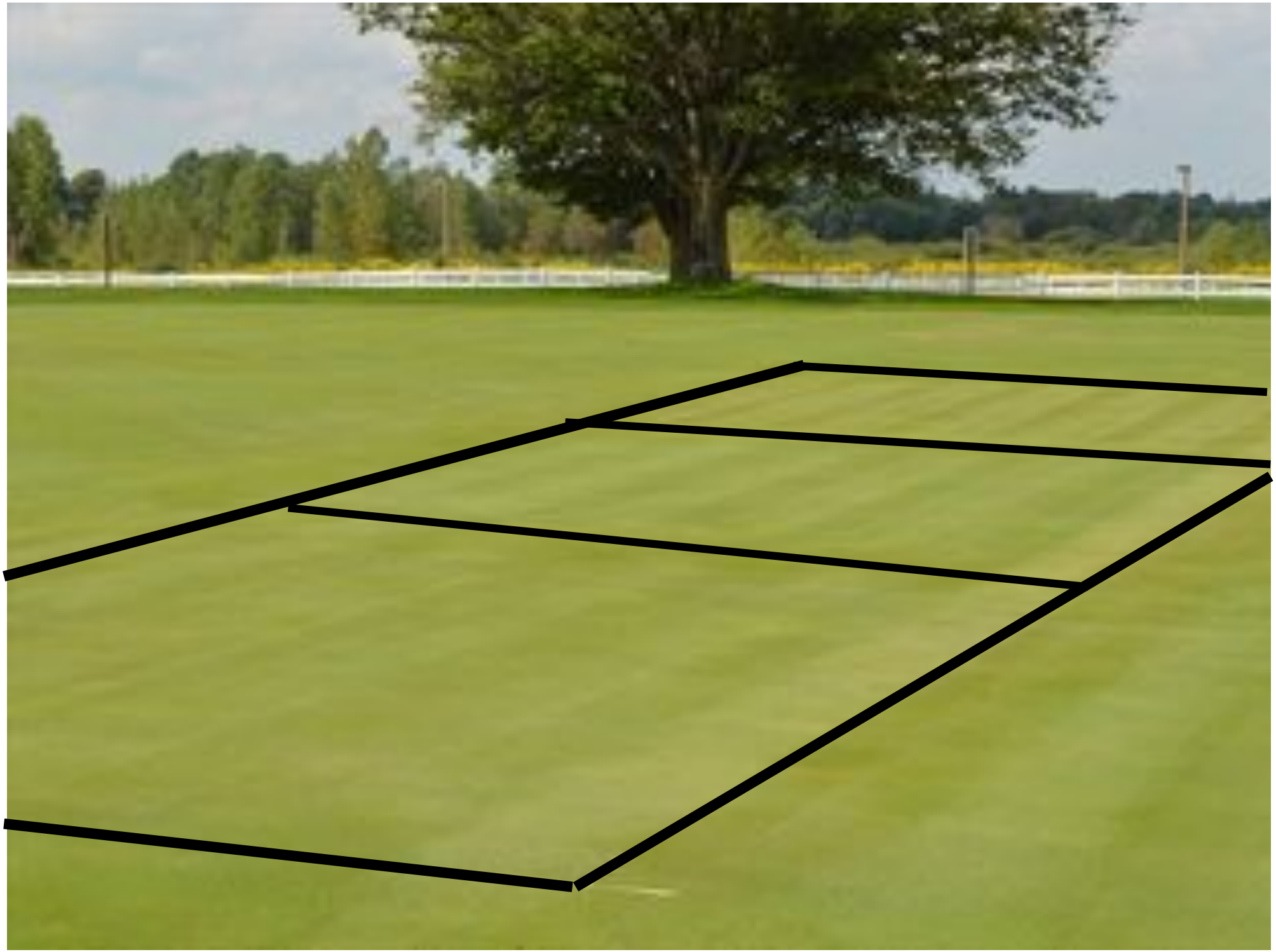
Counterintuitive observations from a 2015 study

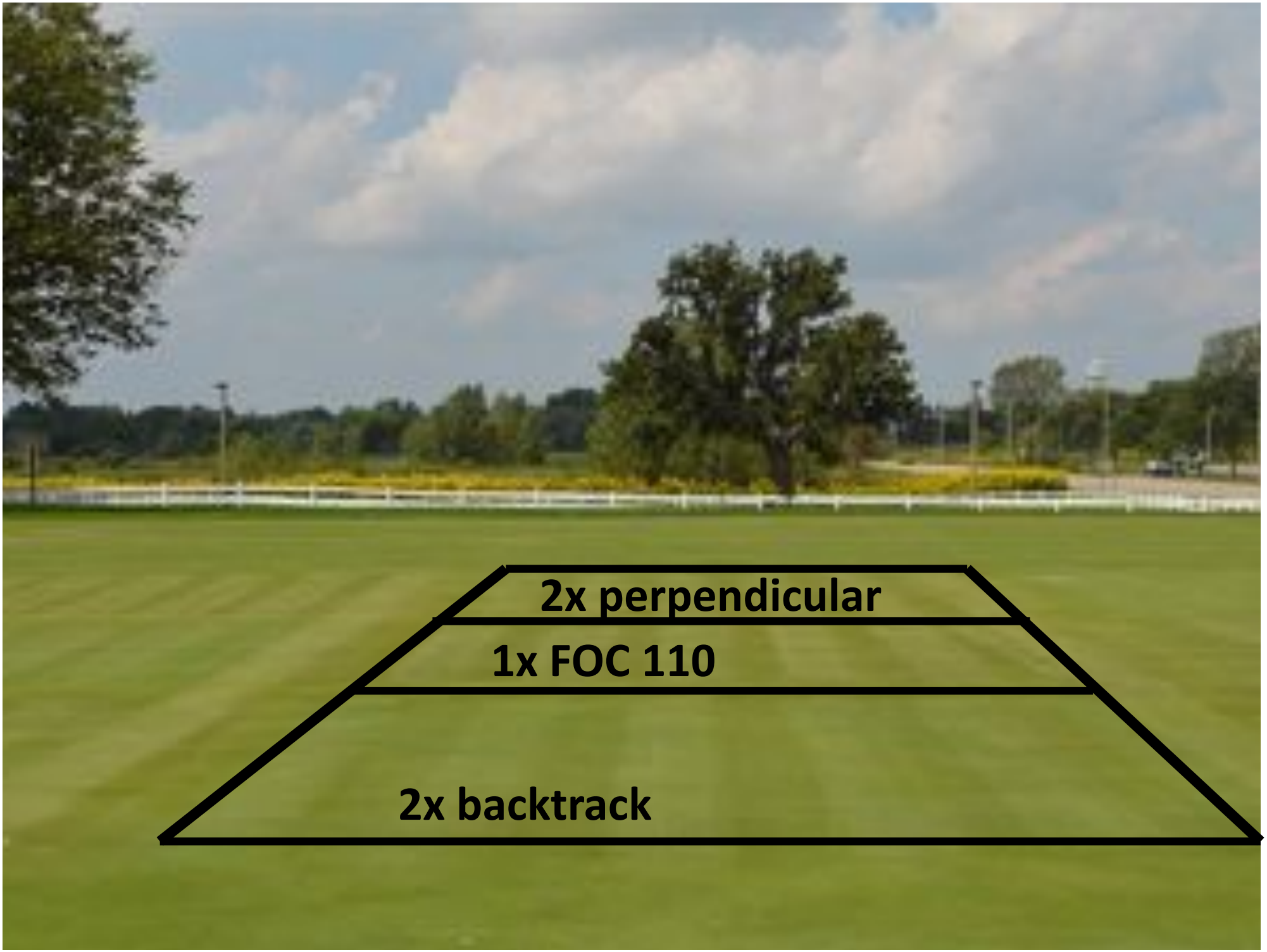






Mowing research 2015 research

- 3 mowers
- All set at 0.120 HOC
  - One treatment double cut perpendicular daily
  - One treatment double cut backtrack daily
  - One treatment single cut daily FOC 0f 110 (double cut mowers were FOC 148)


2x perpendicular
1x FOC 110
2x backtrack

Results

2x backtrack darker color

All result in the same amount of clippings

All result in the same green speed

BRUSHING

Proposed benefits[2]

- **Grain reduction**
- **Raises stolons and shoots for a better cut**
- **Less injury than verticutting or grooming**
- **Annual bluegrass seedhead reduction**

STUDY OBJECTIVES

To determine the validity of proposed benefits of brushing greens on a daily basis.

STUDY DESIGN

- Initiated on May 7, 2012
- Study ran for 12 weeks
- Hancock Turfgrass Research Center – Michigan State Univ.
    - 'G2' creeping bentgrass (2001) & annual bluegrass (2006)
    - Native soil bases

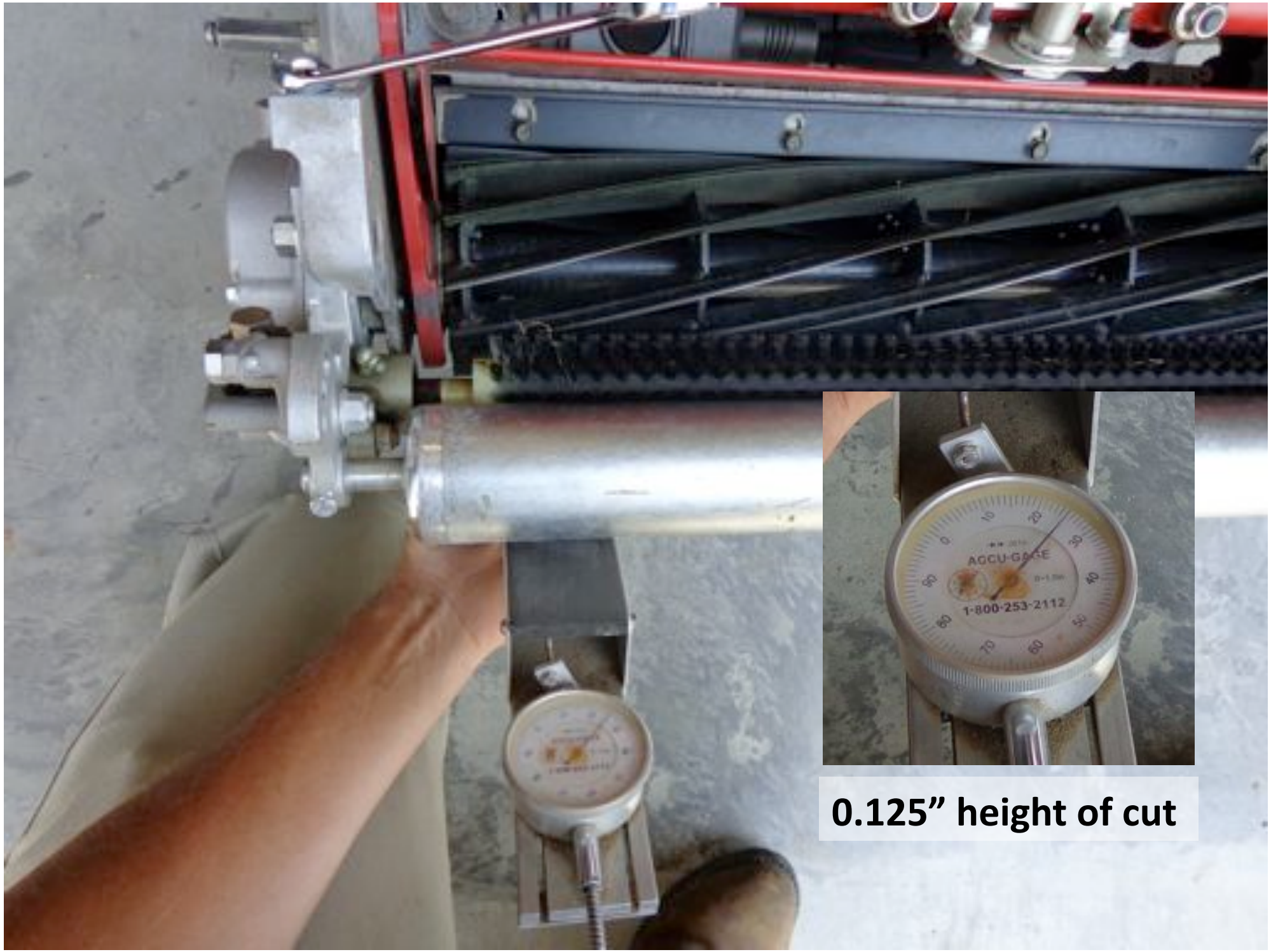

Google, Inc.

STUDY DESIGN

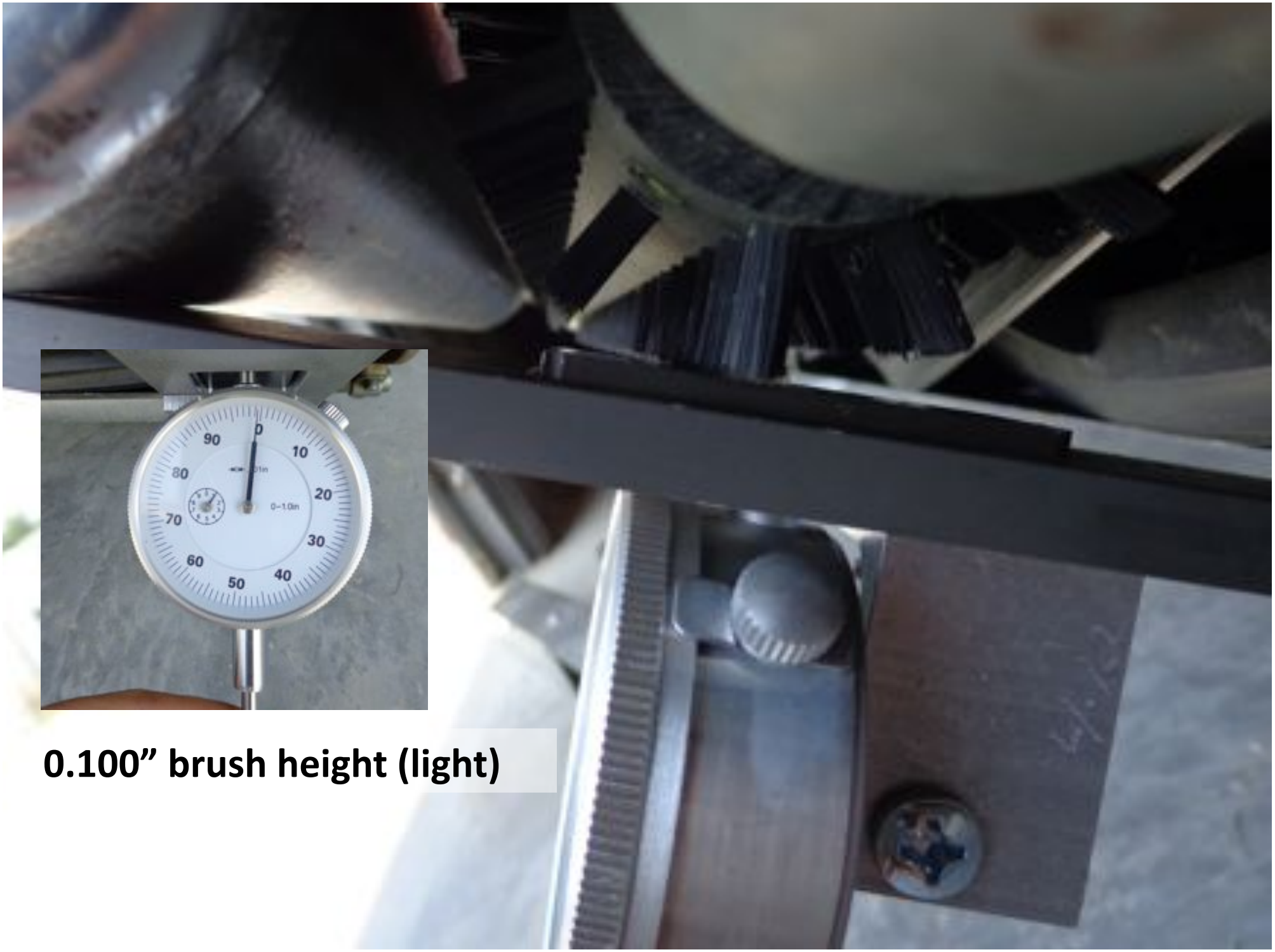
- 54’ x 54’ plots
- One factor, three treatment study
  - No brush
  - Forward rotating brush
  - Counter rotating brush

EQUIPMENT

- Three mowers
  - Toro Greensmaster® *Flex™ 2100*
  - 11 blade reels
  - EdgeMax™ microcut bedknives



0.125” height of cut



0.100” brush height (light)

RESULTS Poa clippings (grams)

	5/21	5/28	6/4	6/10	6/17	6/24	7/1	Avg
No Brush	43	20	18	16	29	25	11	
Forward Brush	42	20	16	17	33	33	9	
Reverse Brush	44	19	16	17	32	27	9	

RESULTS % Poa Seedhead

	5/9	5/16	5/30	6/13	6/27	7/11
No Brush	20	12	14	22	11	7
Forward Brush	16	9	14	23	10	6
Reverse Brush	18	7	15	22	8	5

TURF

RESULTS Poa Sandtopdressing (S)

	5/14	5/21	5/28			6/17	6/24	7/1
No Brush	59	24 b	15	2	16 b	22 b	19 b	13
Forward Brush	51	42 ab	23	9	39 a	54 a	62 a	18
Reverse Brush	59	53 a	24	7	31 a	52 a	61 a	25

TURF

RESULTS Poa Green Speed

	5/7	5/8	5/9	5/10	5/11	5/15	5/16
No Brush	----	--- b	----	--- b	----	----	----
Forward Brush	- 2	+4 a	+2	+6 a	+4	+ 3	+5
Reverse Brush	- 4	--- b	+ 1	+6a	+3	+3	+5

TURF

RESULTS Poa Green Speed

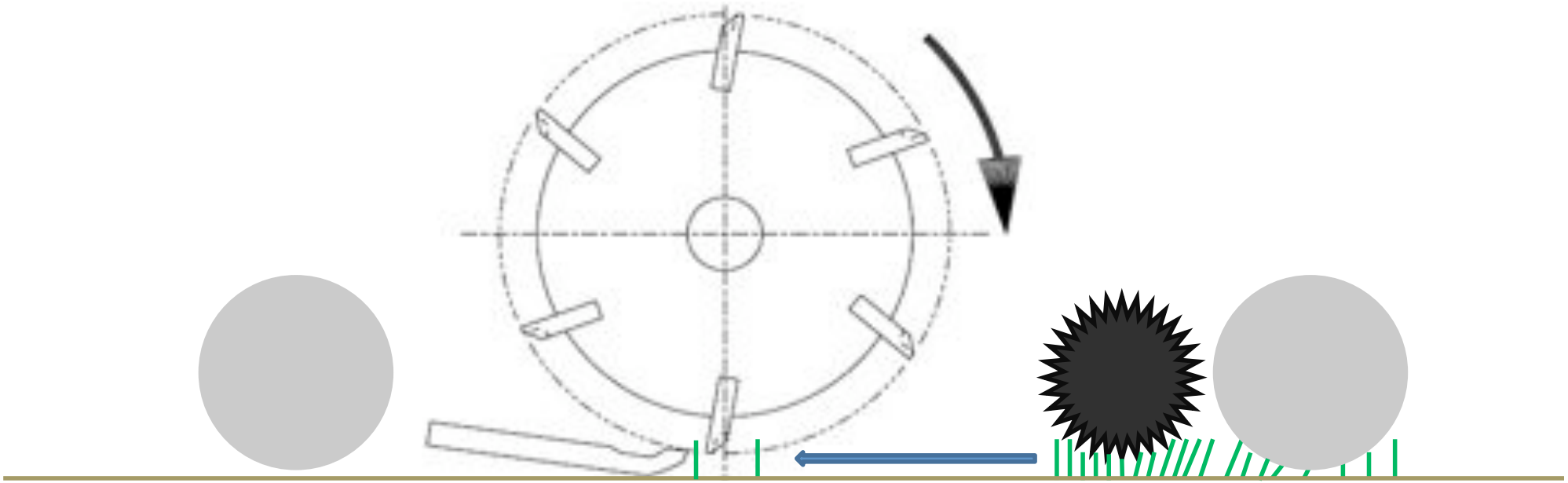
	5/15	5/22	5/24	5/29	5/31	6/5	6/7
No Brush	----	----	----	----	----	----	----
Forward Brush	+5	+1	+2	+3	+5	-2	+4
Reverse Brush	-3	+2	+4	+1	+8	+3	+3

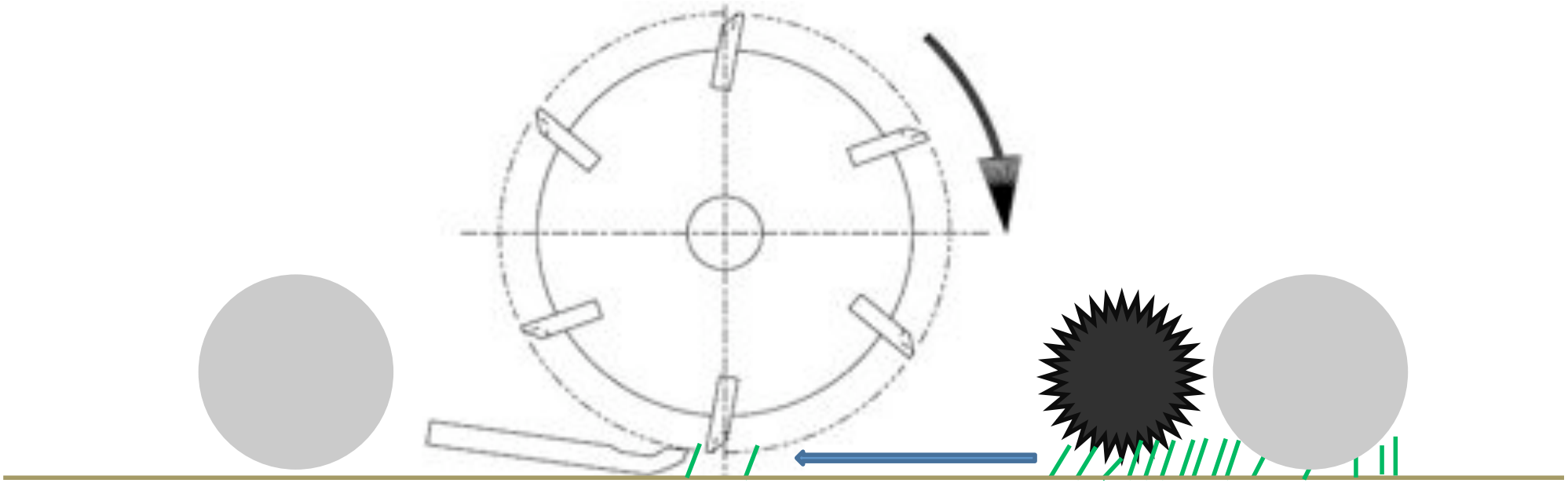
RESULTS Poa Green Speed

	6/12	6/15	6/18	6/21	6/25	6/28	7/2
No Brush	----	----	----	----	----	----	--a
Forward Brush	-7	+2	----	+6	-3	+5	+3 a
Reverse Brush	+2	-5	+2	+5	-4	----	-8 b

RESULTS Poa Green Speed

	7/5	7/9	7/12	7/16	Average
No Brush	----	----	----	----	--------
Forward Brush	+5	+5	+7	+3	+3 inches
Reverse Brush	-4	-4	----	-4	--------






No brush (control)


Forward rotating


Counter rotating


No Brush
Counter Brush
Forward Brush

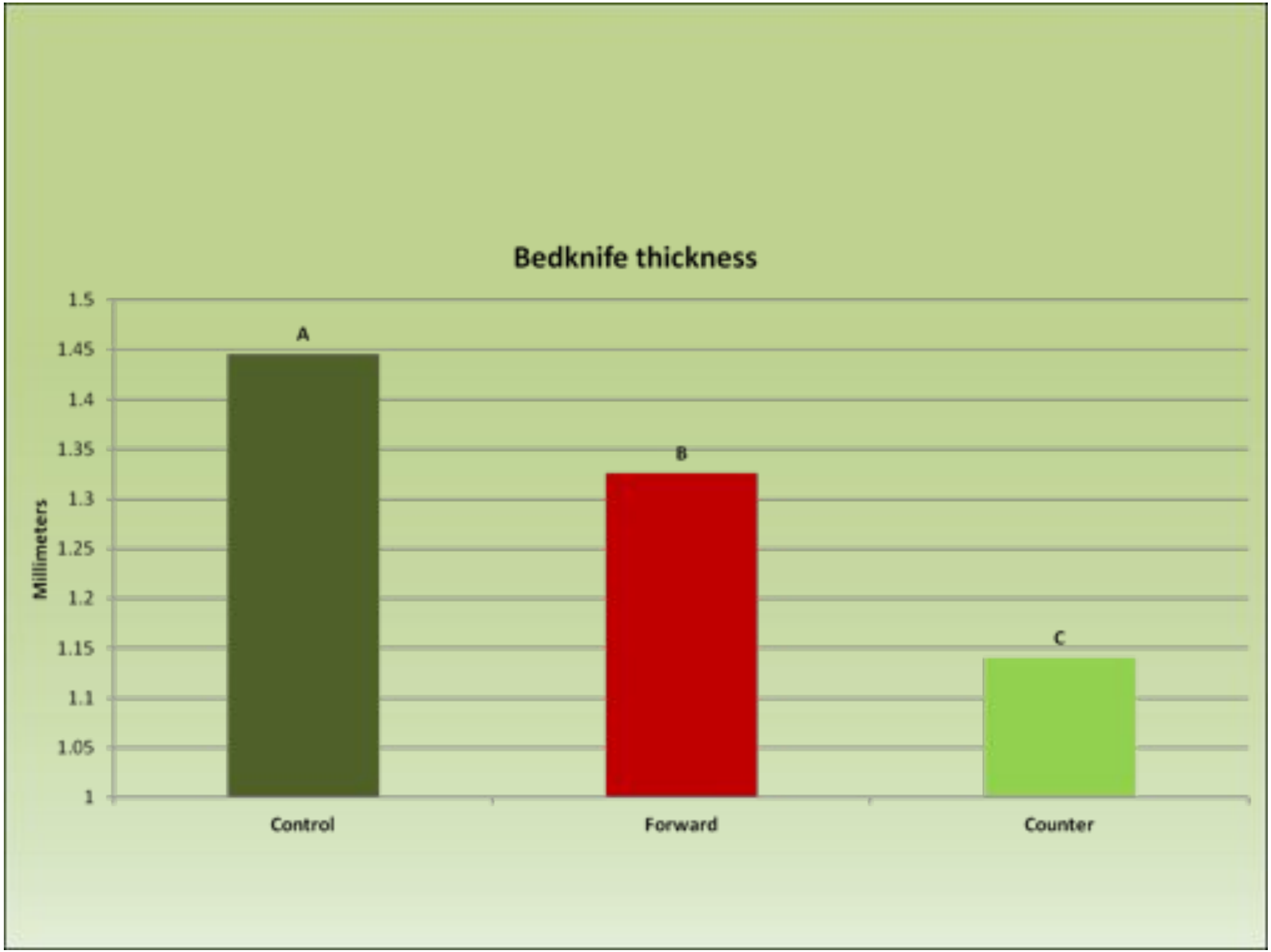

DATA/HOLD
BATTERY

Diameter of Roller (mm)

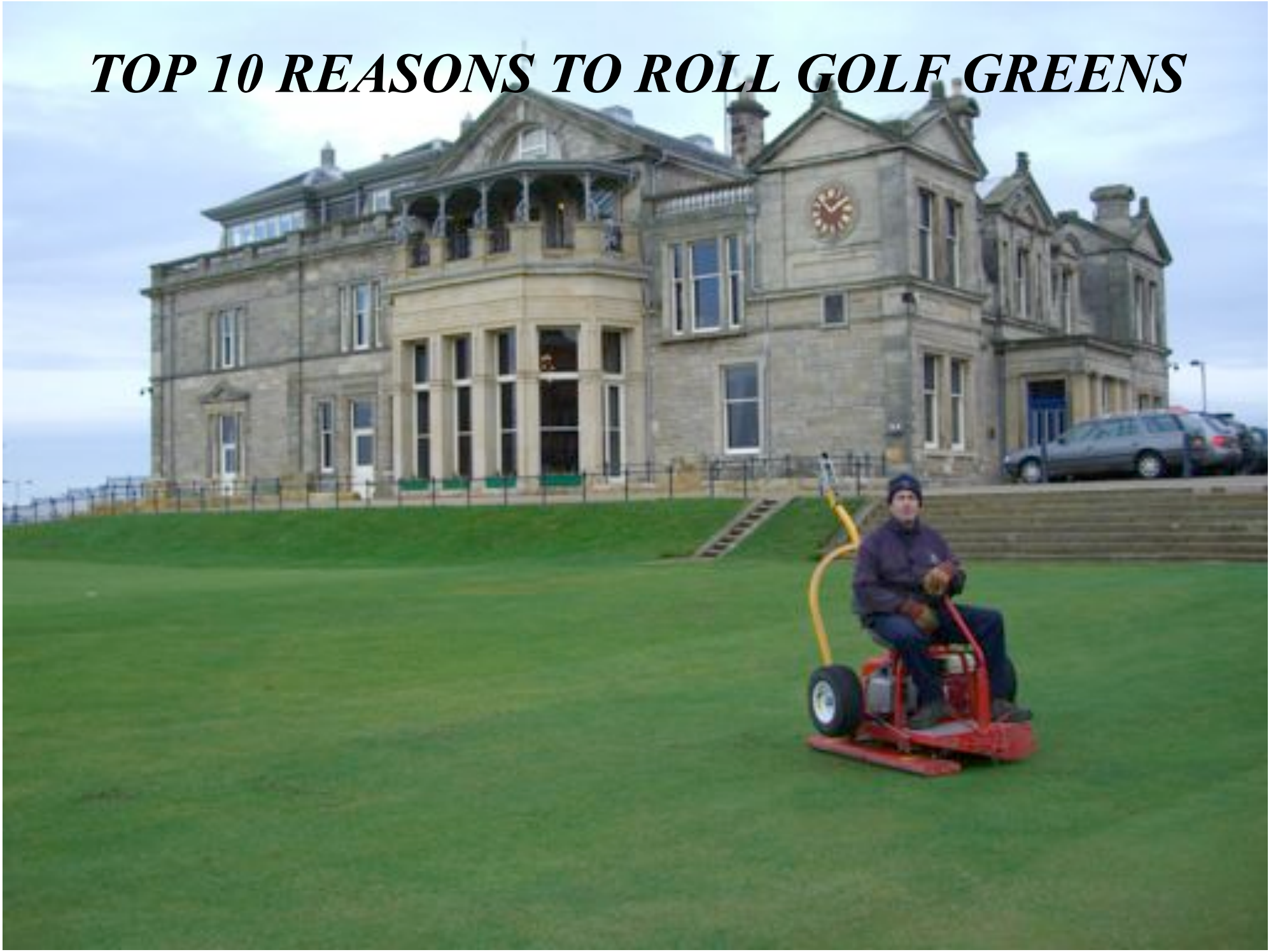
	No Brush	Counter Brush	Forward Brush
	61.75	61.49	61.75
	61.70	61.53	61.69
	61.69	61.43	61.70
	61.73	61.57	61.66
	61.71	61.53	61.74
Average	**61.716**	**61.51**	**61.708**

Bedknife thickness

- **Measured at 5 locations across the bedknife**


Bedknife thickness
Millimeters
1.5
1.45
1.4
1.35
1.3
1.25
1.2
1.15
1.1
1.05
1
A
B
C
Control
Forward
Counter

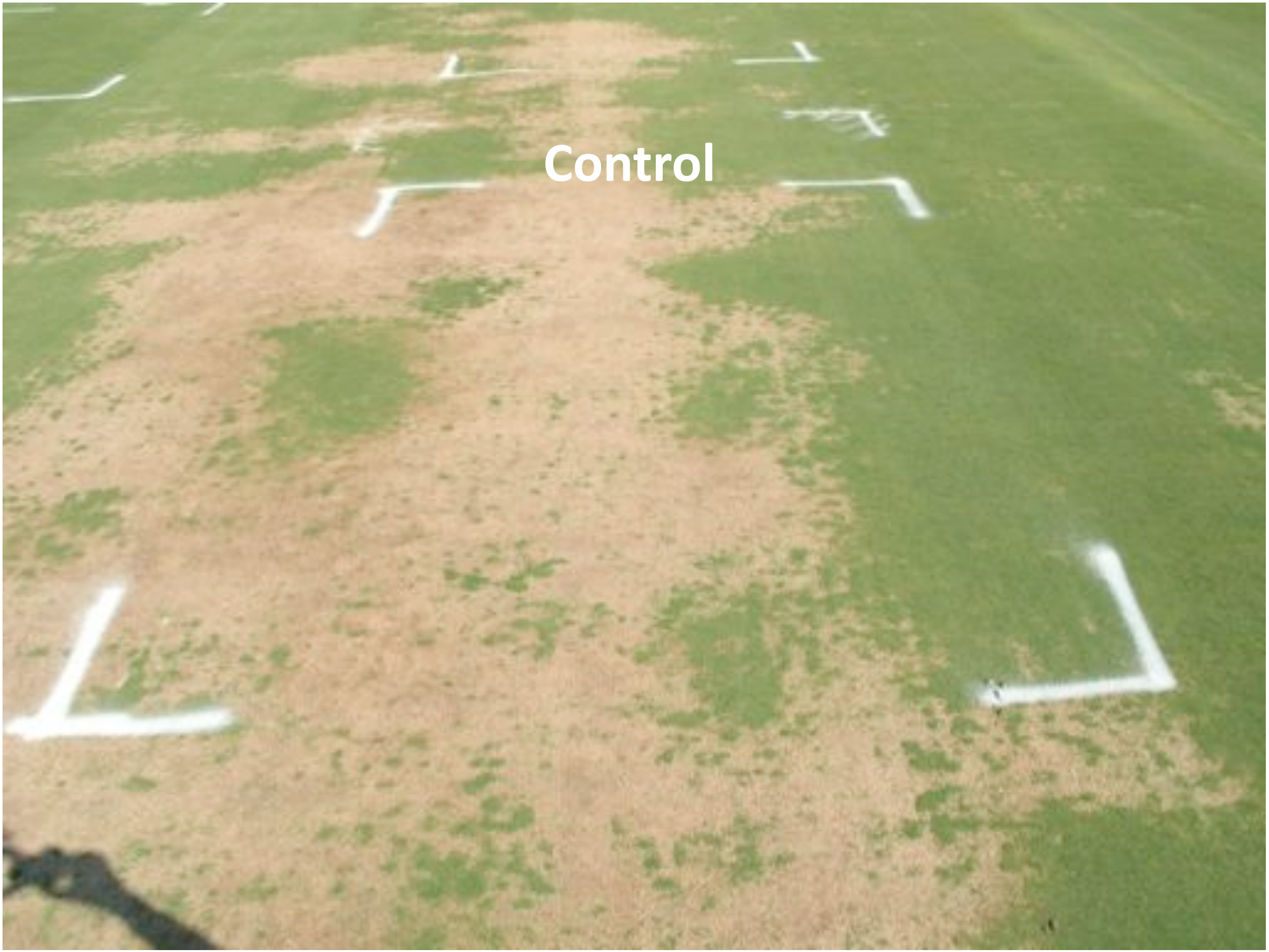
TOP 10 REASONS TO ROLL GOLF GREENS

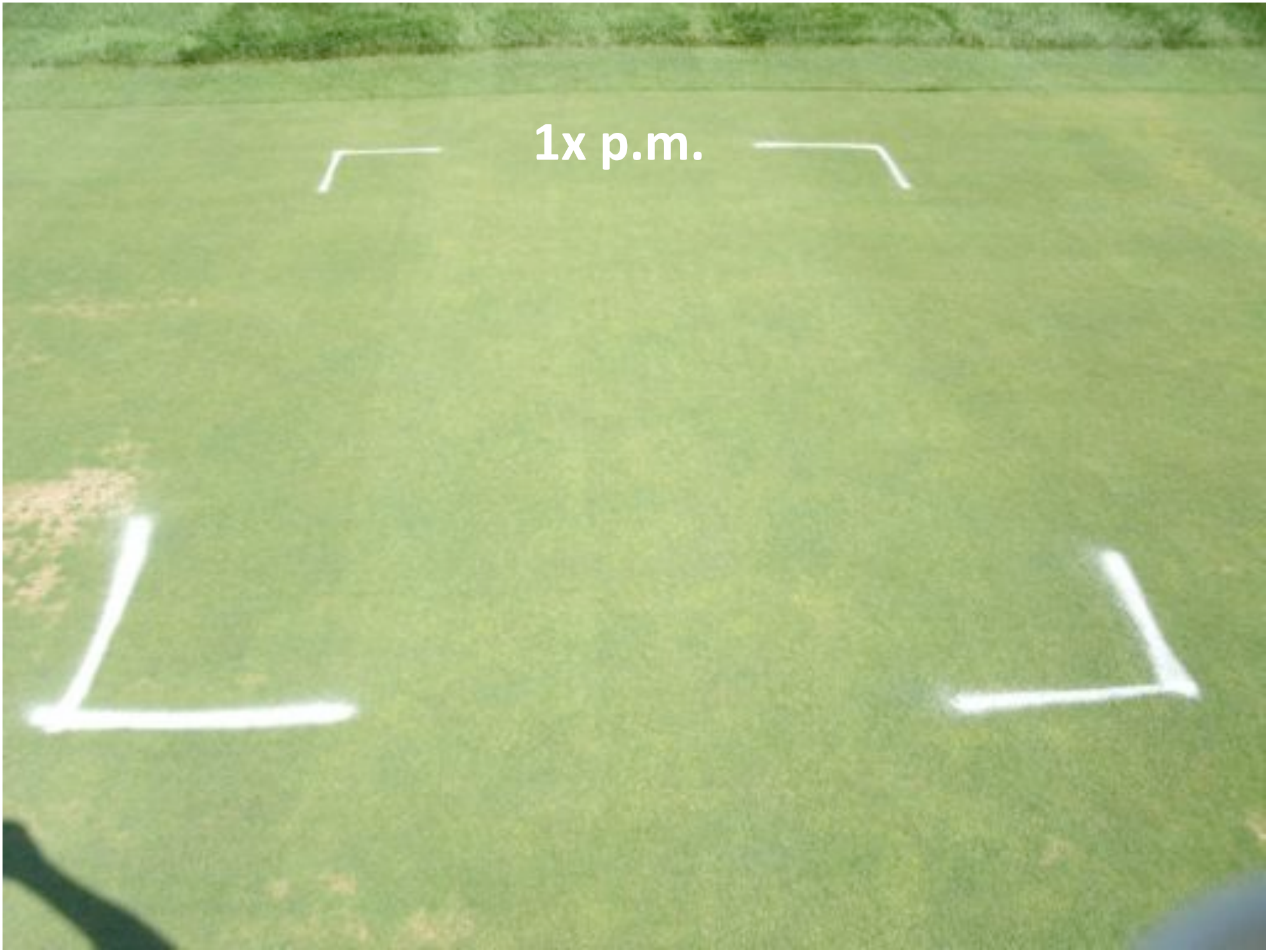


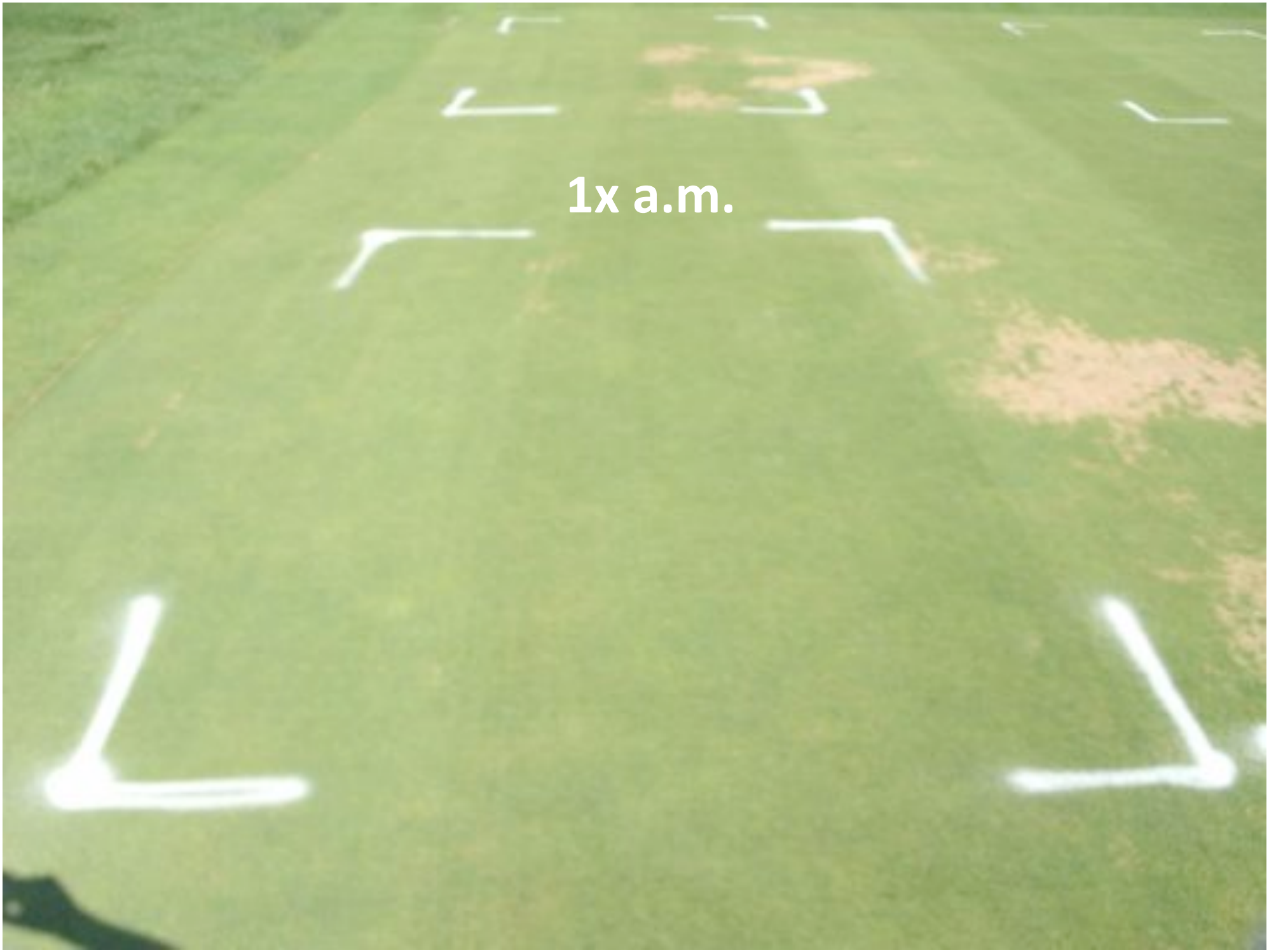
TOP 10 REASONS TO ROLL GOLF GREENS

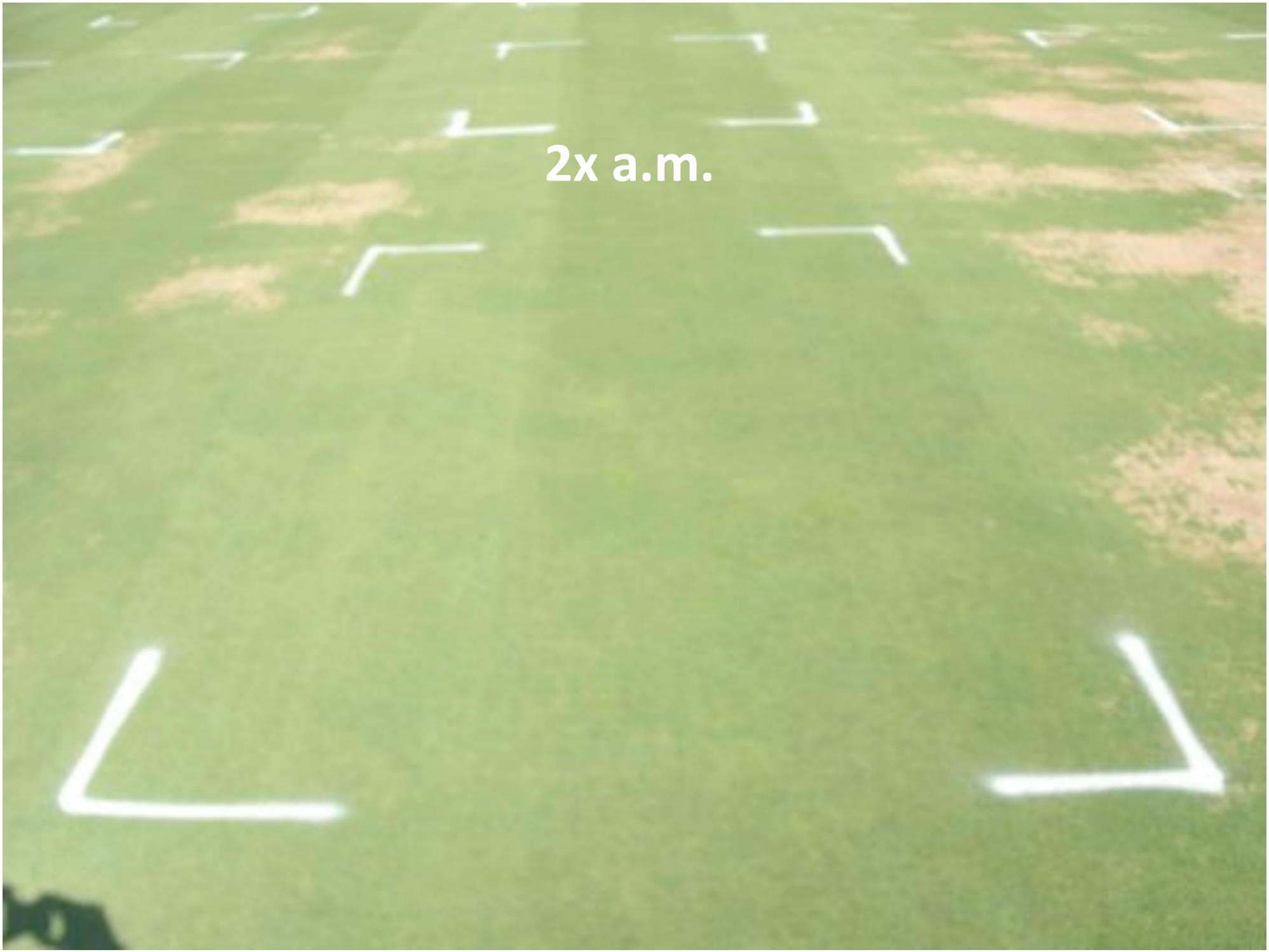
10. Alleviate heaving, scalping, and aerification

Photo sent by Josh Cull Asst. Superintendent, The Chicago Highlands Club


Control


1x p.m.


1x a.m.


2x a.m.


Is it counterproductive to roll after Aerification?

Before **After**

2014 lightweight roller aeration study

Toro GP 1240
626 lbs.

Salsco GGR 9065
840 lbs.

2014 rolling aeration study

- **Two rollers and a non-rolled check**
  - **Rolled 5x & 3x per week**
- **Bentgrass green 0.125-inch HOC**
- **Sandy-clay loam root zone**
- **Toro Pro Core ½ inch tines**


TORO
PROCORE


NOT ROLLED
ROLLED


NOT ROLLED
ROLLED

2014 lightweight roller aeration study

Hole closure data

1= no recover & 9 =no observable holes

Treatment	5 DA-A	8 DA-A	11 DA-A	25 DA-A
Toro 1240	3.0	5.0	6.7 a	7.2 a
Salso	2.7	4.3	6.7 a	7.2 a
No Roller	2.3	4.3	5.8 b	6.3 b

2014 lightweight roller aeration study

POST-AERATION GREEN SPEED

Change in speed in inches compared to check

Treatment	1 DA-A	7 DA-A	14 DA-A	21 DA-A
Toro 1240	+12 a	+13 a	+27 a	+18 a
Salso	+13 a	+13 a	+ 20 a	+20 a
No Roller	-----	-----	-----	-----

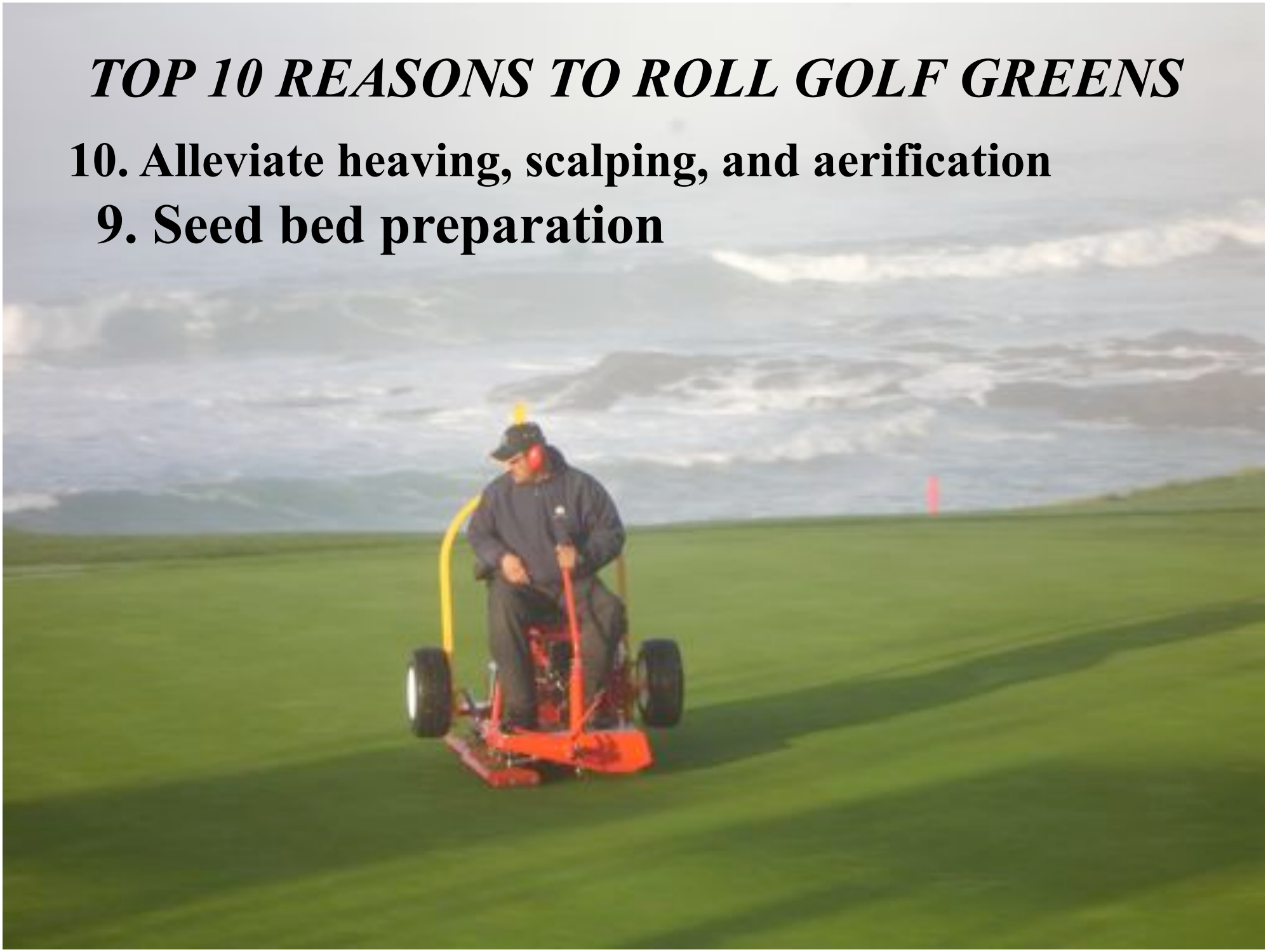
2014 lightweight roller aeration study RESULTS

- **Visual differences to hole closure took 11 DA-A**
- **Rolling after aeration immediately resulted in a smoother putting surface (*faster green speeds*).**
- **Roller style (weight) had no impact on hole closure of playability (smoothness or *speed*).**
- **No increase in bulk density (compaction) from rolling after aeration (data not shown).**

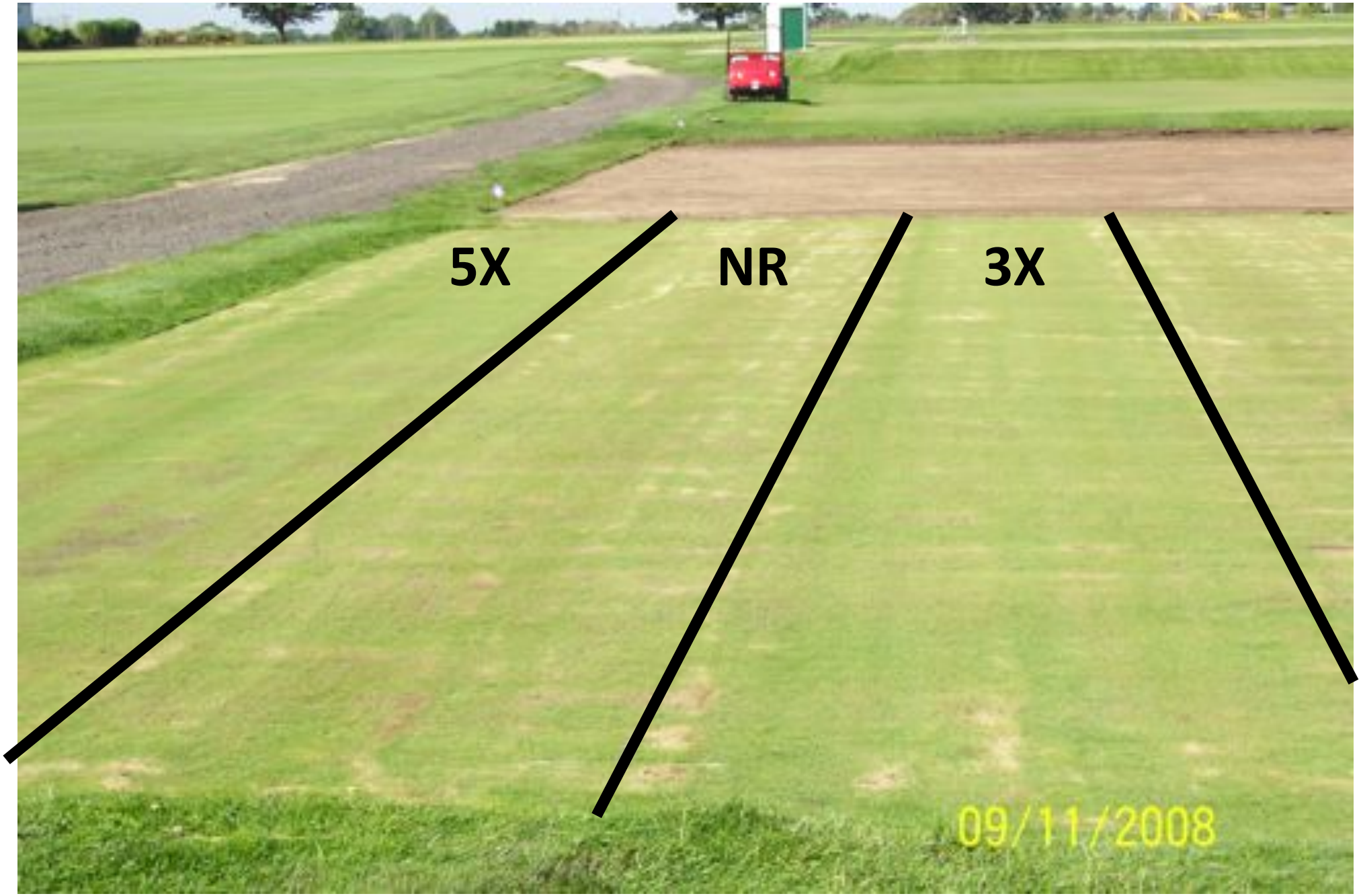
TOP 10 REASONS TO ROLL GOLF GREENS

10. Alleviate heaving, scalping, and aerification

9. Seed bed preparation

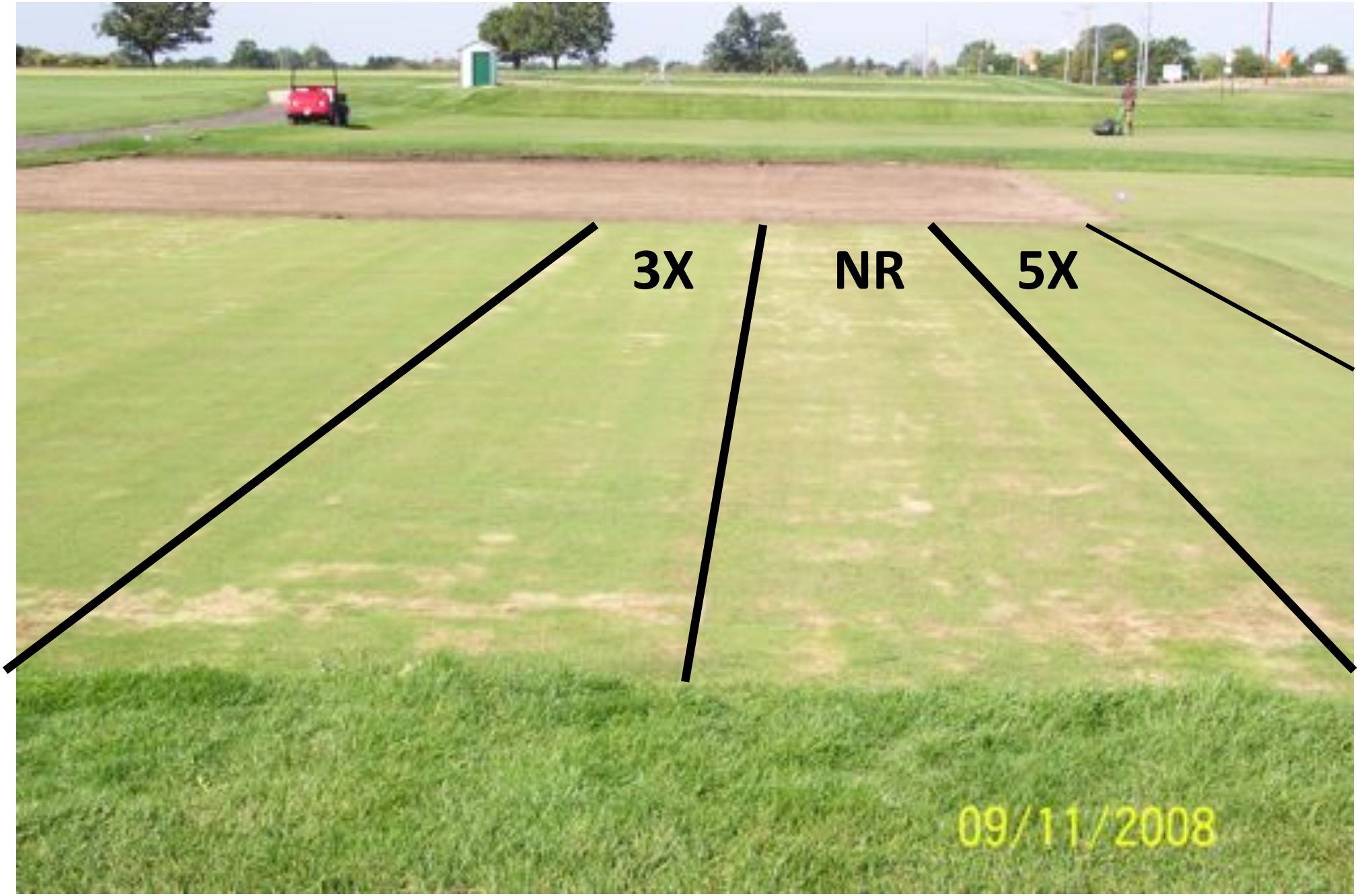



True Surface rolling establishment study



True Surface rolling establishment study

True Surface rolling establishment study



True Surface rolling establishment study

TOP 10 REASONS TO ROLL GOLF GREENS

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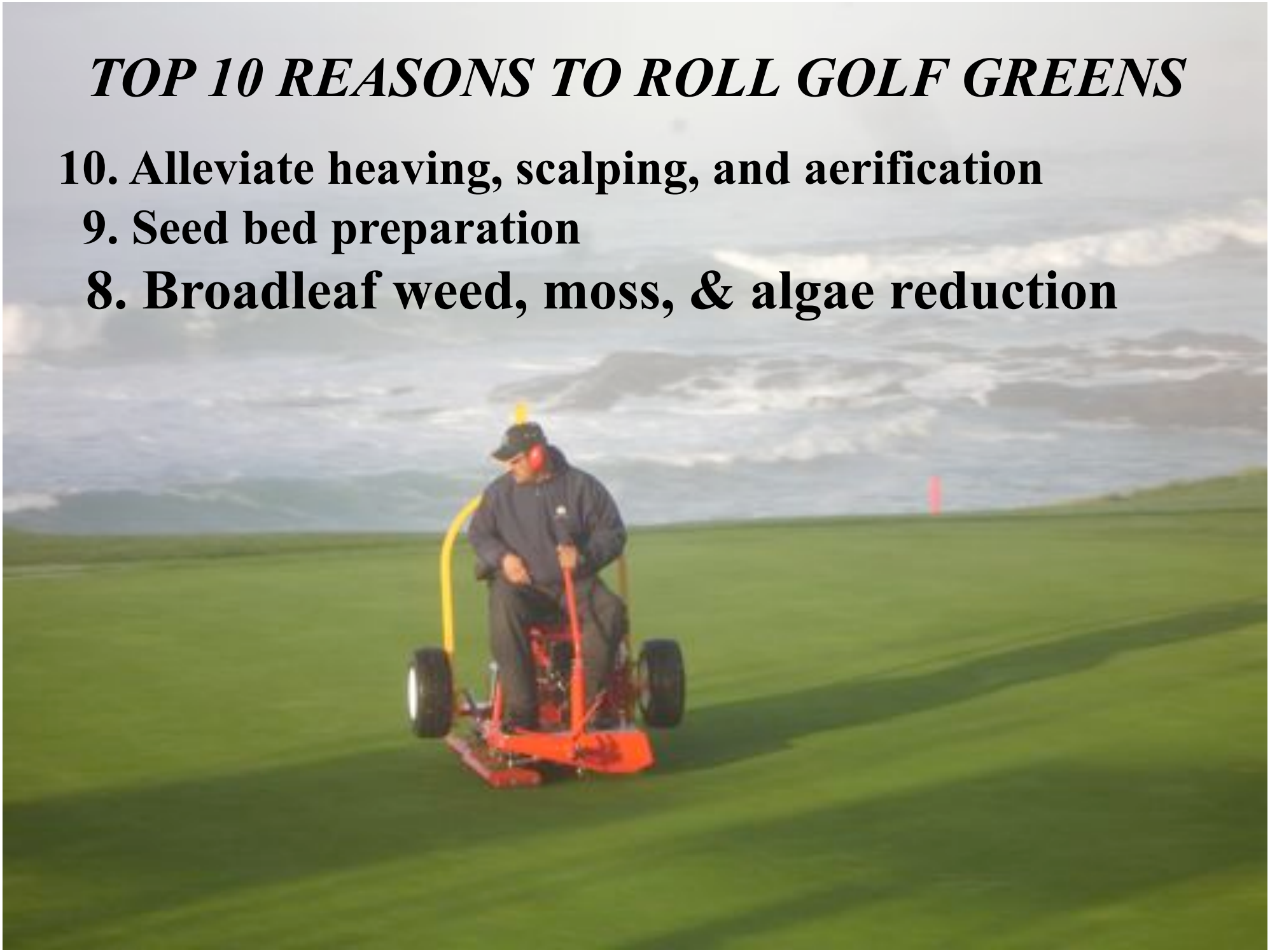
9. Seed bed preparation

8. Broadleaf weed, moss, & algae reduction



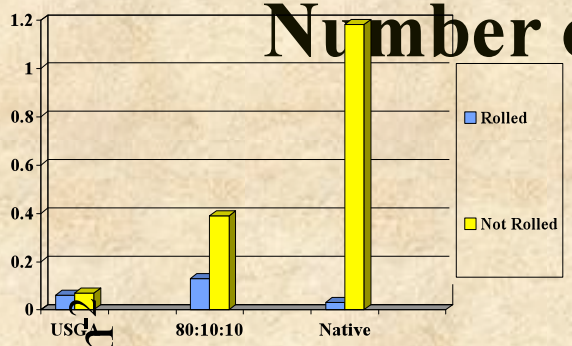

1998

Broad leaf weed counts
2 October 1998

6 lb N/yr	0.5	rolled	0.7
3 lb N/yr	1.3	not rolled	1.2
	***		***

***, Significant at 0.001

Number of moss spots m^{-2} 7 June 1996.



Number of moss spots m^{-2}

a*

b

b b

b

b

Root Zone

*, Significant at the 0.05 probability level.

Dr. Nikolai,

You seem to have done quite a bit of research regarding rollers and dollar spot. Have you or are you aware of anyone who is looking into rolling and moss control? As a golf course superintendent I have seen over the past few years with aggressive rolling practices (daily) that my silvery thread moss populations on my Poa annua putting greens has been on the decline

I think that it would be beneficial for some research institution to conduct studies to see if rolling does in fact reduce moss populations on putting greens and if so how often and at what times of the year are most effective.

The reason I have sent this to you is that you are the Dr. Greenspeed!

Thanks for your time,

--

Jason Haines,Superintendent,
Pender Harbour Golf Club

I think that the moss is being suppressed from the roller due to wear and not so much increased turf density. …

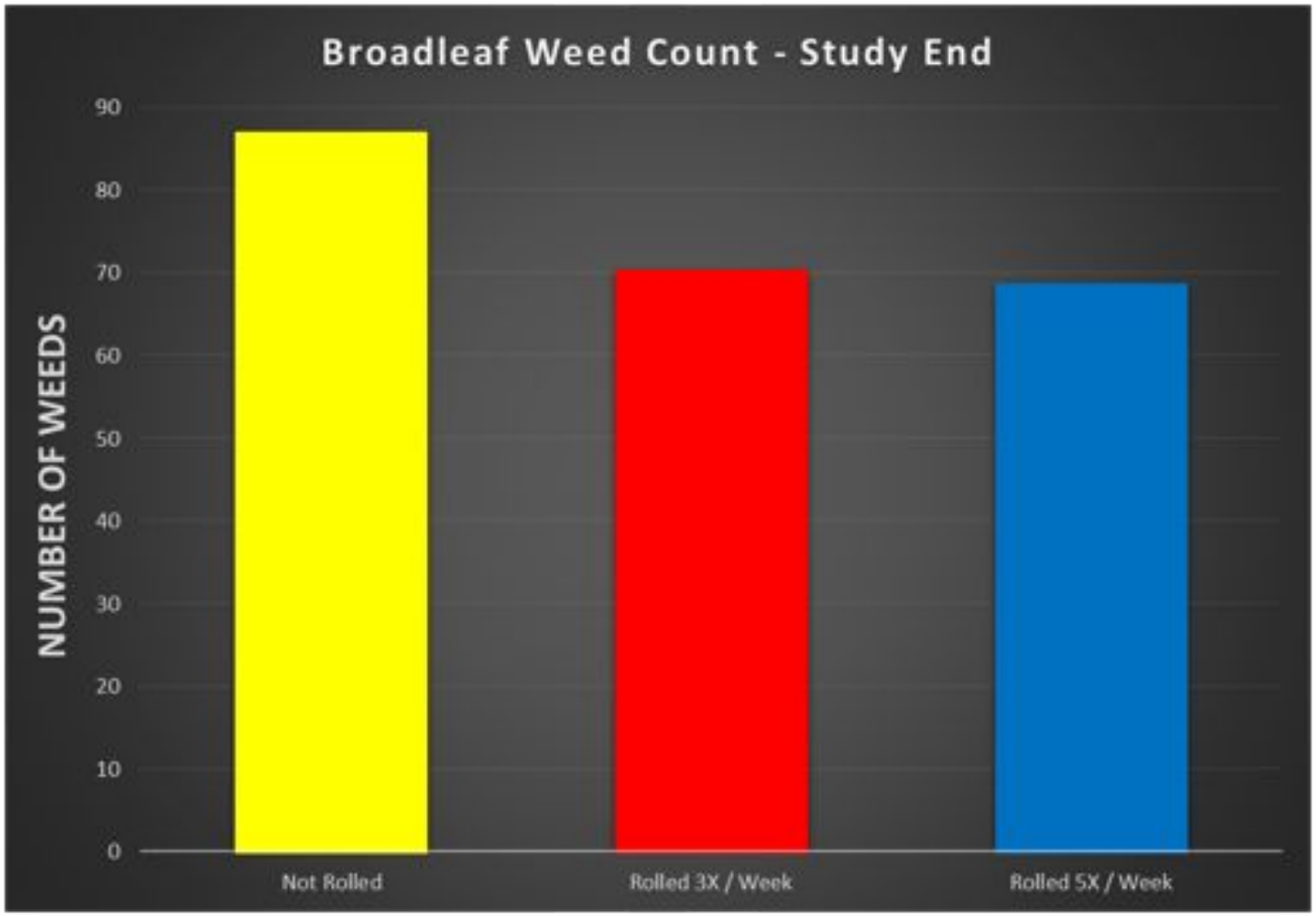
I have Poa annua …. I roll daily from April-October and cut every other day. The last 2 years I have used an old Woodbay Greensiron 3000. I just purchased a brand new Truturf roller for next season.

The course in the first picture doesn't roll regularly and when he does he uses a pull behind heavyweight roller. I don't think that his rolling has any effect on the moss. I also think that my rolling techniques might have some effect but potentially not the greatest effect that it could.

I have rolled daily for two years and have only seen positive results. Healthier better quality putting surfaces. Less labor and wear and tear on my greens mower and less moss and dollar spot.


SR72 Sports Turf Roller

RESULTS


Broadleaf Weed Count - Study End
NUMBER OF WEEDS
90
80
70
60
50
40
30
20
10
0
Not Rolled
Rolled 3X / Week
Rolled 5X / Week

Lawn Height Weed/rolling study 2014

Quackgrass plants per plot

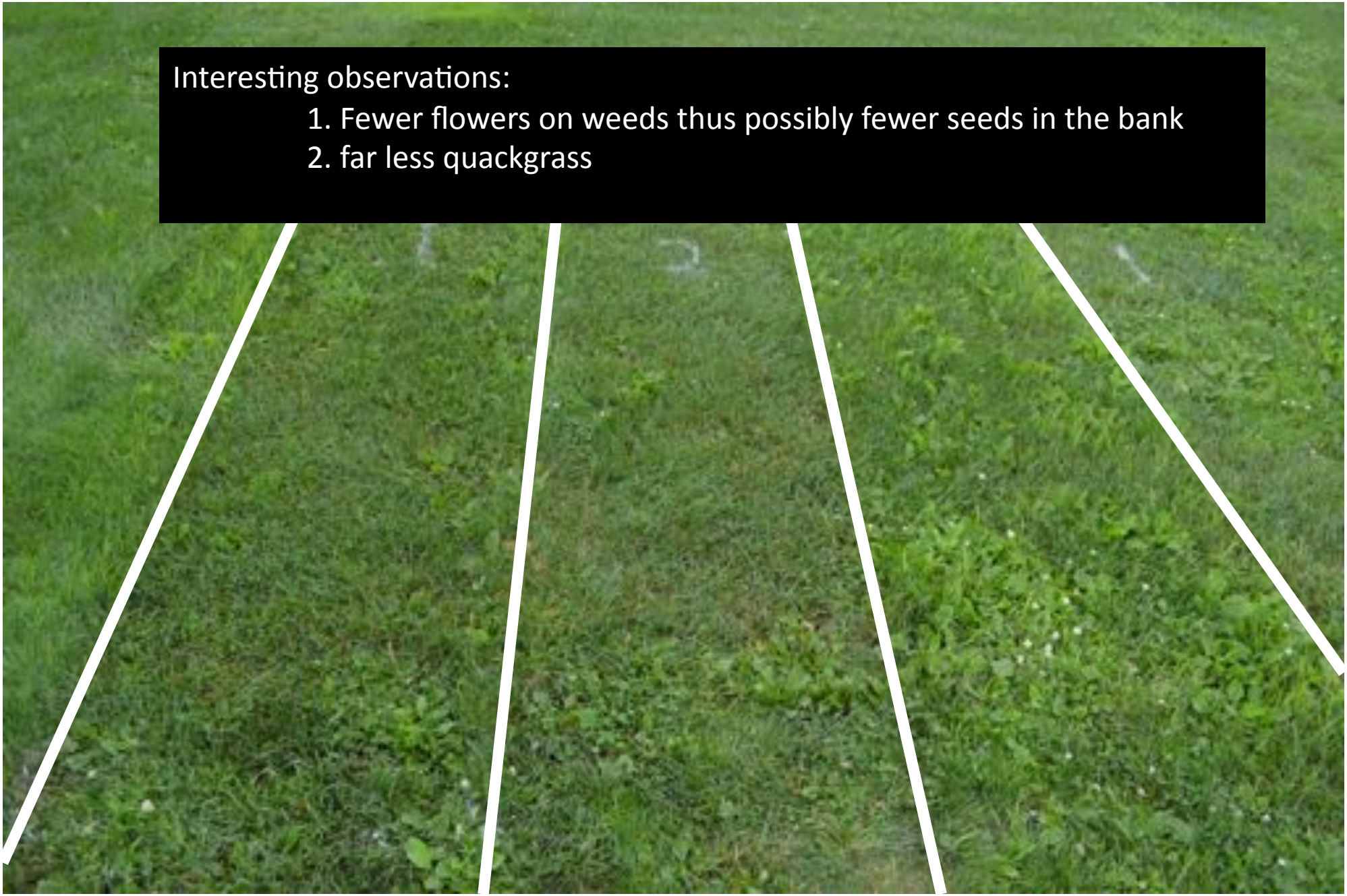
	July 23	August 4
Rolled Daily	6 b	0 b
Rolled 2x	0 b	0 b
Control	22 a	17 a

Lawn Height Weed/rolling study 2014

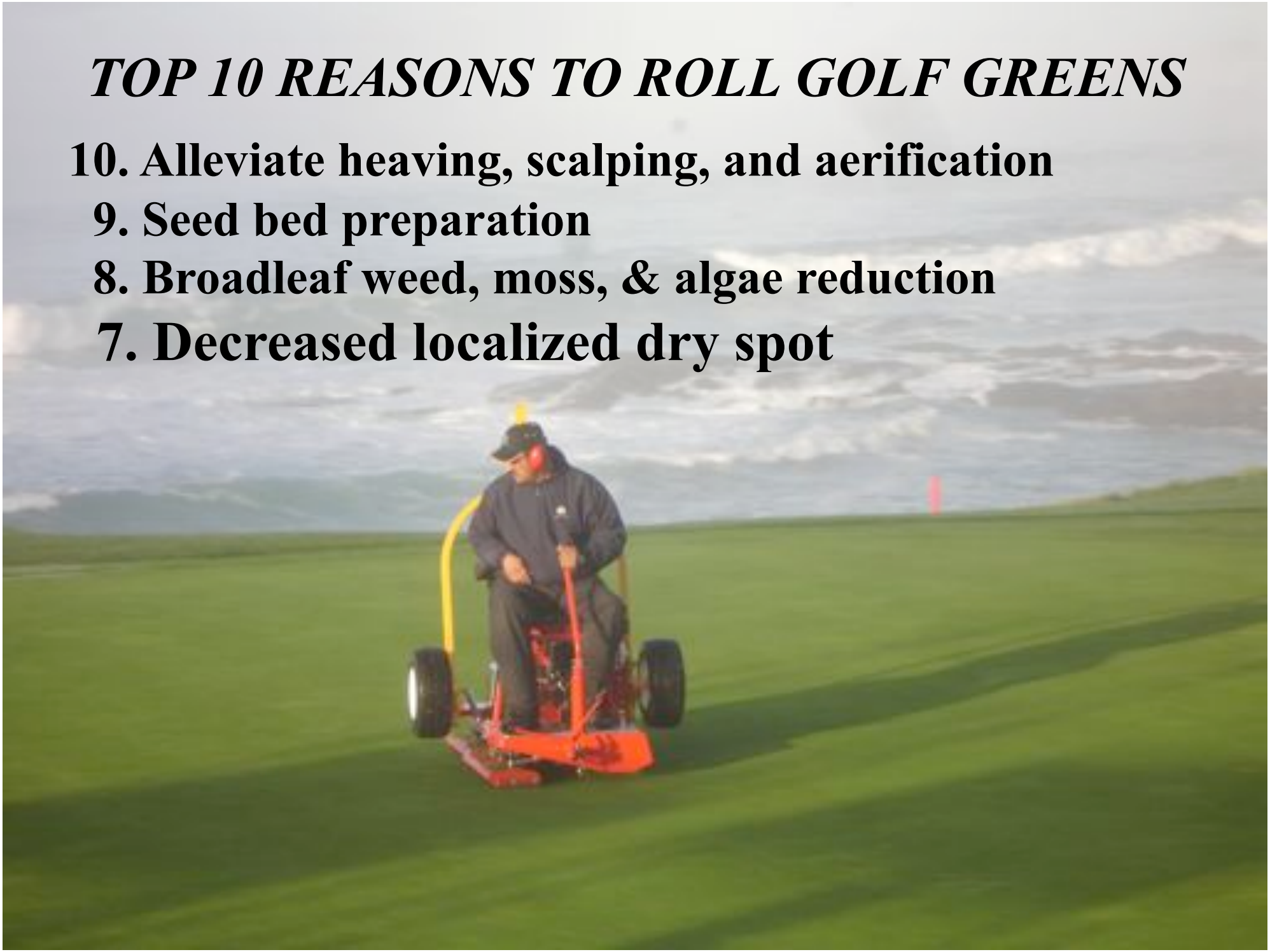
Dandelions per plots

	May 28	August 18
Rolled Daily	10	7 b
Rolled 2x	9	2 c
Control	5	12 a

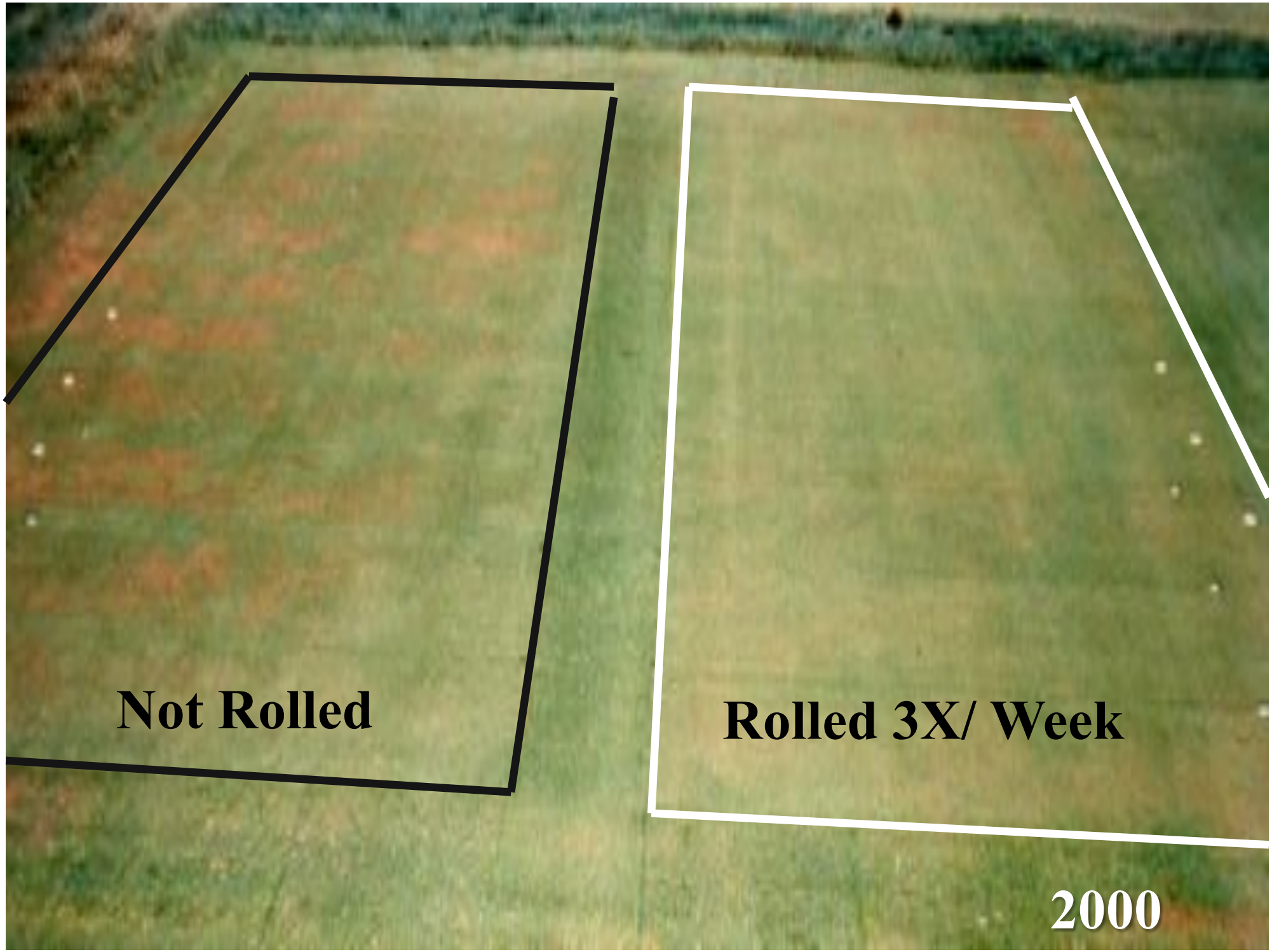
Lawn Height Weed/rolling study 2014



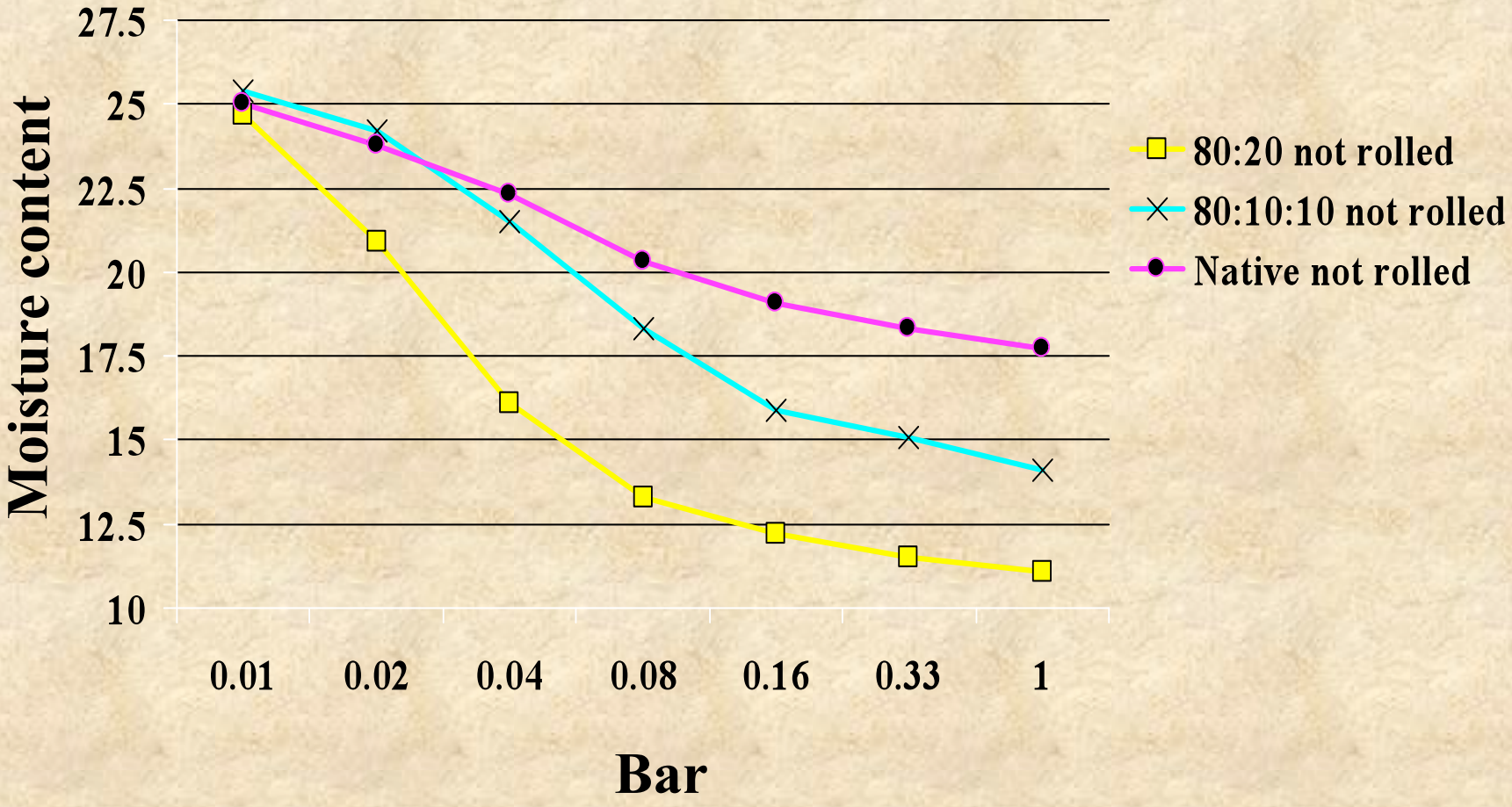
Lawn Height Weed/rolling study 2014


TOP 10 REASONS TO ROLL GOLF GREENS
10. Alleviate heaving, scalping, and aerification
9. Seed bed preparation
8. Broadleaf weed, moss, & algae reduction
7. Decreased localized dry spot

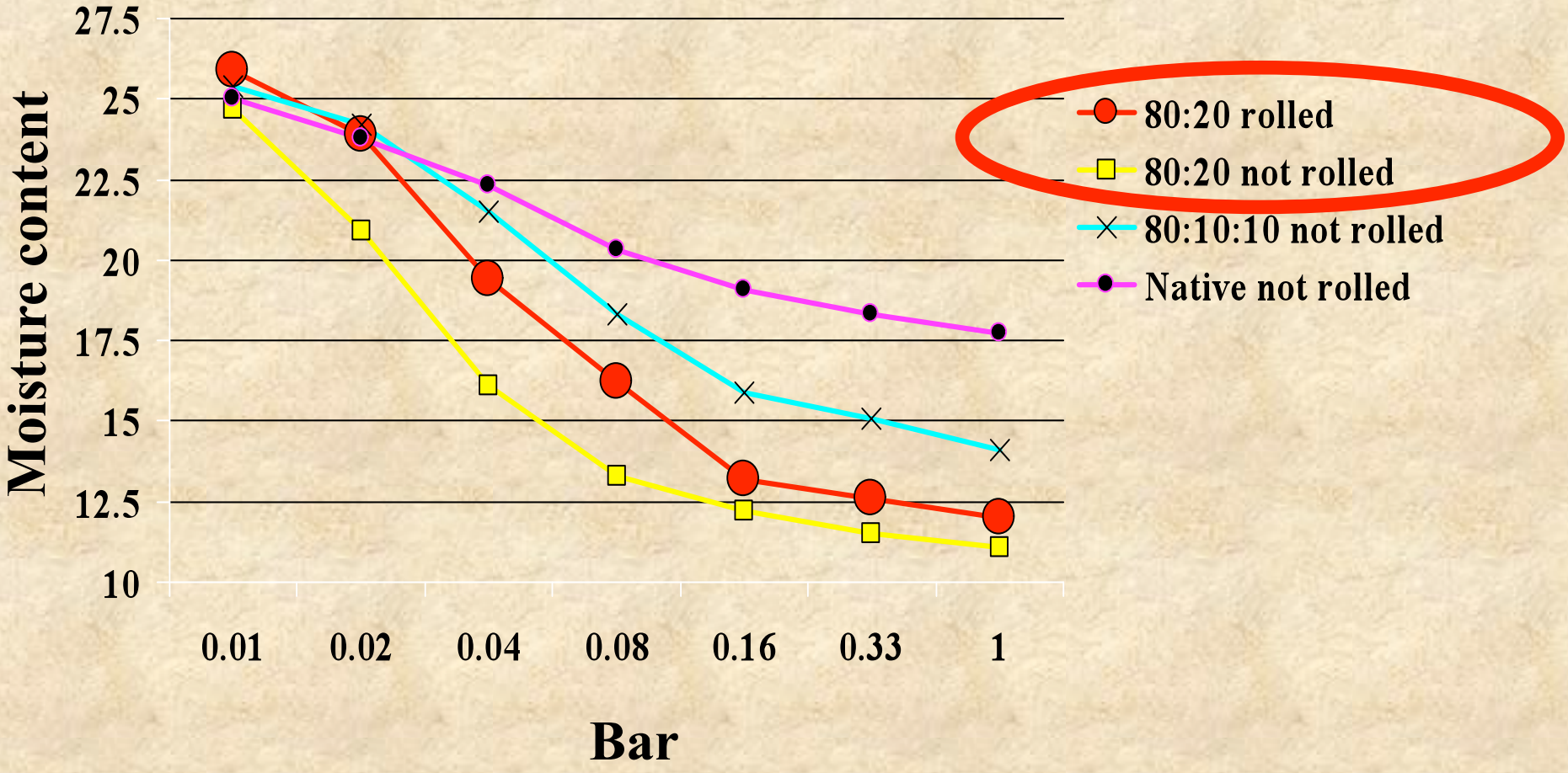

Not Rolled
Rolled 3x/week
1995

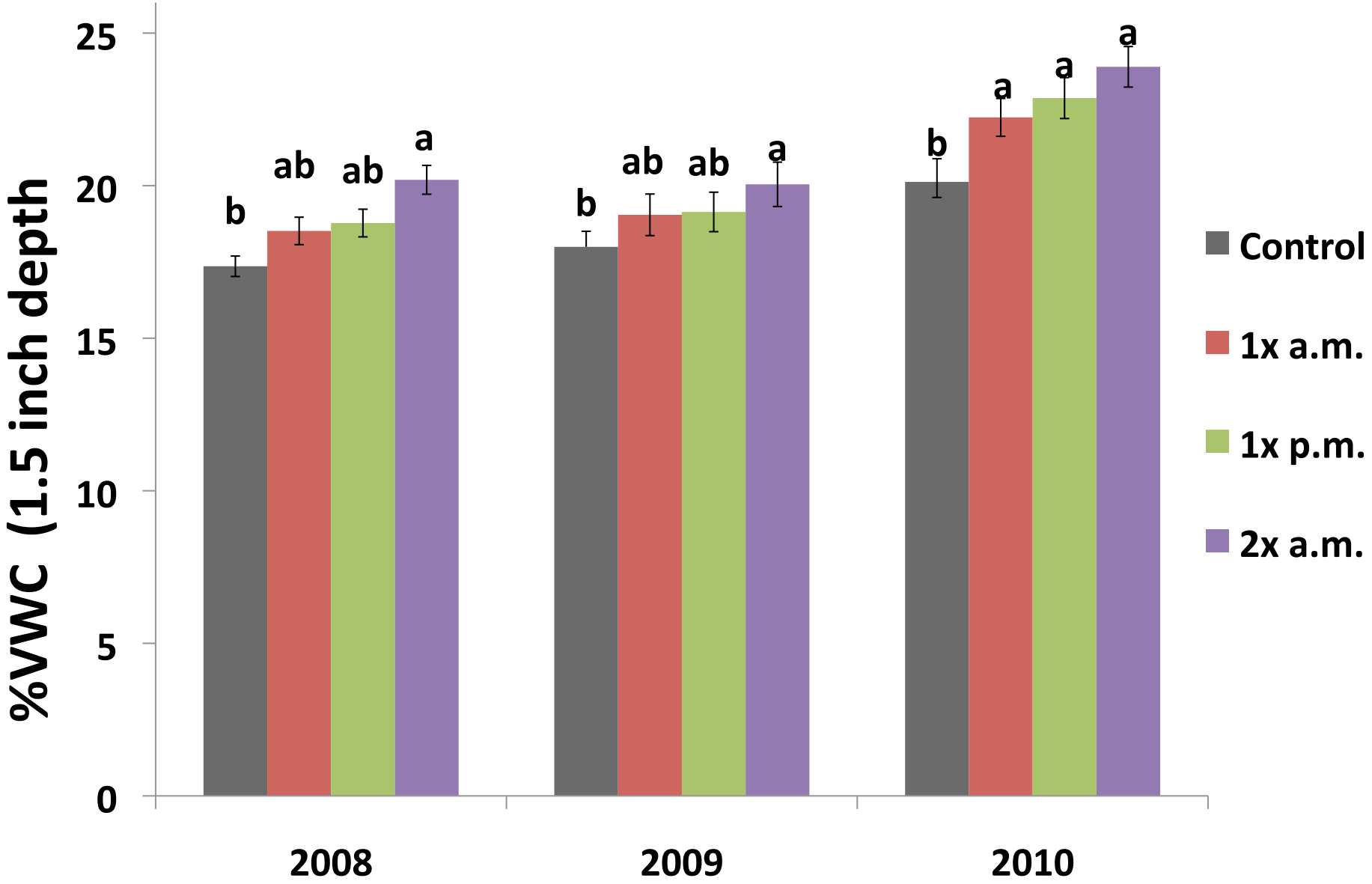

Not Rolled
Rolled 3X/ Week
2000

Moisture release curve



Moisture release curve



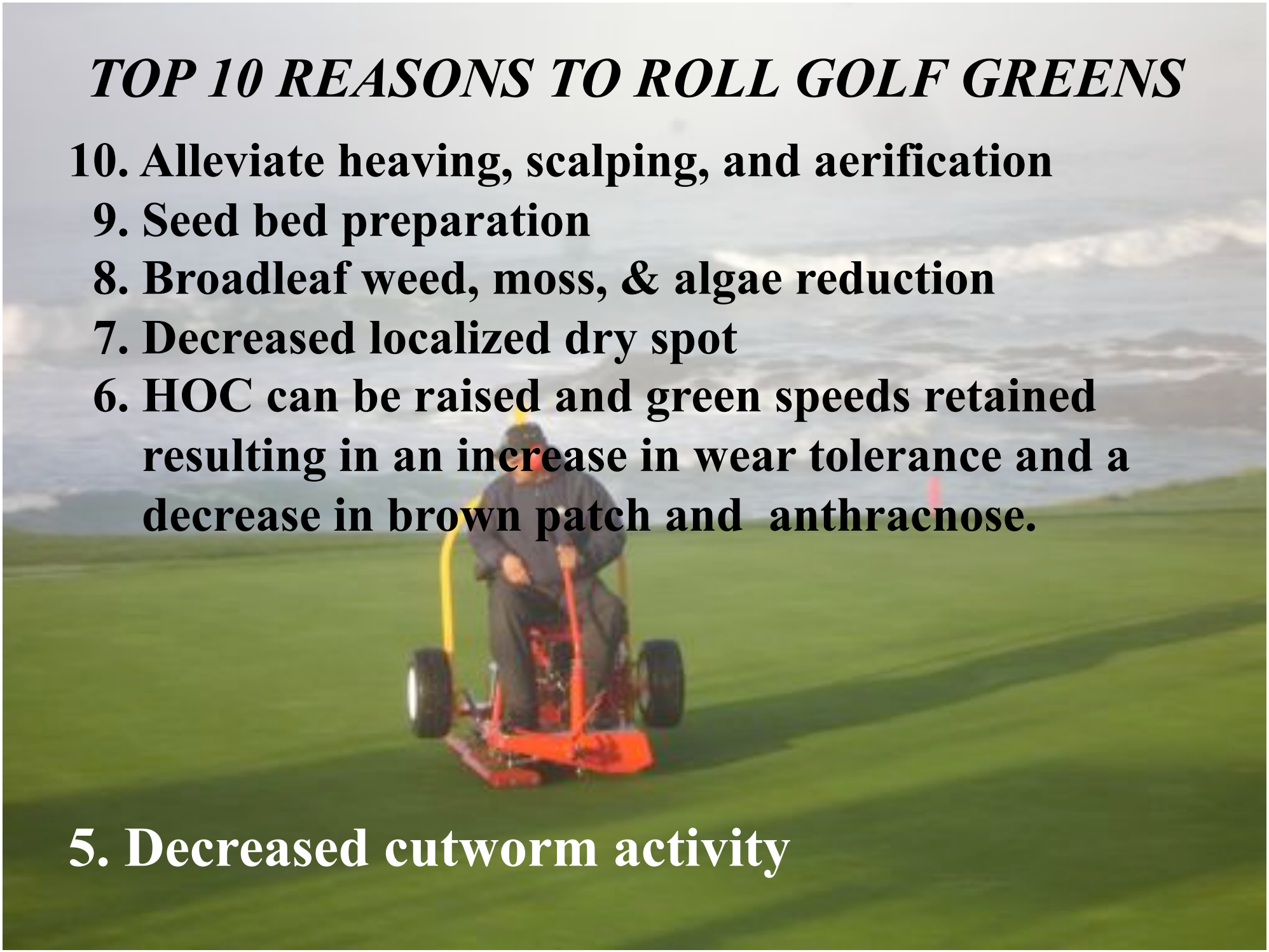

%VWC (1.5 inch depth
25
20
15
10
5
0
b
ab
ab
a
b
ab
ab
a
b
a
a
a
2008
2009
2010
Control
1x a.m.
1x p.m.
2x a.m.

Root weights in grams

	31 August 1999			28 August 2000		
	TDL	0-3”	3-6”	TDL	0-3”	3-6”
Rolled	1.584	0.462	0.118	1.296	0.366	0.123
Not Rolled	1.303	0.444	0.120	1.000	0.403	0.120
	*	NS	NS	**	NS	NS

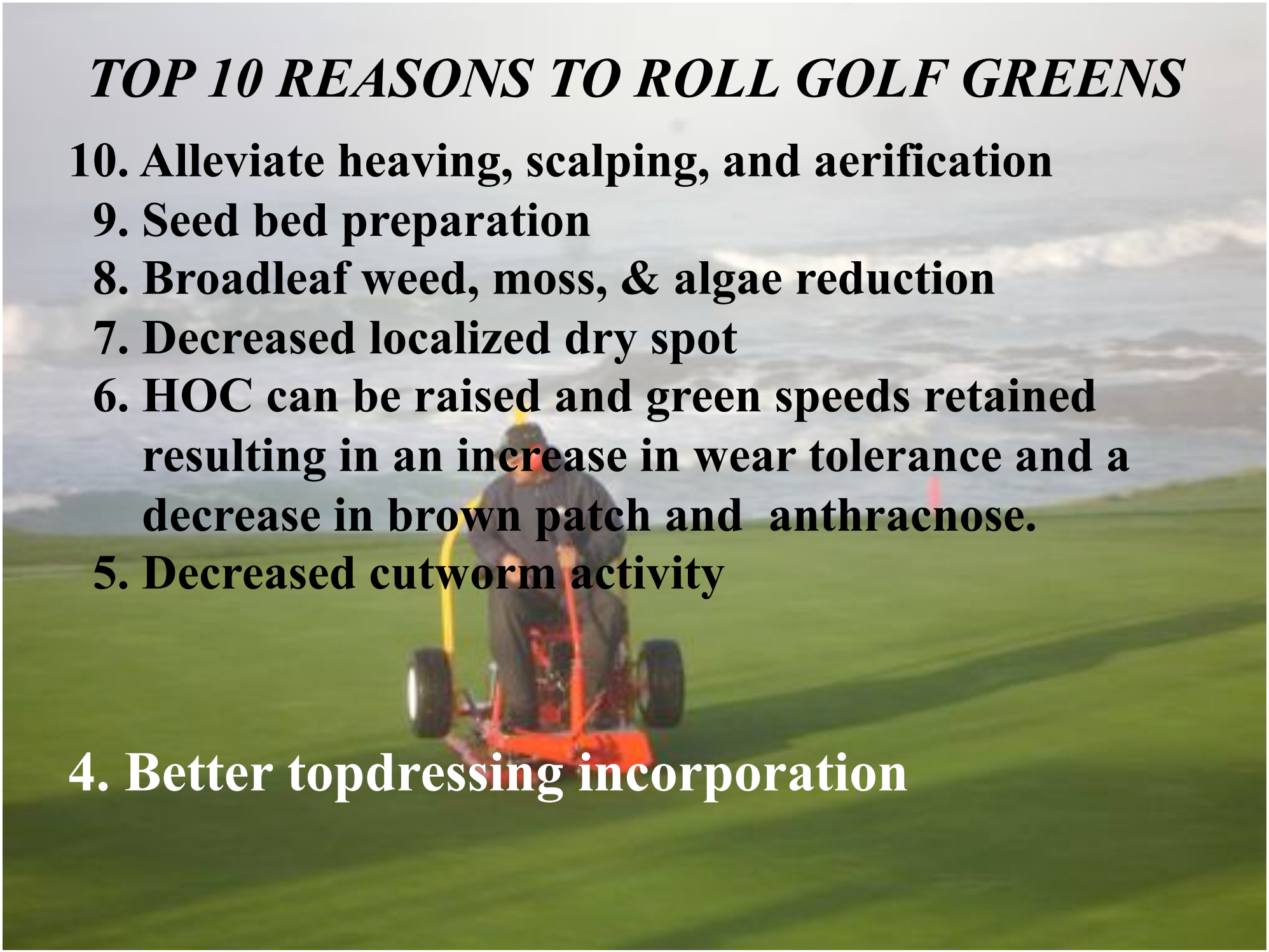
*, ** Significant at the 0.05 and 0.01 probability levels, respectively.


TOP 10 REASONS TO ROLL GOLF GREENS
10. Alleviate heaving, scalping, and aerification
9. Seed bed preparation
8. Broadleaf weed, moss, & algae reduction
7. Decreased localized dry spot
6. HOC can be raised and green speeds retained resulting in an increase in wear tolerance and a decrease in brown patch and anthracnose.



TOP 10 REASONS TO ROLL GOLF GREENS

10. **Alleviate heaving, scalping, and aerification**
9. **Seed bed preparation**
8. **Broadleaf weed, moss, & algae reduction**
7. **Decreased localized dry spot**
6. **HOC can be raised and green speeds retained resulting in an increase in wear tolerance and a decrease in brown patch and anthracnose.**
5. **Decreased cutworm activity**



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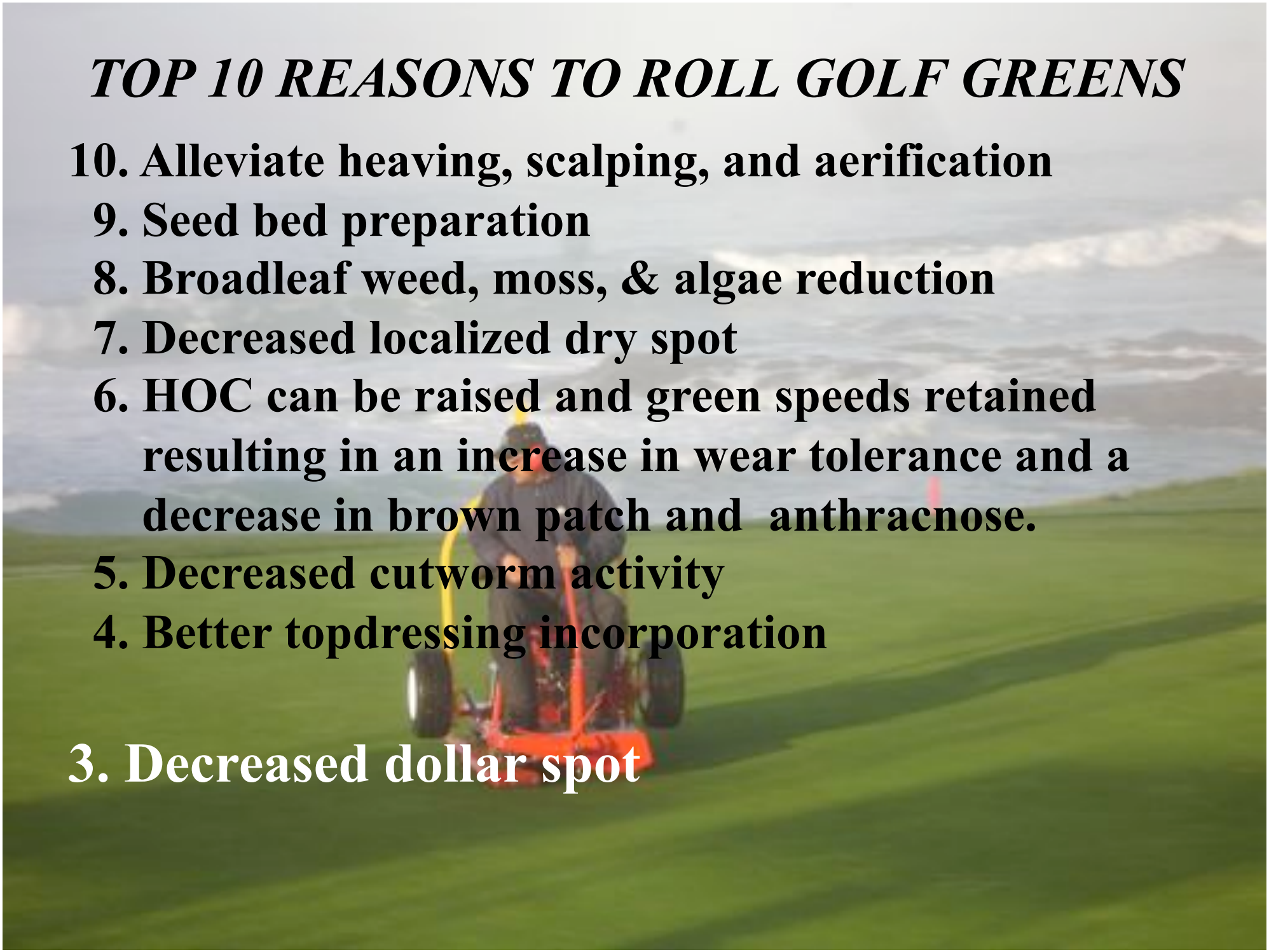
5. Decreased cutworm activity

4. Better topdressing incorporation



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6. **HOC can be raised and green speeds retained resulting in an increase in wear tolerance and a decrease in brown patch and anthracnose.**
5. **Decreased cutworm activity**
4. **Better topdressing incorporation**

3. Decreased dollar spot


Not Rolled
Rolled 3x/Week

Why rolling may decrease dollar spot activity

- Removes dew
  - (Williams and Powell, 1996; Ellram et al., 2007; Walsh et al., 1999)
- Removes leaf litter
  - (Williams et al., 1996)
- Decrease concentration of guttation
  - (Vargas, 2005; Williams et al., 1996)
- Increases soil moisture holding capacity (altered microbial populations?)
  - Couch and Bloom, 1960; Liu et al., 1995; Nikolai, 2005)
- Induced plant defense responses
  - Nikolai, 2005; Hammerschmidt, (unpublished)

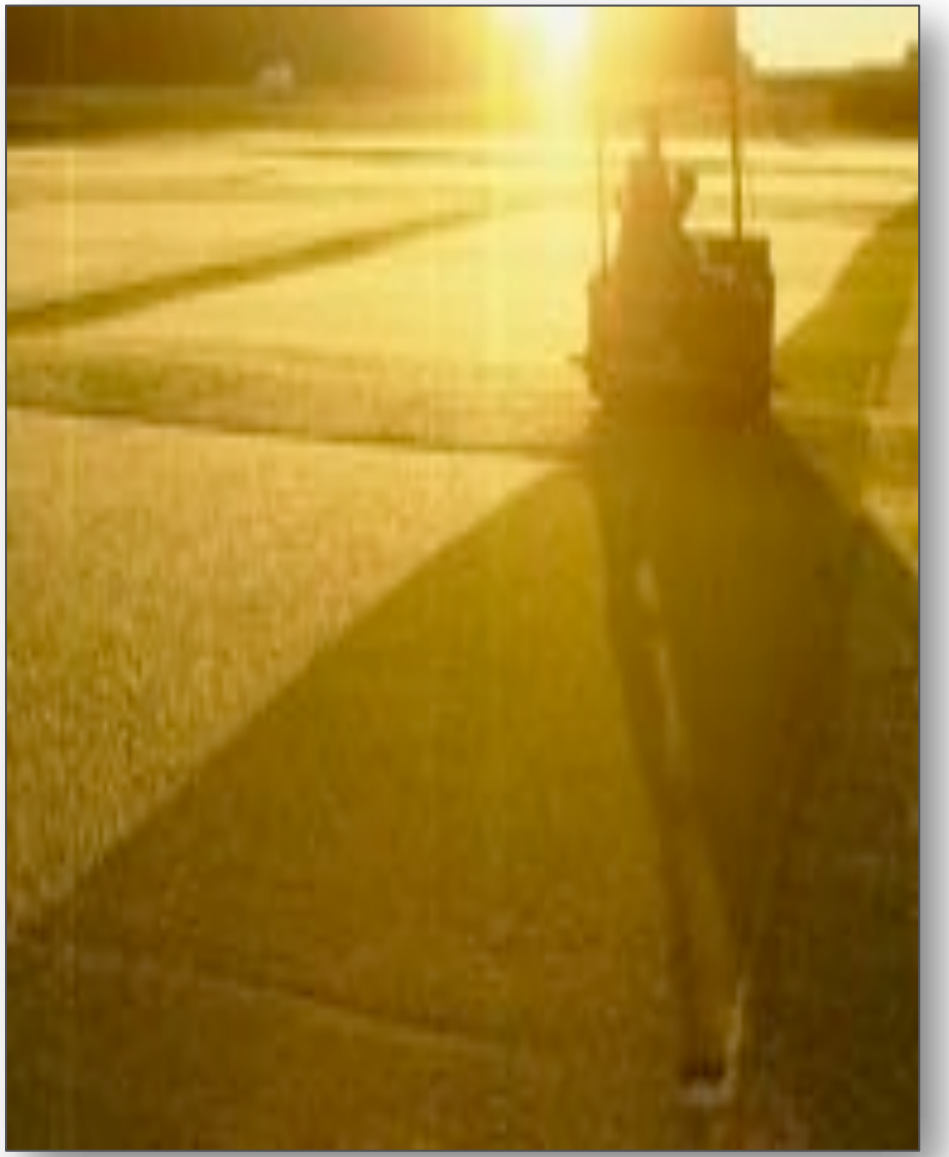
Materials and Methods

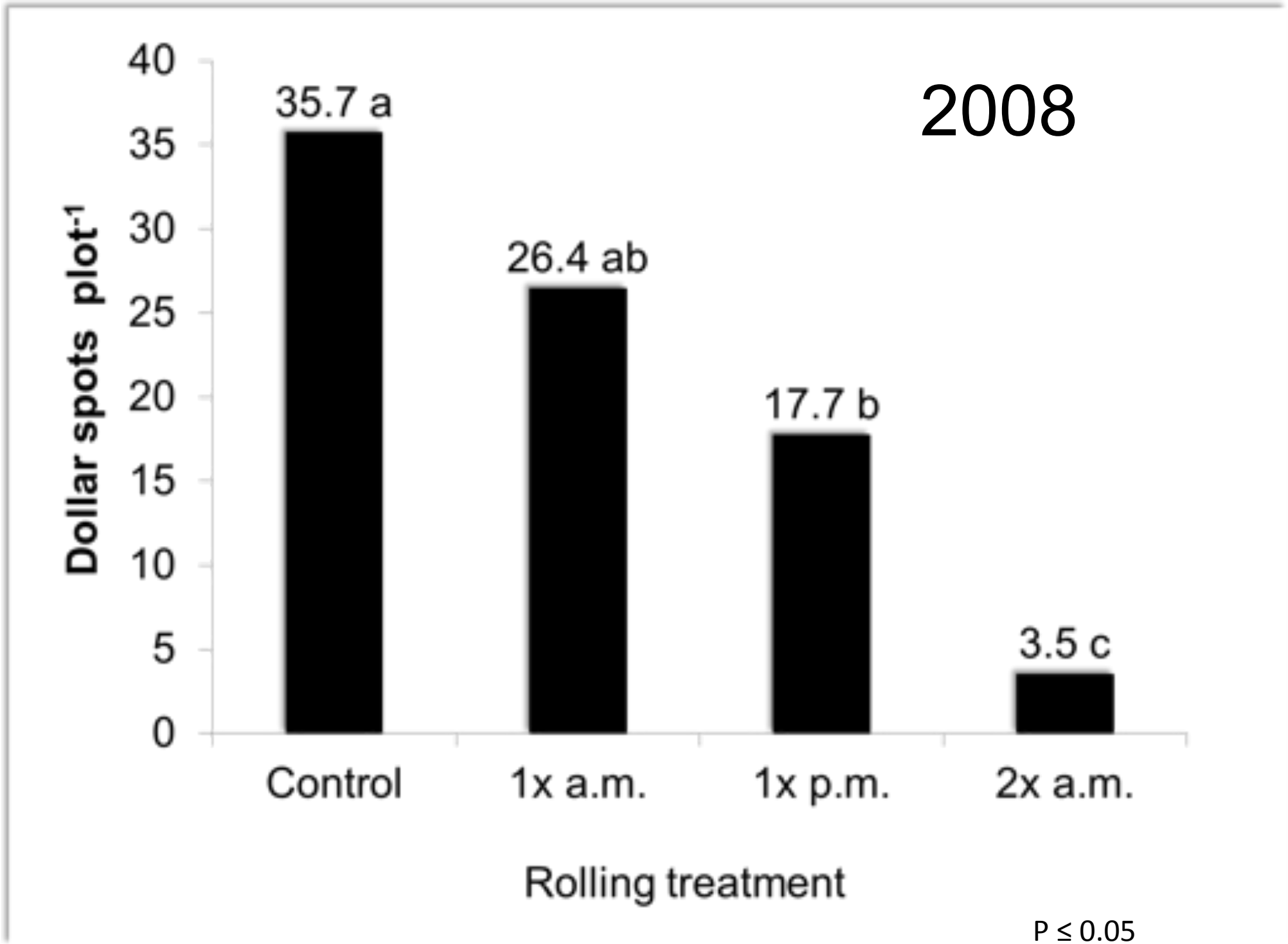
- USGA green mix soil
  - Topdressed bi-weekly
- Mixed stand *Agrostis stolonifera* cv. '*Independence*' and *Poa annua*
- Tru-Turf R52-11T greens roller
  - Rolled June-October
- Hand mowed 6 days/wk
  - @ 0.156" (3.96mm)
- NO FUNGICIDES

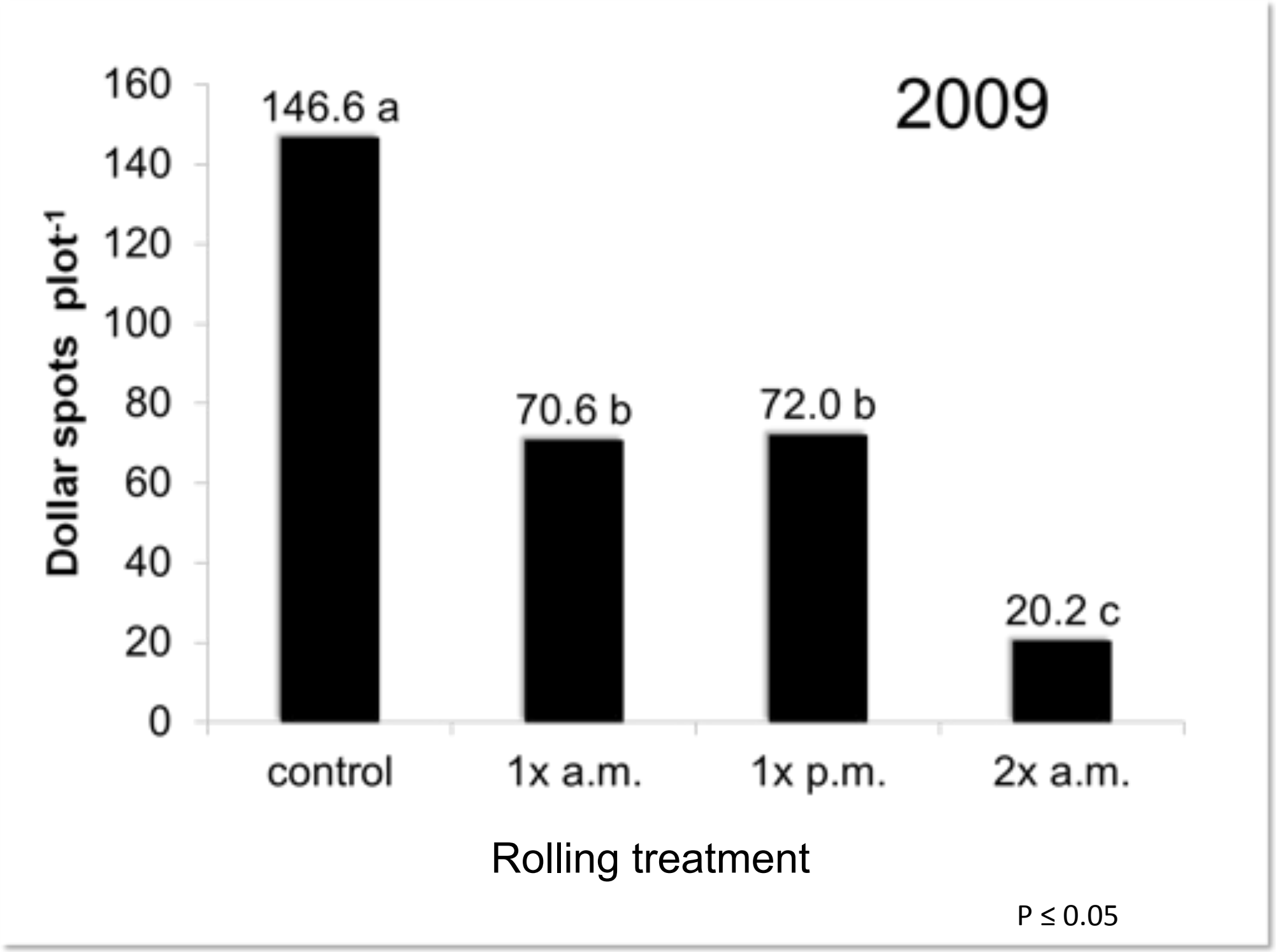
Hypothesis I

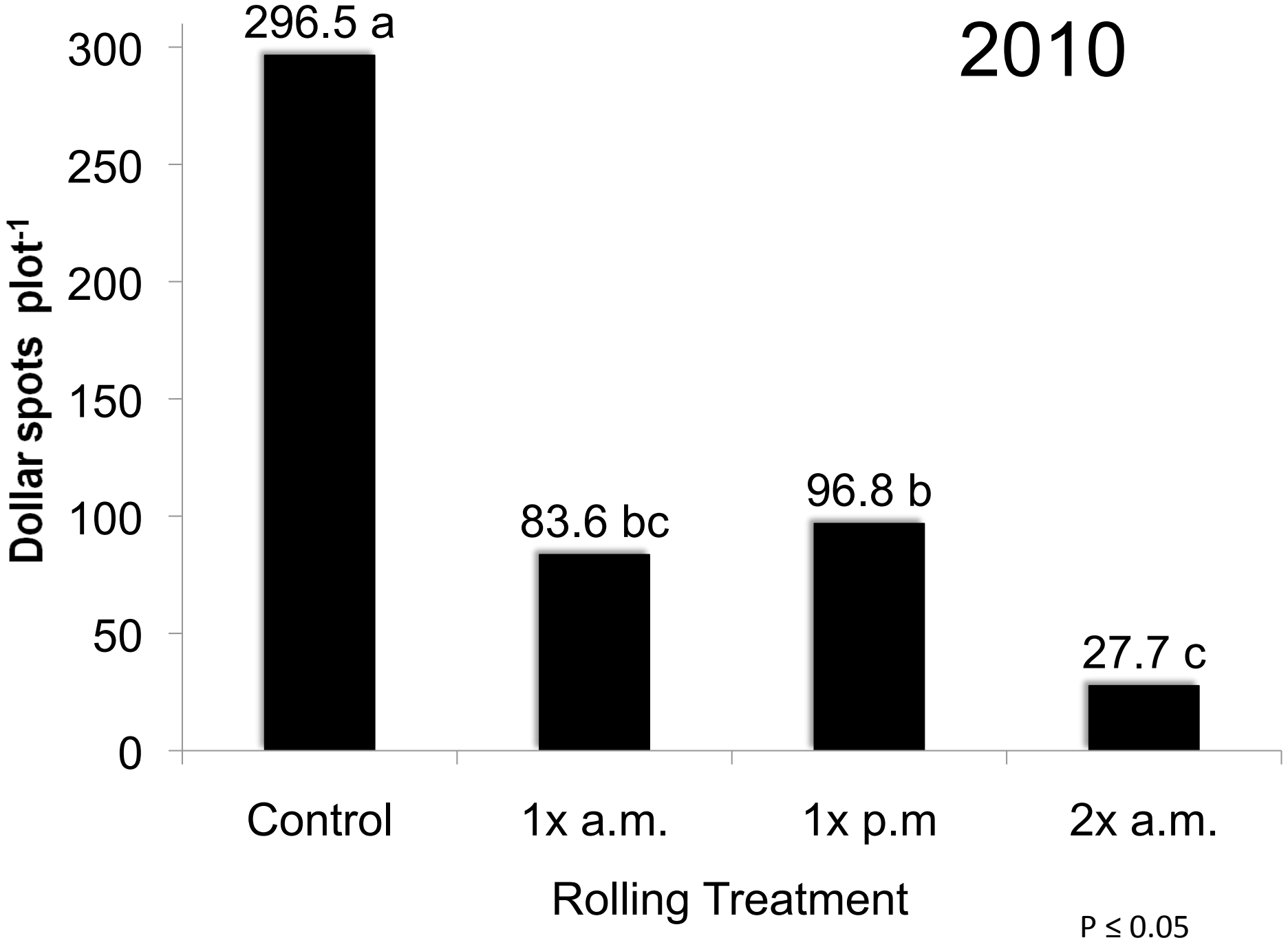
- Rolling (typically in the morning), removes excess dew and plant guttation fluid

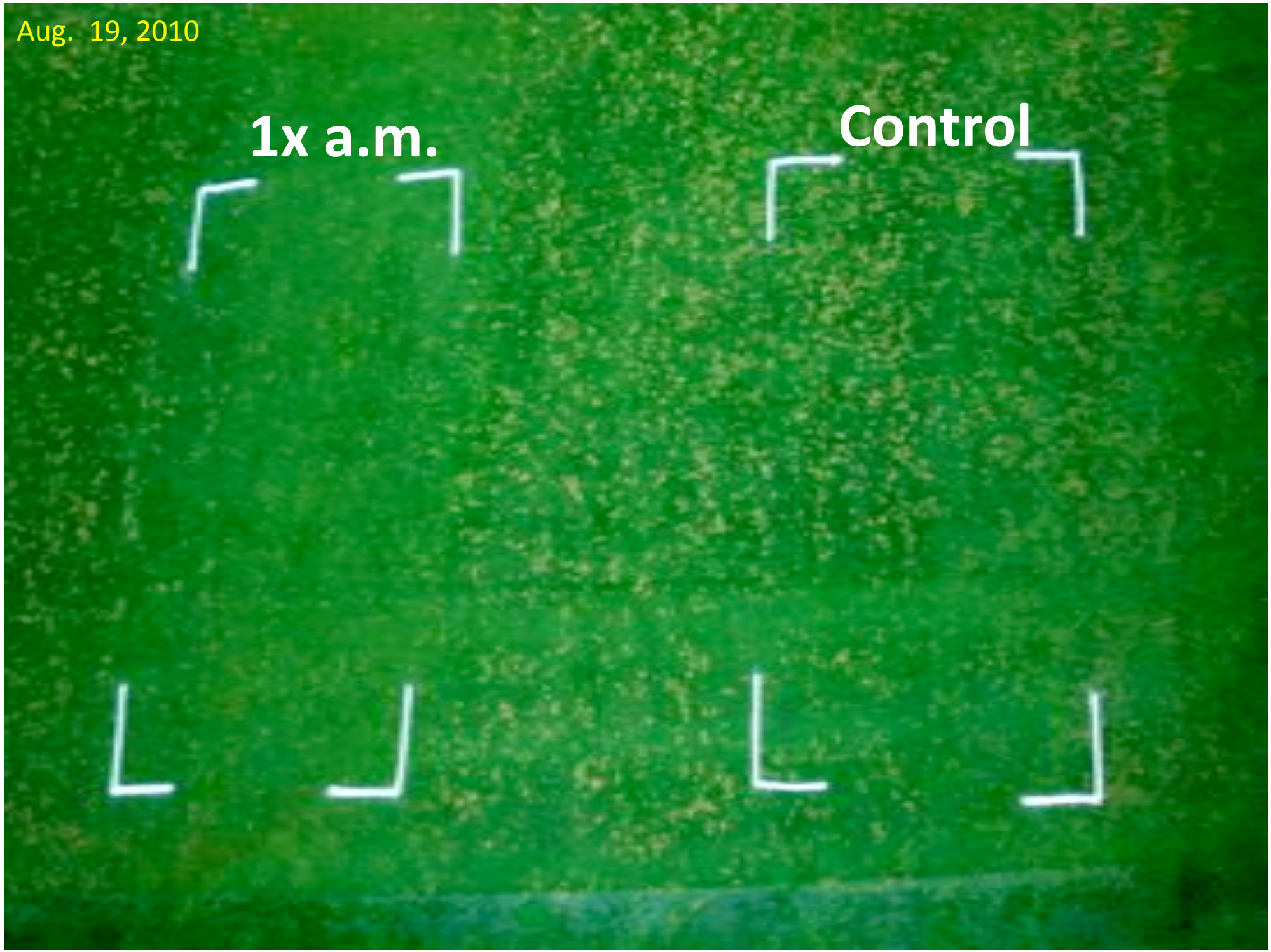
- Removal/dispersal limits pathogen proliferation
  - Moisture
  - Food source
  - Inoculum

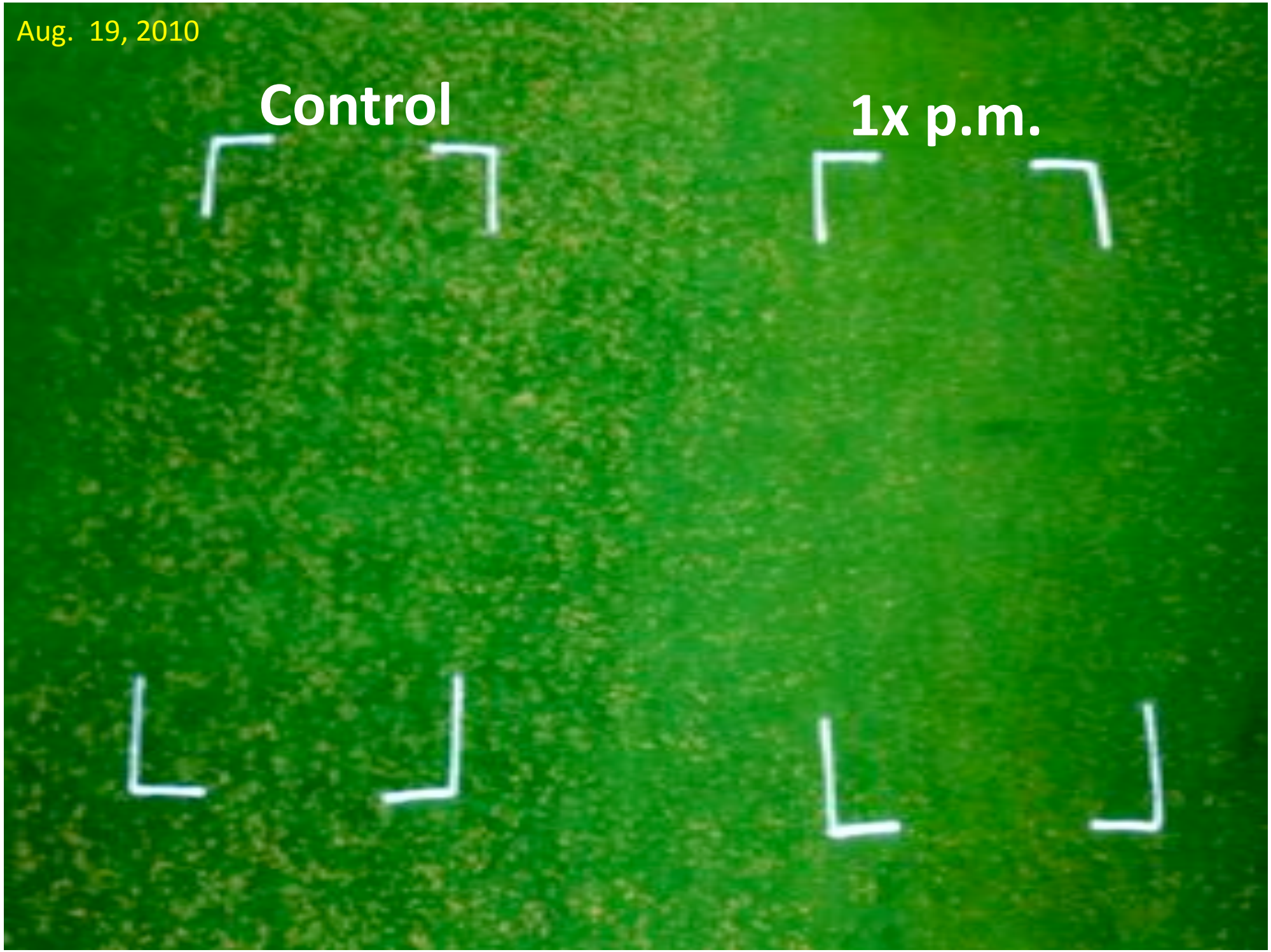



2008
Dollar spots plot-1
40
35
30
25
20
15
10
5
0
35.7 a
26.4 ab
17.7 b
3.5 c
Control
1x a.m.
1x p.m.
2x a.m.
Rolling treatment
P ≤ 0.05


2009
Dollar spots plot-1
160
140
120
100
80
60
40
20
0
146.6 a
70.6 b
72.0 b
20.2 c
control
1x a.m.
1x p.m.
2x a.m.
Rolling treatment
P ≤ 0.05


2010
296.5 a
83.6 bc
96.8 b
27.7 c
300
250
200
150
100
50
0
Dollar spots plot-1
Control
1x a.m.
1x p.m
2x a.m.
Rolling Treatment
P ≤ 0.05


Aug. 19, 2010
1x a.m.
Control

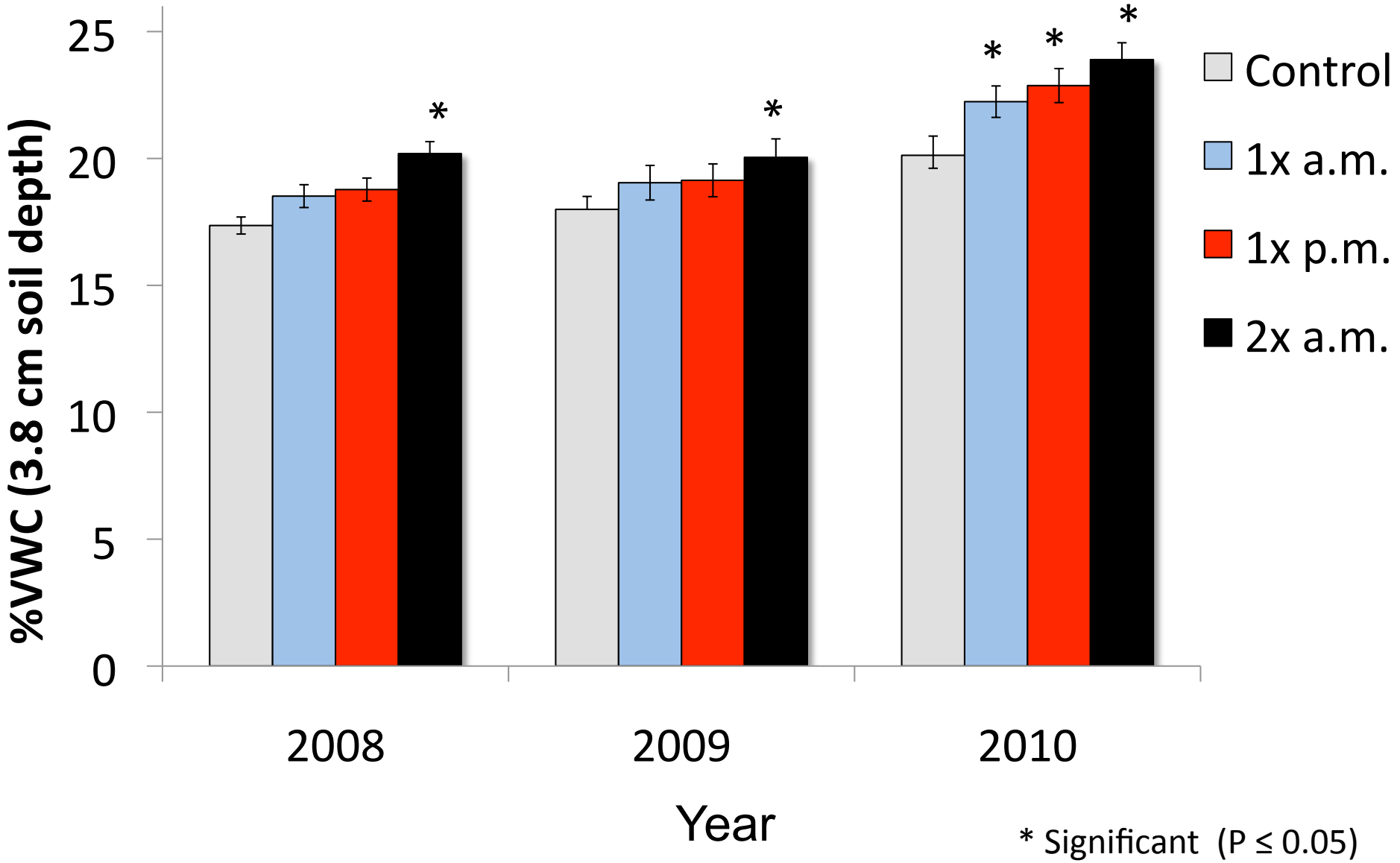

Aug. 19, 2010
Control
1x p.m.


Aug. 19, 2010
Control
2x a.m.

Why rolling may decrease dollar spot activity

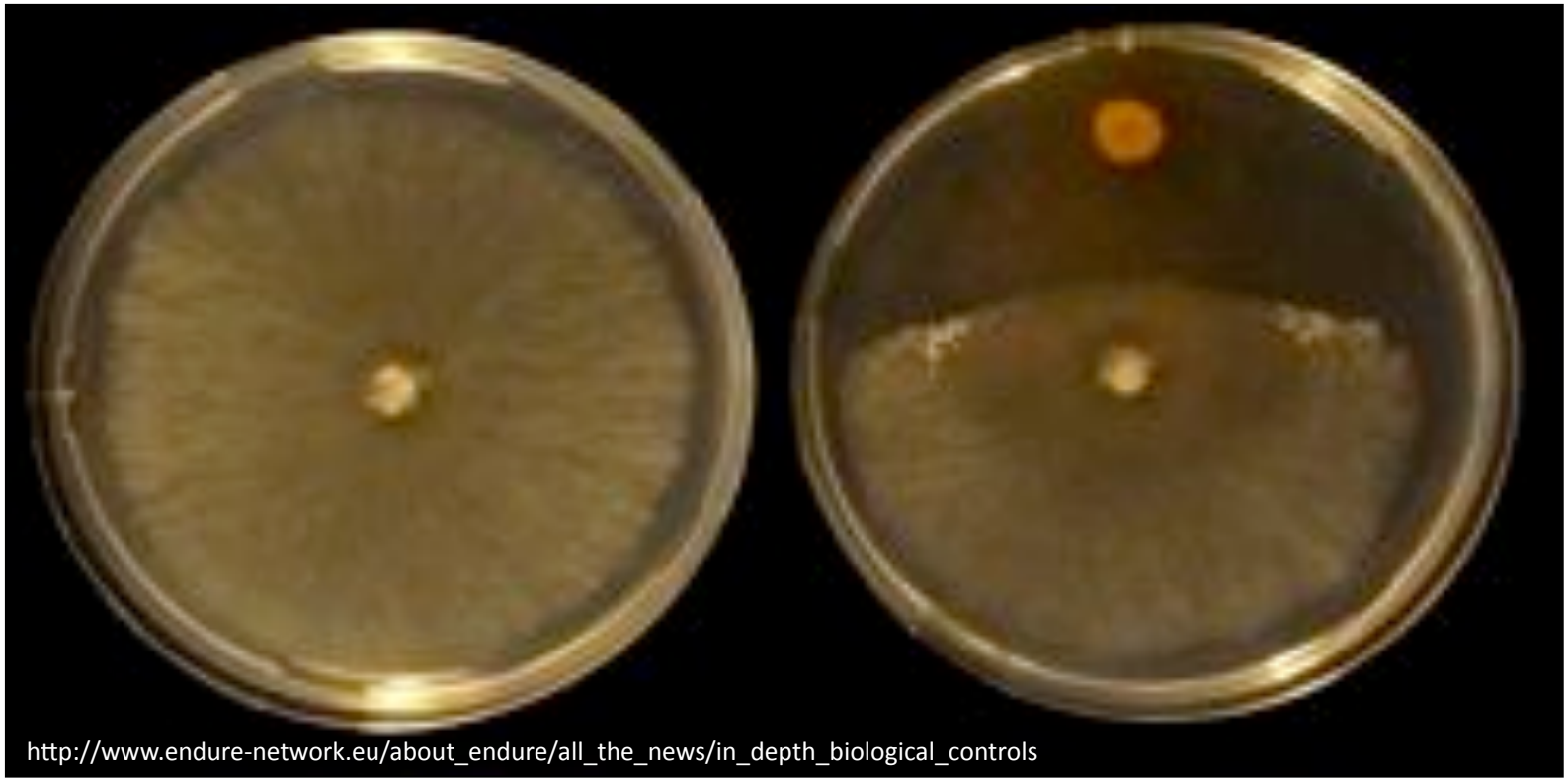
- Removes dew
  - (Williams and Powell, 1996; Ellram et al., 2007; Walsh et al., 1999)
- Removes leaf litter
  - (Williams et al., 1996)
- Decrease concentration of guttation
  - (Vargas, 2005; Williams et al., 1996)
- Increases soil moisture holding capacity (altered microbial populations?)
  - Couch and Bloom, 1960; Liu et al., 1995; Nikolai, 2005)
- Induced plant defense responses
  - Nikolai, 2005; Hammerschmidt, (unpublished)

Soil Moisture



Hypothesis II

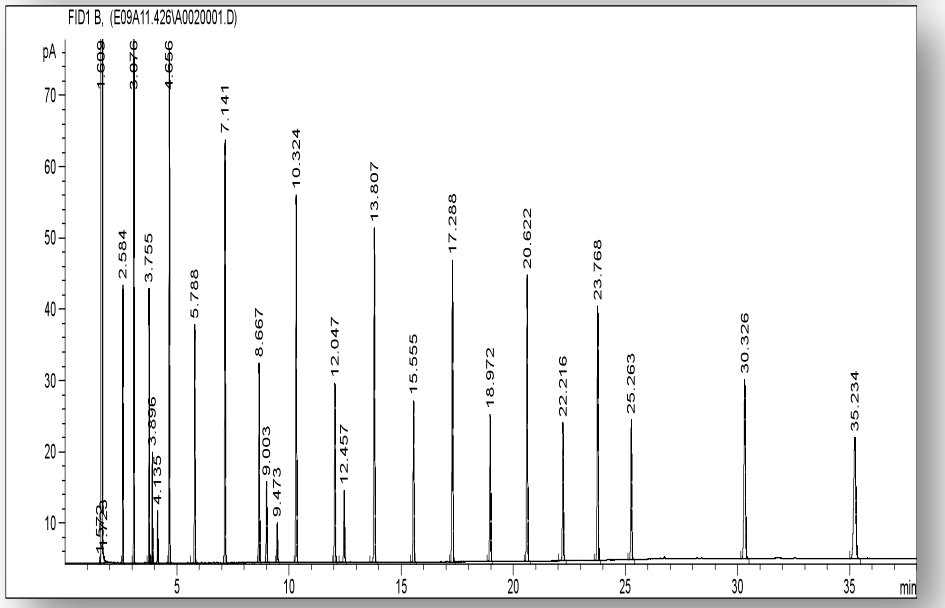
- Rolling suppresses dollar spot by promoting microbial mediated inhibition (i.e. antagonism, competition etc.)



http://www.endure-network.eu/about_endure/all_the_news/in_depth_biological_controls

Microbial Analysis

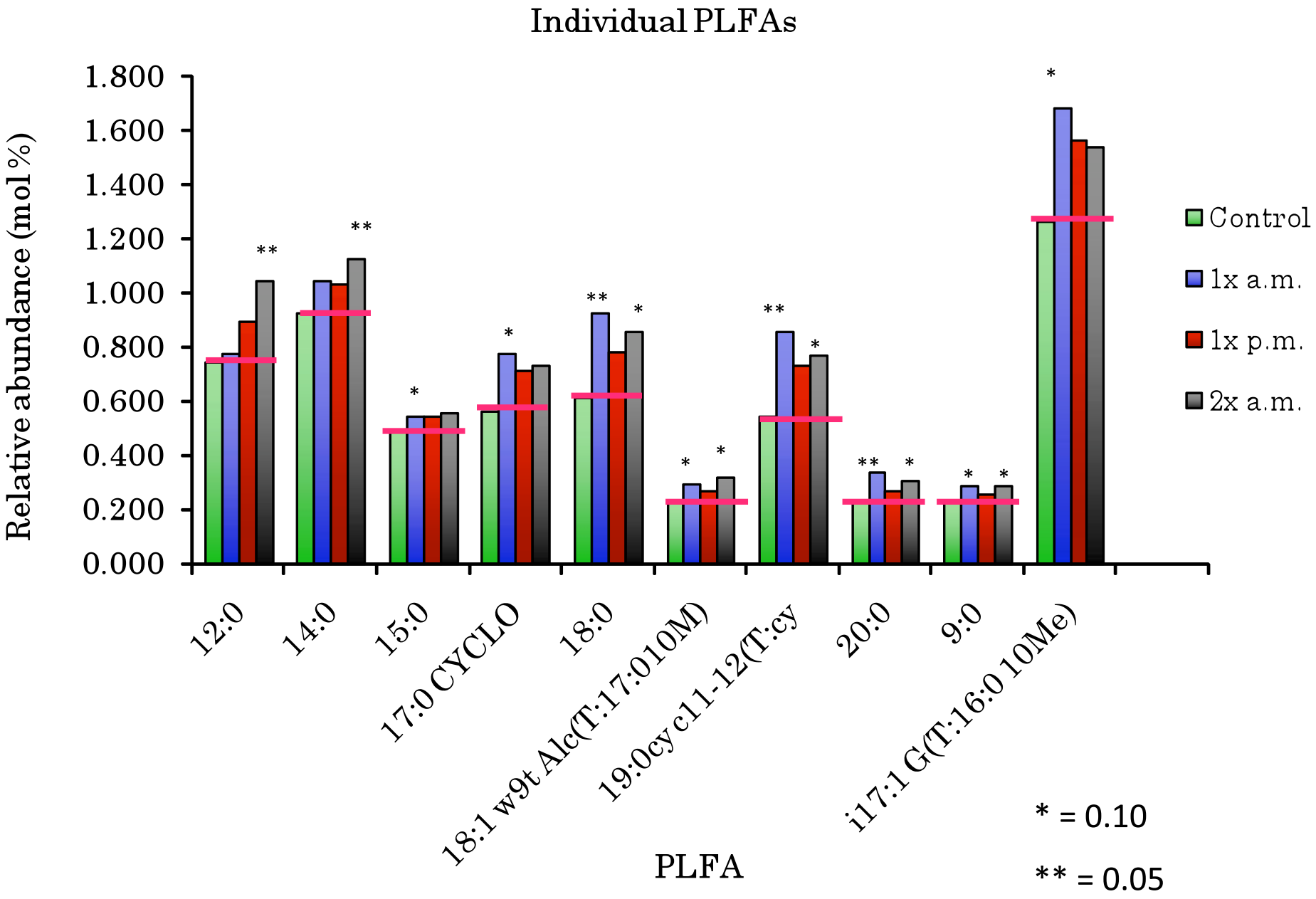
- 20 soil cores taken from each plot
- Homogenized to get a representative root zone sample
- Prepped and analyzed for phospholipid fatty acids (PLFA)
- Measurements recorded and compared

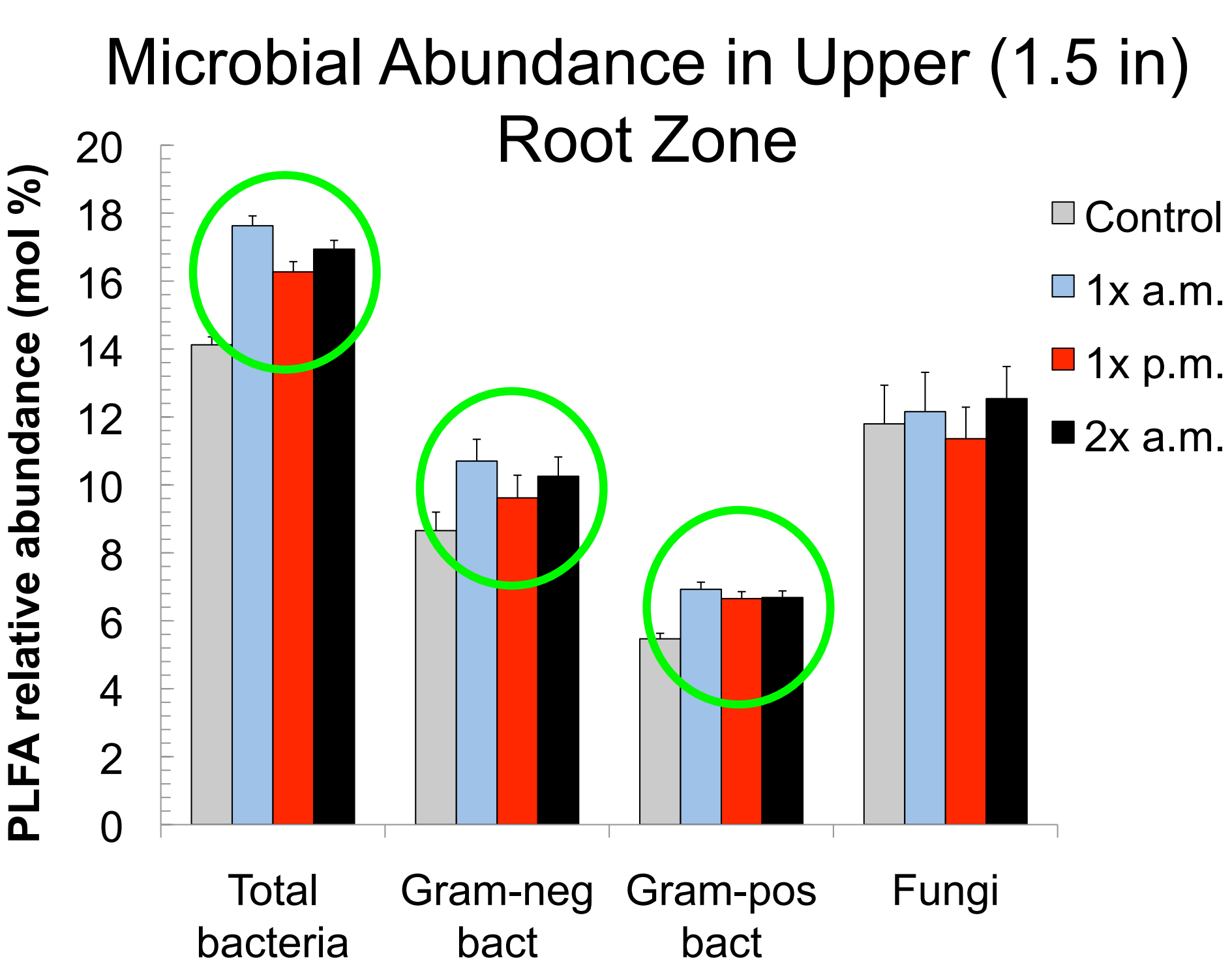


PLFA Analysis

- Extracts fatty acids from soil samples and detects them via gas chromatography
- Different microbial groups can be distinguished by exclusive or shared PLFAs
- By measuring the relative abundance in soil samples, a general “fingerprint” of microbial activity can be obtained

Treatment	Control	Roll 1x a.m.	Roll 1x p.m.	Roll 2x a.m	Lipid biomarker
12:0	0.7446	0.7797	0.8962	1.0465 **	Bacteria
14:0	0.9251	1.0461	1.0315	1.1277 **	Bacteria
14:0 ISO 3OH	0.3279	0.4073	0.3889	0.4011	
14:1 w5c	0.2097	0.2226	0.2189	0.1428	Gram - bacteria
15:0	0.4878	0.5458	0.5477	0.5591 *	Bacteria
15:0 ANTEISO	1.1086	1.4309	1.3757	1.3671	Gram + bacteria
15:0 ISO	2.4031	2.9951	2.8863	2.9857	Gram + bacteria
16:0	15.949	16.699	16.540	16.714	Bacteria and fungi
16:0 ISO	0.6792	0.7681	0.7288	0.7313	Gram + bacteria
16:1 ISO H	0.5080	0.6876	0.6872	0.4279	Gram - bacteria
16:1 w5c	36.410	31.143	32.753	31.096	Arbuscular mycorrhizae (AMF)
16:1 w7c	2.6360	3.0052	2.9210	2.9093	Gram - bacteria
16:1 w9c	0.4481	0.5341	0.5392	0.5150	
17:0	0.1997	0.2736	0.2936	0.1700	Bacteria
17:0 ANTEISO	0.3466	0.4717	0.4321	0.4319	Gram + bacteria
17:0 CYCLO	0.6662	0.77704 *	0.7137	0.7324	Gram - /anaerobes
17:0 ISO	0.3466	0.4717	0.4321	0.4319	Gram + bacteria
17:1 w8c	0.4281	0.5226	0.6033	0.5518	Gram - bacteria
18:0	0.6818	0.9294 *	0.7805	0.9958 **	Bacteria
18:1 w5c	0.4178	1.2252	0.8376	0.4040	
18:1 w9c	7.6882	7.4477	7.5651	8.2416	Sapro or ecto
18:1 w9t Alc(T:17:010M	0.2344	0.29724 *	0.2694	0.3214 **	Actinomycetes
18:3 w6c	0.6733	0.69630	0.6054	0.6865	Sapro or ecto
19:0	0.1108	0.1500	0.1235	0.1403	bacteria
19:0cy c11-12(T:cy	0.5445	0.8611 **	0.7305	0.7731 *	gram - /anaerobes
20:0	0.2256	0.33705 **	0.2714	0.3060 *	bacteria
9:0	0.2318	0.28886 *	0.2576	0.2904 *	bacteria
i17:1 G(T:16:0 10Me)	1.3662	1.6838 *	1.5674	1.5392	Actinomycetes
Sum In Feature 19	3.6361	4.0160	3.1897	3.6111	saprophytic fungi
Sum In Feature 8	4.9096	6.0662 *	5.2525	6.0397	Gram - bacteria


Individual PLFAs
Relative abundance (mol %)
1.800
1.600
1.400
1.200
1.000
0.800
0.600
0.400
0.200
0.000
Control
1x a.m.
1x p.m.
2x a.m.
12:0
14:0
15:0
17:0 CYCLO
18:0
18:1 w9t Alc(T:17:010M)
19:0cy c11-12(T:cy
20:0
9:0
i17:1 G(T:16:0 10Me)
PLFA
* = 0.10
** = 0.05


Microbial Abundance in Upper (1.5 in) Root Zone
PLFA relative abundance (mol %)
20
18
16
14
12
10
8
6
4
2
0
Control
1x a.m.
1x p.m.
2x a.m.
Total bacteria
Gram-neg bact
Gram-pos bact
Fungi

Results and Conclusions

- A.M. and P.M. rolling resulted in significant dollar spot reductions
  - Suggests dew/guttation removal is not the underlying mechanism
- Rolling 2x day^{-1} consistently resulted in the lowest seasonal dollar spot incidence
  - Cumulative effects
- Increases in %VWC in the upper root zone in rolled plots.
  - Potential ecological effects
  - Trends toward higher bacterial proportions
  - Possibly contributing to dollar spot reduction

Rolling 2 x per day

Two-Site Study

Michigan State

- East Lansing, MI
  42°44′5.28″N 84°28′50.88″W
- Native soil (Capac loam)
- *Agrostis stolonifera* cv. 'Pennlinks'
- 15 May – 25 June, 2009

Arkansas

- Fayetteville, Arkansas
  36°4′35″N 94°9′39″W
- USGA sand-based soil
- *Agrostis stolonifera* cv. Penn G-2
- 24 July – 31 August, 2009

Fertilization

- **N** – 25 kg ha^{-1} $month^{-1}$
- **P** – 2.5 kg ha^{-1} $month^{-1}$
- **K** – 25 kg ha^{-1} $month^{-1}$

Topdressed bi-weekly

Mowed 6 days/week @ 4.0 mm

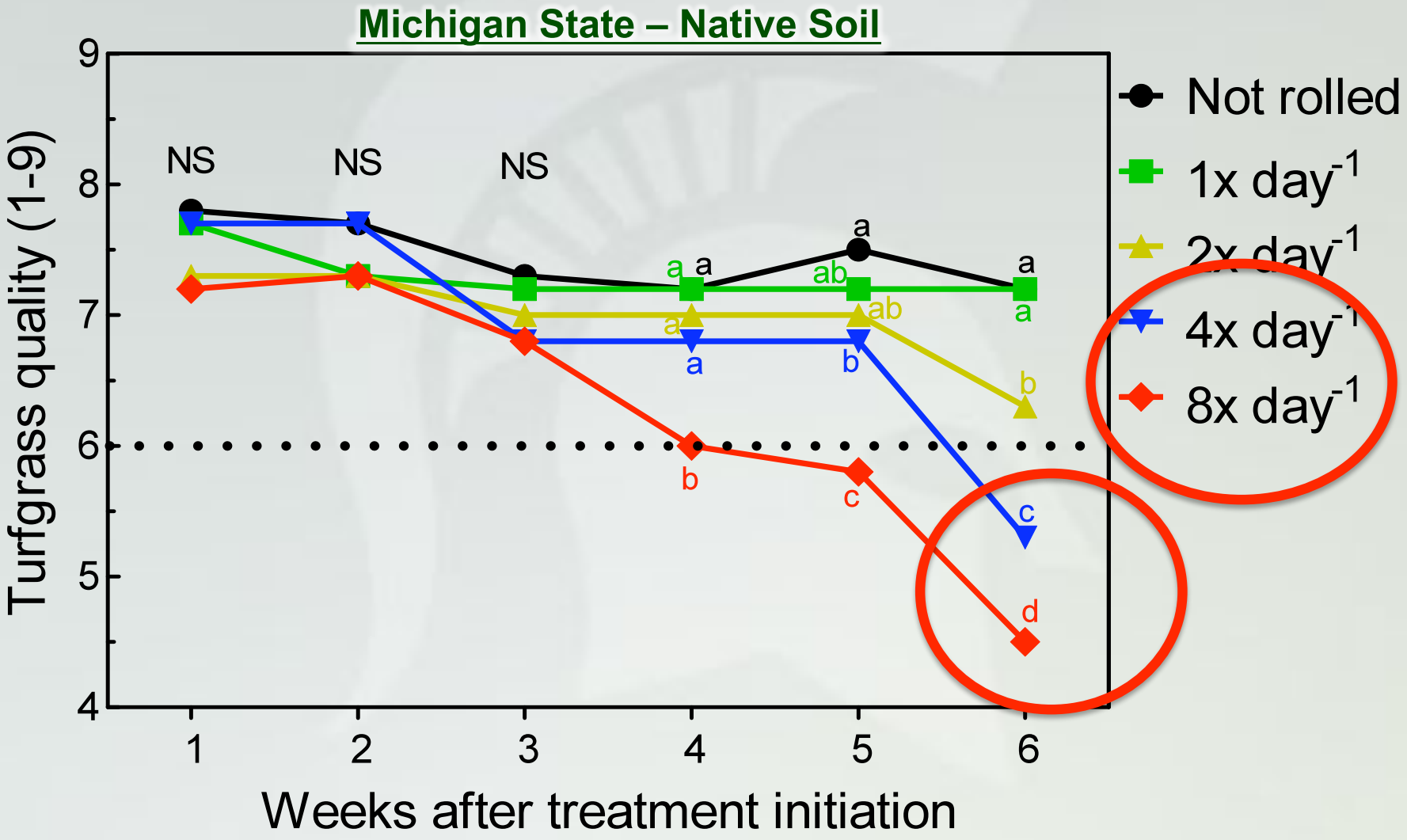
Irrigation as needed based on regional ET

Rolling Treatments

- Control – No rolling
- 1x per day
- 2x per day
- 4x per day
- 8x per day
  - 1.5 m x 7.5 m plots
  - Randomized block design (3 replications)
  - Multiple rolling events carried out consecutively
  - Treatments carried out 6 times per week for 6 weeks

Tru-Turf RS4811C greens roller

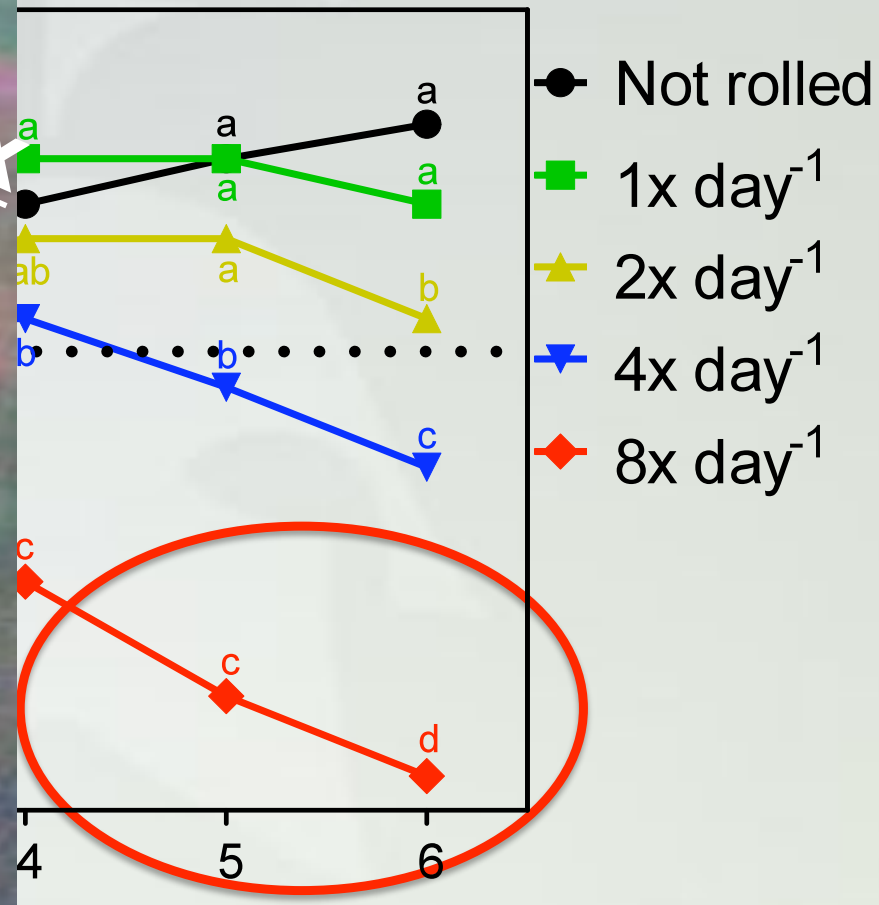
Turfgrass Quality



Means within same rating date followed by different letters are significantly different according to Fisher's protected LSD ($P \leq 0.05$)

Turfgrass Quality

and base

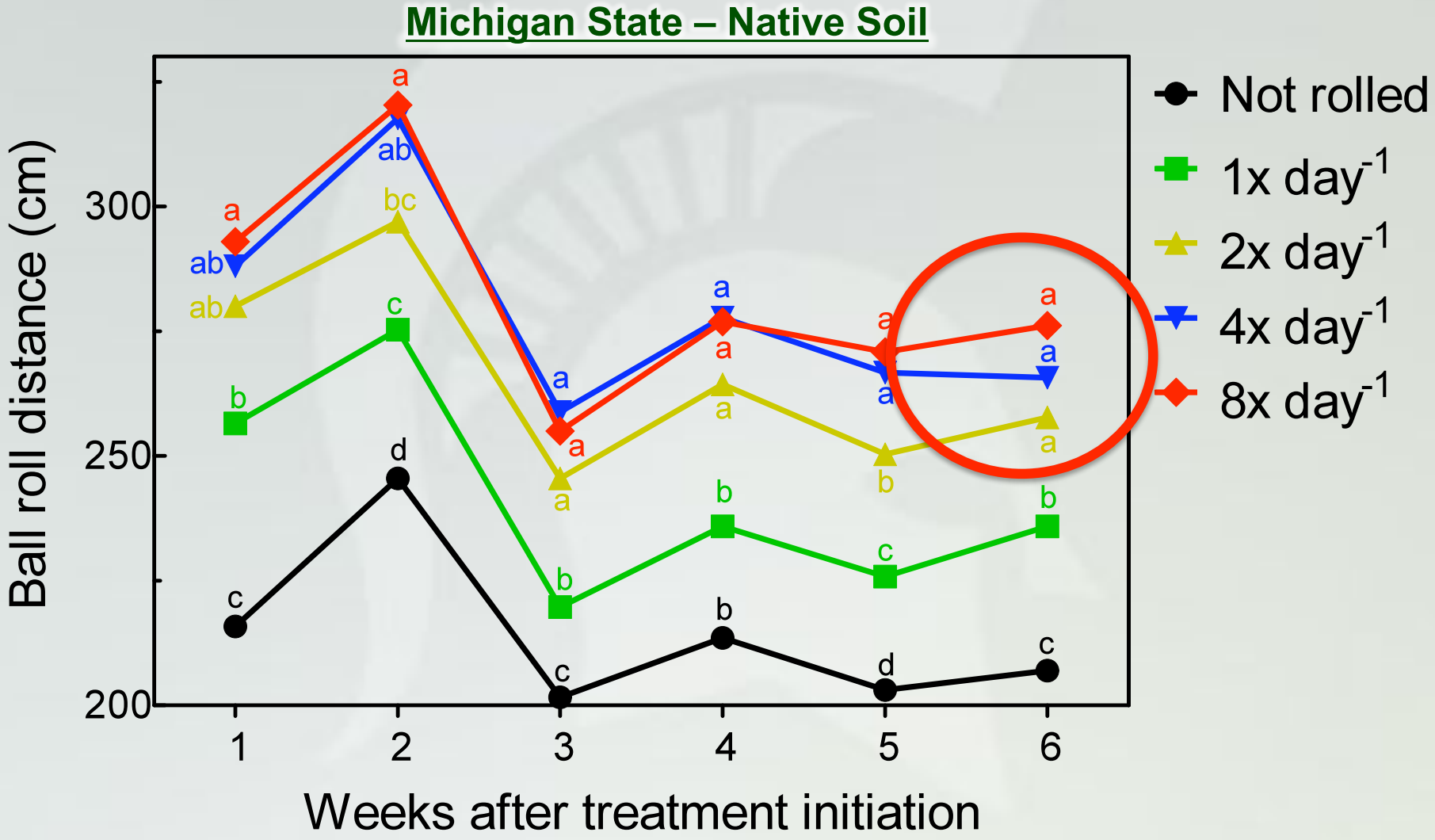


ent initiation

erent letters are significantly different

according to Fisher's protected LSD ($P \leq 0.05$)

Ball Roll Distance



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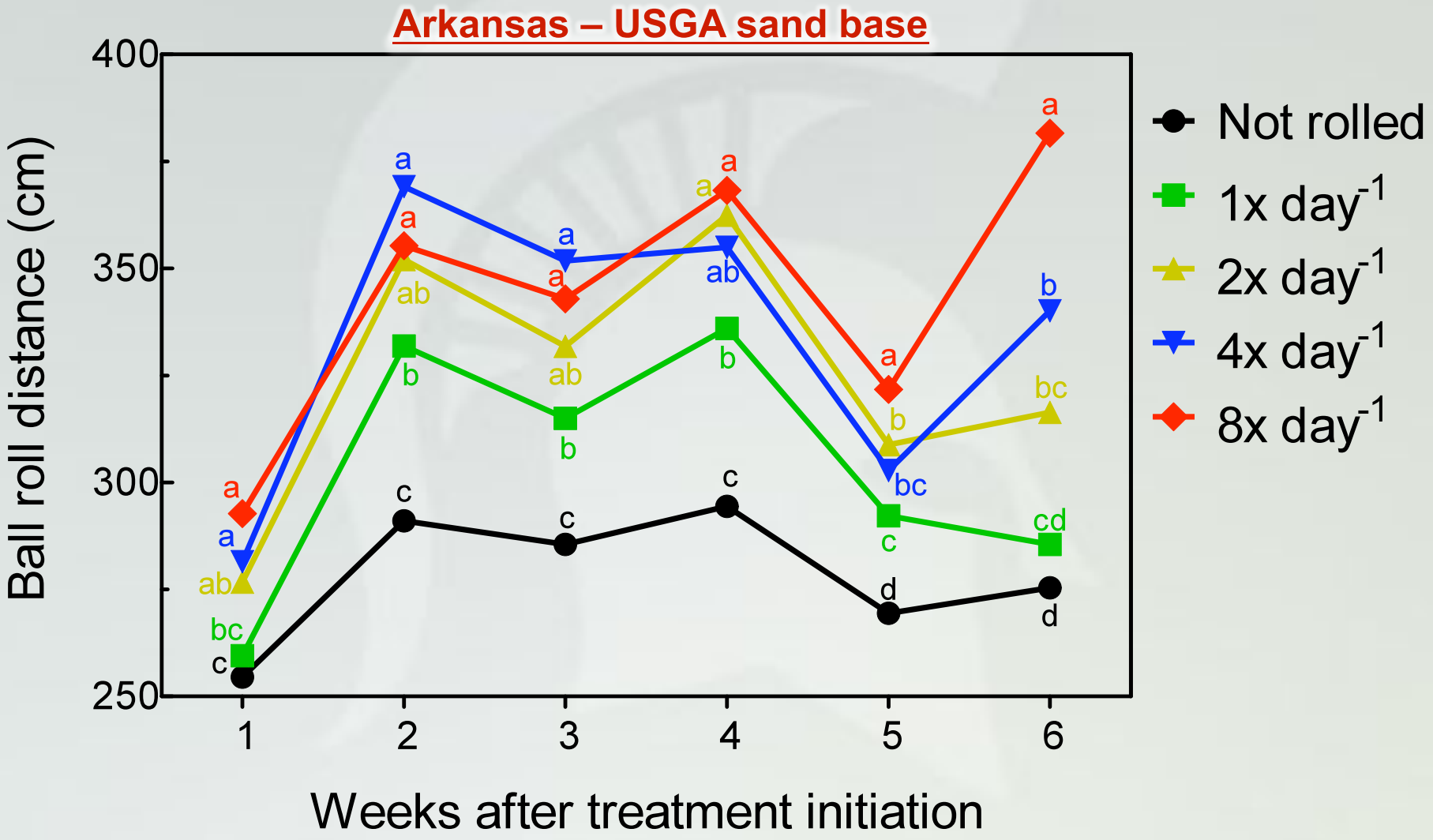
Ball Roll Distance

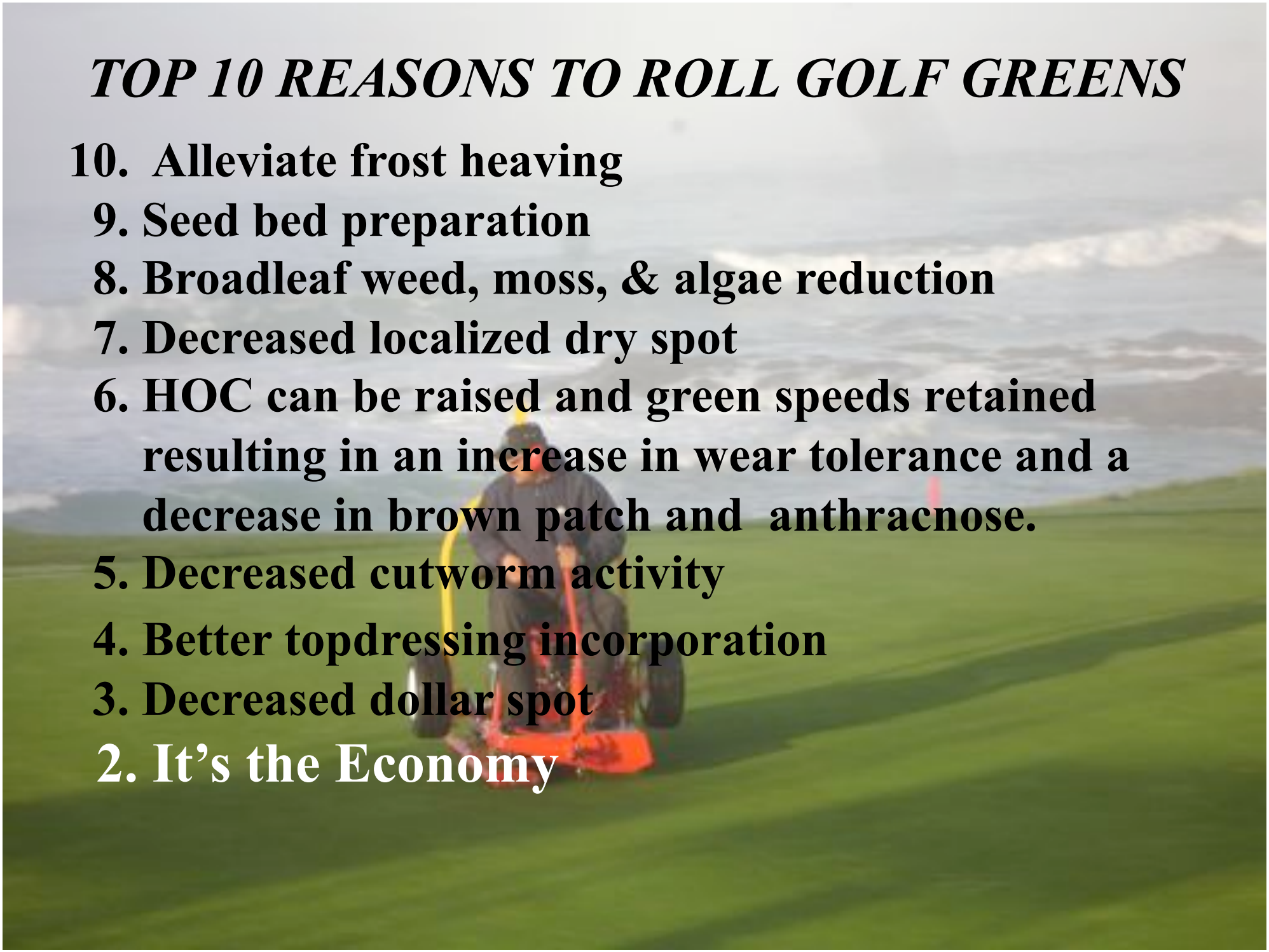


Means within same rating date followed by different letters are significantly different according to Fisher's protected LSD ($P \leq 0.05$)

Conclusions

- Rolling 2x/day for long periods of time (> 21 days) can sustain significant increases in ball roll distance with significant decrease in dollar spot and little turfgrass injury, or negative effects on water infiltration

- Rolling more than 2x/day on a consistent basis results in minimal increases in green speed and decreases in turfgrass quality



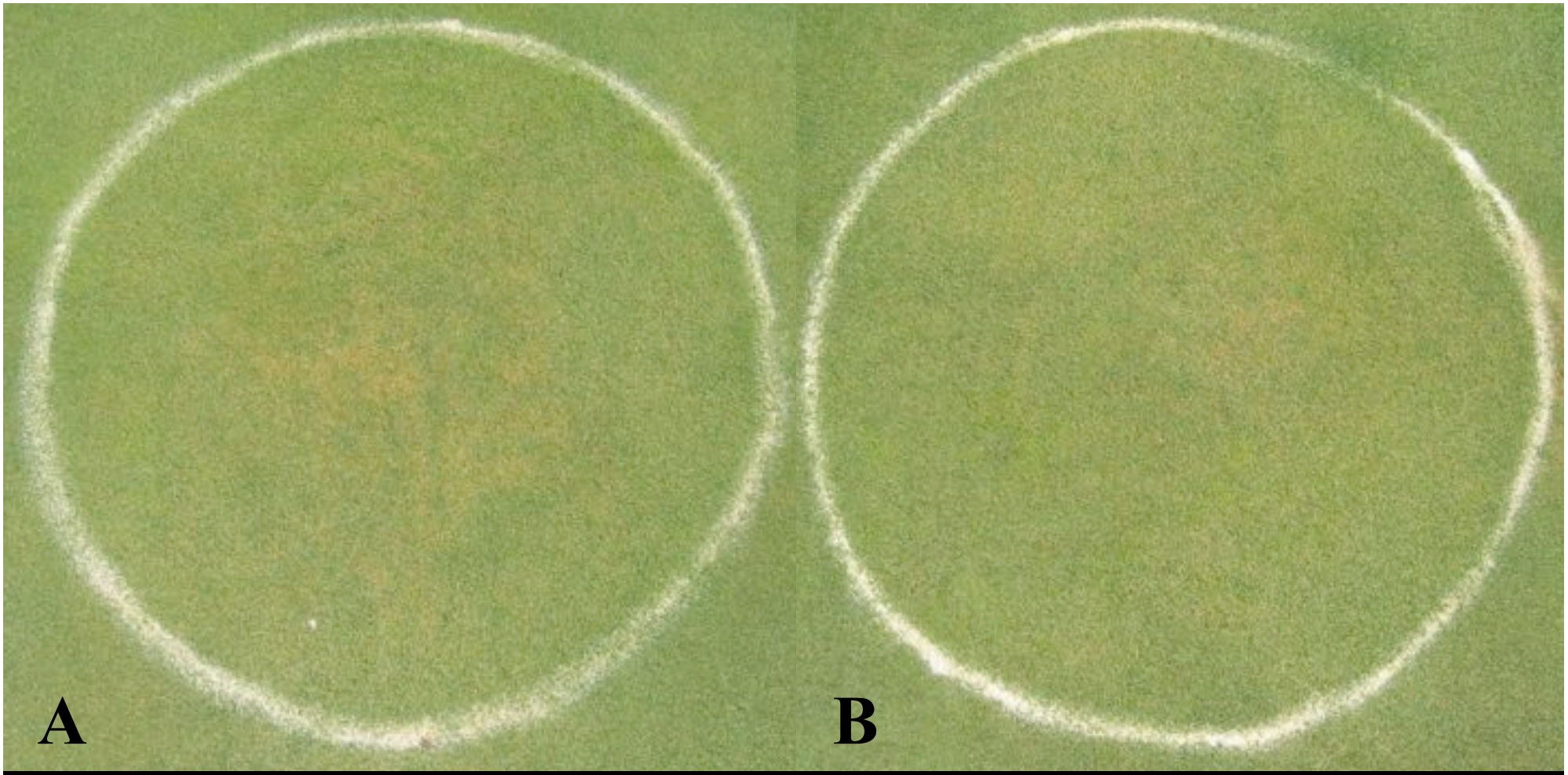
TOP 10 REASONS TO ROLL GOLF GREENS

10. Alleviate frost heaving
9. Seed bed preparation
8. Broadleaf weed, moss, & algae reduction
7. Decreased localized dry spot
6. HOC can be raised and green speeds retained resulting in an increase in wear tolerance and a decrease in brown patch and anthracnose.
5. Decreased cutworm activity
4. Better topdressing incorporation
3. Decreased dollar spot
2. It's the Economy

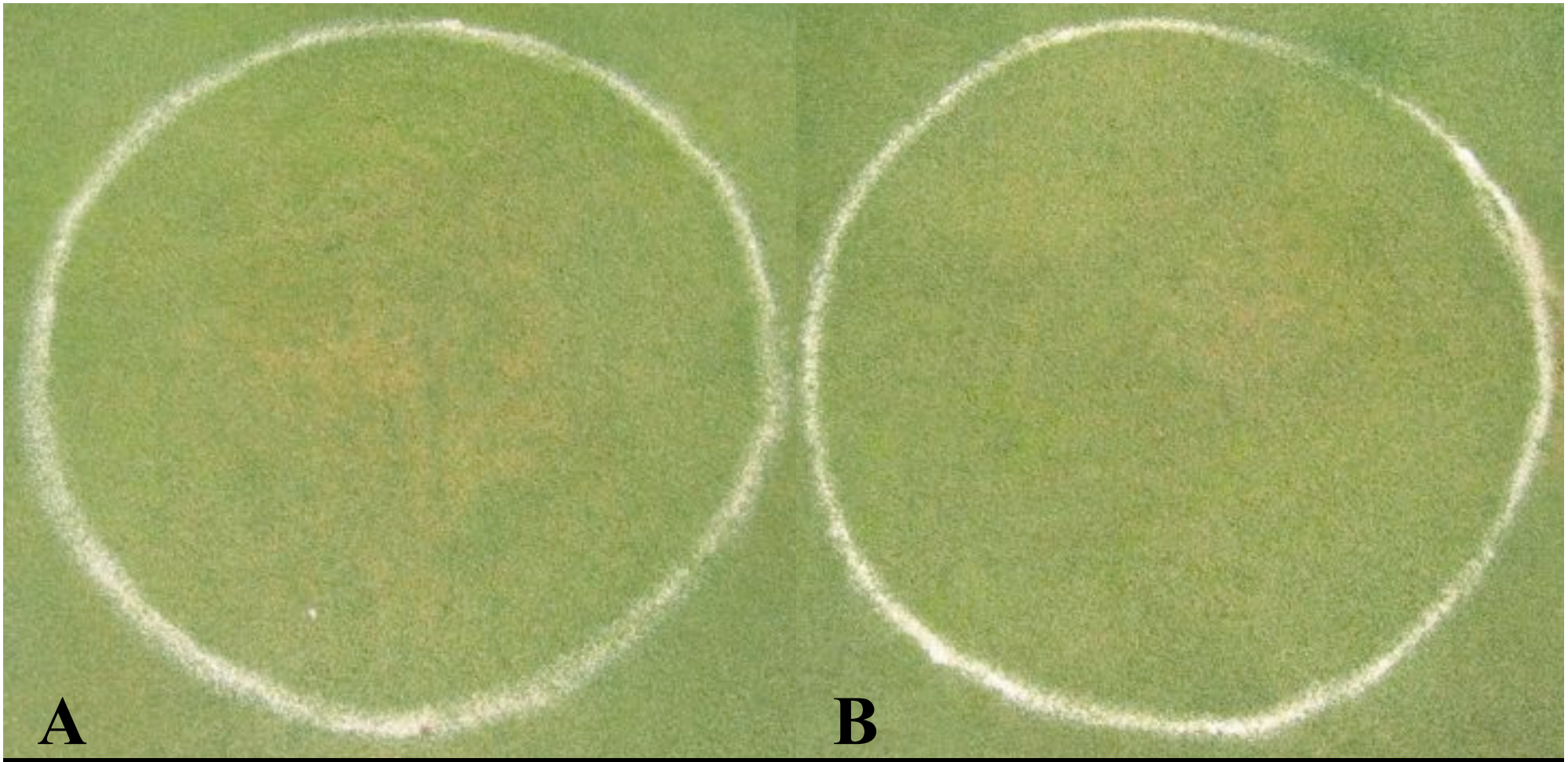
Mowing/Rolling Frequency Studies

Season Averages

Treatments (0.156 HOC)	Not rolled	**Rolled**
Mowed daily never rolled	-----	-----
Mowed daily **rolled** every other	+7”	+16”
Mow and roll daily	+22”	+21”
Roll daily mow every other	+19”	+19”
Alternate mow and **roll**	+4”	+11”
Roll every other day double cut on days not rolled	+12”	+20”
Probability	0.00	0.00

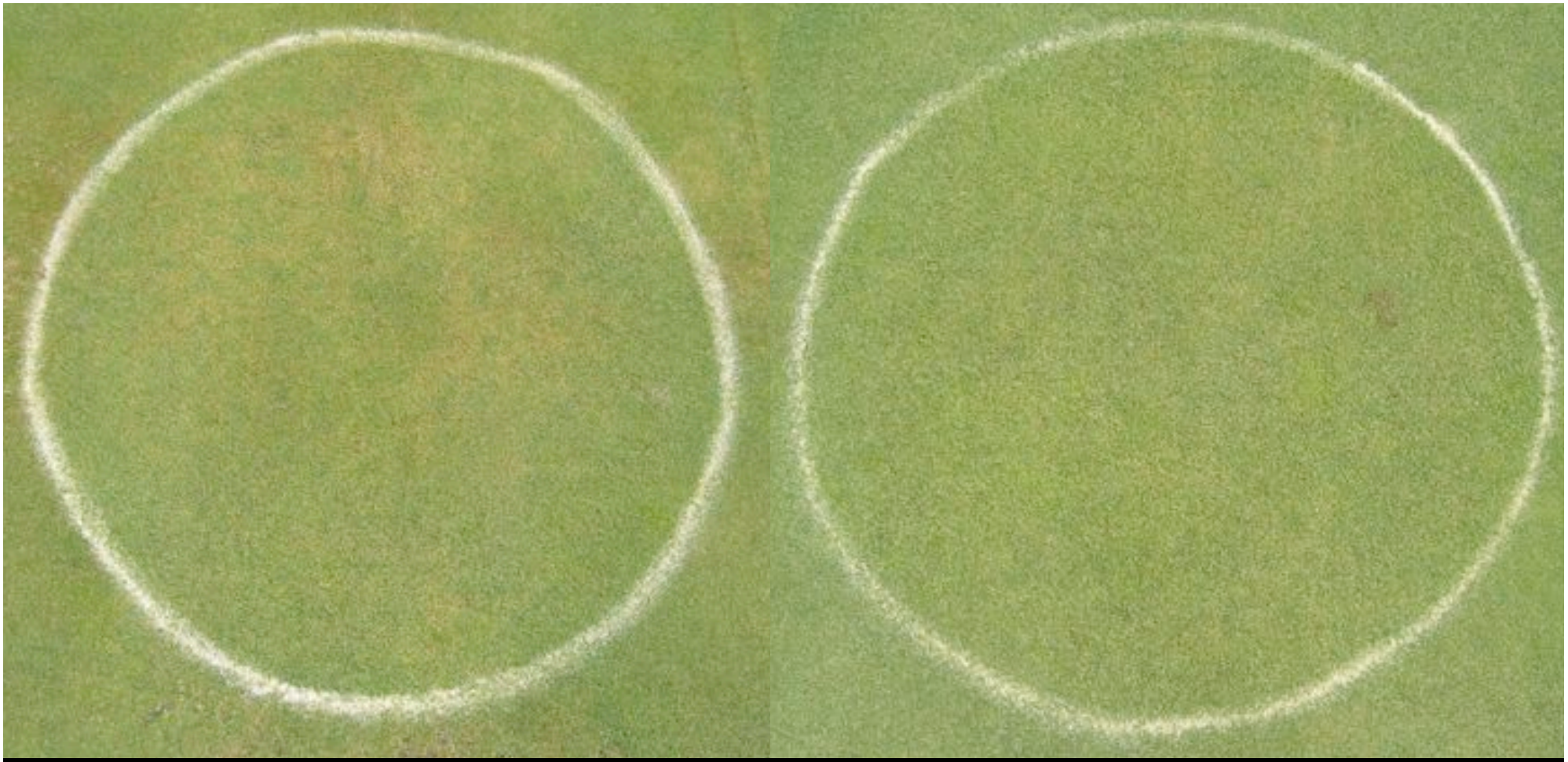


Which of these two plots, if either, do you think displays greater wear from traffic?



0.125 mowed daily

0.125 HOC alternating mowing & lightweight rolling daily basis



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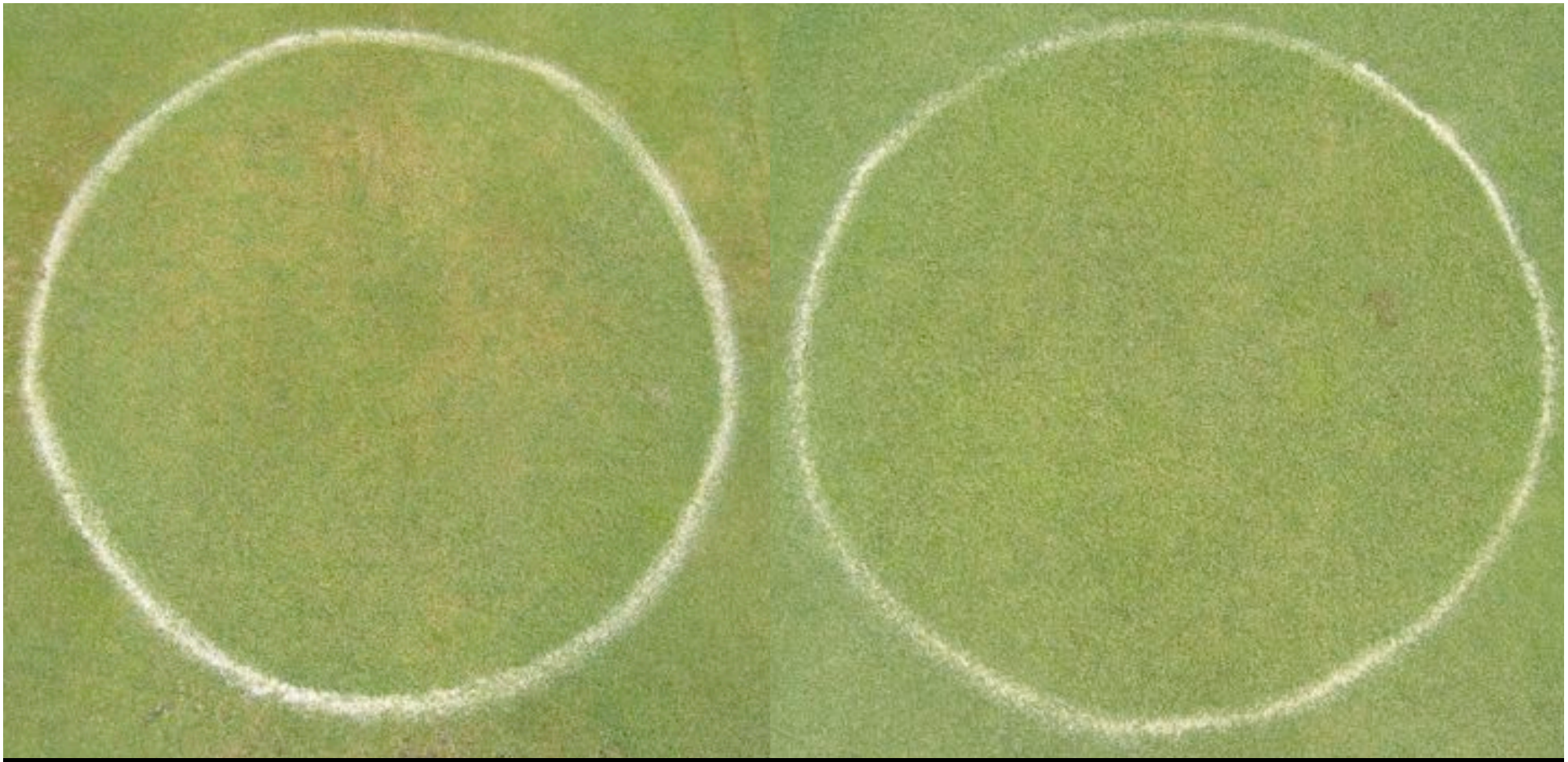


0.094 mowed daily

0.156 mowed & rolled daily

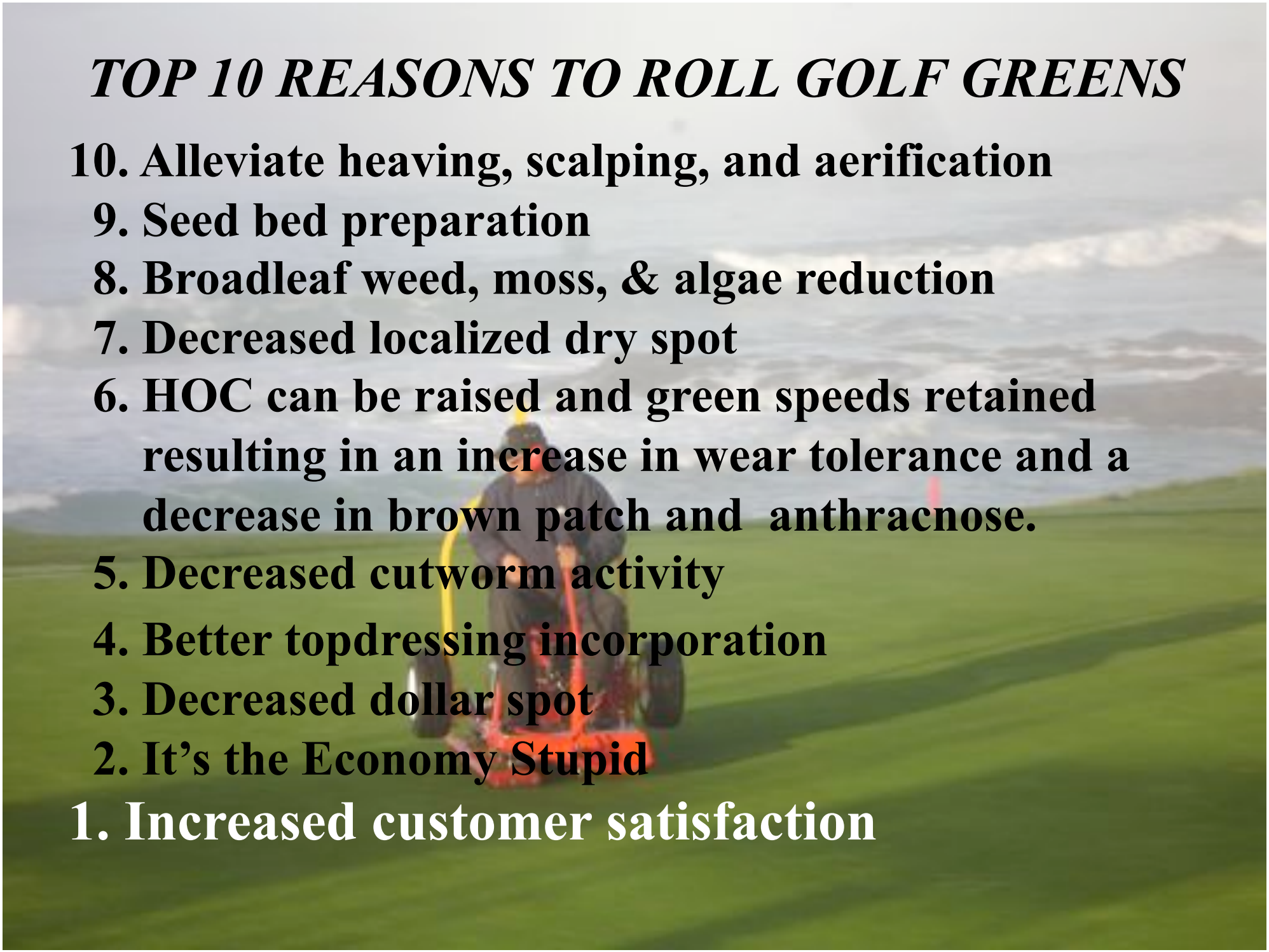
0.094 mowed daily

0.156 mowed & rolled daily

Season average
15” > speed


2013/11/19 11:17

We roll to manage thatch, disease, playability and cost savings versus mowing.



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5. Decreased cutworm activity
4. Better topdressing incorporation
3. Decreased dollar spot
2. It's the Economy Stupid
1. Increased customer satisfaction

USA TODAY Snapshots®

Green speed most important on course

What golfers say is the most important thing to know about a course:

Customer satisfaction

By April Umminger and Dave Merrill, USA TODAY


USA TODAY Snapshots®
Outdoor activities generate large sales
Biggest categories of consumer sports equipment sales in 2009: (in billions)
Camping
$1.7
Firearms hunting
$3.1
Golf
$2.5
Fishing
$2.0
Source: Sporting Goods Manufacturers Association
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Bob Vavrek USGA

"Green speed was often the main topic of concern that green committees would express during USGA visits. Now speed is almost a non-issue due in part to the widespread acceptance of lightweight rolling on a regular basis since the late 1990's. Today, during times of extreme environmental stress many courses are alleviating the stress by substituting daily mowing with daily rolling, a practice that was virtually unheard of 5 years ago".

Michigan Ski & Learn Turfgrass Conference March, 2011


Thank you!