30 years of Turf Research, Advice, and Learning in under 2 hours

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Turfgrass Science
University of Nebraska

Utah Chapter GCSAA
Golf Course Superintendents Association of America

2021 Annual Education Conference & Trade Show
October 5-6, 2021
Rainbow Hotel & Casino – Wendover, NV

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Heads up!

- Presentation
- Supplemental reading
- Access by QR code
- Use your phone to access and download or save the image.

https://turf.unl.edu/

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Agricultural & Environmental Letters

RESEARCH LETTER

Estimating economic minimums of mowing, fertilizing, and irrigating turfgrass

Douglas J. Soldat[1] | James T. Brosnan[2] | Ambika Chandra[3] | Roch E. Gaussoin[4] | Alec Kowalewski[5] | Bernd Leinauer[6] | Frank S. Rossi[7] | John C. Stier[2] | J. Bryan Unruh[8]

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Abstract
The public health crisis and economic recess

Received: 4 August 2020 | Accepted: 2 September 2020
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Agricultural & Environmental Letters

COMMENTARY

A justification for continued management of turfgrass during economic contraction

James T. Brosnan[1] | Ambika Chandra[2] | Roch E. Gaussoin[3] | Alec Kowalewski[4] | Bernd Leinauer[5] | Frank S. Rossi[6] | Douglas J. Soldat[7] | John C. Stier[1] | J. Bryan Unruh[8]

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[2] Texas A&M AgriLife Research and

Abstract
A novel coronavirus, termed COVID-19, spread worldwide and become a global pandemic in 2020. Forecasts show that COVID-19 will cause substantial eco-

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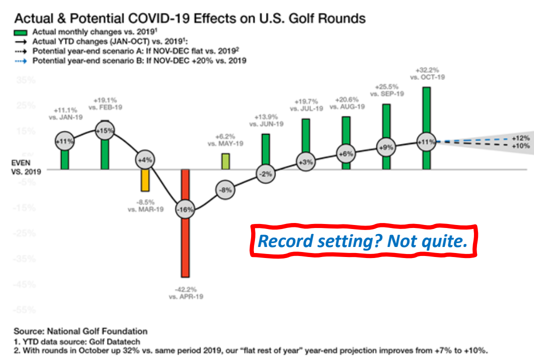

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What Year exceeded 2020 golf rounds increase?

1. 2004
2. 1995
3. 1997
4. 2012

5

Perspective

1991	vs.	2021
	Fertility ⬇	
3.5-8 lbs N/M	bentgrass green	1.5-3 lbs N/M
	Pesticide Rates ⬇	
5-14 lbs ai/acre	preemergence	0.125-0.25 lbs ai/acre
	Mowing heights ⬇	
0.125-0.25"	bentgrass green	<0.125"
14	Cultivars (bentgrass) ⬆	26

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How to begin……

- Weed Management
- Liquid/Foliar Nutrition, biostimulants
- Organic Matter Management
- Random Thoughts

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Weed Management

8

Credit: Channa Prakash via Twitter

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Ross Braun
@Ross_Braun
These two lawns were established with the same sod at the same time (2017). Both lawns have never received a pesticide application. However, one is fertilized twice a year (mainly fall) and mowed higher all year. #Lowinputturf pic.twitter.com/2l4Hy0nEYp
7/31/20, 7:24 AM

Note: both receive similar amounts of water (rain only with no in-ground irrigation) with the one on the right receiving hose sprinkler watering when minimal rain has occurred for 3+ weeks.

Management matters (KB in Indiana)

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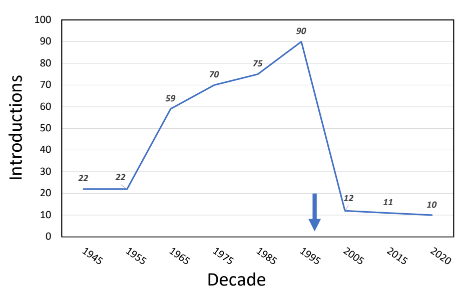
Herbicide Active Ingredient Introduction (US) by Decade



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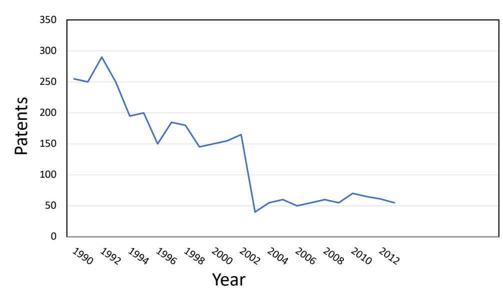
Herbicide Patent Approval (US) Since 1990



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PoaCure

- methiozolin
- Provides PRE and POST control of *Poa annua*
- Controls *Poa trivialis (label approval pending)*
- Golf Course only at this point

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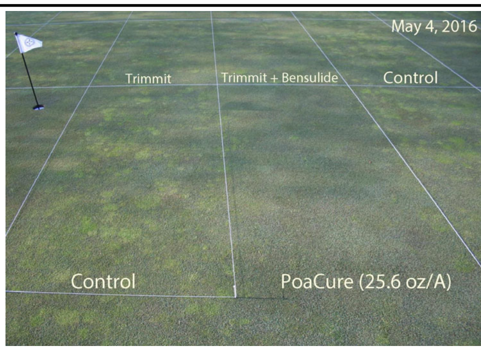

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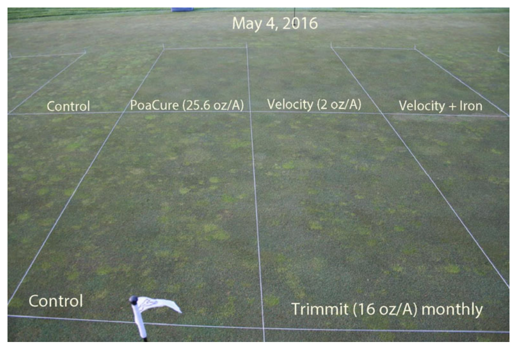

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PoaCure Words of wisdom from Bruce Branham, Ph.D., University of Illinois

*"I recommend starting with 2 apps in the fall at 0.6 oz/M {label recommends 1.2 oz/M} applied two weeks apart. Start between 9/15 and 10/15. Apply two more times the next spring. {*some data indicate a spring start date results in better control*}.*

The following fall, you can repeat the program while potentially going to 3 fall applications depending on the level of control achieved the previous year and your level of comfort with the product. {lots of poa = lots of bare ground}.

I always like to start slowly. Remember, this is just like crabgrass, you'll have do to something every year, at least for quite awhile, until you've not only controlled the visible Poa but have knocked down the seed bank."

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Cost:
$250/16 Fl oz or $5000 for 20-16 oz bottles = $15.63 oz.
Applying at 0.6 oz/M = $9.39/M per application
X 4 applications in a 12-month period = $37.50/M or $1,634/Acre

Other points of interest:
Be careful when using a single MOA approach to any pest. Rotation of chemistries with Poa is problematic.

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Pesticide resistance can be reduced by:

1. Using a pesticide until resistance develops than switch to another one
2. Rotate different pesticides
3. Rotate pesticides with different modes of action (MOA) in cohort with appropriate management

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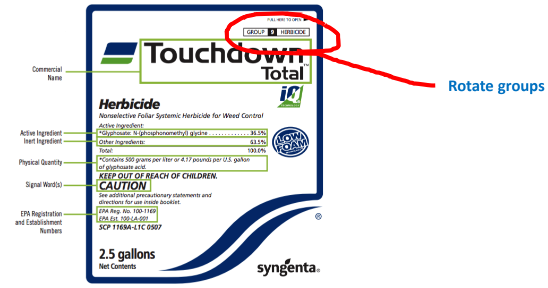

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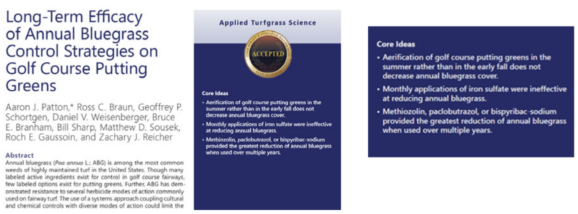

"The effectiveness of season-long treatments will vary depending on location, but methiozolin (WSSA Group 30 herbicide), paclobutrazol (Type II, Class B PGR), or bispyribac-sodium (WSSA Group 2 herbicide) reduced ABG populations. These three options with diverse mechanisms could be incorporated into an integrated ABG management system that also included mechanical removal, interseeding of improved creeping bentgrass cultivars, the reduction of tree shade on putting greens, and careful management of N and P"

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- **Bispyribac sodium (Velocity; Group 2) availability is in question (stopped being made in 2017)**
- **Amicarbazone (XONERATE; Group 6) or ethofumasate (Prograss; Group 16) are good *P. annua* herbicides and not labeled for greens…………**
- **Mesotrione (Tenacity; Group 27) is herbicidal on bentgrass**

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Table 6. Annual bluegrass (ABG) cover at spring seedhead production during and after 4 years of season-long applications of herbicides, iron sulfate, growth regulators~~, or aerification treatments~~ to creeping bentgrass/ABG maintained at putting green height in West Lafayette, IN.

Treatment	Application/year and rate	May 2014†	May 2015	May 2016	April 2017	May 2018
		% cover‡				
Iron sulfate	6 @ 704 oz/acre	74 a§¶	49 a	22 ab	9 bc	27 a
Iron sulfate + bispyribac-sodium	6 @ 704 oz/acre + 4 @ 2 oz/acre	69 ab	32 bc	7 c	6 c	11 bc
Methiozolin	4 @ 25.6 oz/acre	66 b	26 c	7 c	6 c	6 c
Paclobutrazol	6 @ 16 oz/acre	63 b	31 bc	14 bc	12 ab	10 bc
Paclobutrazol + bensulide	6 @ 16 oz/acre + 2 @ 240 oz/acre	73 a	42 ab	17 ab	13 ab	14 b
Bispyribac-sodium	4 @ 2 oz/acre	70 ab	41 ab	15 bc	9 bc	8 c
Nontreated	–	65 b	51 a	24 a	14 a	22 a
P-value		0.0206	0.0005	0.0040	0.0037	< 0.0001

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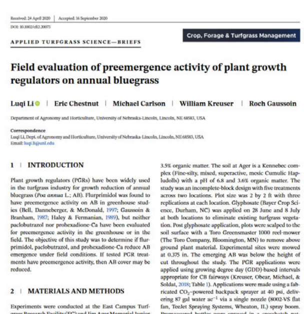

"Results of this study suggest flurprimidol and paclobutrazol have preemergence activity on AB under field conditions, but not prohexadione-Ca. Despite the preemergence benefit of these PGRs, golf course superintendents should not use them exclusively to control AB. However, one may expect reduction in AB seed germination (15-18%) and reduced AB cover by incorporating Class-B PGRs, especially paclobutrazol, into the management program."

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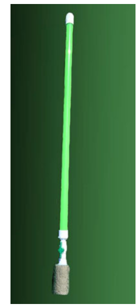
Smucker RWTD00 Drift Free Sponge Dauber



Fill with 2-4% solution of glyphosate

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POA ANNUA RATINGS OF CREEPING BENTGRASS CULTIVARS GROWN ON A GREEN 2/
2004-07 DATA

POA ANNUA RATINGS 1-9; 9=NONE 3/

NAME	PA1	VA1	WI1	MEAN
SHARK (23R)	8.0	8.7	8.3	8.4
TYEE (SRX 1GD)	8.0	8.7	8.0	8.3
AUTHORITY (235050)	7.3	8.7	8.0	8.2
007 (DSB)	7.0	8.8	8.0	8.2
MACKENZIE (SRX 1GPD)	6.3	8.7	8.7	8.1
CY-2	6.0	8.8	7.7	7.8
DECLARATION	6.0	8.5	8.0	7.8
PENN A-1	6.0	8.0	6.3	7.1
13-M	4.7	8.0	7.3	7.0
KINGPIN (9200)	5.7	7.7	7.0	7.0
MEMORIAL (A03-EDI)	4.7	7.8	7.3	6.9
INDEPENDENCE	6.0	7.2	7.0	6.8
T-1	5.7	6.7	6.7	6.4
BENGAL	5.0	6.8	7.0	6.4
COBRA 2 (IS-AP 9)	4.3	6.8	7.3	6.3
ALPHA	5.7	7.0	5.3	6.3
LS-44	4.0	6.2	6.7	5.8
BENCHMARK DSR	4.3	5.8	6.7	5.7
PENNCROSS	3.3	4.8	4.3	4.3
PENNLINKS II	3.7	3.5	5.0	3.9
LSD VALUE	1.4	1.5	1.3	1.0

POA ANNUA RATINGS OF CREEPING BENTGRASS CULTIVARS GROWN ON A GREEN
2009-13 DATA

POA ANNUA RATINGS 1-9; 9=NONE 2/ 3/

NAME	PA1
PURE DISTINCTION (PST-OJO)	8.7
PROCLAMATION (LTP-FEC)	8.3
BARRACUDA (MVS-AP-101)	8.0
DECLARATION	8.0
FOCUS (SRP-1GMC)	8.0
LUMINARY (A08-TDN2)	8.0
PIN-UP (HTM)	8.0
V8	8.0
SRP-1BLTR3	7.7
AFM	7.3
AUTHORITY	7.3
ALPHA	6.7
PENN A-2	6.7
T-1	6.7
PENN A-1	5.7
L-93	5.3
PENNCROSS	4.3
LSD VALUE	1.3

NTEP.org

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Organic/natural weed control options

- Preemergence
  - Corn gluten meal
  - Distiller grains
- Postemergence
  - multiple
- Non-selective
  - multiple

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Corn Gluten Meal

- Multiple years required to attain equivalent synthetic control (cumulative effect)
- Significant N input in first year
- Available mail order and limited retail

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Dried distiller grains (DDGs)

- Dried distiller grains (DDGs) are a co-product of the dry milling process, which currently accounts for approx 75 percent of the domestic ethanol production
- DDGs are used almost exclusively used as animal feed
- Much like corn gluten meal, weed control ,and fertilizer value has been documented
- DDGs contain an estimated 10% fatty oils that causes the byproduct to go rancid if not used in a relatively short time period
- Research by the USDA has been ongoing since 2008

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Selective postemergence trial

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Materials and Methods

Spring Applications: May 4 and May 31, 2018 (4 weeks after initial treatment)
Fall Applications: September 13 and October 5, 2018

Product	Active Ingredient	Rate
Untreated Check	N/A	N/A
Iron X	26.52% Iron HEDTA	25.2 oz/M
A.D.I.O.S.	Sodium chloride + NIS	1 lb product/gallon
ICT Halo	Eugenol, Clove Oil	10 oz/M
Fiesta Weed Killer	26.52% Iron HEDTA	12.6 fl oz/M or 25.2 fl oz/M
Fiesta Weed Killer + Xiameter OFX-0309	26.52% Iron HEDTA and Silicon Adjuvant	12.6 oz/M
Natria Lawn Weed and Disease Control	26.52% Iron HEDTA	25.2 fl oz/M
Trimec Classic	2,4-D	4 pt/A
Borax	Boric Acid	Spray to runoff
EcoSmart Weed & Grass Killer	Rosemary Oil	Spray to runoff
AgraLawn Weed and Crab Killer	Cinnamon	Shake on foliage

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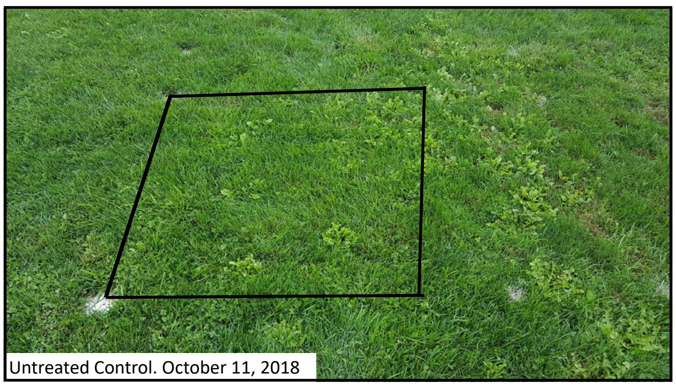

Untreated Control. October 11, 2018

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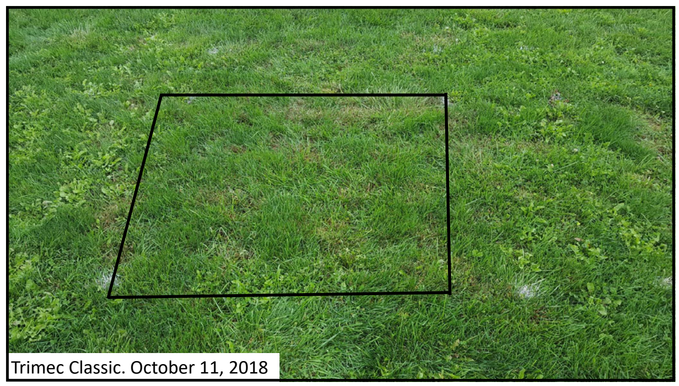

Trimec Classic. October 11, 2018

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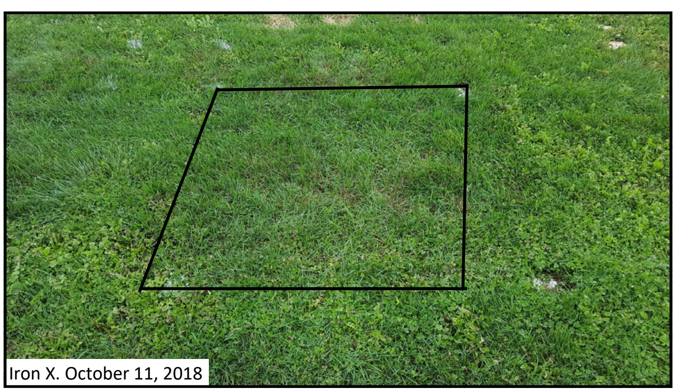

Iron X. October 11, 2018

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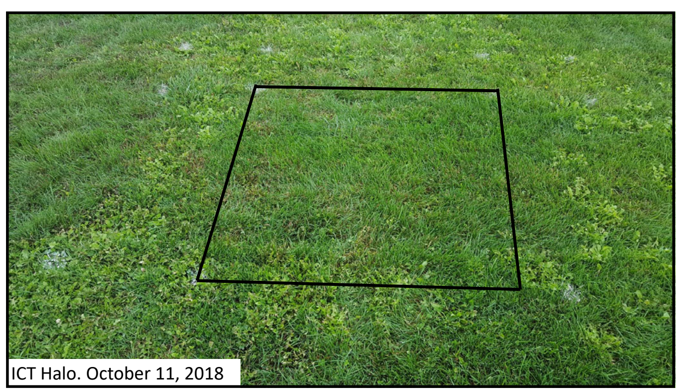

ICT Halo. October 11, 2018

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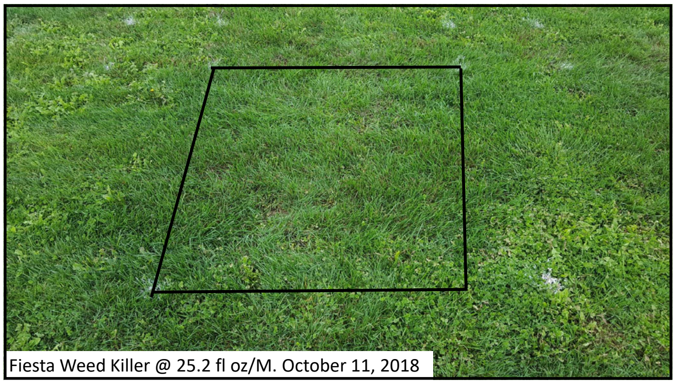

Fiesta Weed Killer @ 25.2 fl oz/M. October 11, 2018

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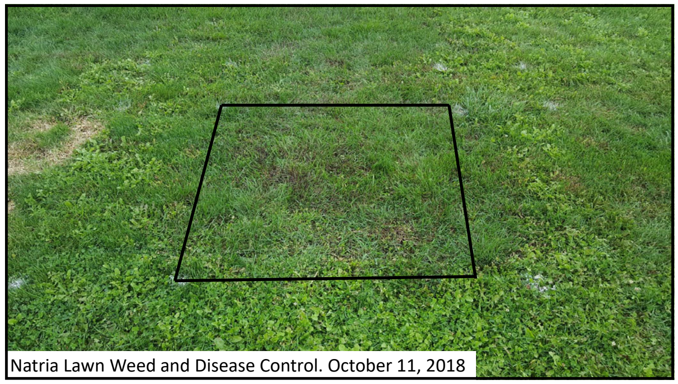

Natria Lawn Weed and Disease Control. October 11, 2018

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Materials and Methods

Spring Applications: May 4 and May 31, 2018 (4 weeks after initial treatment)
Fall Applications: September 13 and October 5, 2018

Product	Active Ingredient	Rate
Untreated Check	N/A	N/A
Iron X	26.52% Iron HEDTA	25.2 oz/M
A.D.I.O.S.	Sodium chloride + NIS	1 lb product
ICT Halo	Eugenol, Clove Oil	10 oz/M
Fiesta Weed Killer	26.52% Iron HEDTA	25.2 fl oz/M
Fiesta Weed Killer + Xiameter OFX-0309	26.52% Iron HEDTA and Silicon Adjuvant	12.6 oz/M
Natria Lawn Weed and Disease Control	26.52% Iron HEDTA	25.2 fl oz/M
Trimec Classic	2,4-D	4 pt/A
Borax	Boric Acid	Spray to runoff
EcoSmart Weed & Grass Killer	Rosemary Oil	Spray to runoff
AgraLawn Weed and Crab Killer	Cinnamon	Shake on foliage
Fiesta Weed Killer	26.52% Iron HEDTA	12.6 fl oz/M

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Conclusions

- Trimec Classic was always numerically the top performer for both trials
- Products containing iron HEDTA and ICT Halo often were statistically as effective as Trimec Classic
  - Iron X
  - Fiesta Weed Killer (full rate or w/ Xiameter)
  - Natria Lawn Weed and Disease Control
- When using most organics, multiple applications will be required
  - Unpublished UNL study showed significantly diminished effectiveness if no reapplication is made

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Cost Analysis

Product	Rate	Cost per 1000 sq. ft.
Untreated Check	N/A	--
Iron X	25.2 oz/M	$102.00
A.D.I.O.S.	1 lb product/gallon	$202.74
ICT Halo (name changed to Branch Creek Weed Shield)	10 oz/M	$6.58
Fiesta Weed Killer	25.2 fl oz/M	$16.73
Fiesta Weed Killer + Xiameter OFX-0309	12.6 oz/M	$38.78
Natria Lawn Weed and Disease Control	25.2 fl oz/M	$17.85
Trimec Classic	4 pt/A	$0.61
Borax	Spray to runoff	$5.00/ 64 oz
EcoSmart Weed & Grass Killer	Spray to runoff	$25/ 64 oz
AgraLawn Weed and Crab Killer	Shake on foliage	$23/ 2 lb
Fiesta Weed Killer	12.6 fl oz/M	$8.37

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Organic glyphosate alternatives (non-selective)

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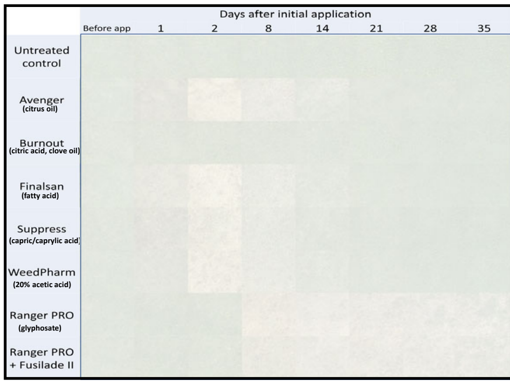

Organic alternatives to glyphosate applied to hybrid bermudagrass in central California

Credit: Maggie Reiter
@maggie_reiter
University of California Cooperative Extension

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Comparison of Acetic Acid to Glyphosate for Weed Suppression in the Garden

Jacob C. Domenghini[1]

ADDITIONAL INDEX WORDS. garden establishment, organic garden, vinegar

SUMMARY. Interest in organic vegetable gardening has increased in recent years. Organic growers are searching for alternatives to glyphosate for weed suppression. This study was conducted twice. Each data collection period lasted 132 days during the growing seasons of 2016 and 2017 in Richmond, KY. Treatments included application of glyphosate, vinegar [5% acetic acid (AA)], 20% horticulture grade vinegar (20% AA), 30% horticulture grade vinegar (30% AA), and a negative control. Treatments were applied in a factorial arrangement with two application periods (fall and spring or spring only). The percentage of weed cover within plots was evaluated visually with a 0–10 rating scale (0 – 0% weeds or 100% of the plot is dead; 5 – 50% weed growth; 10 – 100% of the plot is alive with weeds). All plots began the study with a rating of 10. After the initial treatment applications, visual ratings of the 5%, 20%, and 30% AA declined to a rating of 0 within 48 hours, whereas the glyphosate required 7 days (P – 0.05). Treatments were reapplied to part of the plots (subplots) in the spring when ≈50% of the plot had regrown with weeds. Glyphosate required 71 to 80.8 days to reach 50% regrowth and required only one retreatment. The 20% and 30% AA applications required three (2016) and four (2017) retreatments. Glyphosate has proven to be more effective at weed control in vegetable gardens when compared with vinegar, although 20% AA and 30% AA are viable alternatives.

control weeds globally (Malik et al., 1989). With conservation tillage systems, glyphosate is commonly applied before planting (Bruff and Shaw, 1992) and has been successful at controlling weeds with some residual control (Buhler and Werling, 1989; Wilson and Worsham, 1988). Several studies have evaluated the effectiveness of glyphosate at controlling weeds in crop production systems (Culpepper, 2006; Griffith et al., 2006; Norris et al., 2001; Shaw and Arnold, 2002), whereas others have compared glyphosate with natural products to control weeds (Abouziena et al., 2008; Patton and Weisenberger, 2012; Young, 2004).

Research of the use of natural products to control weeds before garden establishment with continued control throughout the growing season is limited. Additionally, research comparing the efficacy of weed suppression treatments applied in the fall for a spring garden compared to spring-only weed

Table 1. Summary of the weed control products with active ingredients and manufacturer sources used during weed suppression studies in 2016 and 2017 in Richmond, KY.

Weed control product	Product name	Concn in spray solution	Product source or manufacturer
Acetic acid (5%)	Great Value distilled white vinegar	Undiluted	Walmart, Bentonville, AR
Acetic acid (20%)	Natural safe 20% vinegar	Undiluted	Factory Direct Chemicals, Long Island, NY
Acetic acid (30%)	Natural safe 30% vinegar	Undiluted	Factory Direct Chemicals
Glyphosate	FarmWorks 41% glyphosate plus	1.6% a.i.	Ragan and Massey, Ponchatoula, LA

- Results indicated that glyphosate, when compared with AA, is the more effective weed suppression method.
- Although all three AA treatments (5%, 20%, and 30%) initially damaged weeds faster than glyphosate, AA did not control weeds for an extended period like glyphosate.
- The 20% and 30% AA applications required 3 to 4 treatments for equivalent control to glyphosate.

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Organic weed control synopsis

- Pro's
  - Viable options available, with research ongoing
  - Market or regulatory niche products
- Con's
  - Product cost
  - Labor cost
  - Contact vs systemic
  - More applications
  - Selectivity
  - Efficacy

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Turfgrass Weed Control for Professionals

https://mdc.itap.purdue.edu/item.asp?Item_Number=TURF-100

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Other resources:

- http://www.mobileweedmanual.com/ Jim Brosnan, Ph.D.

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Liquid/Foliar Nutrition, biostimulants

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Spray Solution Effects on Foliar Uptake

- Surfactants/Adjuvants
  - Beneficial to critical
- pH
  - Slightly acidic to neutral

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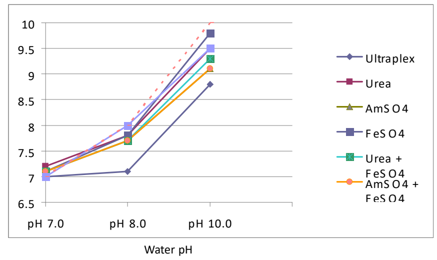
Liquid fertilizer effects on spray solution pH



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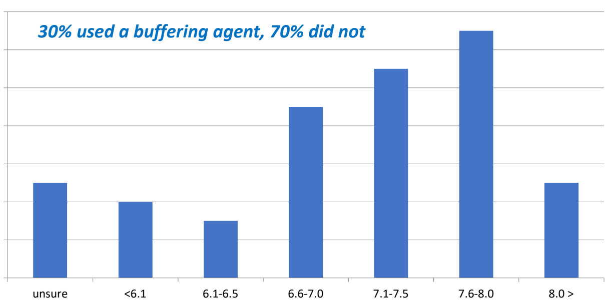
Survey of 100+ superintendents across the US

pH of H20 used for liquid application



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SECONDARY UTILITY ADJUVANTS

Acidifying Agent. An acidifying agent is defined as "a material that can be added to spray mixtures to lower the pH" (ASTM 1995). Typically, acidifying agents are dilute solutions of strong acids. They will rapidly lower the pH of the spray solution. However, because they are strong acids, the pH of the spray solution will rise if alkaline-based products are added to the spray solution.

Buffering Agent. A buffering agent is defined as "a compound or mixture that, when contained in solution, causes the solution to resist change in pH, with a characteristic limited range of pH over which it is effective" (ASTM 1995). Both buffering agents and acidifying agents will reduce spray solution pH. A buffering agent will maintain a pH range of the spray solution when other acid- or alkaline-based materials are added to the spray solution, whereas an acidifying agent will not maintain the spray solution pH. Buffering agents have a characteristic pH range that they will maintain, and they vary in buffering capacity.

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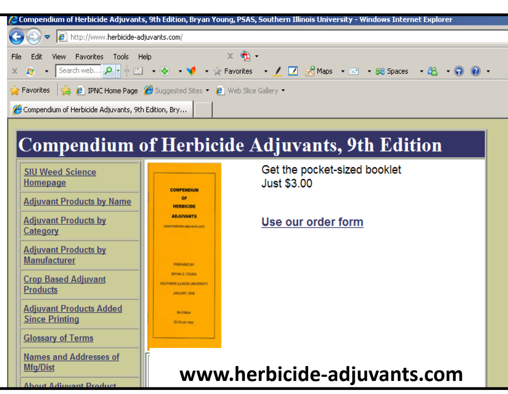

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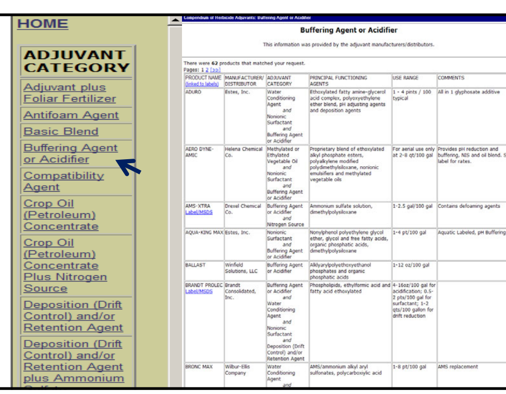

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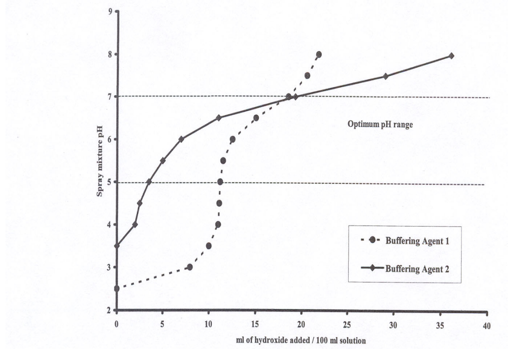

Figure 2. Spray mixture pH as influenced by buffering agent and caustic added. Adapted from Roberts et al. (1997).

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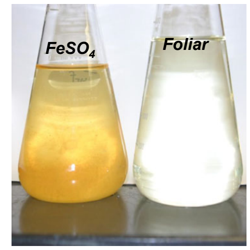
Precipitate Formation

- $FeSo_4$ = precipitate at pH = 8 & 10
- Foliar (buffered) solution no precipitate
- Weight equaled ca. 60% of what was initially dissolved
- In 100 gallons = ca. 0.25 lbs



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How do you know if you need a buffering agent?

- Recommended on label
- pH >7.5
- Tank mixing multiple products

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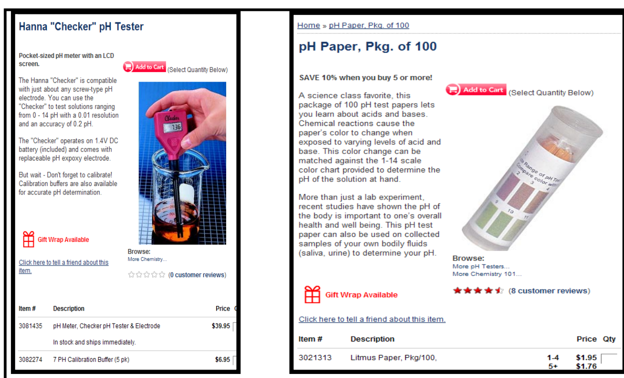
How do you know your spray solution pH?

- Measure it, but how?
  - How accurate do you need to be?
  - When should you test?
- For some water sources, pH fluctuates with season, test frequently

58



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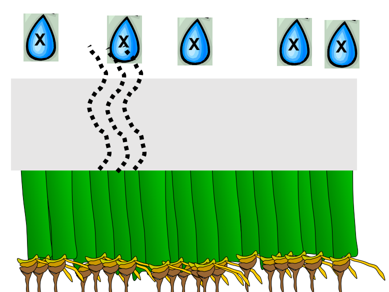


60

Uptake of Foliar Nutrients on a Putting Green

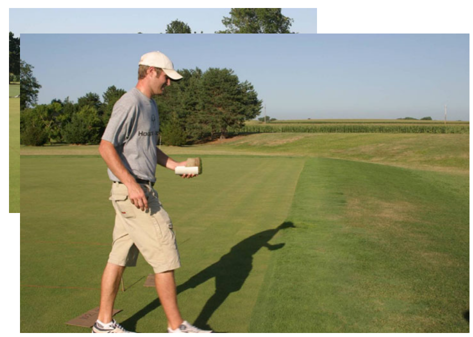
- Conducted in in Nebraska (L-93)
- Conducted in Nebraska, Michigan (Poa & Bent)
- Univ of Nebraska, Michigan State Univ (Kevin Frank)
- 3 Treatments
- 2 times of year (cool vs. hot)
- Not with radio-isotopes
  - **“uptake by subtraction”**

61

California green, L-93, 3 years old, 0.11 mowing height

62

63



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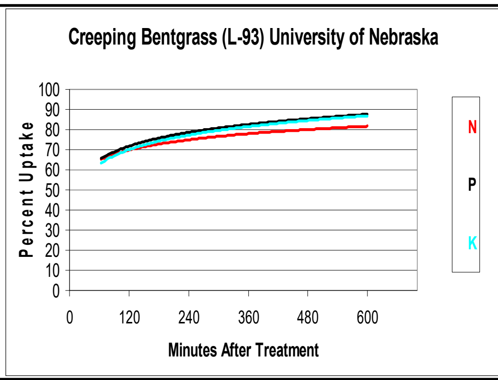
67

- amount applied per unit area (from food saver)
- amount in untreated (from wash)
-amount in wash
= *(amount absorbed)*

68



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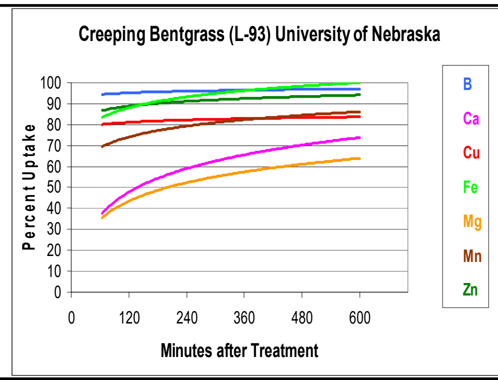

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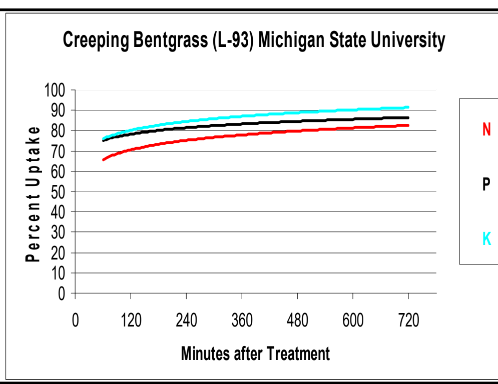

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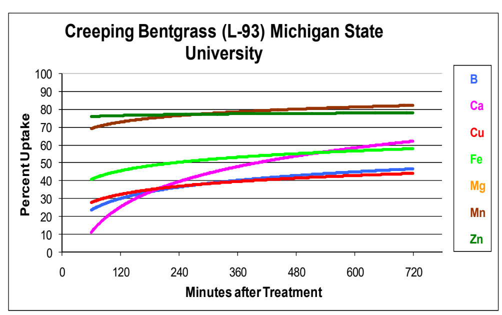

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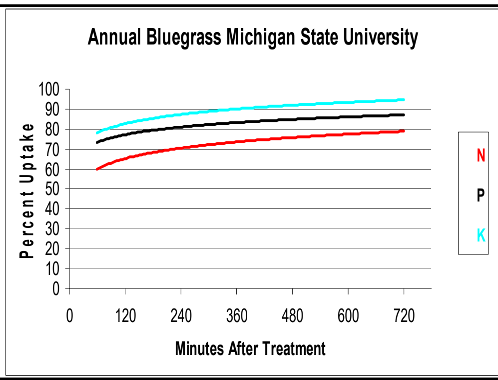

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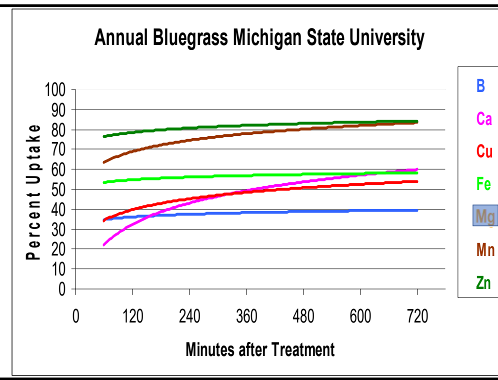
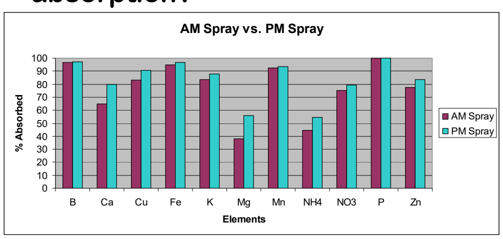


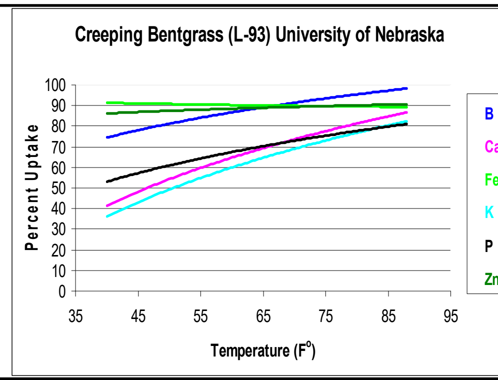
74

Does spraying time affect absorption?



AM Spray = 52^{O} F, PM Spray = 71^{O} F

75



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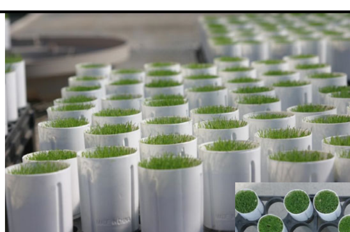
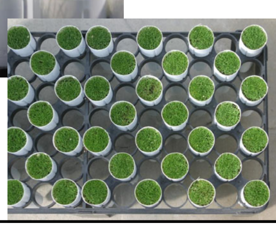


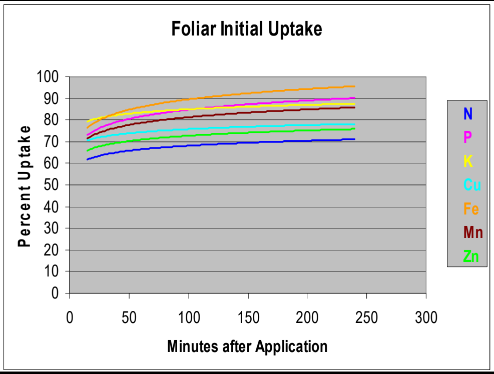


Work was also done in greenhouse under controlled conditions

77

How quickly can the nutrient get into the leaf?
Does shade or cultivar affect absorption?

78



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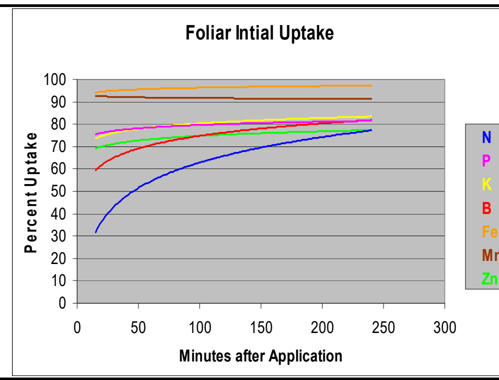

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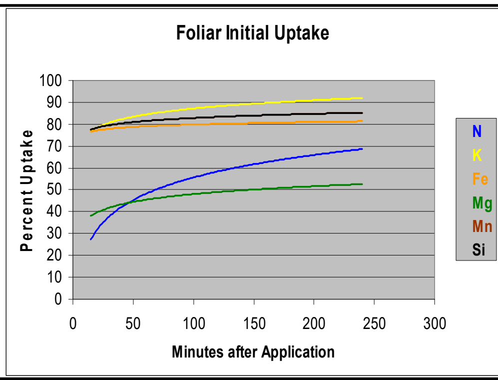

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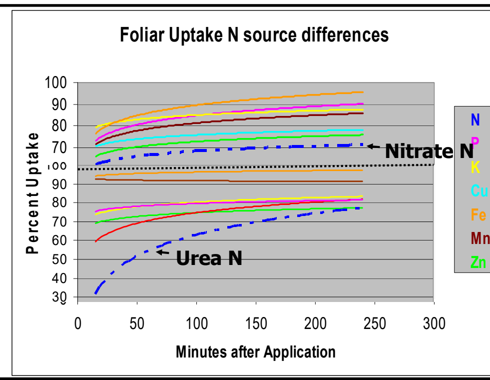


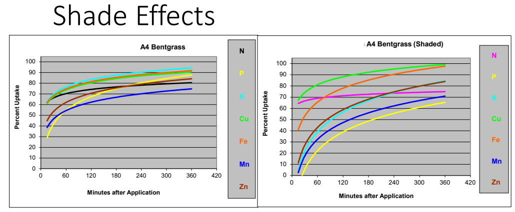
82

How quickly does the nutrient get into the leaf?

- Intake is rapid, often within 15 minutes
- Carrier will influence speed

83

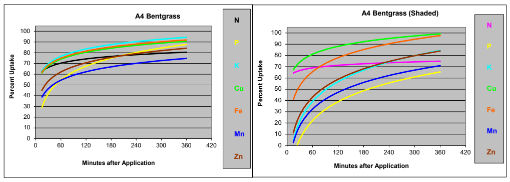
Shade Effects



		no shade	shade
15 minutes	N	65	65
360 minutes		81	77
15 minutes	P	30	0
360 minutes		88	65
15 minutes	K	65	5
360 minutes		92	85

84

Shade Effects



% uptake @		no shade	shade
15 minutes	Cu	60	68
360 minutes		91	99
15 minutes	Fe	62	40
360 minutes		92	98
15 minutes	Mn	38	5
360 minutes		75	70
15 minutes	Zn	45	11
360 minutes		85	83

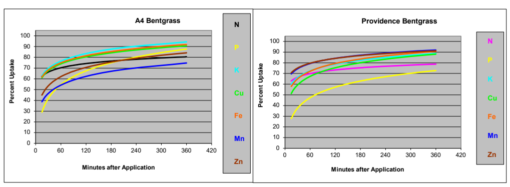
85

Shade Effects

- Initial uptake (i.e. first 15 minutes) is impeded by shade
- Shaded turf (@ 6 hrs) is at or near un-shaded
- Shaded turf should be mowed first, delay irrigation or mowing if possible

86

Cultivar Effects



% uptake @		A4	Providence
15 minutes	Cu	60	55
360 minutes		91	89
15 minutes	Fe	62	58
360 minutes		92	92
15 minutes	Mn	38	70
360 minutes		75	91
15 minutes	Zn	45	58
360 minutes		85	91

87

Cultivar Effects

- For some nutrients, the denser cultivar delayed or slightly impaired uptake (density?)
- This was especially true of Mn
- A good spreading agent may eliminate this impairment

88

Complexing and Chelating Agents

- **Process removes the positive charge from the metals, allowing the neutral or slightly negatively charged, chelated molecule to slide through the pores on the leaf and root surface more rapidly.**
- **These pores are negatively charged, so there is a problem with fixation of positively charged minerals at the pore entrance.**
- **No barrier for the neutral mineral.**

89

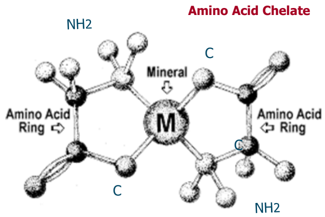
Complexing and Chelating Agents

- **“Organic Facilitators” have the capacity of binding substantial amounts of metals and other nutrients.**

90

Amino Acid Chelate

Form a very strong bond



91

Why Use Properly Chelated Products?

- **Compatibility and stability mixing with other nutrients and products**
- **They are better absorbed because they are non-ionic**
- **Protects nutrient from falling out (precipitating) and assists in plant uptake and translocation**

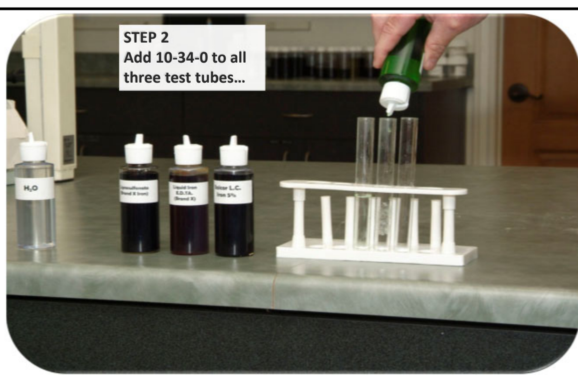
92

Why use properly chelated products?

A CHELATION DEMONSTRATION

93

94



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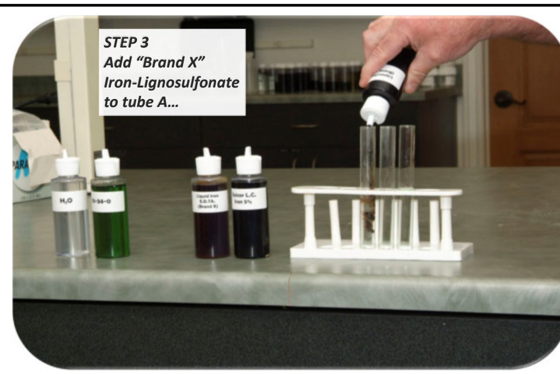

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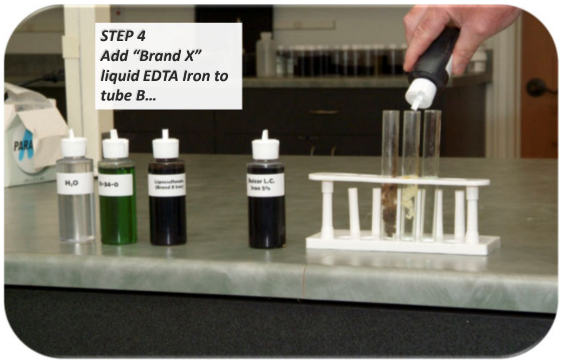

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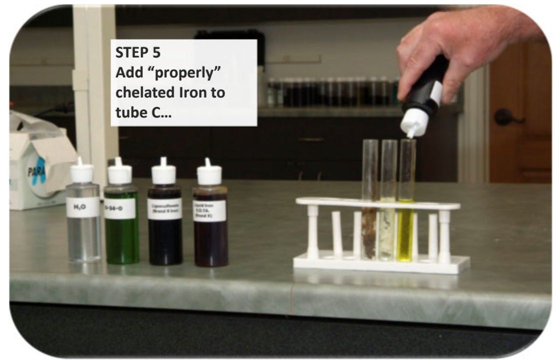

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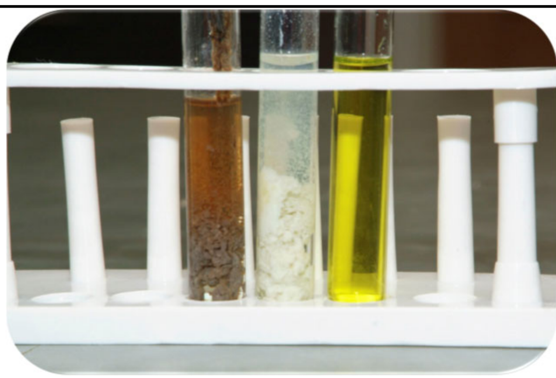


99

Label Summary

- Look for evidence of organic chelating/complexing agents
- Look for presence of or compatibility with a buffering agent
- Look for compatability with PGR's, fungicides etc.
- ***Ask for data***

100

Increase in absorption for foliar vs soluble for nutrients statistically different

	N	Fe	Mn	Cu	B	Ca*	Mg*
Bent UNL	*4.4X*	*1.3X*	*2.8X*	*1.4X*	*19.2X*	*72%*	*61%*
Bent MSU	*1.3X*	*5.3X*	*3.5X*	*NS*	*4.0X*	*62%*	*NA*
Poa MSU	*1.4X*	*8.0X*	*7.9X*	*NS*	*4.0X*	*61%*	*NA*

Not in soluble product; data indicates maximum absorption
NA = not applied

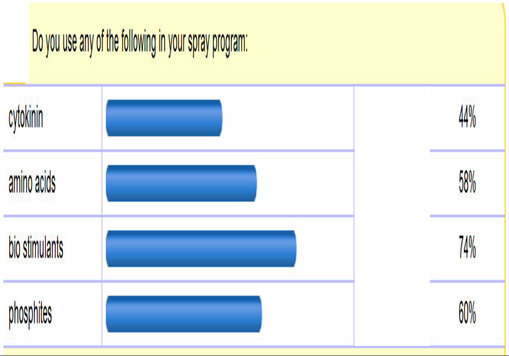
In all elements the increase in efficiency was always attributed to the foliar product (of the products tested)

101

Could you "create" your own foliar product?

- Maybe, but why?
- Soluble, granular and foliar fertilizers can all be used to fine tune management options.
- In the current economy reducing costs is critical.
- Choose the cost reduction that will have the most economic benefit and least agronomic deficit.

102



103

Elicitors

- **Elicitors are molecules that stimulate plant defense mechanisms**

104

Literature Review

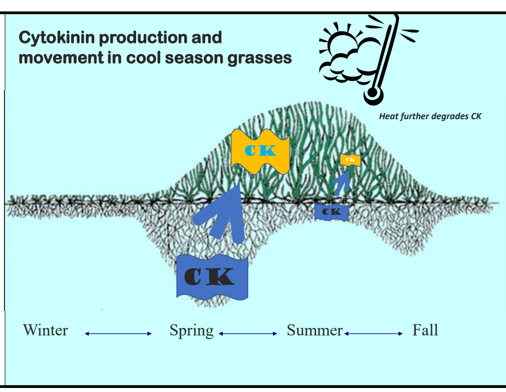
- **Elicitors that have been identified include phytoalexins, specific amines or amino acids, carboxylic acids, phosphites, silicon, glycoproteins and oligosaccharides, peptides, jasmonic acid, salicylic acid, sugar analogs and others...........**
- **AKA- phytohormones, biostimulants and snake oils.**

105

<u>Cytokinins</u> (CK) are a class of plant growth substances (plant hormones) that promote cell division. They are primarily involved in cell growth, differentiation, and other physiological processes. Their effects were first discovered through the use of coconut milk in the 1940s by a scientist at the University of Wisconsin–Madison named Folke Skoog.

Cytokinins are involved in many plant processes, including cell division, shoot and root morphogenesis, chloroplast maturation, cell enlargement, auxiliary bud release and senescence. The ratio of auxin to cytokinin is crucial during cell division and the differentiation of plant tissues

106



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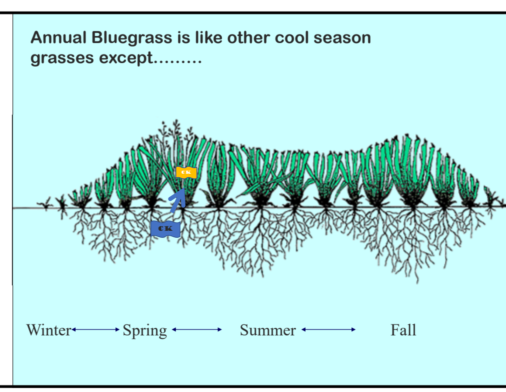


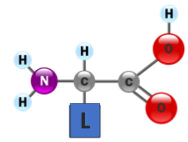
108

Cytokinin Summary

- Early research was very inconsistent
- Better understanding resulted in fine tuning recommendations
- Seaweed is very high in CK hence seaweed extract products are plentiful

109

<u>**Amino acids**</u> are molecules containing an amine group, a carboxylic acid group and a side chain that varies between different amino acids.
These molecules are particularly important in biochemistry, and have many functions in metabolism. One particularly important function is as the building blocks of proteins, Amino acids are also important in many other biological molecules, such as forming parts of coenzymes, and in N transport

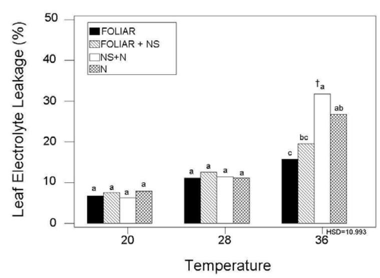


110

Activity of Foliar Macro-Sorb Amino Acids

- **Gordon Kauffman, Ph.D. (Penn State)**
- **perennial ryegrass**
- **"ramped" temperature stress (68-97^0 F)**
- **Treatments:**
  - **FOLIAR**
  - **FOLIAR plus nutrient solution (NS)**
  - **NS + an equivalent amount of N contained in FOLIAR**
  - **NS + N**
  - **N**

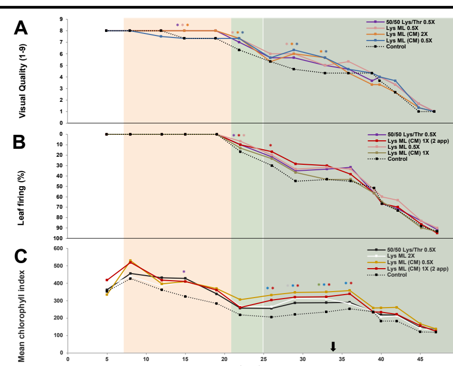
111



112

36^0 C (97^0 F)

113



114

Amino Acids

- **When environmental conditions are optimal the plant produces more than adequate AA's**
- **Under heat and drought stress production is severely limited**
- **Much like CK topical applications during stress will be beneficial**

115

AA & CK are not "true" elicitors

- Like an IV…….

116

Phosphites

- **Phosphite salts are documented to increase plant health and resistance to numerous soil borne pathogens.**

117

Phosphites

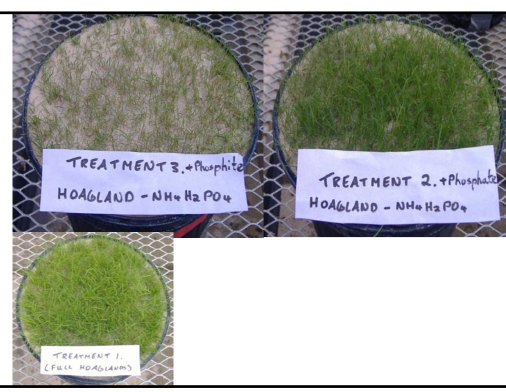
- **Phosphite (H_2PO_3) differs from Phosphate (HPO_4) in that one O atom is replaced by one H atom.**
- **There are many salts of phosphites.**
- **Phosphite salts are registered as fungicides and several are used in liquid nutrient formulations.**

118

Phosphites

- **Research shows that the phosphites do have a direct effect on plant health and restrict some pathogens.**
- **Research shows phosphites do not provide phosphorous nutrition and some research that suggests in the absence of good P fertility phosphites may be detrimental to plant growth.**

119



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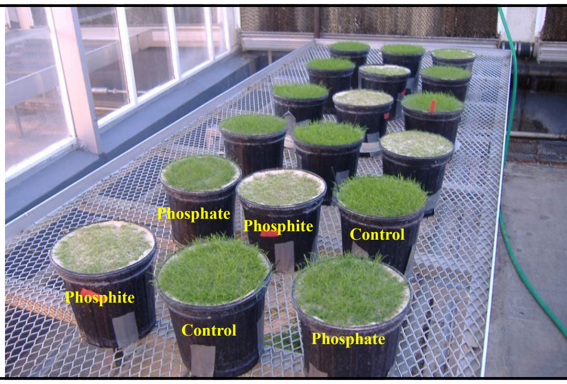


121

Phosphites have also been shown to:

- Suppress diseases
- Increase plant health

122

Silicon

- The positive properties of silicon against plant disease have been recognized for centuries.
- Several researchers are now looking at recent evidence that silicon may also induce 'systemic acquired resistance' in plants, sometimes referred to as SAR.

123

Silica for Increased Ball Roll and Traffic Tolerance

124

Treatments

- 3 commercial products
- 3 technical grade materials
- 2-3 rates of each material
- Silica containing material
  - 0.2 to 85 g Si per 1000 ft^2
- Applications made every 14 days
- Stimpmeter (Ball Roll Distance) 1 and 3 DAT
- Traffic tolerance with traffic simulator

125

- Treated Control
  - 22g Na
  - 26g K
- Tech Grade #1-2
  - 43 or 85g Si
  - 12 or 24g Na
- Tech Grade #3-4
  - 43 or 85g Si
  - 31 or 62g K
- Tech Grade #5-6
  - 43 or 85g Si
  - 37 or 74g K
- Ocean Organics #1-6
  - 2 formulations
  - 8, 16 or 32g Si
  - Other stuff
- Floratine #1
  - 43g Si
  - ~0.4 g K
  - Other stuff
- Grigg Bros. #1
  - 1.1g Si
  - 26g K
- Grigg Bros. #2
  - 0.2g Si
  - 26g Ca
- Grigg Bros. #3
  - 0.9g Si
  - 17g Ca
  - 17g K

All Rates per 1000 ft^2

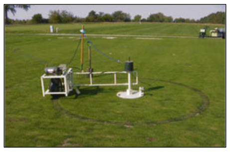
126

Results

- No differences between
  - Ball Roll Distance
  - Color
  - Quality

127

Traffic Simulator



128

Traffic Results

- No differences among treatments for increased traffic tolerance or recovery unless K was the carrier

129

Wear Tolerance

- Spraying potassium silicate at 1.1 and 2.2 kg Si/hectare or soil applying (drench) at 22.4 kg Si/hectare
- Wear injury was reduced about 20% on two greens-quality ecotypes of Seashore paspalum
- However, potassium alone or together with Si produced the same effect.
- Little evidence that Si alone enhanced wear tolerance

Trenholm et al., 2001

130

Silicon – Take Home

- **There is an "*observed*" increase in structural rigidity of turf well supplied with Si. This is the primary reason for its use on putting greens. Structural rigidity "*may*" increase green speed without lowering cutting height.**
- **Mowing quality is also "*observed*" to increase**
- **Evidence exists that there is greater resistance of plants well supplied with Si to fungal attack.**

131

Sports Turf Grow-In Experiment

132

Experimental Process

- **Solicited cooperators**
  - Follow each company's recommended protocol
  - Included treatments to separate out each component of each protocol
- **Kentucky bluegrass blend**
- **90:10 Spec. sand:Dakota Reed Sedge Peat**

133

- **Two planting dates:**
  - July 9, 2003 (Suboptimal)
  - September 22, 2003 (Optimal)
- **37 treatments; 111 plots**
- **Analyze**
  - Fertilizer
  - Mycorrhizae
  - Biostimulant

134

Treated Control Andersons Golf Products

- **Preplant incorporated**
  - 21-3-20 Poly S
  - 16-25-12 Poly S
  - A-TEP Hi-Mag
    - 3.3#N, 2.5 #P, 2.4 #K / 1000 ft^2

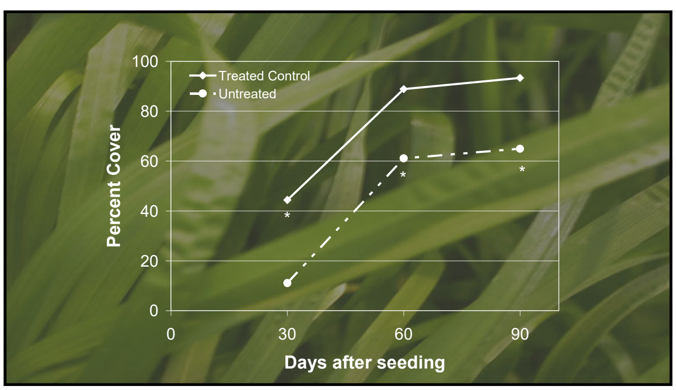
  Weekly applications after germination
  - 17-3-7
    - 0.8 #N / 1000 ft^2
- **Also used in combination with other products**

135

Other treatments included:

- **Mycorrhizae (Mix with seed or PPI); biostimulants; organic carriers; biologicals etc.**

136



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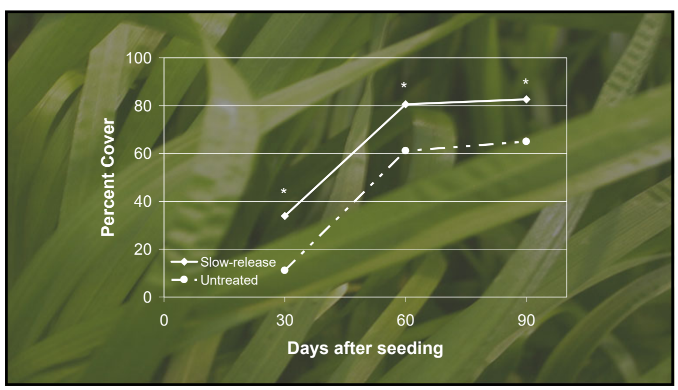

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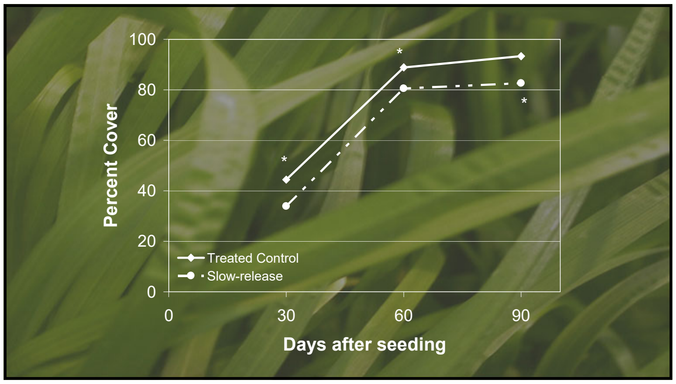

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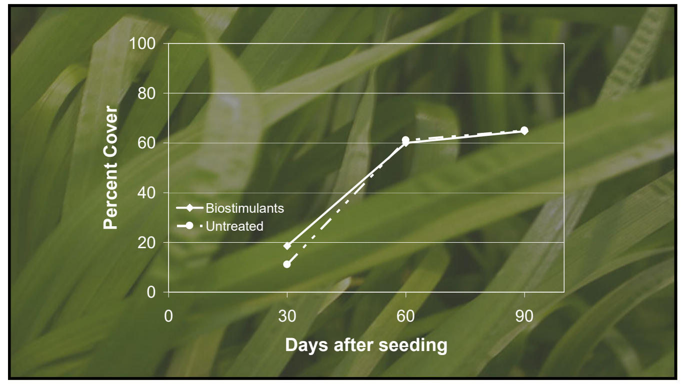

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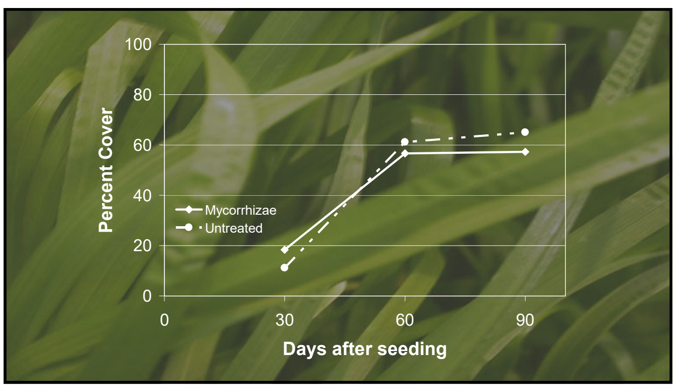

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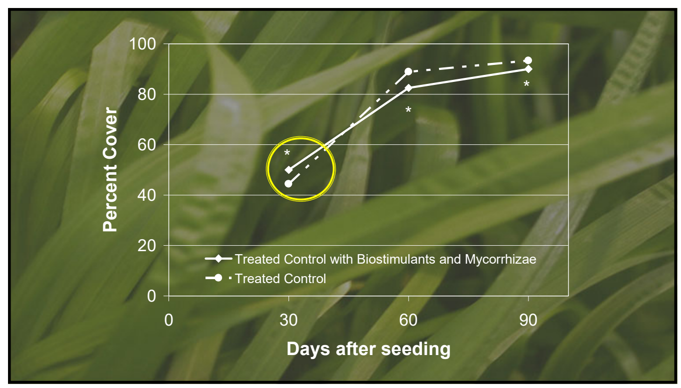

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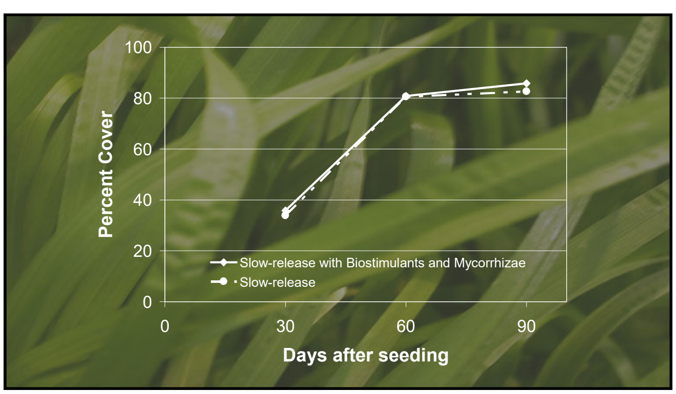

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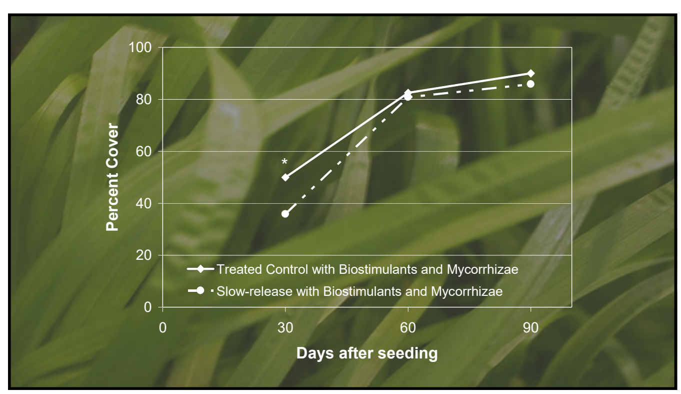

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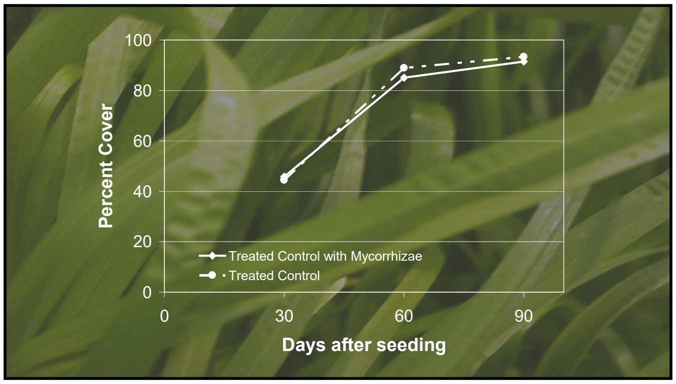

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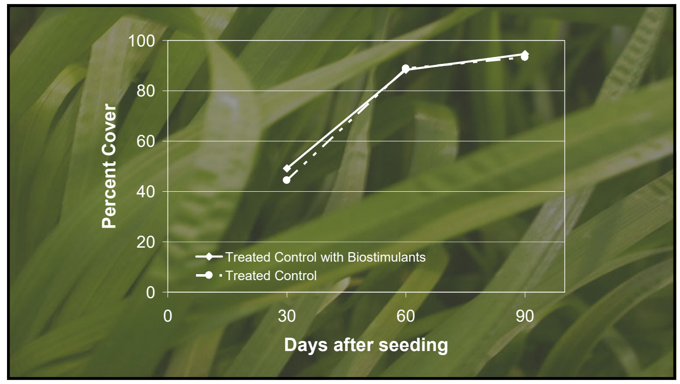

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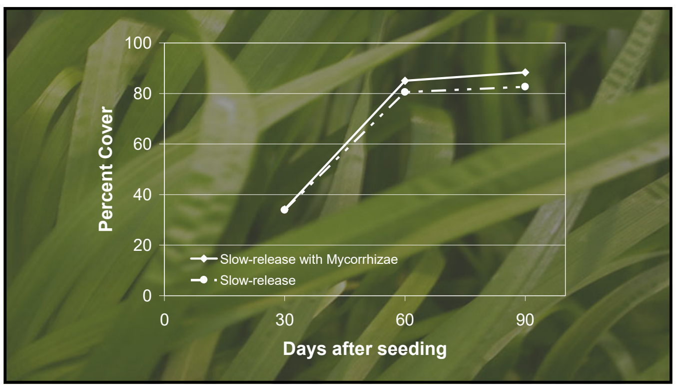

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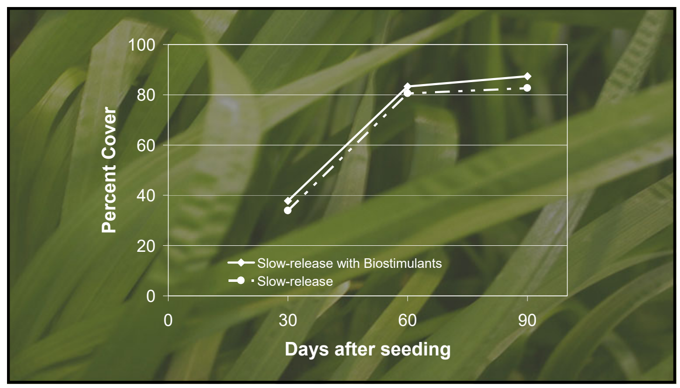

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Bottom Treatments

1. **Untreated**
2. **Mycorrhizae and/or biostimulant alone or in combo with synthetic fertilizer**

Mycorrhizae and/or biostimulant did not significantly speed up establishment

149

Bottom Line *for Establishment*

- **Amount of N and P applied**
  - **At establishment**
  - **During first 30 days after germination**
- **Readily available fertilizers provide best establishment**
  - **Quick vs. slow release**
- **Little benefit was realized from mycorrhizae, biostimulants or foliar fertilizers**

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Organic Matter Management

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"the solution to pollution is dilution"

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Charlie Goode
@GoodeTurf

#11 Green is being renovated currently. Originally constructed on native soils in 1919, it's finally getting its USGA makeover. Awesome to see what 100+ years of rootzone looks like. Lots of variety in top dressing habits over the decades. #layers

4:56 PM · May 3, 2021 from Pebble Beach Golf Links · Twitter for iPhone

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Todd Lowe
@TloweTgrass

I saw this on Facebook last night and had to share it here as well (thanks, @explorerman). From a 25-year old green in SFL. Note the original USGA-spec mix on bottom and 25 years of growth above. Last six years have seen black sand topdressing in upper horizon. Incredible image!!

10:14 AM · Jul 8, 2020 · Twitter for iPhone

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<u>Chapter 12</u> ASA Monograph (3RD Edition)

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

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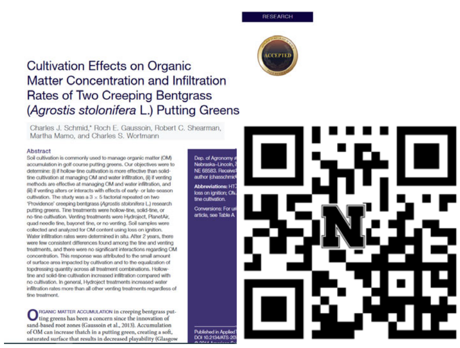

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~~The~~ *My* organic matter journey……

- USGA/EIFG Greens Study (9 years).
- People a lot brighter than me
  - "Talking Turf" GCSAA conversation.
  - Paul Rieke, USGA visit
  - Conversation with Paul Vermeulen. Director, Competitions Agronomy at PGA TOUR, former USGA Agronomist.
- Great funding/time support from USGA/EIFG (initially), NE-GCSA, GCSA of SD, Peaks and Prairies GCSA, industry and a slew of GC supers.
- Road Show.

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Physical properties of sand-based root zones over time

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Objectives

- Develop a better understanding of the impact of grow-in procedures on putting green establishment and performance.
- Investigate temporal changes in the soil physical properties of USGA putting greens.

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Materials and Methods

- Field experiment initiated in 1997
- Greens constructed every year for four years
- Two rootzone mixtures
  - 80:20 Sand:Peat (v:v)
  - 80:15:5 Sand:Peat:Soil (v:v:v)
- Two establishment treatments
  - Accelerated
  - Controlled

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Soil Parameters

Sample	% Soil Separates			Saturated Conductivity	%OM
	Sand	Silt	Clay	cm/hr	
80-20	98.9	0.8	0.3	31	1.04
80-5-15	97.4	2.2	0.4	20.7	0.75
USGA Specs		<5%	<3%	14-56	0.7-3

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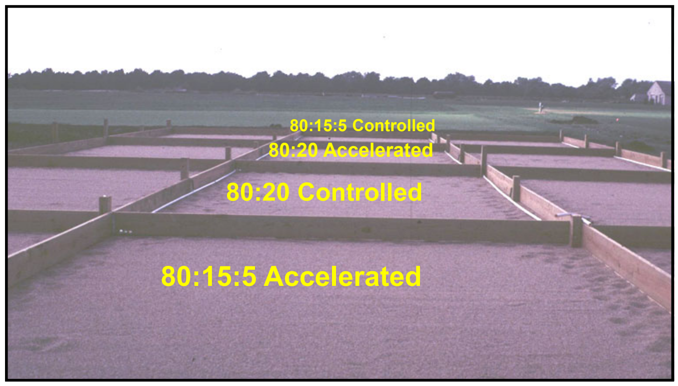

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Project Schedule (Phase I)

1996 | 1997 | 1998 | 1999 | 2000

Greens construction (one set per year)

Seeding

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

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Project Schedule (Phase II)

2002 | 2003 | 2004 | 2005

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

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Data Collection

- Soil Physical
  - Ksat, bulk density etc.
- Soil Chemical
- Soil Microbial
  - biomass, stability
- Agronomic
  - surface hardness, ball roll, quality etc.

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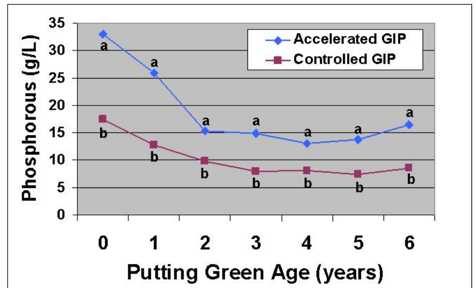

Figure 6. Effect of grow-in procedure (GIP) on phosphorous (P) in the upper 15cm (6") of USGA-specification root-zones. Means are averages of 80:20 and 80:15:5 root-zone mixes because rot-zones were not significantly different. Data means within years with different letters are significantly different based on Fishers Protected LSD (P=0.05).

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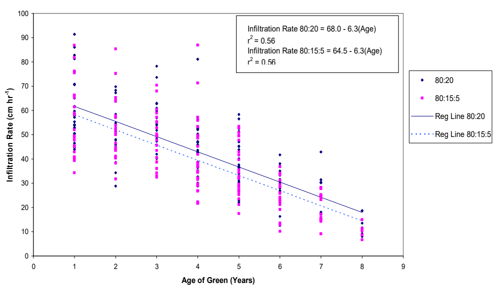

Figure 1. Data points and regression lines of infiltration rate decline on USGA specification putting greens at Mead, NE. Rootzones were an 80:20 (v:v) sand, and sphagnum peat mixture and an 80:15:5 (v:v) sand, and sphagnum peat, soil (Tomek silty clay loam) mixture.

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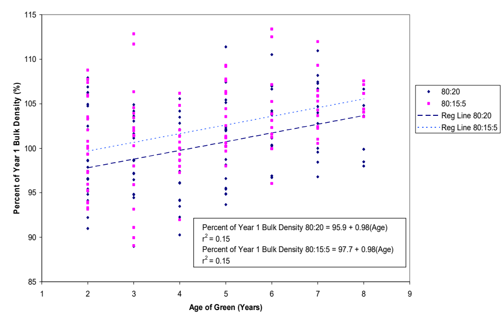

Figure 2. Data points and regression lines of the percent change of bulk density compared to year 1 values of USGA specification putting greens rootzones at Mead, NE. Rootzones mixtures were an 80:20 (v:v) sand, and sphagnum peat mixture and an 80:15:5 (v:v) sand, sphagnum peat, and soil (Tomek silty clay loam) mixture.

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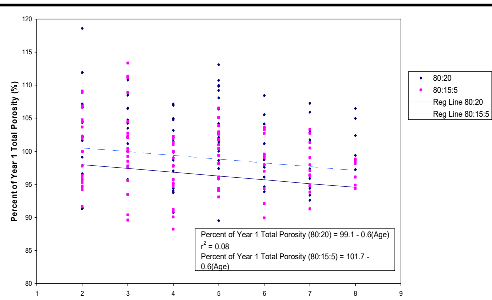

Figure 4. Data points and regression lines of the percent change of total porosity compared to year 1 values of USGA specification putting green rootzones at Mead, NE. Rootzones were an 80:20 (v:v) sand, and sphagnum peat mixture and an 80:15:5 (v:v) sand, sphagnum peat, and soil (Tomek silty clay loam) mixture.

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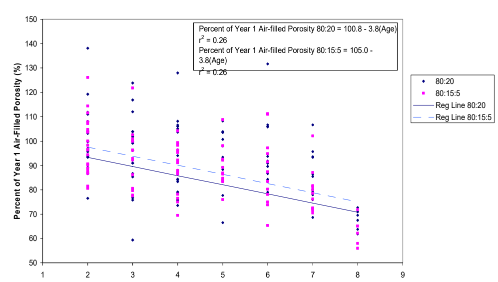

Figure 3. Data points and regression lines of the percent change of air-filled porosity compared to year 1 values of USGA specification putting green rootzones at Mead, NE. Rootzones mixtures were an 80:20 (v:v) sand, and sphagnum peat mixture and an 80:15:5 (v:v) sand, sphagnum peat, and soil (Tomek silty clay loam) mixture.

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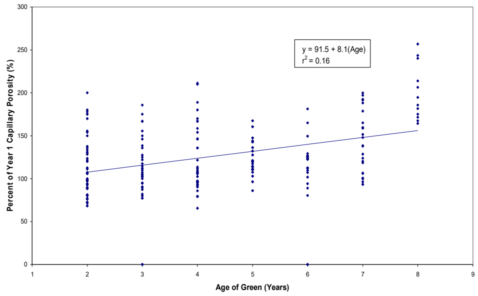

Figure 5. Data points and regression line of the percent change of capillary porosity compared to year 1 values of rootzones of USGA specification putting greens located at Mead, NE. Rootzones were an 80:20 (v:v) sand, and sphagnum peat mixture and an 80:15:5 (v:v) sand, sphagnum peat, and soil (Tomek silty clay loam) mixture. Rootzone material was not significantly different for percent change of year one capillary porosity (p=0.05).

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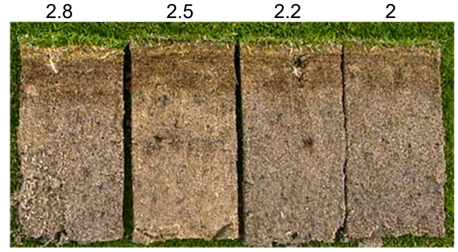
Mat development (cm)

2.8 2.5 2.2 2



8 7 6 5

Green age (years)

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Formation of Mat

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

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

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Materials and Methods

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

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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.

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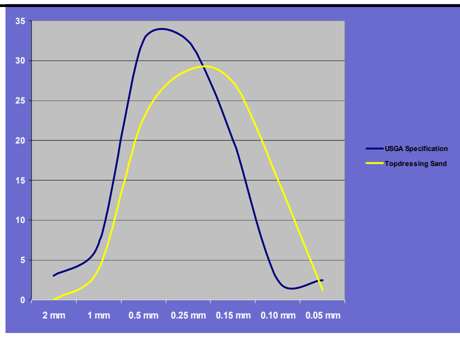

USGA sand specifications compared to sand used in topdressing program for USGA plots at Mead, NE.

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Conclusions

- Based on *in situ* green testing K_{SAT} decreased over time due to organic matter accumulation above the original rootzone.
- Original rootzone K_{SAT} decreased over time due to increased fine sand content originating from topdressing sand.

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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.

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Organic Matter Management

- Is accumulation a "bad" thing??
- Is core aeration the answer??

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Clarification/over-simplification *regarding OM Management* on sand based rootzones

- One size does not fit all
- The universal optimal % OM has not been scientifically determined and may be mythical
- Methodology & sampling differences exist and must be considered
  - *Help is on the horizon (USGA OM Brain Trust)*
- Cultivation is critical to increase efficiency in sand incorporation
- Solid are not different than coring tines
- The benefits of topdressing continue to be identified.

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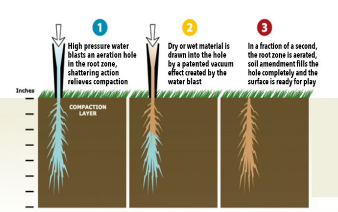
DryJect



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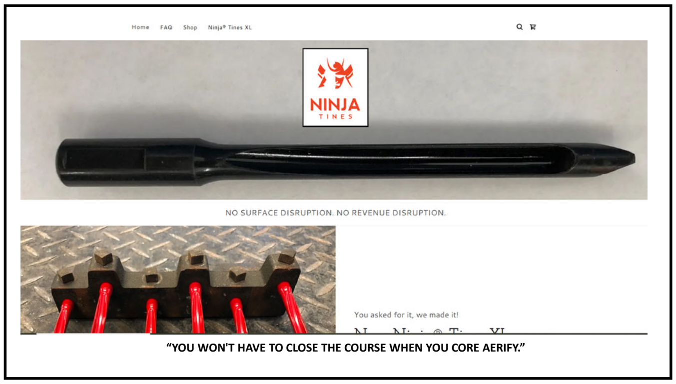

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GRIGG

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