Turfgrass Management in a Changing Climate

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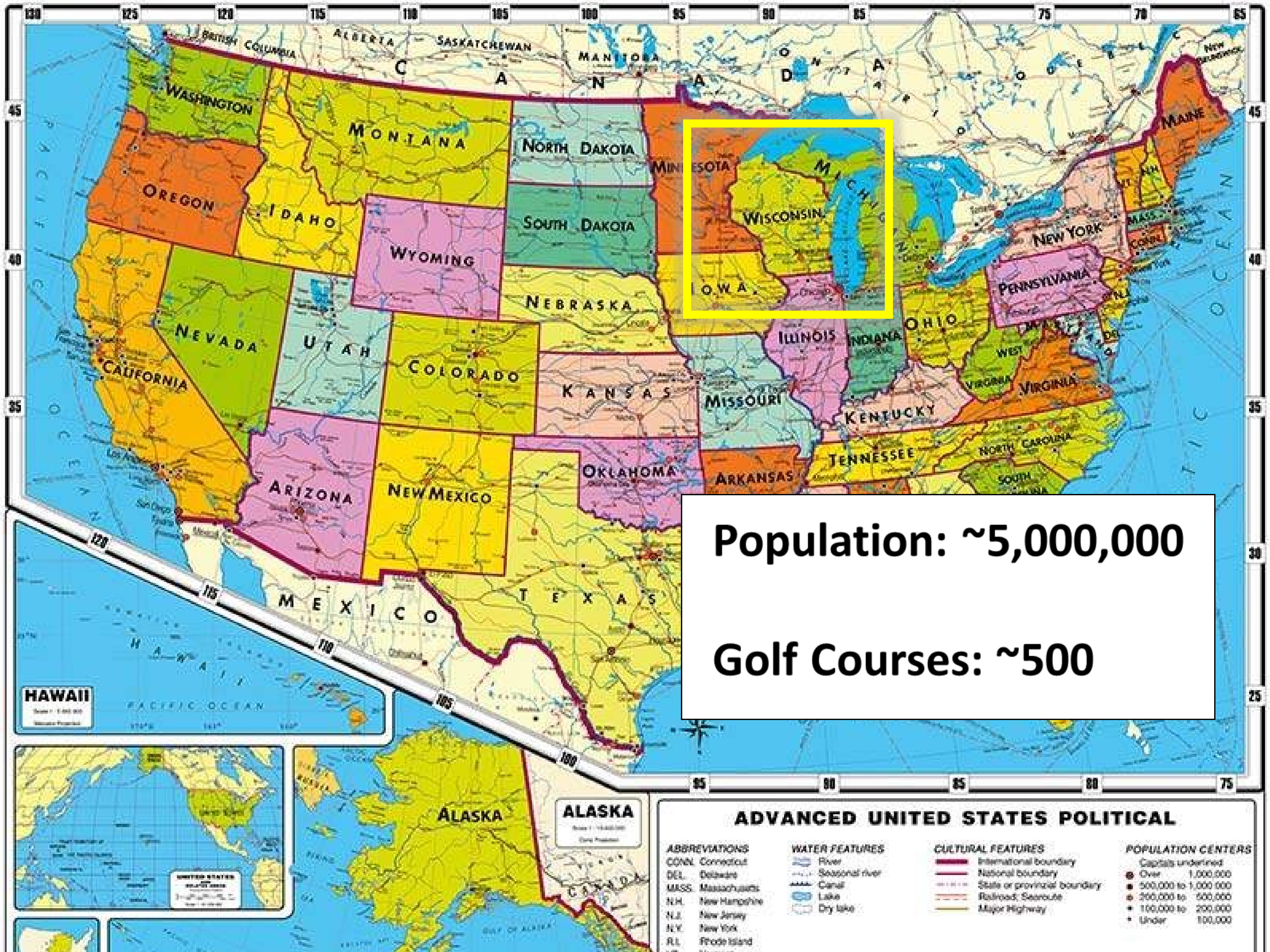
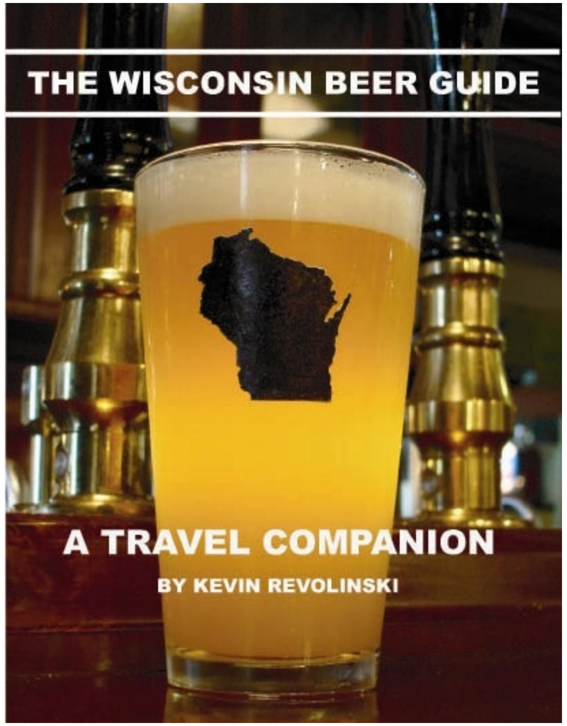


Population: ~5,000,000

Golf Courses: ~500

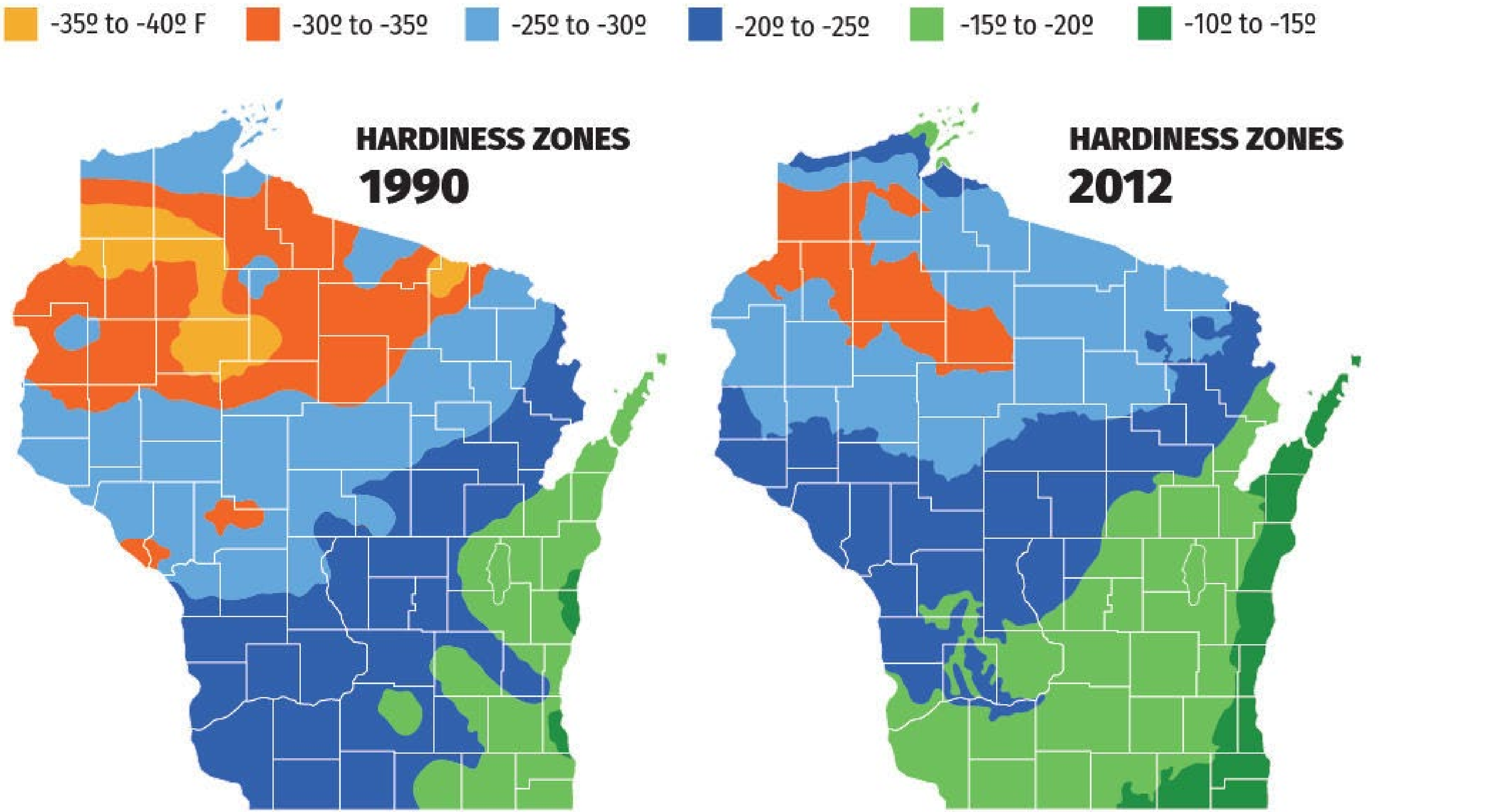


~3.5 Million Cows in Wisconsin

Whistling Straits: 2020 Ryder Cup (to be played in 2021)
2004, 2010, 2015 PGA Championship

Erin Hills, 2017 US Open

How is Wisconsin's climate changing?



Globally, similar trends are expected

By 2050, USDA anticipates that:

- Mean annual temp will increase 2.0 °C
  - Average extreme minimum temperature will increase by 2.0 °C
- Mean annual precipitation will vary from -20% to 20% of current
  - Extreme precipitation events increase by 20%

Observed climate change and future projections – some key findings

The last decade (2002–2011) was the warmest on record in Europe, with European land **temperature** 1.3° C warmer than the pre-industrial average. Various model projections show that Europe could be 2.5–4° C warmer in the later part of the 21st Century, compared to the 1961–1990 average.

Heat waves have increased in frequency and length, causing tens of thousands of deaths over the last decade. The projected increase in heat waves could increase the number of related deaths over the next decades, unless societies adapt, the report says. However, cold-related deaths are projected to decrease in many countries.

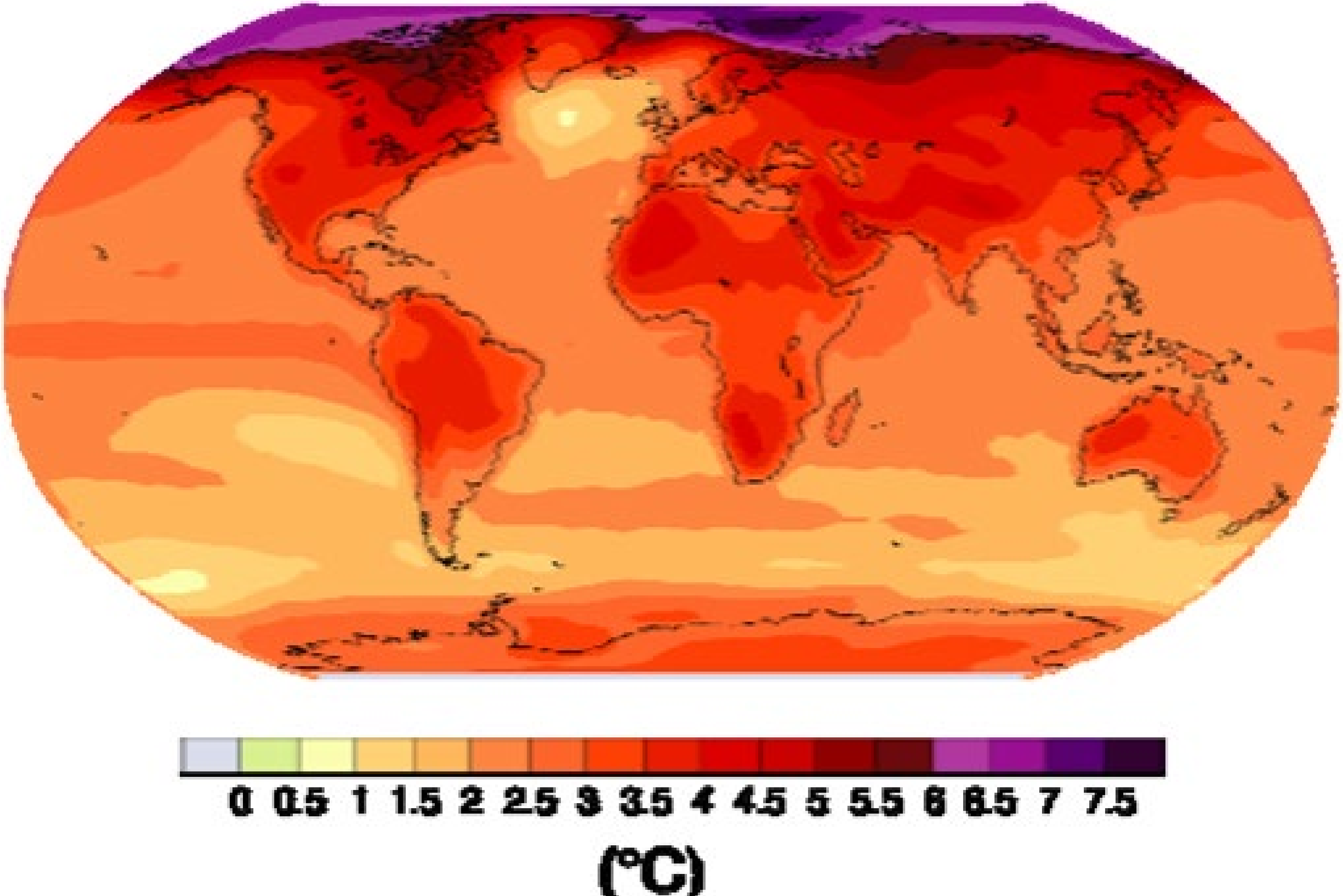
While **precipitation** is decreasing in southern regions, it is increasing in northern Europe, the report says. These trends are projected to continue. Climate change is projected to increase **river flooding**, particularly in northern Europe, as higher temperatures intensify the water cycle. However, it is difficult to discern the influence of climate change in flooding data records for the past.

River flow droughts appear to have become more severe and frequent in southern Europe. Minimum river flows are projected to decrease significantly in summer in southern Europe but also in many other parts of Europe to varying degrees.

The **Arctic** is warming faster than other regions. Record low **sea ice** was observed in the Arctic in 2007, 2011 and 2012, falling to roughly half the minimum extent seen in the 1980s. Melting of the **Greenland ice sheet** has doubled since the 1990s, losing an average of 250 billion tonnes of mass every year between 2005 and 2009. **Glaciers** in the Alps have lost approximately two thirds of their volume since 1850 and these trends are projected to continue.

Sea levels are rising, raising the risk of coastal flooding during storm events. Global average sea level has risen by 1.7mm a year in the 20th century, and by 3mm a year in

Geographical pattern of surface warming

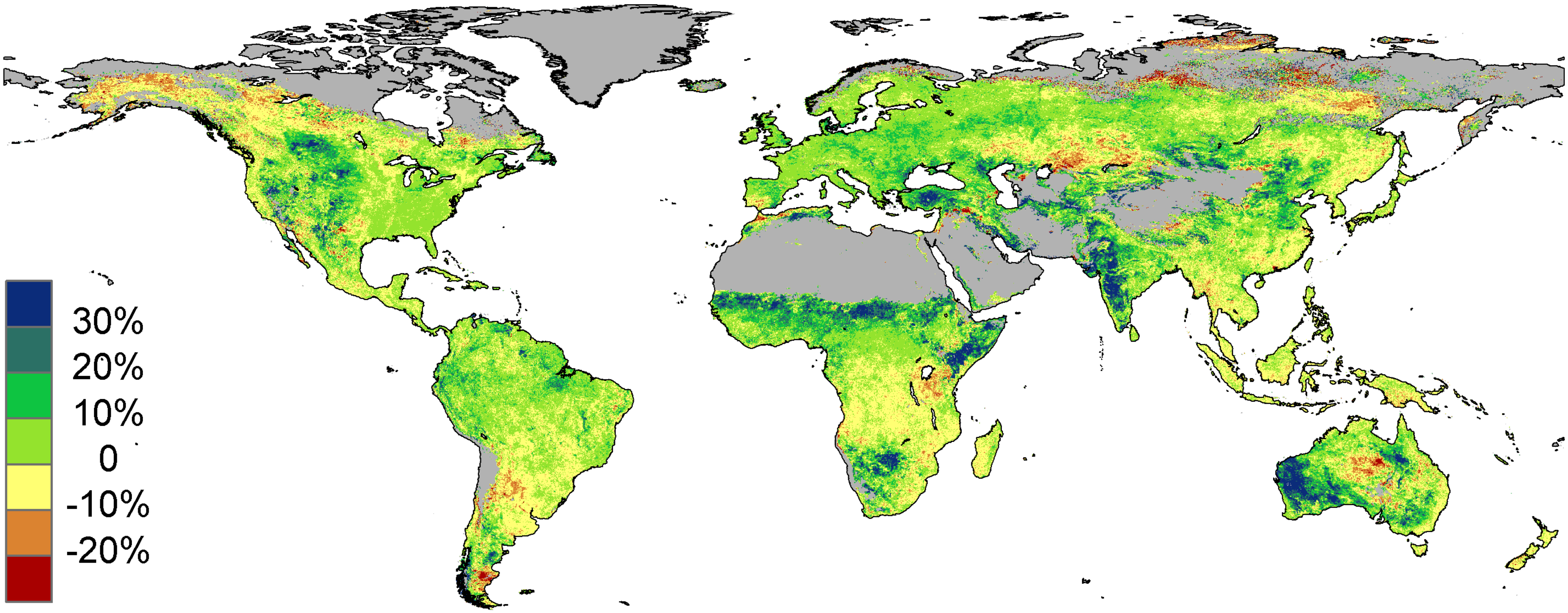


Studies show that enriched CO_2 will increase plant growth with less water use, but reduce protein content

Figure 1: Free-air carbon dioxide enrichment allows experiments with controlled atmospheric concentrations of carbon dioxide to be conducted in the field and avoids potential experimental artifacts from growing plants in enclosed chambers.

Courtesy of David F. Karnosky.

Increased CO_2 has been observed to increase vegetative cover of arid lands (Donohue et al. 2013)

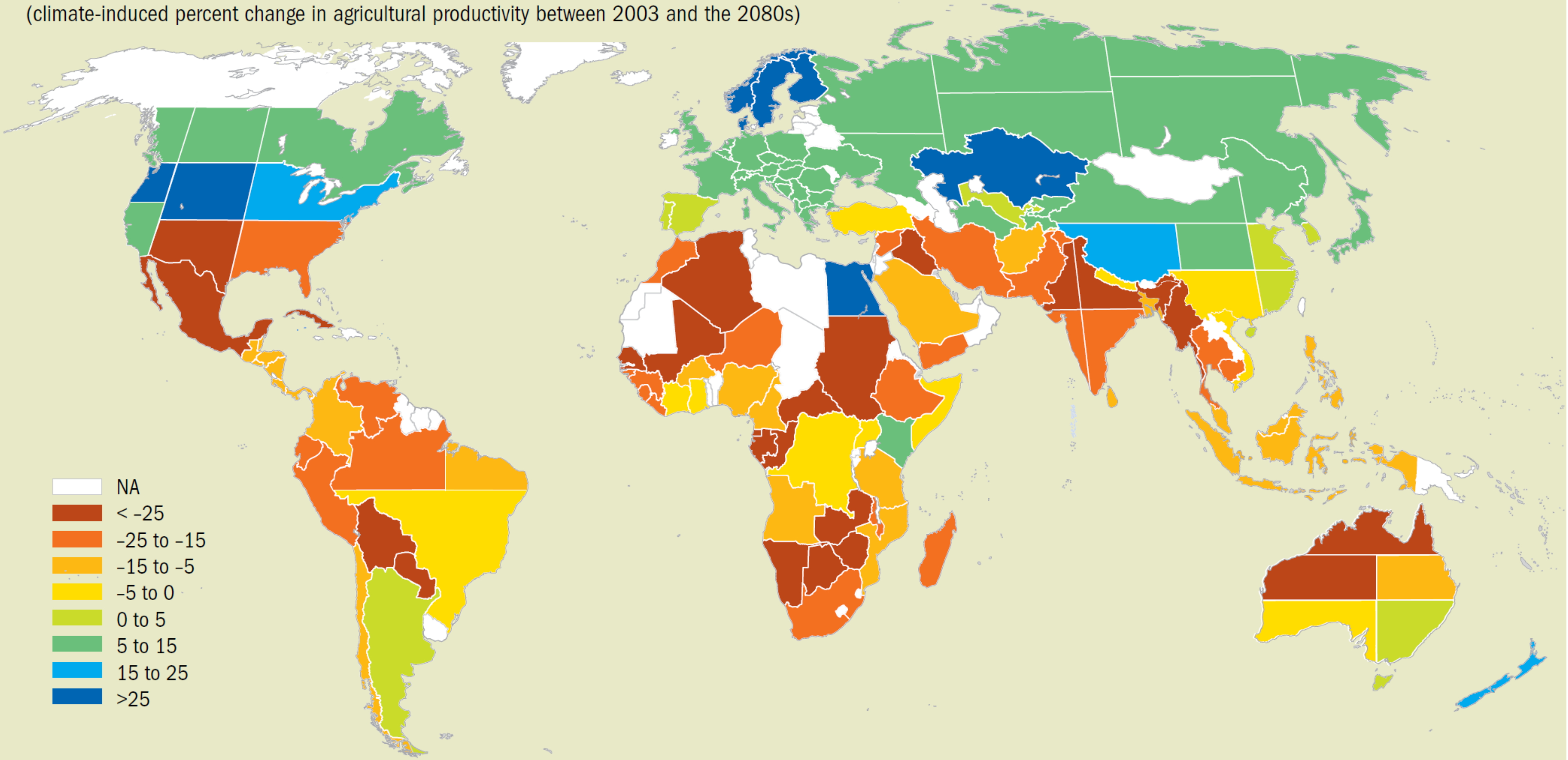


Map 2

With carbon fertilization

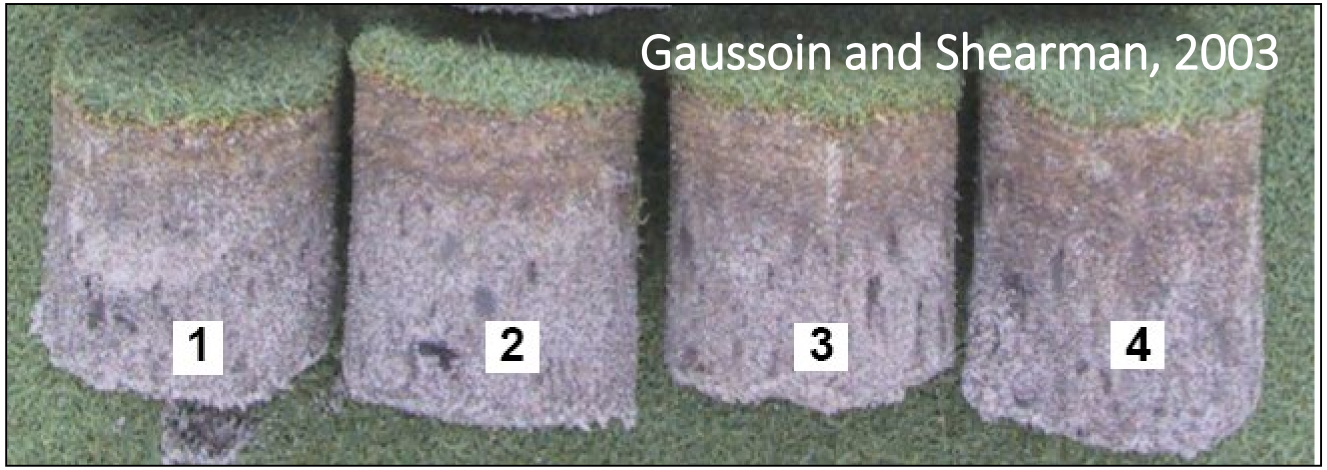
If some crops benefit from increased carbon dioxide, the global impact is less dire and those areas farther from the equator may see some increases in agricultural productivity.

(climate-induced percent change in agricultural productivity between 2003 and the 2080s)



Source: Cline (2007).

Note: NA refers to “not applicable” for Alaska and northern Canada, and to “not available” elsewhere.


Gaussoin and Shearman, 2003
1
2
3
4


8
7
6
5
Green Age (years)
Gaussoin et al., 2006


Van Cline

Nitrogen Management is Growth Management

N drives growth:

Find the ideal growth rate and achieve it by modifying your nitrogen applications

Growth is also affected by:

Weather, soil properties (compaction, organic matter), soil moisture, and traffic/wear.

Superintendents comment on collecting clipping volume

Chris Tritabaugh
@ct_turf
Follow

Simply put, the measurement of #clipvol has, in two seasons, become my most important greenkeeping metric.

Gary Sailer
@GarySailer
Follow

ClipVol down to 6L from 13L one month ago. Great data=great results #clipvol

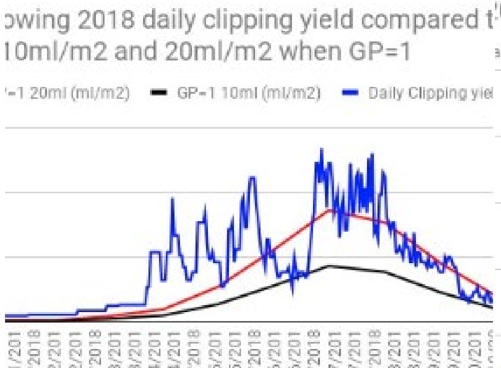
Jason Haines
@PenderSuper
Following

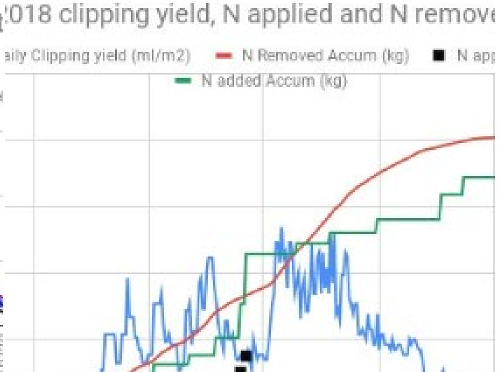
Replying to @PenderSuper @bonnyjk @UNLturf

#clipvol data is the single most important thing I track on my course and has impacted our bottom line and success the most.

James Sergeant
@lonegreenkeeper
Follow

Finally got round to putting together the #ClipVol data for @SudbrookMoorGC. For me #ClipVol is now the most essential piece of data I need to collect, it's easy to do and has helped save time and money in 2018.





#clipvol

Why not?

- I don't know where to find a bucket
  - Amazon
- It takes too long
  - Less than one minute per green
- It's not accurate enough
  - How accurate does it need to be?
- How do I keep track of all this data?
  - Greenkeeper app
- I can tell by looking in the baskets
  - Not like this you can't!

Slide: Tritabaugh

We are not great observers – having data helps

Same wine, one glass has tasteless, odorless red dye

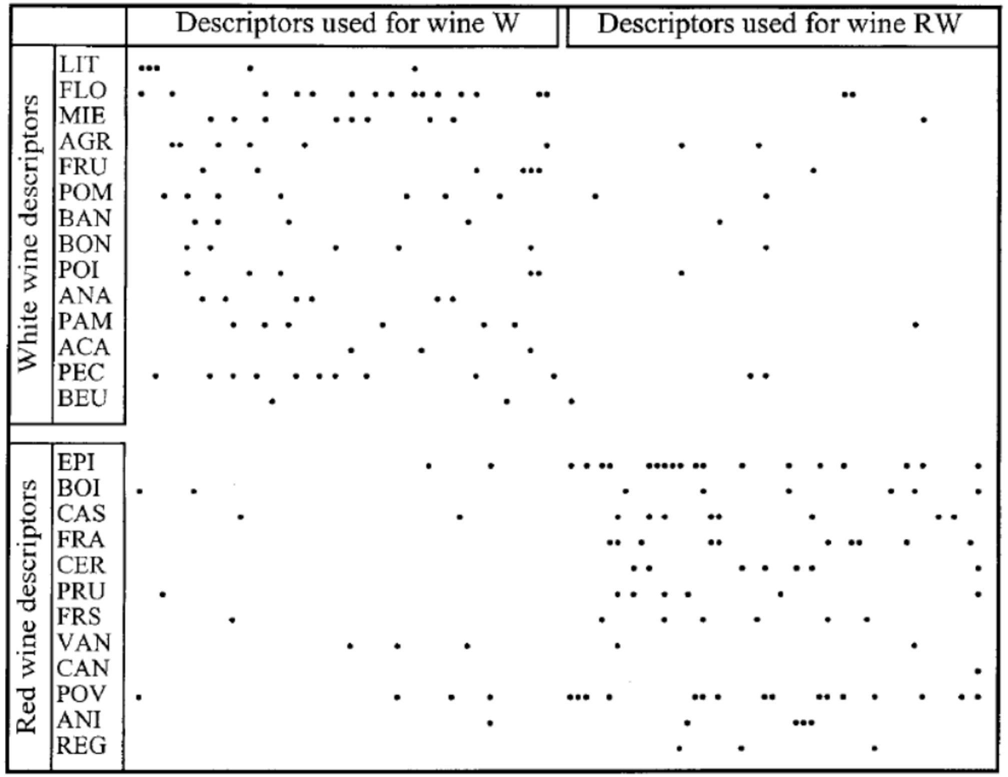
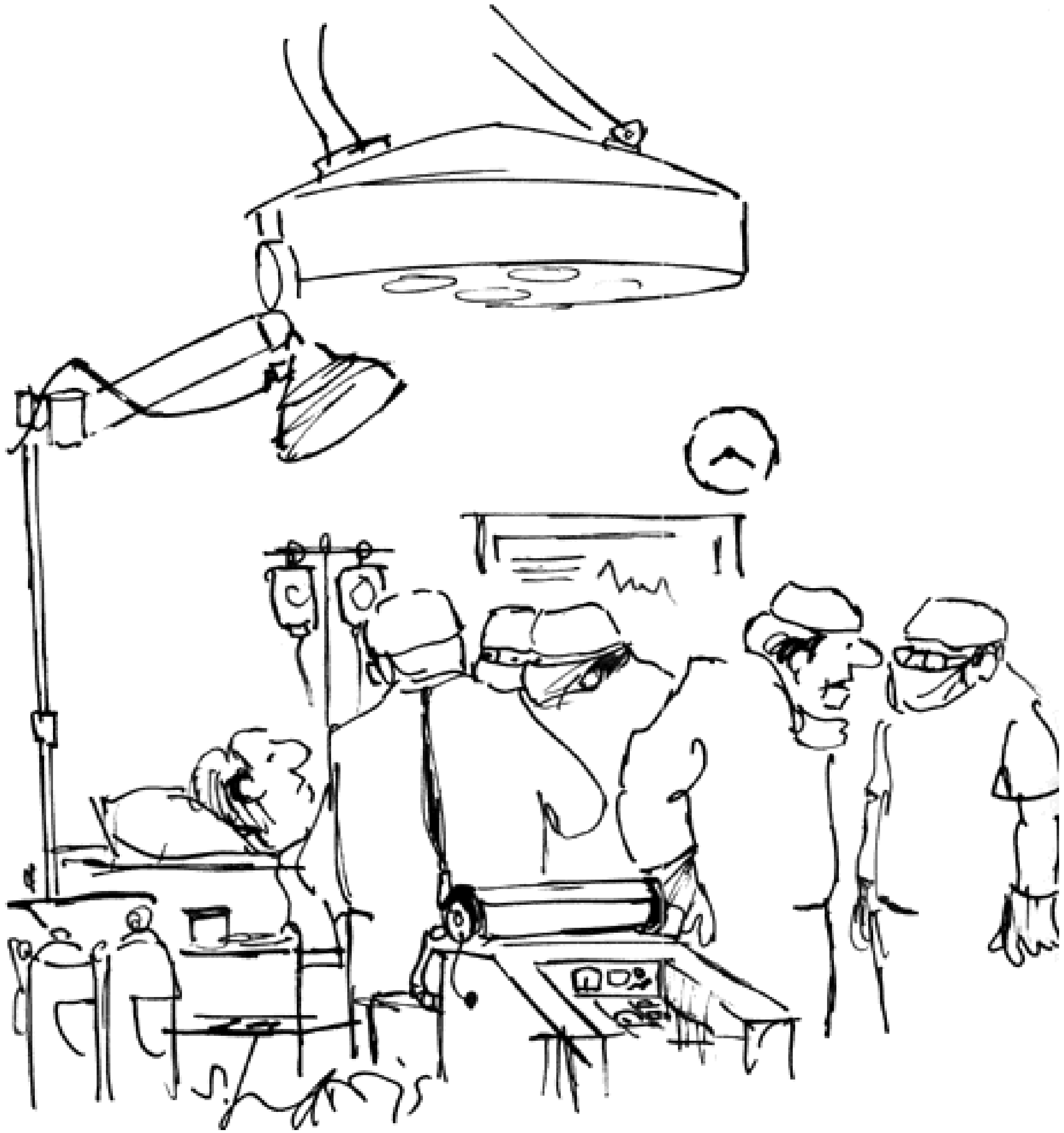


FIG. 2. Distribution of the odor descriptors used by at least 3 different subjects during the second session of the wine comparison test for the description of W and RW by 54 subjects. Labels ''White wine descriptors'' and ''Red wine descriptors'' contain the terms used for describing the W and the R wines during the first session, respectively.
White wine descriptors: LIT = litchi (lychee); FLO = floral (floral); MIE = miel (honey); AGR = agrume (citrus fruit); FRU = fruit de la passion (passion fruit); POM = pomme (apple); BAN = banane (banana); BON = bonbon (candy); POI = poire (pear); ANA = ananas (pineapple); PAM = pamplemousse (grapefruit); ACA = acacia (acacia); PEC = pêche (peach); BEU = beurre (butter). Red wine descriptors: EPI = épice (spice); BOI = boisé (wooded); CAS = cassis (blackcurrant); FRA = framboise (raspberry); CER = cerise (cherry); PRU = pruneau (prune); FRS = fraise (strawberry); VAN = vanille (vanilla); POV = poivre (pepper); ANI = animal (animal); REG = réglisse (liquorice).

(Morrot, 2001)

[redacted]



"We'll just mill around till he's asleep, and and then send him back up. This operation is actually for a placebo effect."

surgeries. The results were all in people's heads.
Michael Williamson/The Washington Post, via Getty Images

A total of 180 patients who had osteoarthritis of the knee were randomly assigned (with their consent) to one of three groups. The first had a standard arthroscopic procedure, and the second had lavage. The third, however, had sham surgery. They had an incision, and a procedure was faked so that they didn't know that they actually had nothing done. Then the incision was closed.

The results were stunning. Those who had the actual procedures did no better than those who had the sham surgery. They all improved the same amount. The results were all in people's heads.

Many who heard about the results were angry that this study occurred. They thought it was unethical that people received an incision, and most likely a scar, for no benefit. But, of course, the same was actually true for people who had arthroscopy or lavage: They received no benefit either. Moreover, the results did not make the procedure scarce. Years later, more than a half-million Americans still underwent arthroscopic surgery for osteoarthritis of the knee. They or their insurers spent about $3 billion that year on a procedure that was no better than a placebo.

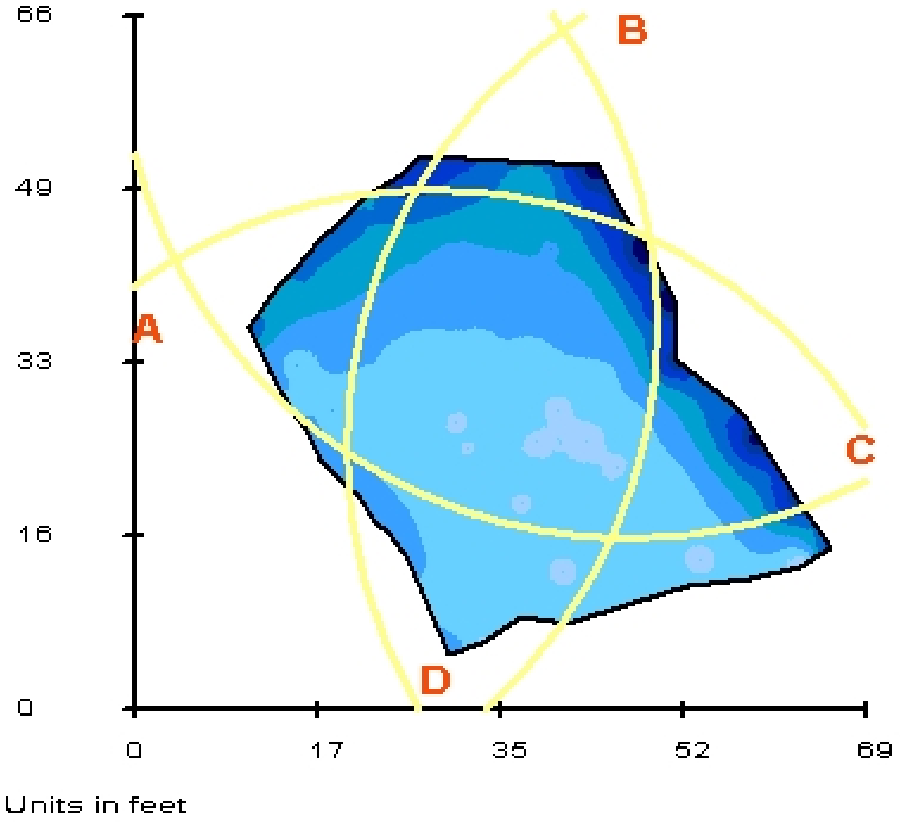
Sham procedures for research aren't new. As far back as 1959, the medical literature was reporting on small studies that showed that

SpecMaps ProTurf

MAIN | FILE | MAP | HE

Map Name	B6 DU
File Name	June 17 DU.txt

Sensor Model	TDR 300
Sensor Type	Soil Moisture



Color Legend				Count
	14.9	to	18.1	11
	18.1	to	21.3	26
	21.3	to	24.5	19
	24.5	to	27.7	3
	27.7	to	30.9	5
	30.9	to	34.1	2
	34.1	to	37.3	6
	37.3	to	40.5	4

Units of measurement are in 'Standard VWC'

Uploaded on 17/Jun/2011

Irrigation DU = 80%

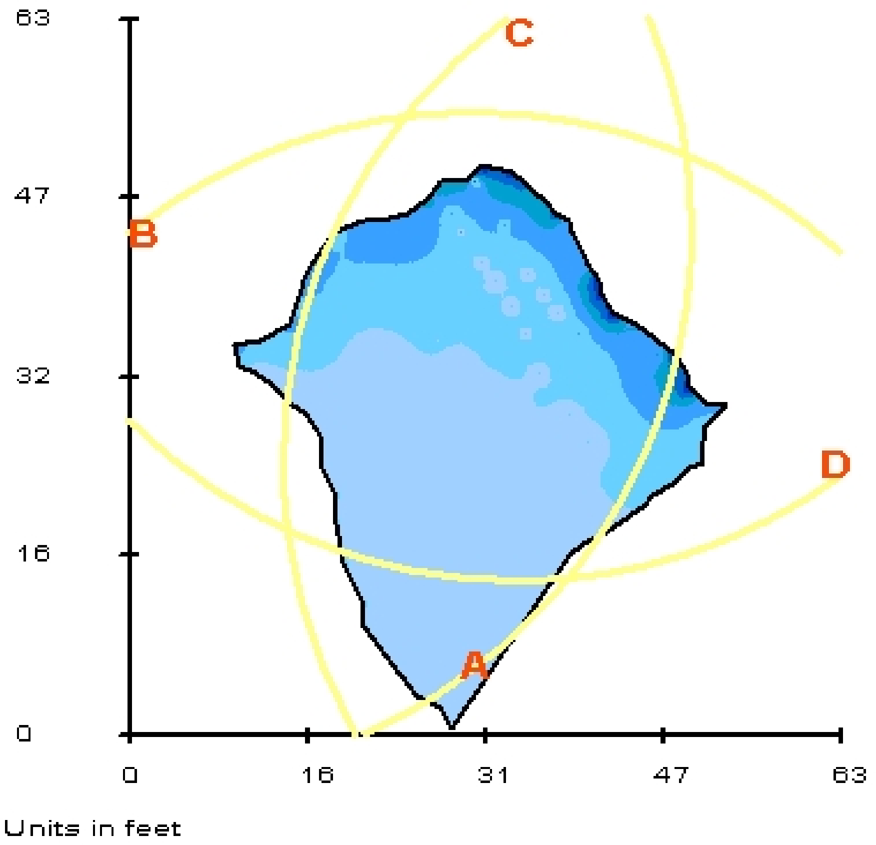
SpecMaps ProTurf

Spectrum Technologies, Inc.

MAIN | FILE | MAP | HELP

Map Name B6 DU July5
File Name DU B6 Only July 5th.txt

Sensor Model TDR 300
Sensor Type Soil Moisture



Color Legend				Count
	10.0	to	13.9	47
	13.9	to	17.7	35
	17.7	to	21.6	14
	21.6	to	25.5	8
	25.5	to	29.3	4
	29.3	to	33.2	6
	33.2	to	37.0	1
	37.0	to	40.9	1

Units of measurement are in 'Standard VWC'

Uploaded on 05/Jul/2011

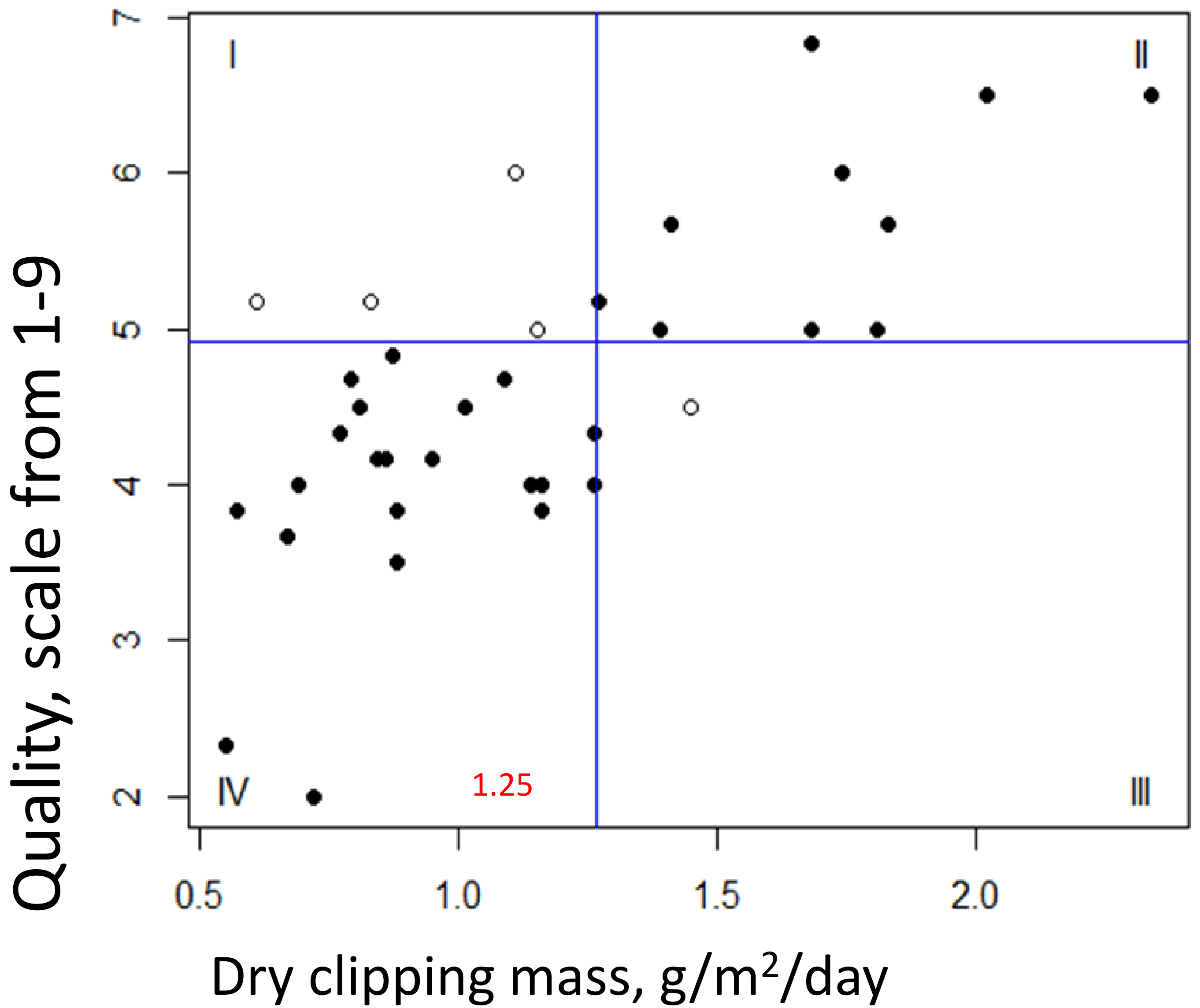
Irrigation DU = 12%

The question that needs to be answered

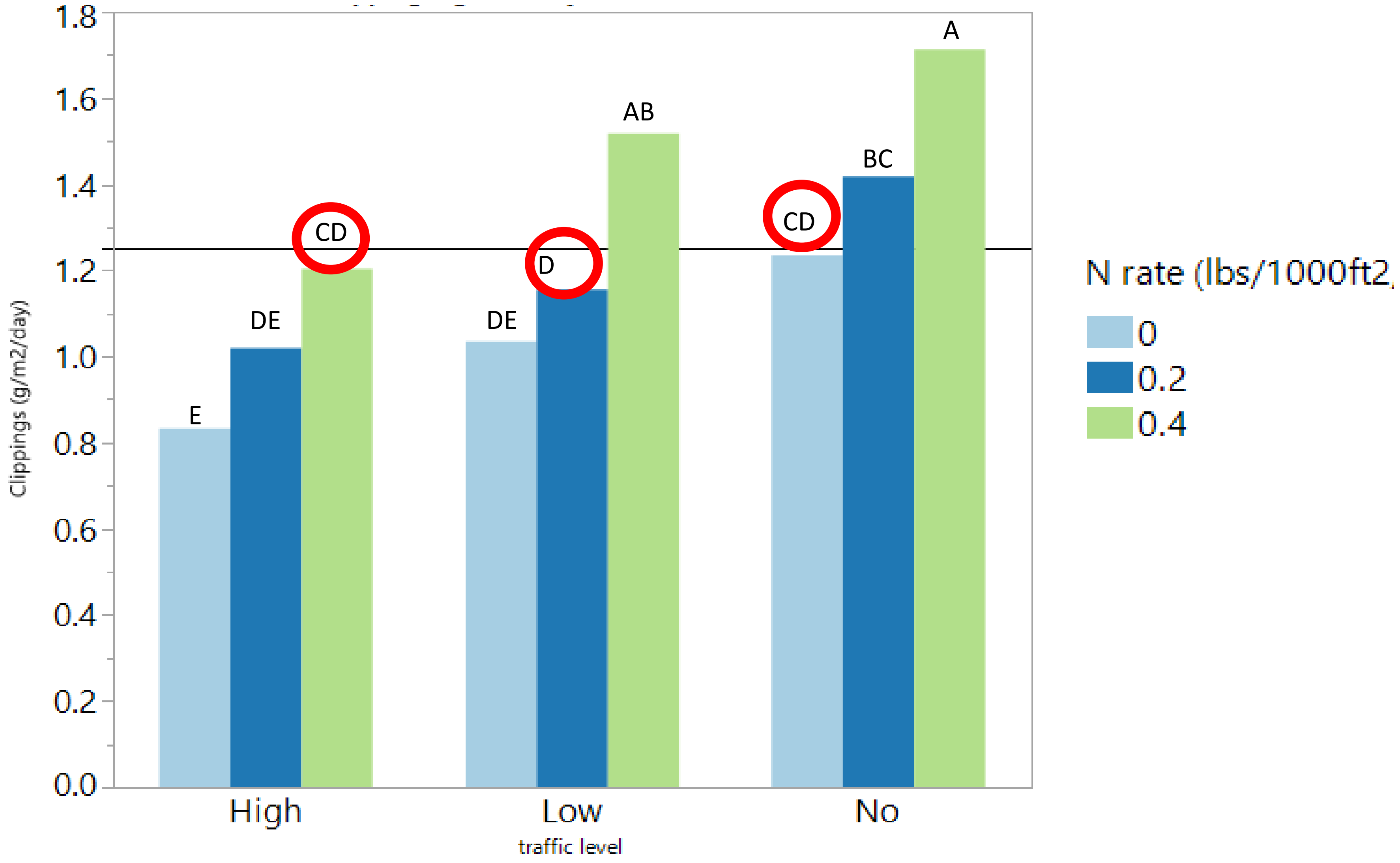
- Are there optimum growth rates for greens, tees, fairways, etc.?

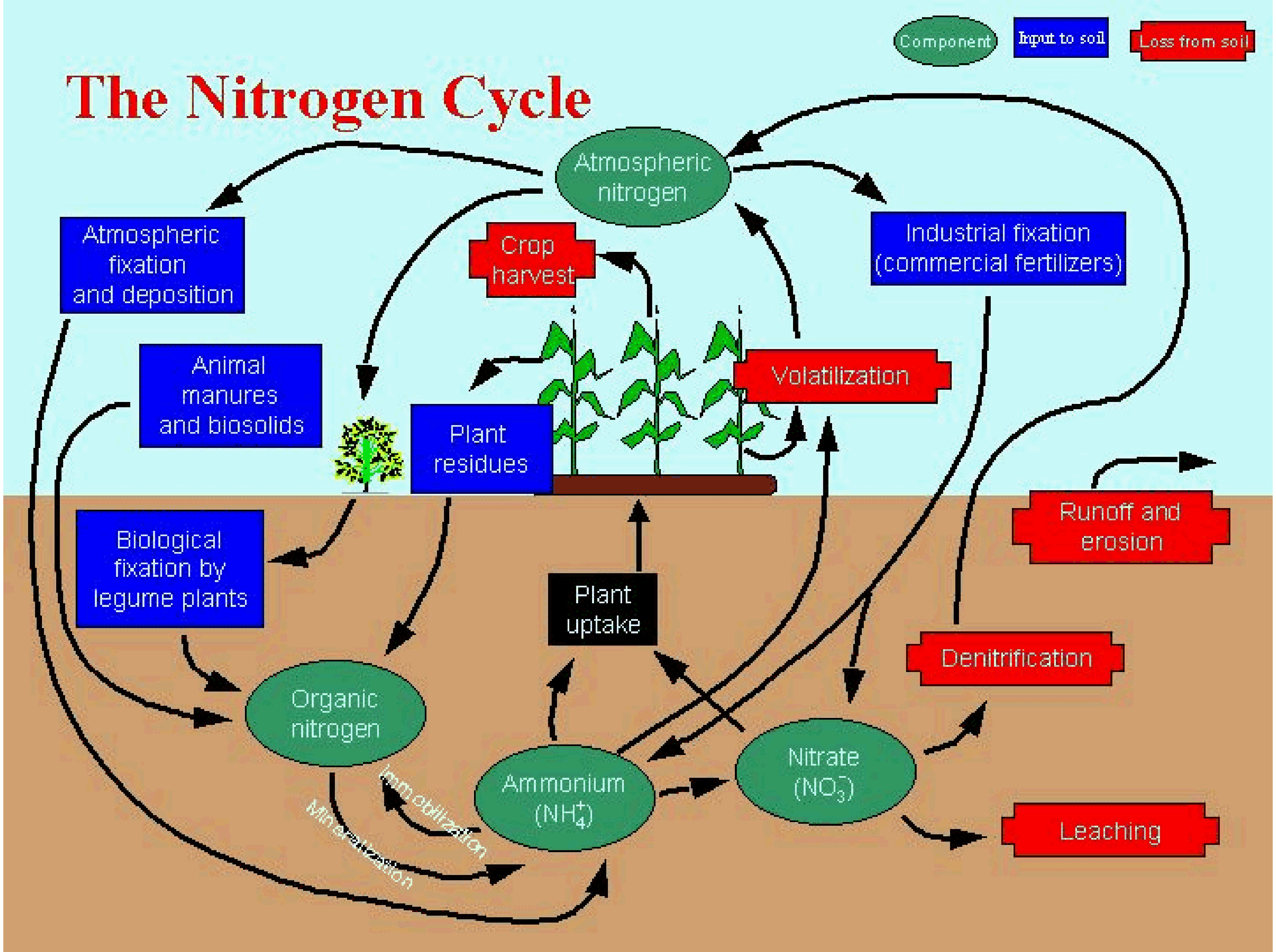
Photo: Micah Woods

Turf quality versus dry CBG clipping mass



Traffic & N had a similar impact on clipping yield




Component
Input to soil
Loss from soil
The Nitrogen Cycle
Atmospheric nitrogen
Atmospheric fixation and deposition
Crop harvest
Industrial fixation (commercial fertilizers)
Animal manures and biosolids
Volatilization
Plant residues
Runoff and erosion
Biological fixation by legume plants
Plant uptake
Denitrification
Organic nitrogen
Ammonium (NH_4^+)
Nitrate (NO_3^-)
Immobilization
Mineralization
Leaching

Checkbook Method of N Management

Nitrogen Additions = Nitrogen Removal/Loss

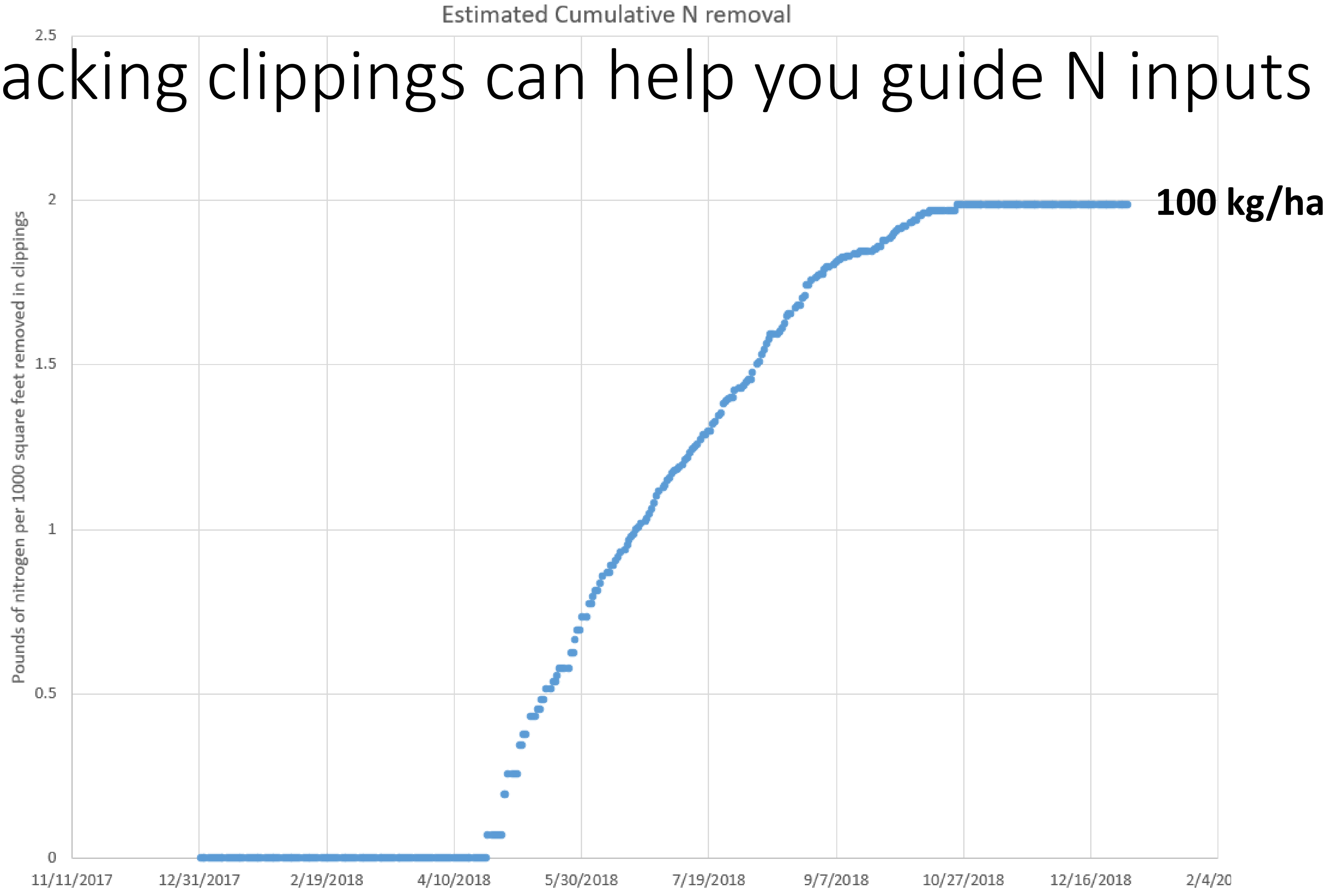
Annual Nitrogen Surplus

- Increasing Soil N
- Excessive Growth/Thatch
- Nitrogen Leaching

Annual Nitrogen Deficit

- Slow Depletion of Soil N
- Steady Decline in Quality
- Eventual Stand Collapse under stress

Tracking clippings can help you guide N inputs



Data on clipping collection from Upper Midwest – 10 courses

- Averages:
  - Rounds = 18,400
  - N applied = 75 kg/ha
  - Soil Organic Matter = 1.9%
  - Bentgrass population = 83%

  - **Clippings = 1.9 L/100 m^2 = 19 mL/m^2**
  - **Estimated N Removal = 55 kg/ha**

<u>Emerging Guidelines:</u>
1 L/100m2 (10 mL/m2) is good for tournament conditions, but probably not sustainable
2 L/100m2 (20 mL/m2) is good target for daily average
4 L/100m2 (40 mL/m2) is excessive

You should probably be testing your greens primarily for organic matter and looking at nutrients levels as a secondary point of interest

General Principles for Organic Matter Testing

• Know how the samples were collected

• Know where the samples were collected

• Know how the samples were analyzed

Cores are split into 4 depths for more specific organic matter analysis.

• Be consistent in sampling methods, testing methods, and locations every year

• Track changes over time – compare your numbers to others with great caution

Specific Methods: **OM246**

- Micah Woods, Asian Turfgrass Center
- Sample at 0 to 2, 2 to 4, and 4 to 6 cm, do not remove any plant material
- Has found average of 7.3% OM in 0 to 2 cm samples
- Recommends sampling at least 3 greens annually, with 5 subsamples per green
- Track changes over time

Although verticutting treatments (left) removed more surface organic matter, plots that were core aerated (right) recovered significantly faster.

Specific Methods: **Nebraska**

- Dr. Roch Gaussoin and others at University of Nebraska
- Sample at 0 to 8 cm, remove verdure
- Has found average of 3.1% OM

Putting greens with excessive organic matter are prone to soft conditions, ball marks, inconsistent green speed, and a host of agronomic problems.

Specific Methods: Linde/Delaware Valley

- Dr. Doug Linde sampled 155 greens (52 different courses) in the Philadelphia region, wide range of budgets, construction methods, grass types, etc.
- Sampled at 0 to 10 cm, in 2.5 cm increments
- 76% had < 3% om in top 2.5 cm, only 17% had > 4% in top 2.5 cm
- Recommends testing your best and worst performing greens annually

Cores are split into 4 depths for more specific organic matter analysis.

You should probably be testing your greens primarily for organic matter and looking at nutrients levels as a secondary point of interest

- Why are we topdressing all the same if there are large differences?
- Can the numbers be used to change your operations?
- You can't manage what you don't measure

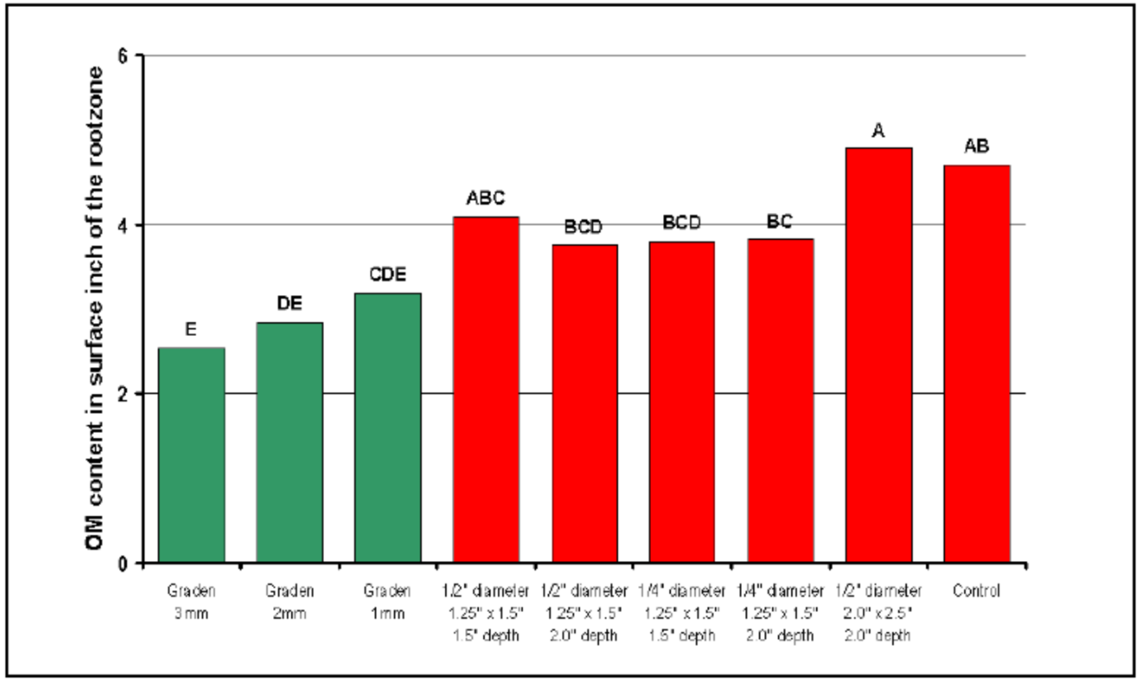
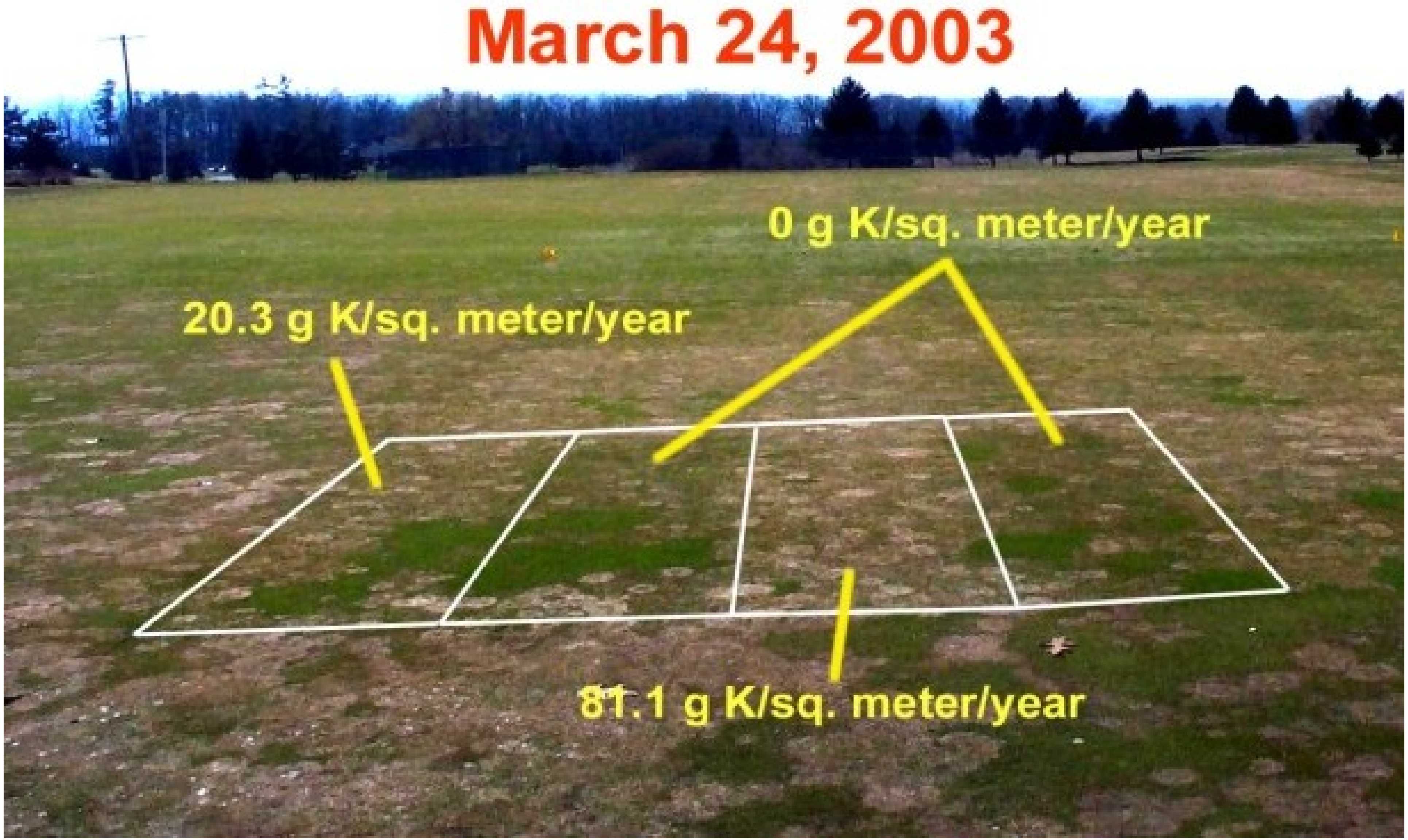
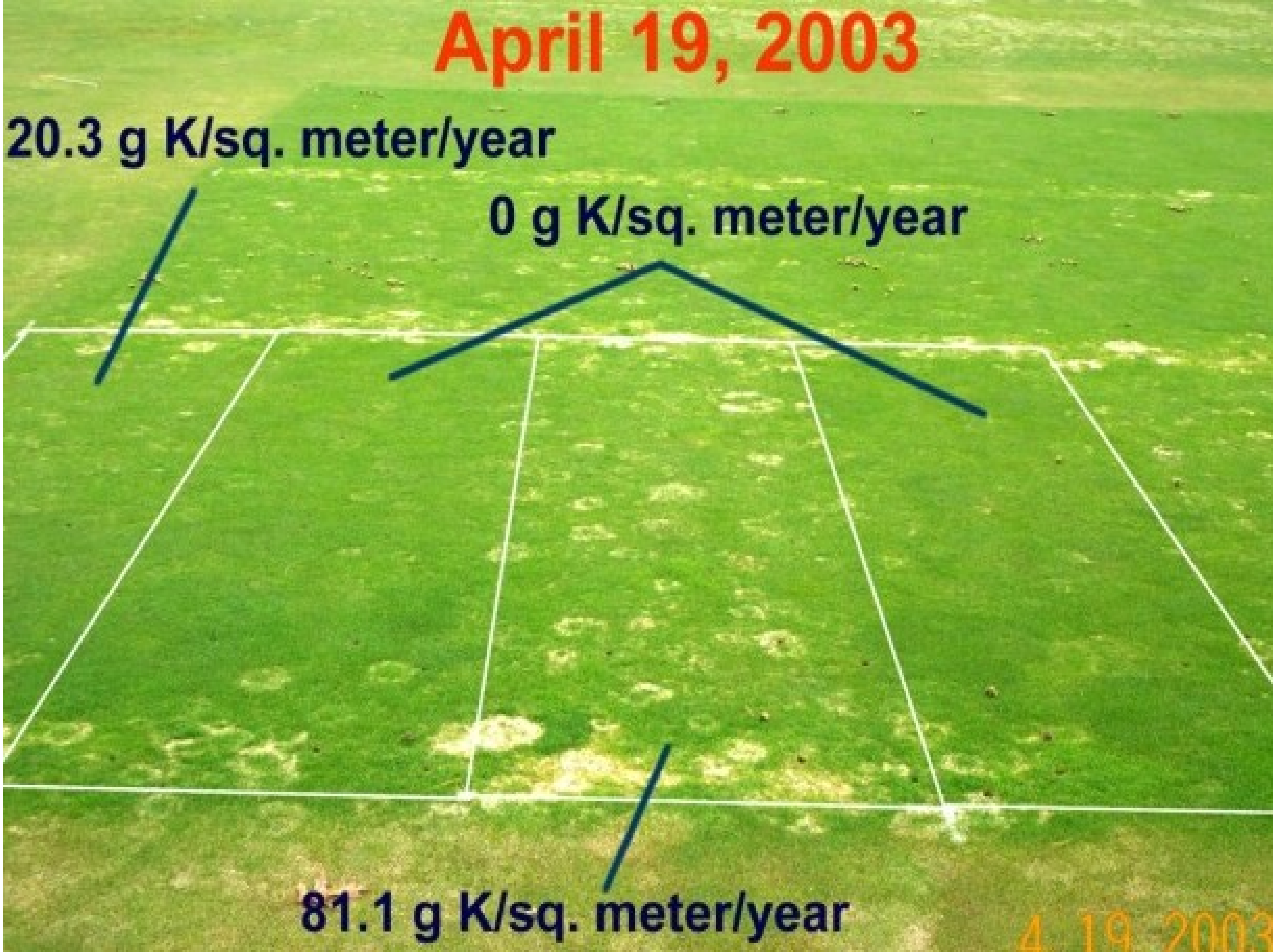


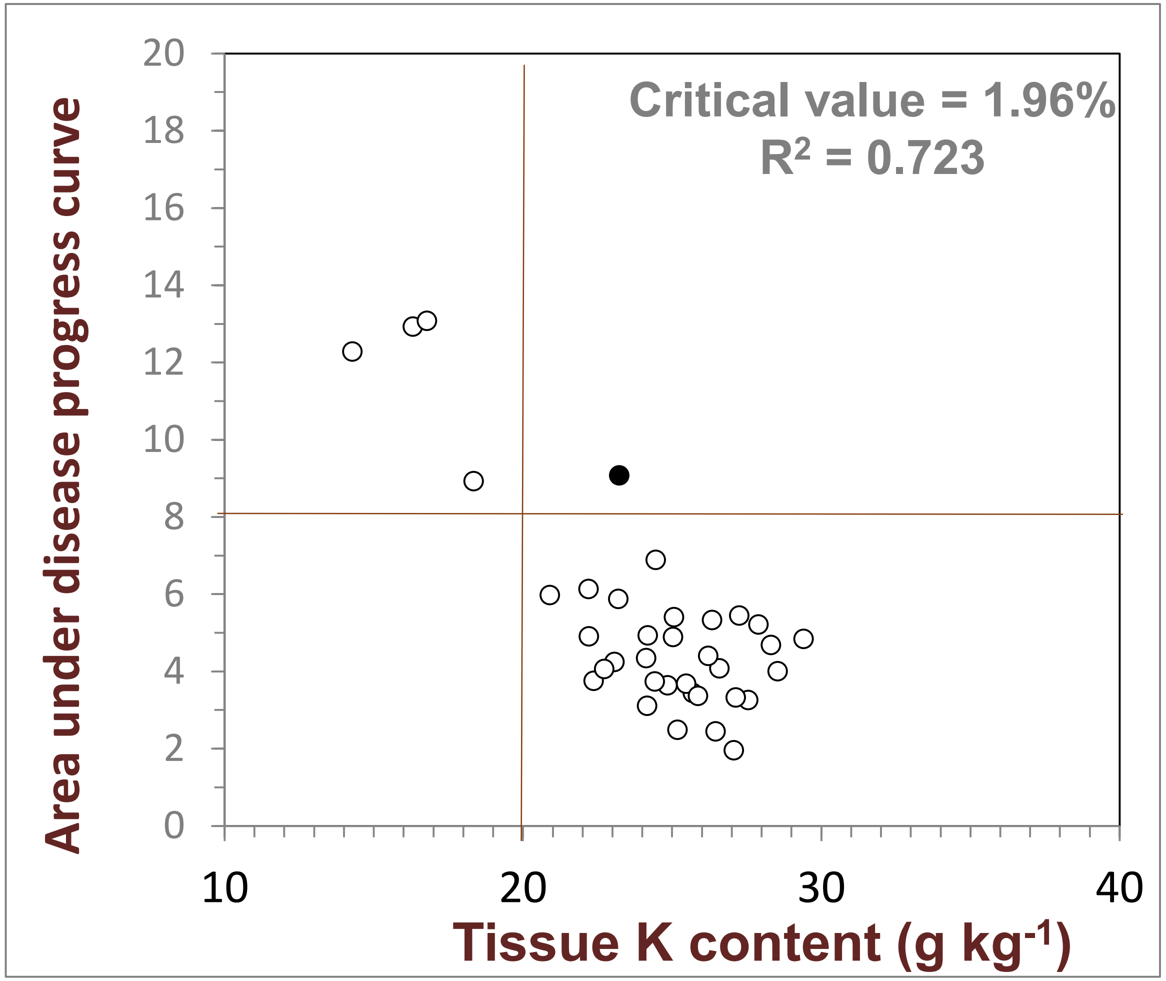
Figure 3. Organic matter content in the surface inch of the rootzone as affected by cultivation treatment. Data collected June 21, 2004, 2 months after the third set of treatments were applied. Treatments with bars sharing a letter are not significantly different.

Woods and Rossi Observed Differences in Snow Mold Damage with K Fertilization



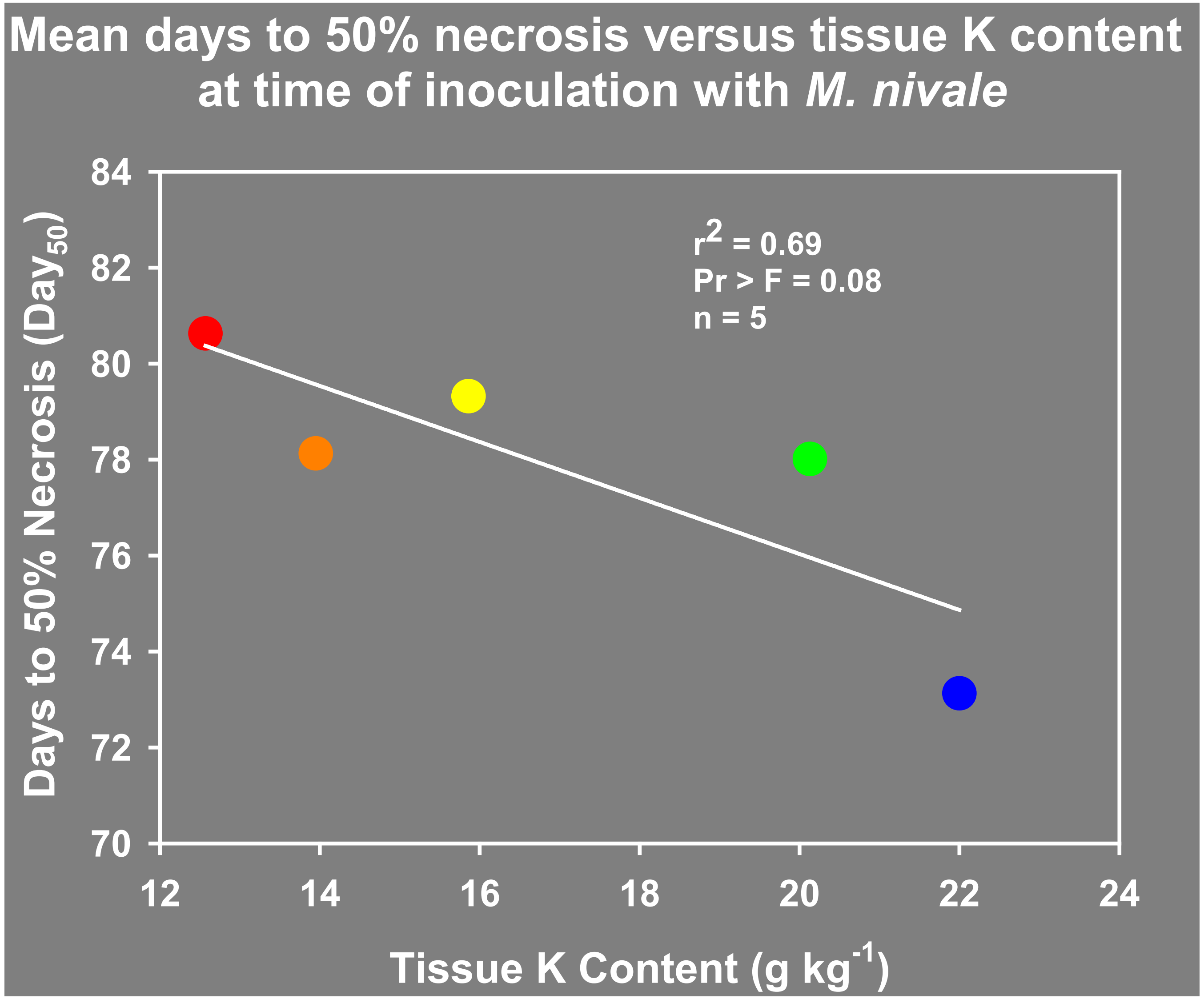

April 19, 2003
20.3 g K/sq. meter/year
0 g K/sq. meter/year
81.1 g K/sq. meter/year
4 19 2003

Rutgers Researchers Observed Differences in Anthracnose Damage with K Fertilization on *Poa annua*



From Charles Schmid, Bruce Clarke, Ph.D., Jim Murphy, Ph.D.

Pink Snow Mold / Microdochium Patch



Adam Moeller @AdamMoeller
Mar 16
Rutgers Poa plots with < 50 ppm soil K much more damaged from freeze injury compared to those with higher soil K

Annual bluegrass winterkill reduced with K

Annual bluegrass under 47 days of snow and ice at Rutgers

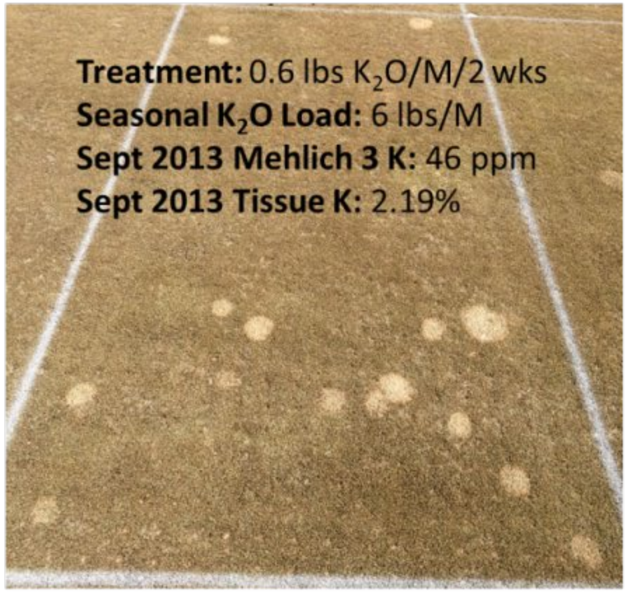
Low tissue K resulted in winterkill

K Fertilizer	Sept. Tissue K	Sept Mehlich-3 STK	Dec 16 LT_{50}
None	1.3%	28 ppm	7°F
1.3-5.4 lbs K	2.6-3.1%	70-185 ppm	2°F

Schmid et al., 2016

Madison, WI on April 2, 2014

Figure 1. Pictures from April 2, 2014 showing light pink snow mold damage, but highly correlated with potassium fertilization and soil and tissue potassium content. Dollar spot damage is also apparent from fall 2013. There were no significant differences in dollar spot damage among the treatments. Grass is 'A4' creeping bentgrass, root zone is 100% sand.




Spring 2015
Madison, WI

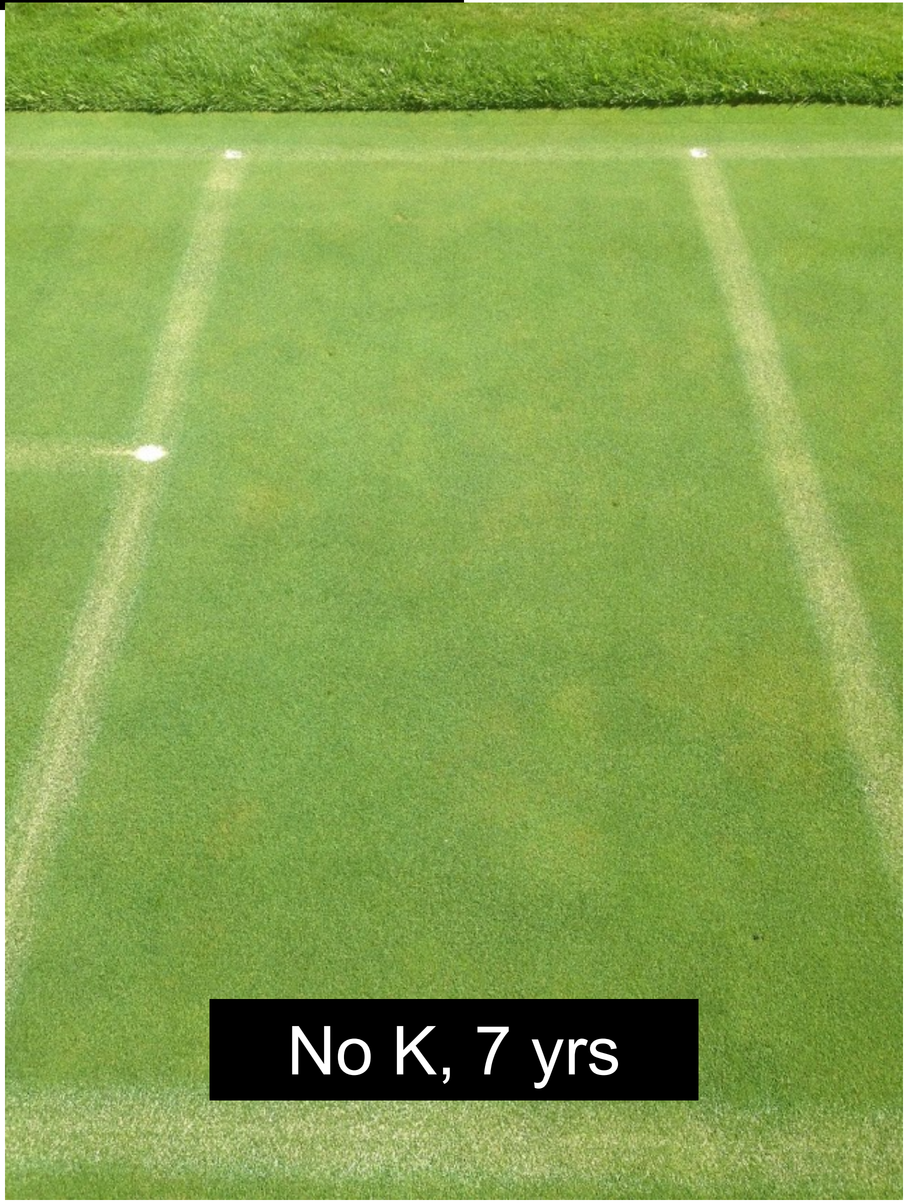

Spring 2016
Madison, WI

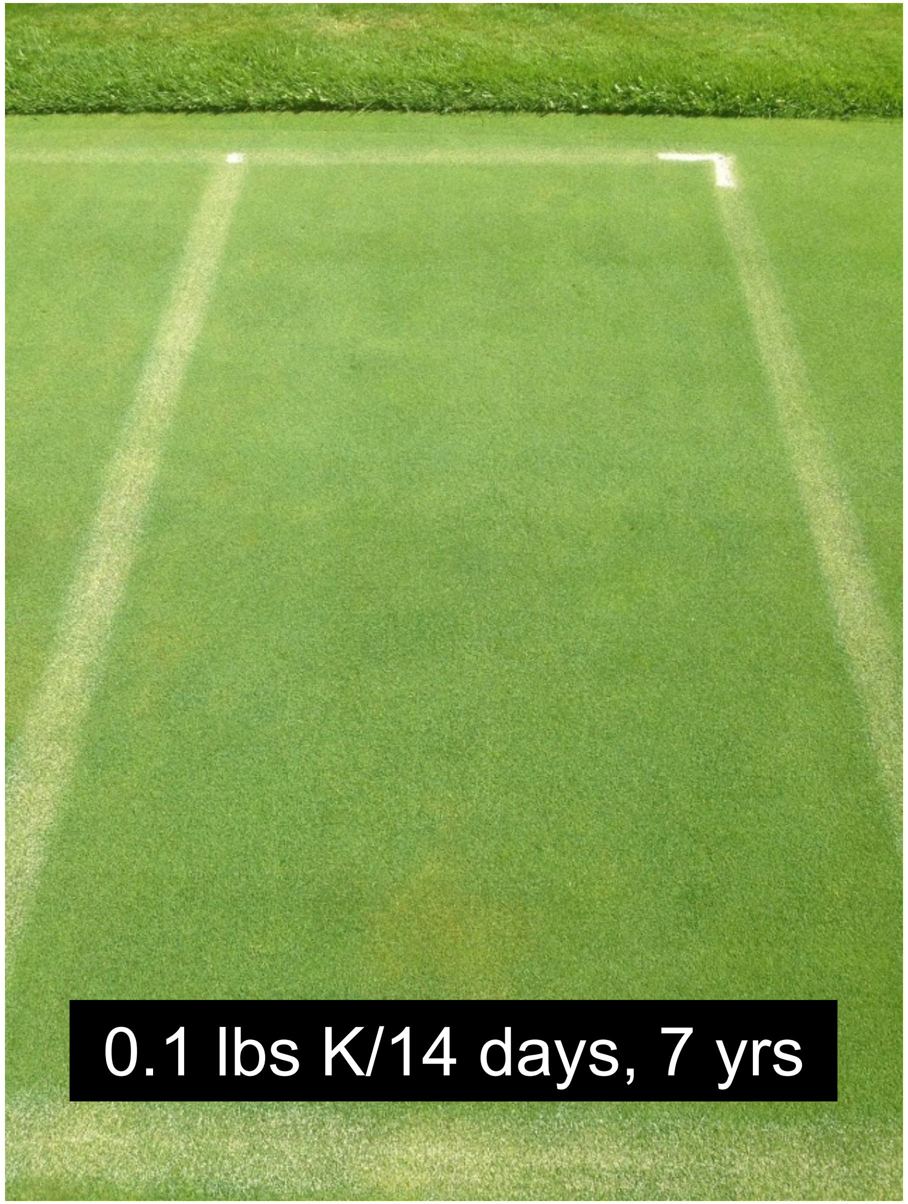
Doug Soldat @djsoldat · Mar 23

No K on top two, 0.6 and 0.1 lbs K/1000 every other week (Left to right) on bottom. A4 CBG, sand root zone

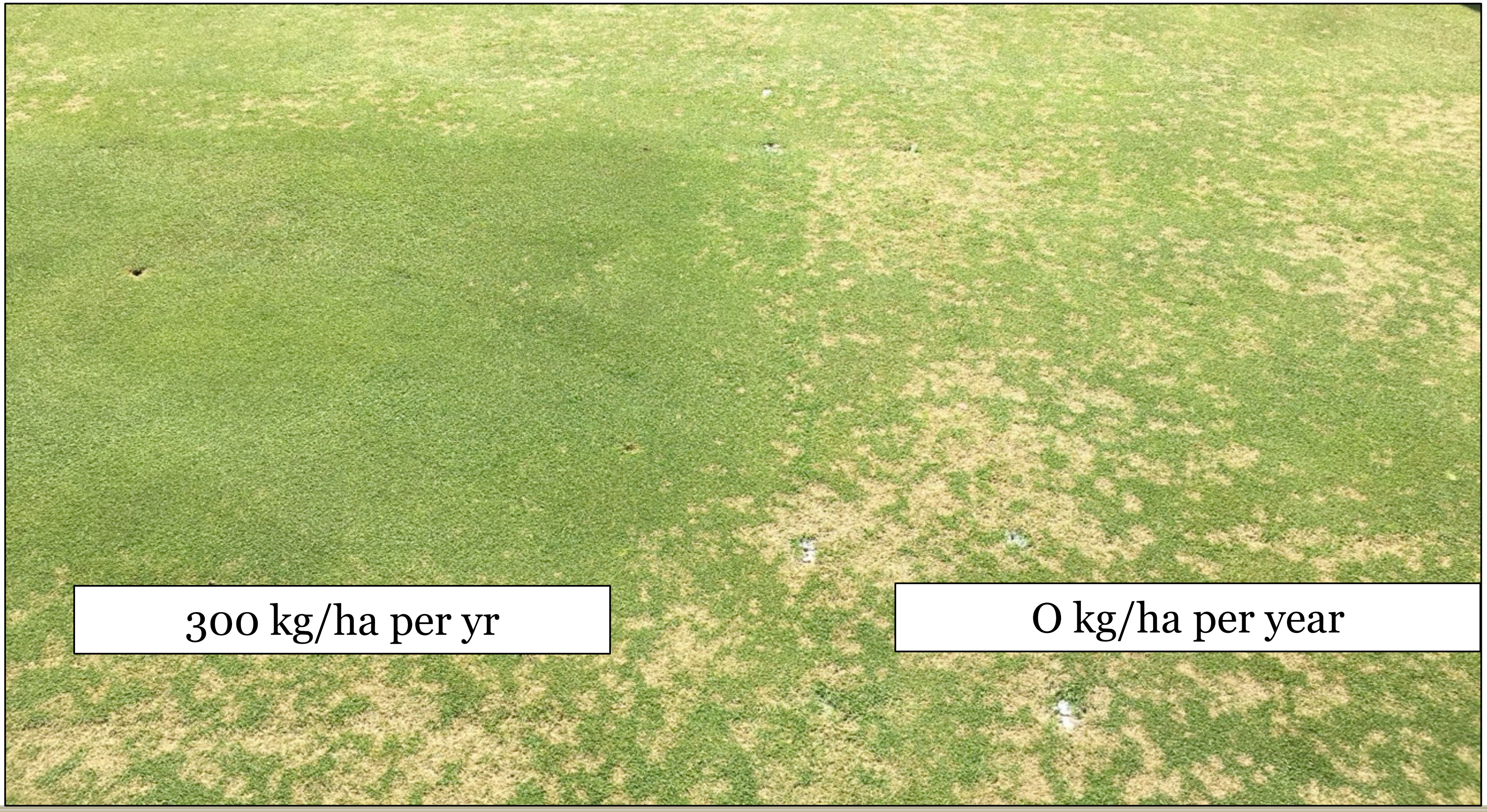

Spring 2017
Madison, WI

Summer 2016
Madison, WI





Influence of nitrogen rate on dollar spot severity

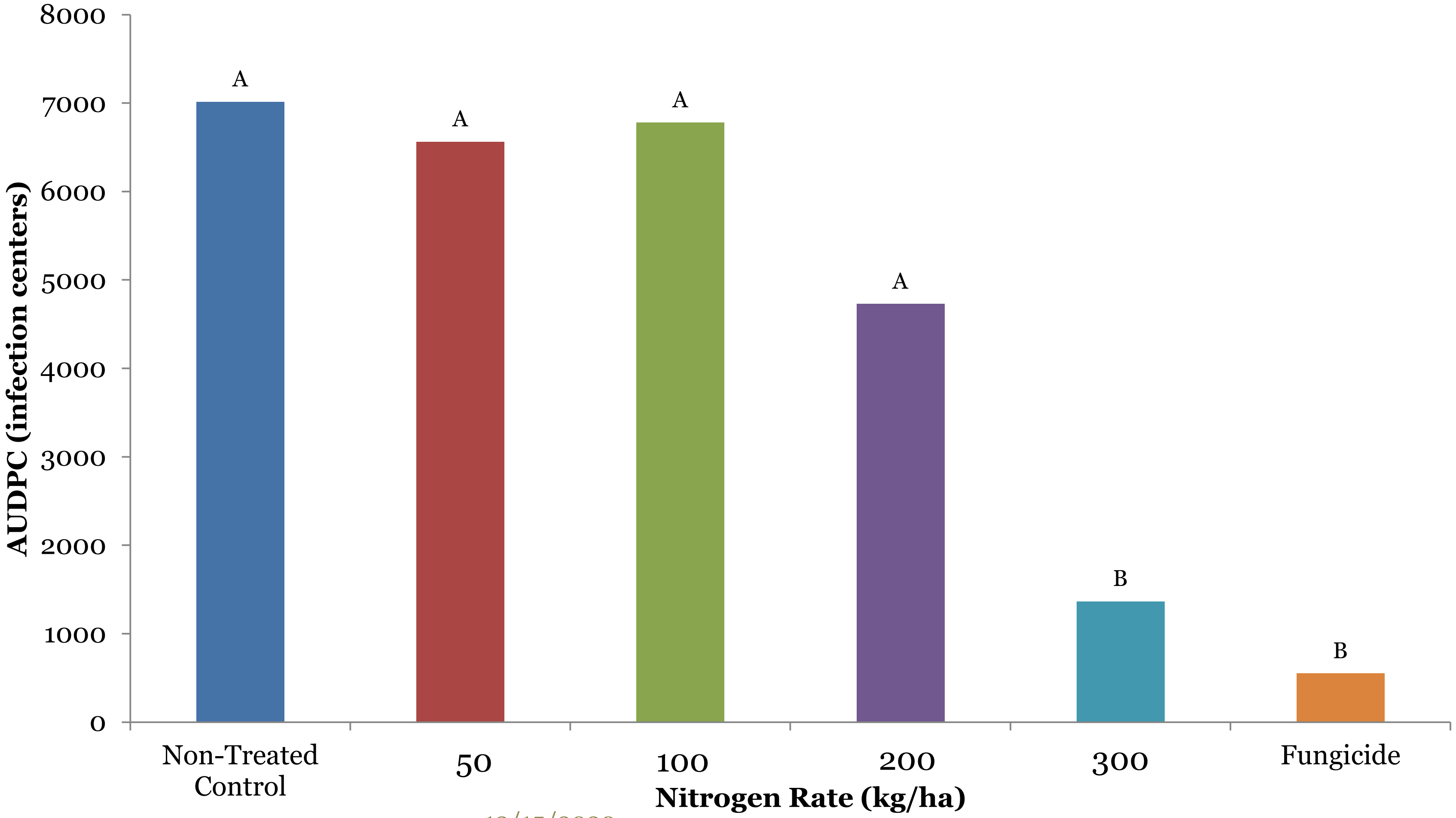


Materials and Methods

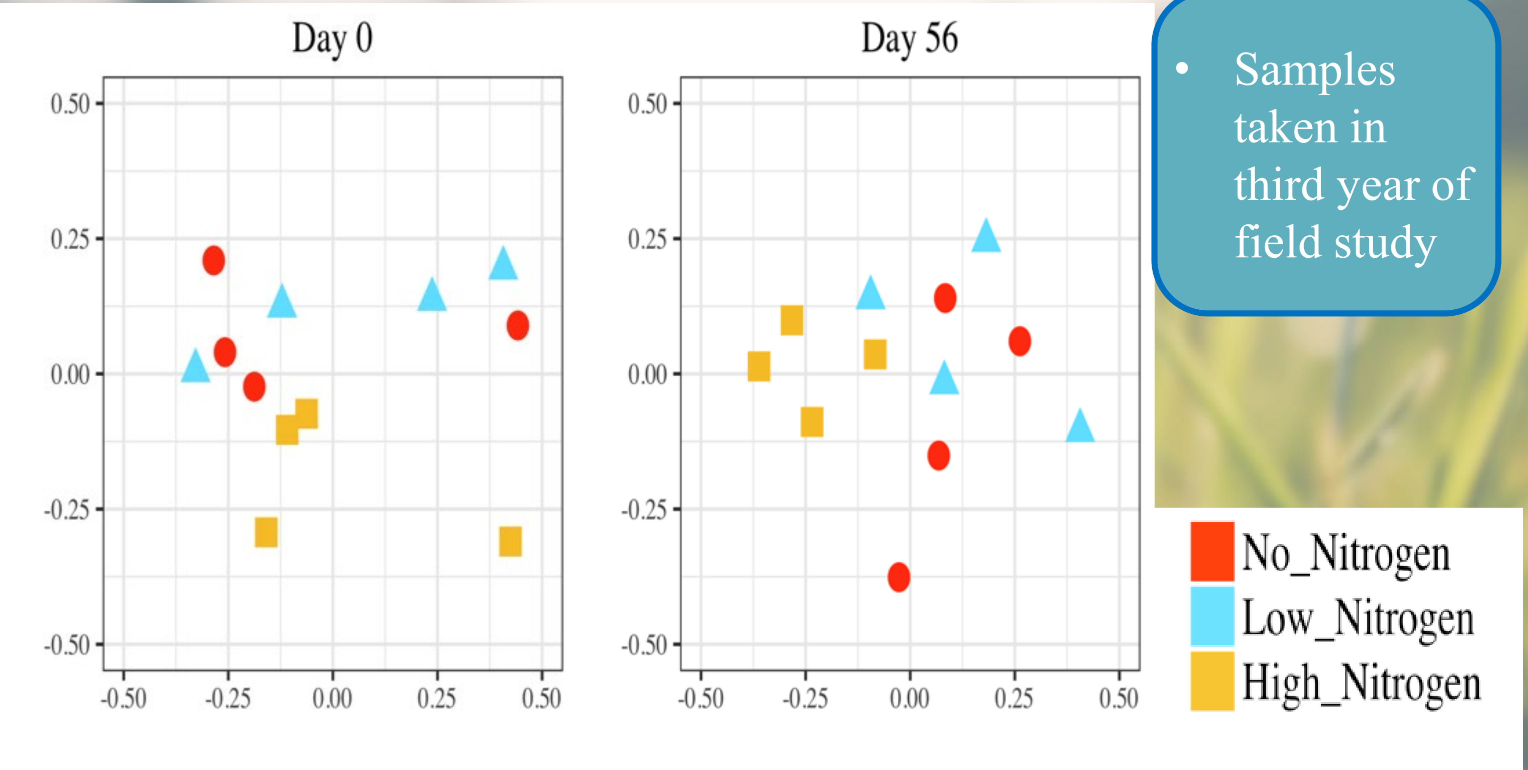
Treatments	Nitrogen Rate (kg/ha)
Non-Treated	0
Urea 46-0-0	50
Urea 46-0-0	100
Urea 46-0-0	200
Urea 46-0-0	300
Fungicide	0

- Locations/Sites
  - OJ Noer, Verona WI
  - North Shore Country Club, Glenview IL
- Trial Design
  - Application made every 2 weeks
  - Randomized Complete Block Design (RCBD)
- Data Collected
  - Infection centers
  - Percent disease cover
  - Foliar nitrogen content
  - Turf quality
  - Normalized Difference Vegetation Index (NDVI)

1. High Nitrogen Rates Provide Dollar Spot Control



Influence of nitrogen fertilization on soil bacterial communities



- Samples taken in third year of field study

- V4 region of 16S genes amplified using primers from Waters et al 2015
- Sequenced on Illumina MiSeq
- Amplicon sequencing data processed using DADA2 package and analyzed using Phyloseq and vegan packages in R

Iron Sulfate and Dollar Spot Control

Wisconsin, Bentgrass Fairway 2018

Wisconsin Bentgrass Fairway 2019

PACE TURF
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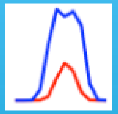

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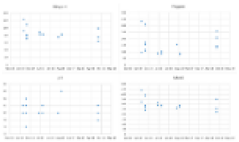
Sunday, July 26, 2020

Iron and take-all patch

Sunday, July 26, 2020 | Permalink | Cultural Practices, Disease,



We recently highlighted research by Dr. Paul Koch describing management of dollar spot using routine applications of ferrous sulfate (FeSO4*7H2O). But now, there may be an interesting twist to the story of ferrous sulfate suppression of dollar spot.

A consultant peer of Larry's in Ontario, Canada shared some interesting observations and data regarding use of ferrous sulfate (FeSO4*7H2O) for control of dollar spot. Several of his clients had noticed an increase in take-all patch attacking bentgrass following routine use of ferrous sulfate for suppression of dollar spot leading to the question: Can applications of ferrous sulfate cause increased take-all patch on bentgrass?

Even though dollar spot was effectively suppressed by the ferrous sulfate applications, take-all patch became a problem after five years of ferrous sulfate treatments (ferrous sulfate was applied every 7 – 10 days, 15 – 20 applications per year, rates up to 8 oz/1000 sq ft, 225 g/1000 sq ft or 2.4 g/m^2). During that time, there were no dramatic changes in soil pH or Mehlich-3 extracted Fe, Mn or MnAI (Mn Availability index), even though these factors may impact take-all patch. When the ferrous sulfate program was terminated, take-all patch disappeared. In the end, the superintendent concluded it was cheaper to use conventional fungicides to control dollar spot using low rates of chlorothalonil than it was to control take-all patch with conventional fungicides.

Although there is no reported direct relationship between ferrous sulfate applications and take-all patch, there is research suggesting an indirect relationship between soil iron levels and biological control of take-all by *Pseudomonas* spp. Apparently, biocontrol by *Pseudomonas* spp. partially relies on its production of molecules called siderophores, which are iron chelators that act on or near the surface of the plant root – the rhizosphere. The siderophore ties up all of the iron in the rhizosphere so that the take-all fungus (*Gaeumannomyces graminis*) is deprived of iron and therefore can't colonize the plant's roots. The researchers found that when excess iron iis present, the siderophore is neutralized, allowing the take-all patch fungus to grow. This type of biological control is considered nutrient deprivation and has been studied in wheat.

Siderophores have been studied for decades and Larry participated in early research on Pseudomonas siderophores that revealed the fungal growth-suppression nature of these bacterial siderophores for inhibition of a wide range of fungi in low iron conditions. These studies may explain the observation that ferrous sulfate applications appeared to trigger take-all patch. However, a great deal more data is required to confirm that this is the case.

Bottom line: There is no reason to stop ferrous sulfate applications for suppression of dollar spot. However, if take-all patch begins to become a persistent problem following routine application of ferrous sulfate, consider splitting a practice area or nursery area and withhold the ferrous sulfate applications to help determine if ferrous sulfate applications might be involved in the increased take-all patch.

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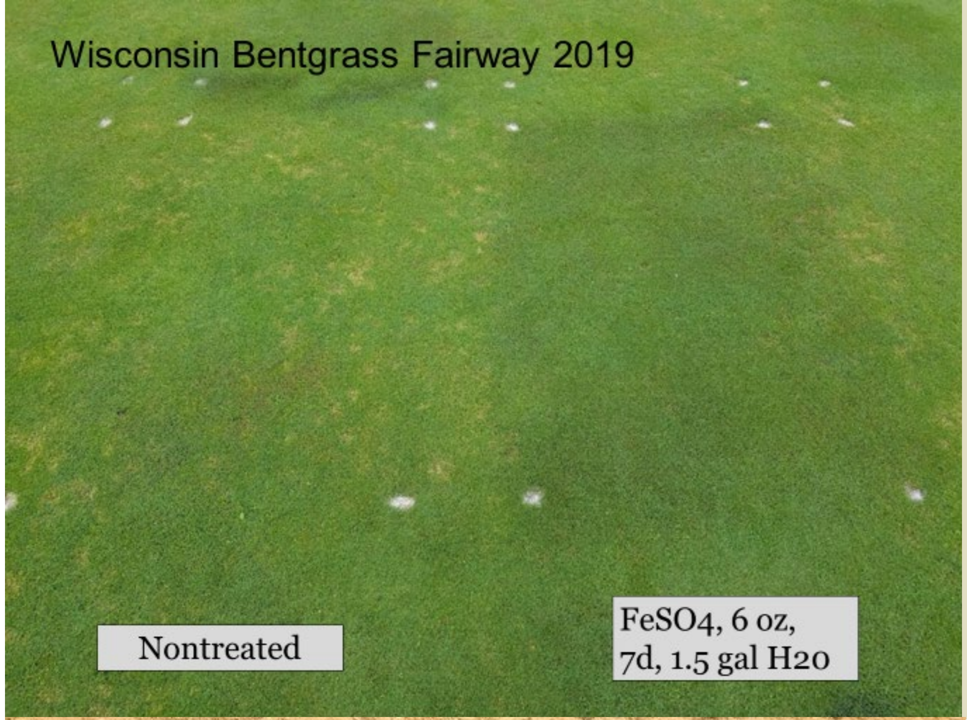
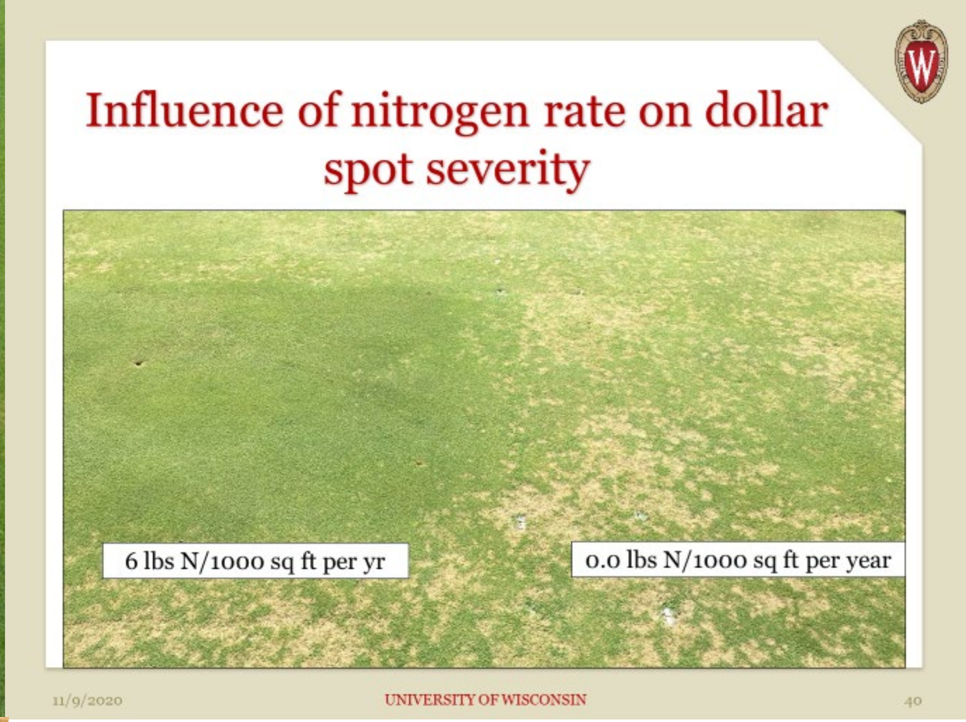
- Keep an eye out for brown patch in the fall and winter
- Fall prevention of crane flies
- March flies vs. crane flies
- Video: Microdochium patch (snow mold) diagnosis
- Personal Avatar
- Bruce Martin on spring dead spot
- NTEP 2020 bentgrass site climate appraisals

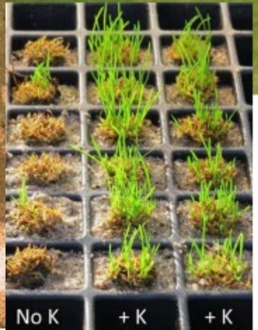
Categories

- Clubhouse Editions
- Cultural Practices
- Disease





Annual bluegrass winterkill reduced with K



Annual bluegrass under 47 days of snow and ice at Rutgers

Low tissue K resulted in winterkill

K Fertilizer	Sept. Tissue K	Sept Mehlich-3 STK	Dec 16 LT_{50}
None	1.3%	28 ppm	7°F
1.3-5.4 lbs K	2.6-3.1%	70-185 ppm	2°F

Schmid et al., 2016