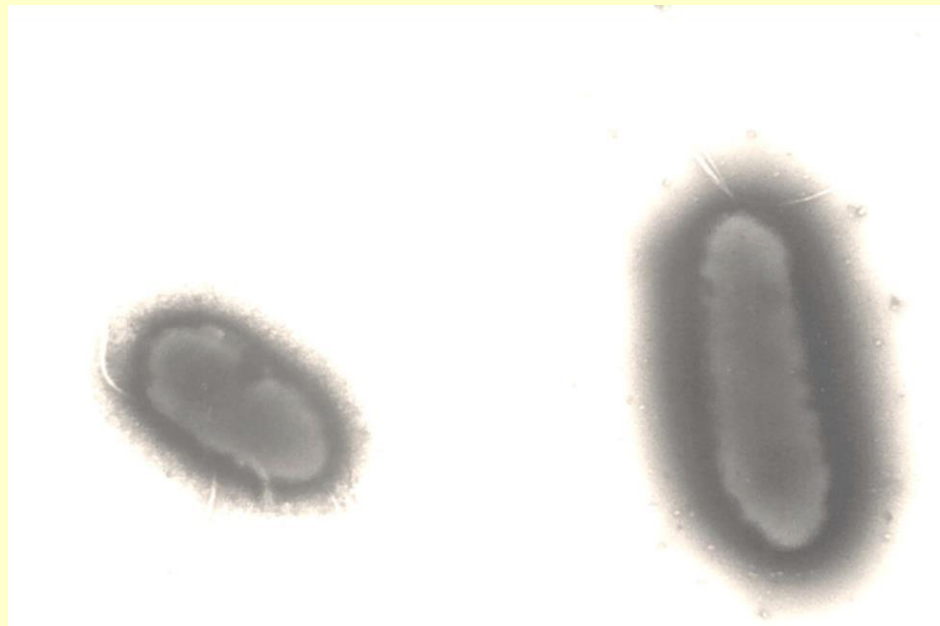


Biocontrol of *Poa annua*

W. J. Johnston and C.T. Golob
Crop & Soil Sciences
Washington State University

2017 NTA Conference
Suncadia, WA
Oct. 1 – 3, 2017



‘D7’ biocontrol – How it all started

Poor growth of winter wheat in spring

(Lloyd Elliott)



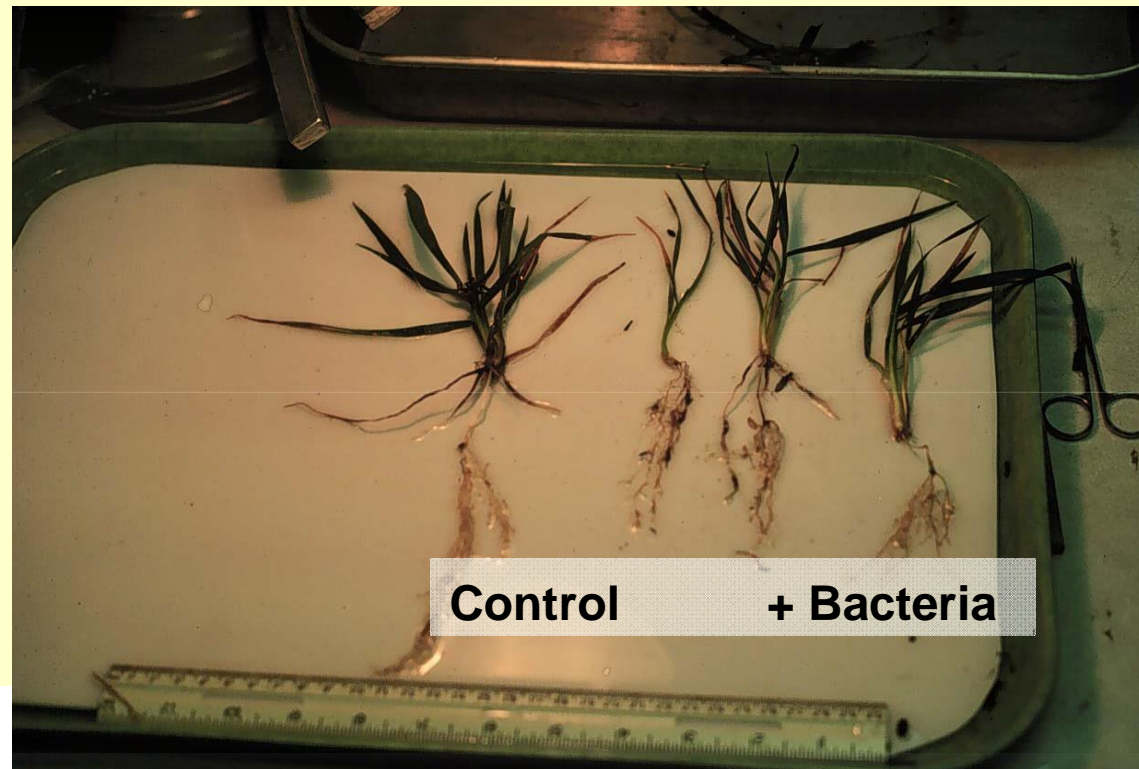
Yellow winter wheat

Poor growth of winter wheat in spring

High numbers of *Pseudomonas* on roots

Toxin was selective against cultivars (Elliott)

- **What
about
grass
weeds?**



Weed-suppressive bacteria

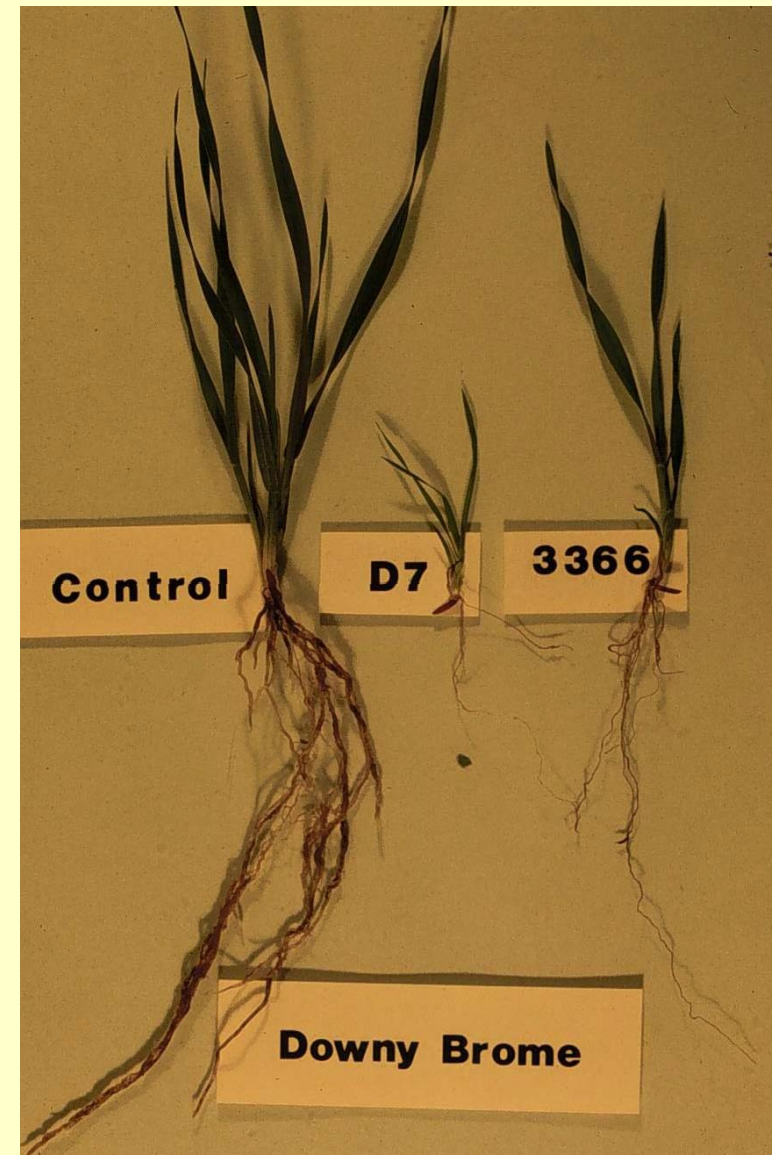


- Colonize residue/root
- Survive well at low temperatures
- Not competitive at warm temperatures
- Go dormant during hot, dry summer
- Produce plant-suppressive compounds
- Members of the genus *Pseudomonas*

Research by Ann Kennedy, USDA, WSU

Plant-Suppressive Compounds

- No visible lesions
- No signs of pathogenicity
- Inhibit root cell elongation
- Interrupt tiller initiation
- Root stunting
- Reduce seedling vigor
- Reduce tiller number
- Reduce seed number



***P.f.* D7 colonization of root**

P.f. D7 on wheat seed



Ritzville
downy brome-top

***P.f. D7 is carried
down wheat root,
intercepts and grows
down downy brome root***

***Pseudomonas fluorescens* strain D7**



Active Compound(s):

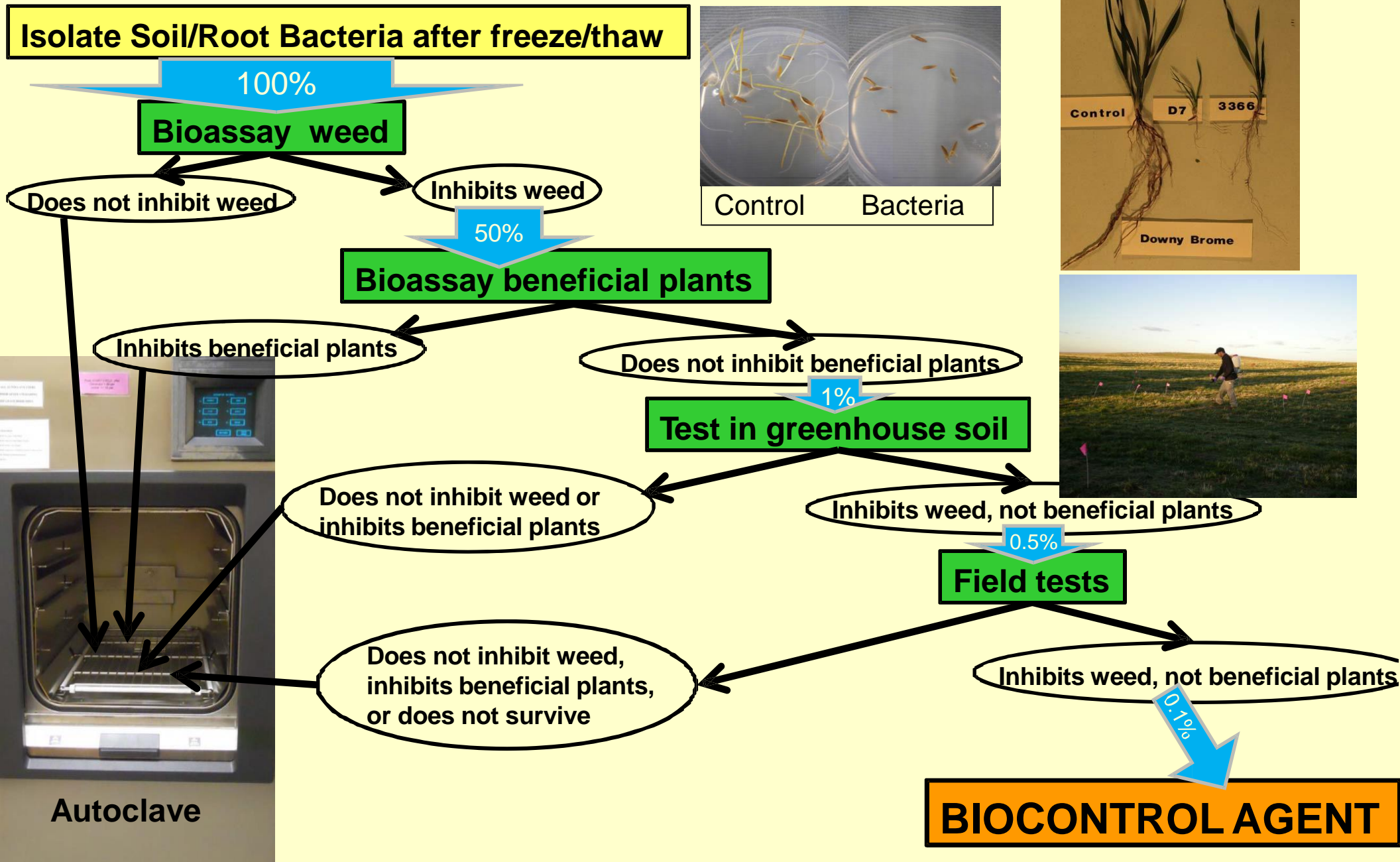
Chromopeptide, peptides, fatty acid esters & polysaccharides

All must be present for activity

Reduces lipopolysaccharide production - No cell elongation

Genes: Multiple loci
(very unlikely to mutate)

SCREENING >10,000+ isolates



D7 - Good match for biocontrol

**Bacteria produces
selective toxin
at low temperatures
that inhibits root growth**

**Reduces competitiveness
of weed in fall and spring
Allows other plants to be more
competitive**



Species inhibited by *P.f.* D7

Greenhouse studies

Downy brome

California brome

Mountain brome

Jointed goatgrass

Medusahead

Bromus tectorum

Bromus carinatus

Bromus marginatus

Aegilops cylindrica

Taeniatherum caput-medusae

***P.f.* D7 DOES NOT INHIBIT**



P.f. D7 inhibits some
grasses, but little else

Characteristics of downy brome are similar to *Poa annua*:

- **Invasive, competitive weed**
- **Germinate in the fall and spring**
- **Competitive low temperature root growth**
- **Produce many tillers and seed**



Field Studies

Winter wheat no-till planted

Natural infestation of downy brome;
Benge, WA

Inoculated Plot



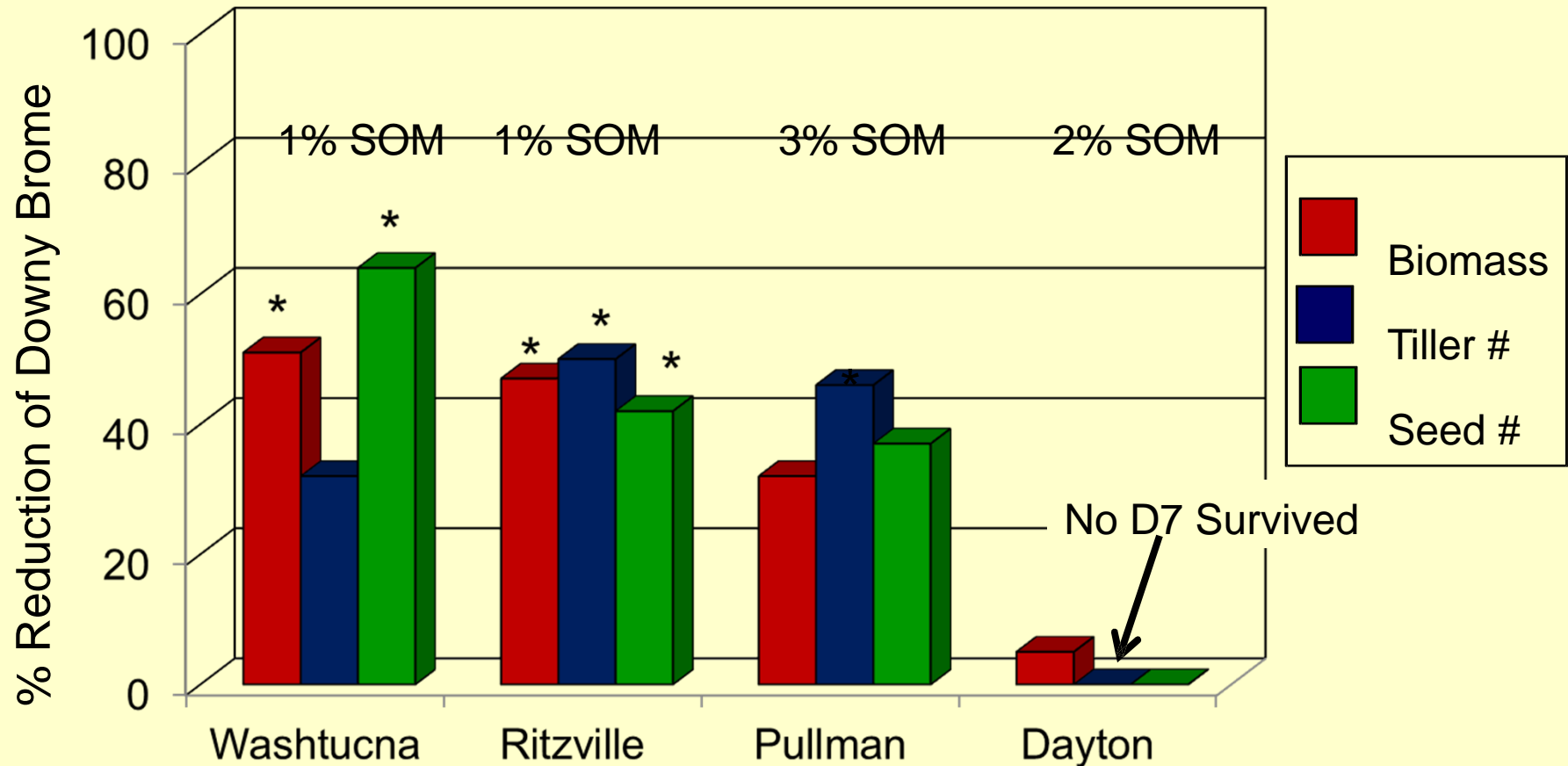
Control Plot

Downy brome was inhibited by
bacteria in the field



WA Winter Wheat Field Trials

P.f. D7 applied in fall as spray;
counts taken following spring.



* = $P < 0.05$

P.f. D7 must survive to suppress downy brome

- Herbicide efficacy - growers wanted weed reductions in first year one
- Years later - growers mention patch-work of downy brome and no downy brome in treated fields



Pasture Field Trials, Pullman, WA

P.f. D7 applied as spray in fall

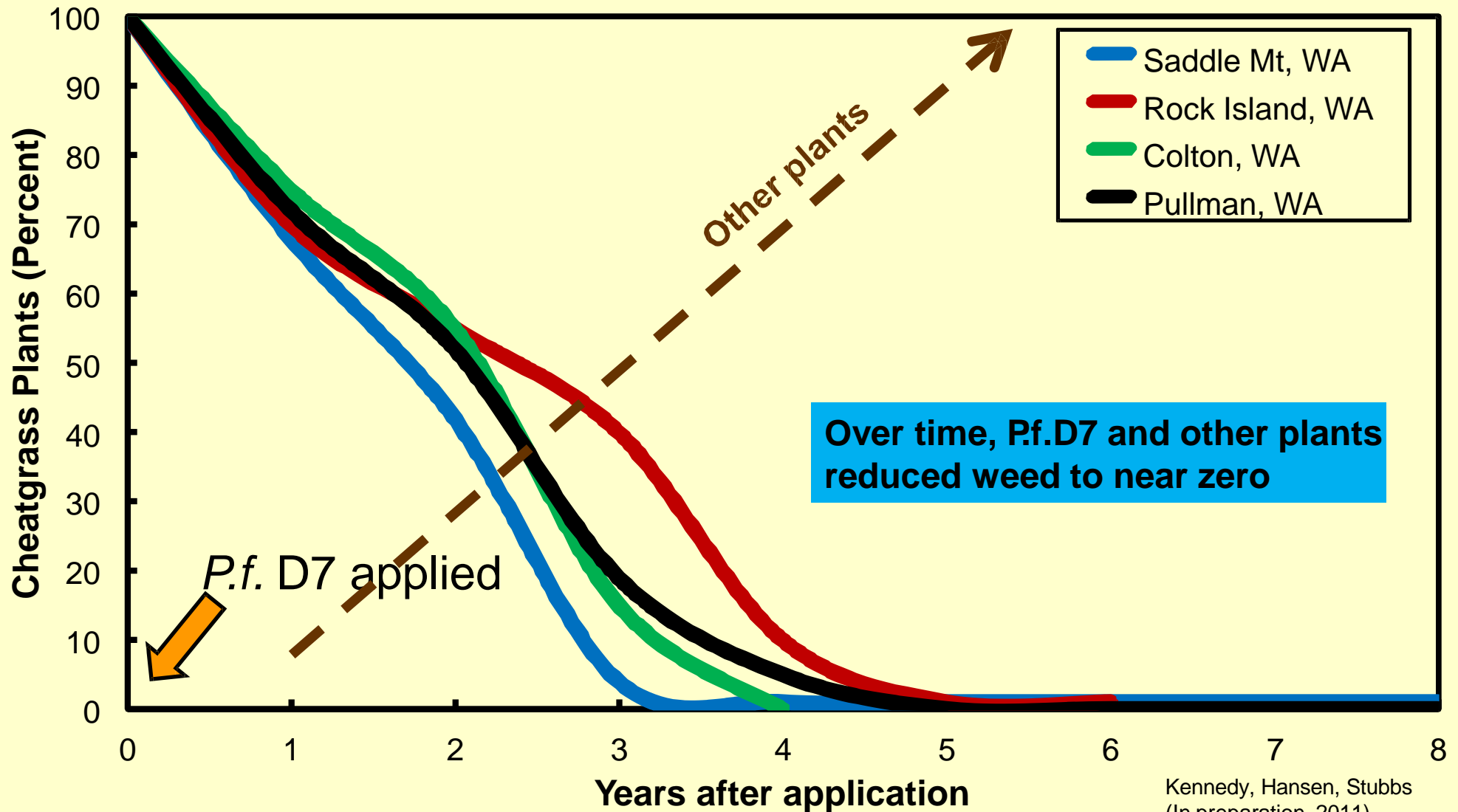
Control

Applied 2004
Pictures 2007

+ Bacteria



Cheatgrass Reduction with *P.f.* D7



5 replicate plots @ each site; $P=0.05$ for all years except $t=0$

Kennedy, Hansen, Stubbs
(In preparation, 2011)



Early turfgrass research by Ann Kennedy's group

**Palouse Ridge GC
2011**

Downy brome grass control in rough



SCALE UP - Fermentors



D7

For suppression of Downy Brome
(cheatgrass), Medusahead, Japanese
Brome, and Jointed Goatgrass on Wheat,
Barley, Triticale, Oats, and Rangeland

ACTIVE INGREDIENT:

<i>Pseudomonas fluorescens</i> , strain D7*:	95.00%
Other ingredients:	5.00%
	100.00%

*Contains a minimum of 2×10^{11} cells/g *Pseudomonas fluorescens* strain D7

**KEEP OUT OF REACH OF CHILDREN
CAUTION**

See directions for use in attached booklet

EPA Reg. No. 71975-4
EPA Est. No. 71975-WA-001

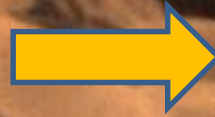
Net weight: 0.44 lb. (200 grams)
Batch #

Northwest Agricultural Products
P.O. Box 3453
Pasco, WA 99302
(509)547-8234



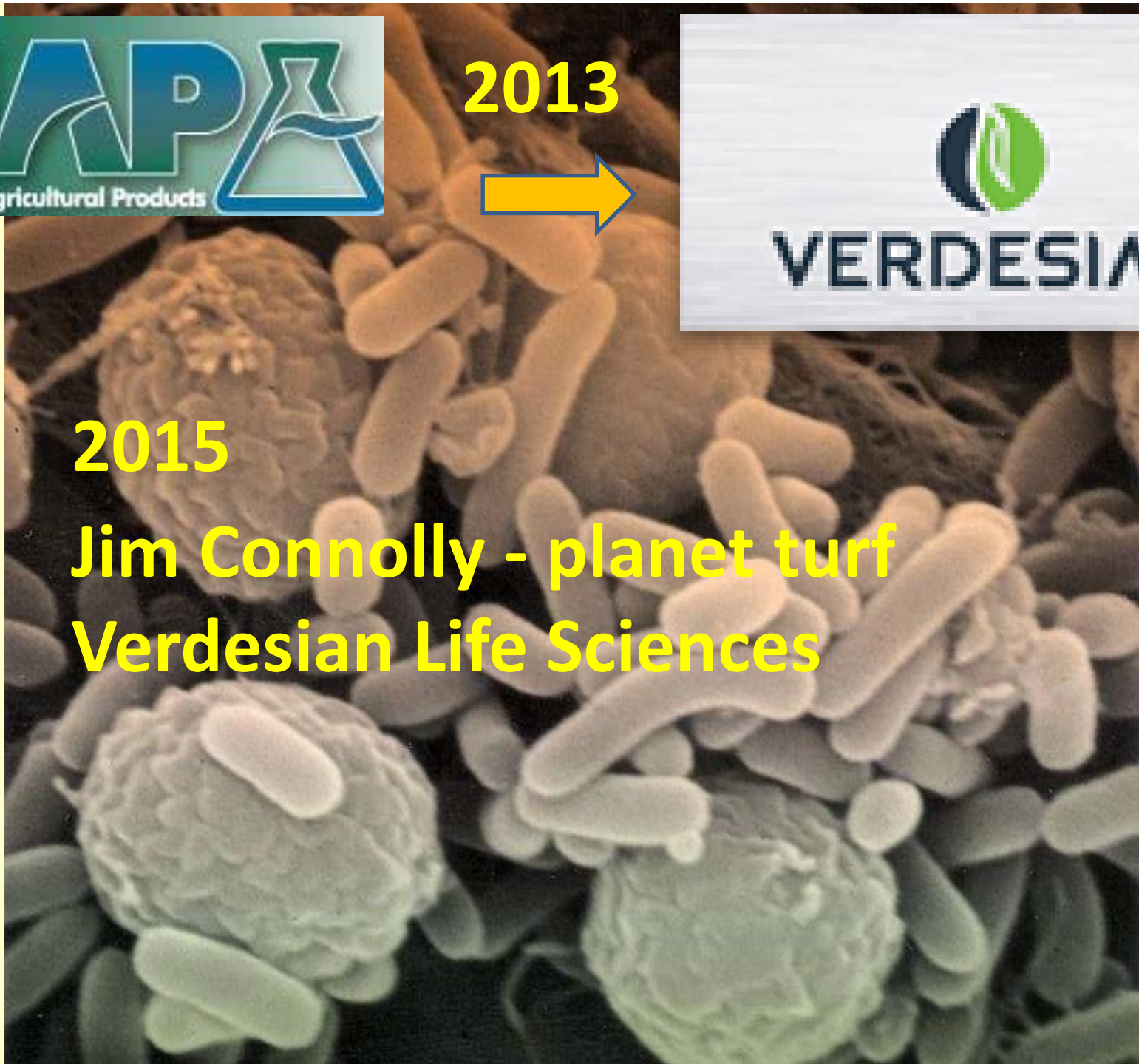


2013



2015

Jim Connolly - planet turf
Verdesian Life Sciences



2016 NTA Research/Education Grant Application

Two Proposals:

- 1. Biological Control of *Poa annua* in Fairways**
- 2. *Poa annua* Control in Fairways – Chemical Programs**

NTA April 7, 2016

“The Research Committee and Board feel that [the] two submitted studies are related closely enough to be considered as one study.”

401	402	403	404	405	406	407
301	302	303	304	305	306	307
201	202	203	204	205	206	207
101	102	103	104	105	106	107

401	402	403	404	405
301	302	303	304	305
201	202	203	204	205
101	102	103	104	105
401	402	403	404	405
301	302	303	304	305
201	202	203	204	205
101	102	103	104	105

3-year studies

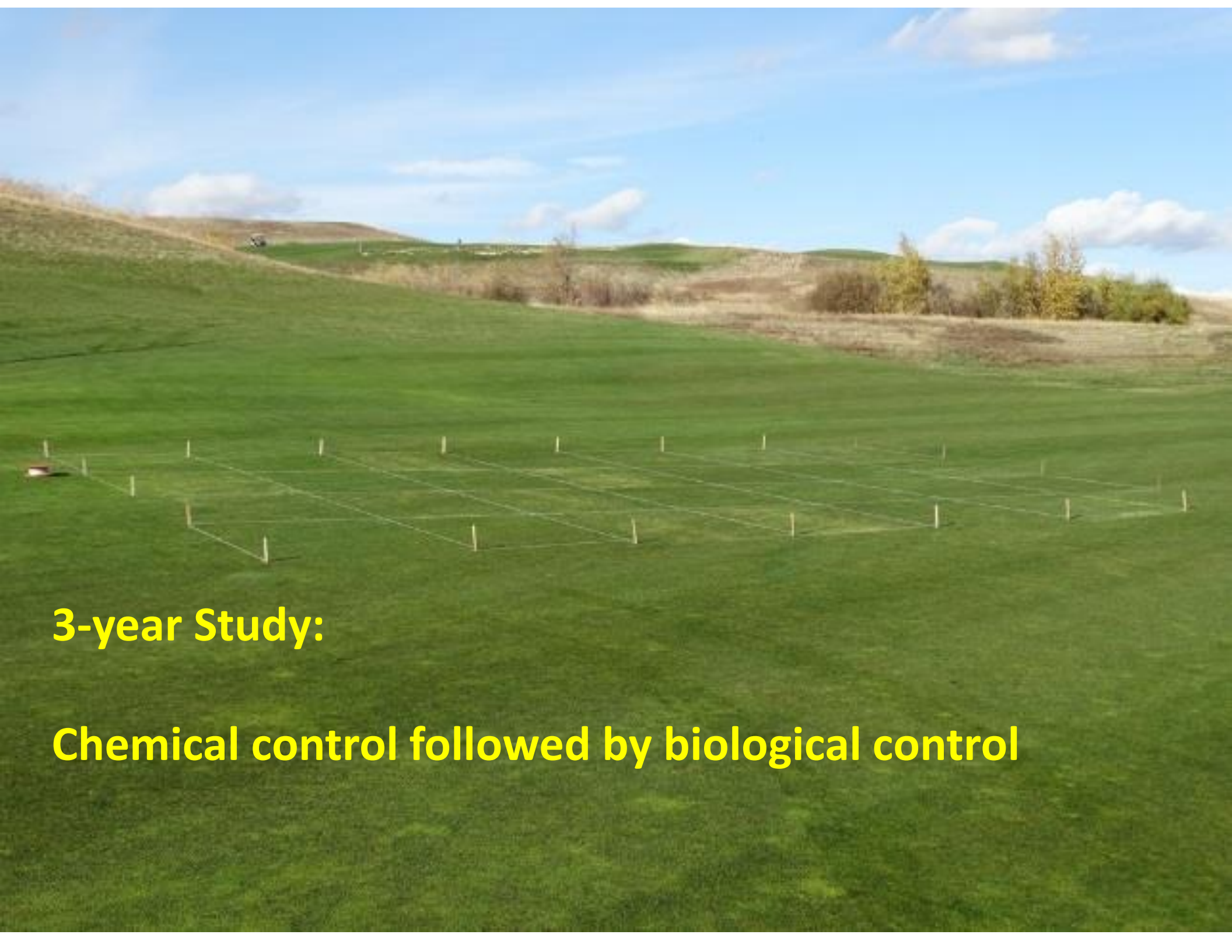
**Chemical followed by
Biocontrol (2016)**

Fall (2015)

Biocontrol vs. Chemical

Fall (2015) – Spring (2016)

Biocontrol vs. Chemical



3-year Study:

Chemical control followed by biological control



3-year Chemical / Biocontrol Study @ Palouse Ridge G C

D-7 1 app fall 2016 and **still to do** fall 2017@ 3 rates
(1, 5, and 15 fl oz/A; same as 2, 10, and 30 g/A)

Tenacity + Xonerate; 3 apps fall 2016 and spring 2017
@ 4 and 1.4 fl oz/A

PoaCure; 3 apps spring 2016, fall 2016, spring 2017
@ 1.26 fl oz/M and **still to do** 3 apps fall 2017

Percent change of *Poa annua* in a Kentucky bluegrass stand

6/13/13 (6 WAIT)

7/24/13 (12 WAIT)

9/6/13 (18 WAIT)

Poa annua (% change)

100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100

Tenacity 5 fl oz/A + Turflon
16 fl oz/A + NIS

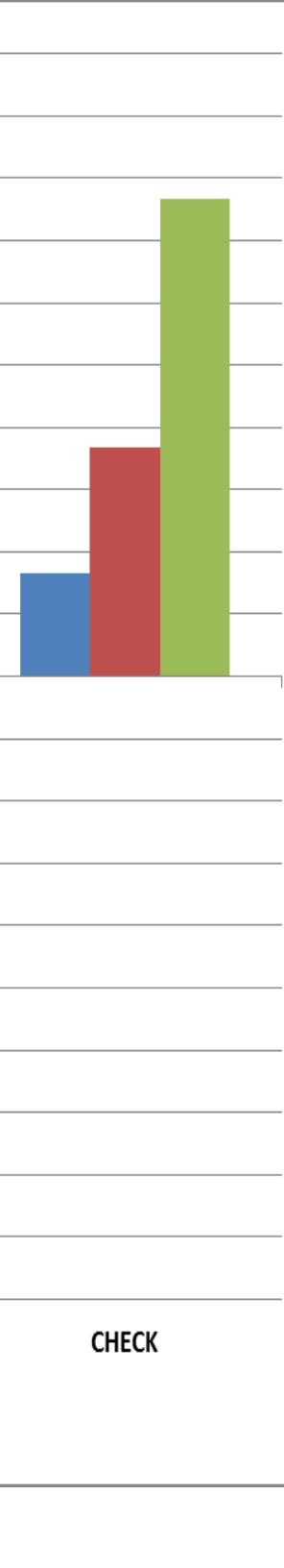
Tenacity 5 fl oz/A + Trimmit
16 fl oz/A + NIS

Tenacity 4 fl oz/A +
Xonerate 1 oz/A + NIS

Tenacity 5 fl oz/A + Trimmit
16 fl oz/A + Turflon 16 fl oz/A
+ NIS

Tenacity 5 fl oz/A +
Xonerate 2 oz/A + NIS

CHECK



18 WAIT (September 6)

CHECK

Tenacity 5 fl oz/A + Xonerate 2 oz/A

CHECK

Herbicides applied May 2, May 23 and June 13



18 WAIT (September 6)

**Tenacity 4 fl oz/A +
Xonerate 1 oz/A**

**Tenacity 4 fl oz/A +
Xonerate 1 oz/A**

Herbicides applied May 2, May 23 and June 13

Charles Golob's thoughts (Nov. 2016 Wa Weed Sci. meeting):

Tenacity/Xonerate treatments did not eliminate *Poa* but did result in significant reductions of *Poa* in the Kentucky bluegrass stand.

However, the high level of *Poa* injury and depressions caused by the Tenacity 5 fl oz/A + Xonerate 2 oz/A treatment leaving pock marked fairways may result in undesirable playing conditions during the peak of the summer when play is highest. (Eventually KBG did grow into and fill these depressions by the end of the study).

Tenacity 4 fl oz/A + Xonerate 1 oz/A also resulted in high levels of *Poa* reduction.

However, this treatment did not cause *Poa* to quickly disappear, thus not creating open areas (depressions) in the fairway. This may be a more desirable *Poa* control option to consider in terms of playability.

Complete *Poa* control was not achieved with any treatment in this study, therefore, a multi-year program may need to be looked at to possibly achieve this goal or maintain *Poa* at lower levels.



PoaCure

Methiozolin

Moghu Research Center

South Korea

Registered for turf in Korea

April 2010

Pine Ridge Country Club, South Korea



Long Island National Golf Club, NY



Photo taken 5/16/15



Baltusrol GC - site of 2016 PGA Championship

Mark Kuhns, CSGS Director of Grounds

psu149@aol.com

June 2017





Poa annua control with PoaCure on bentgrass greens

5% Poa

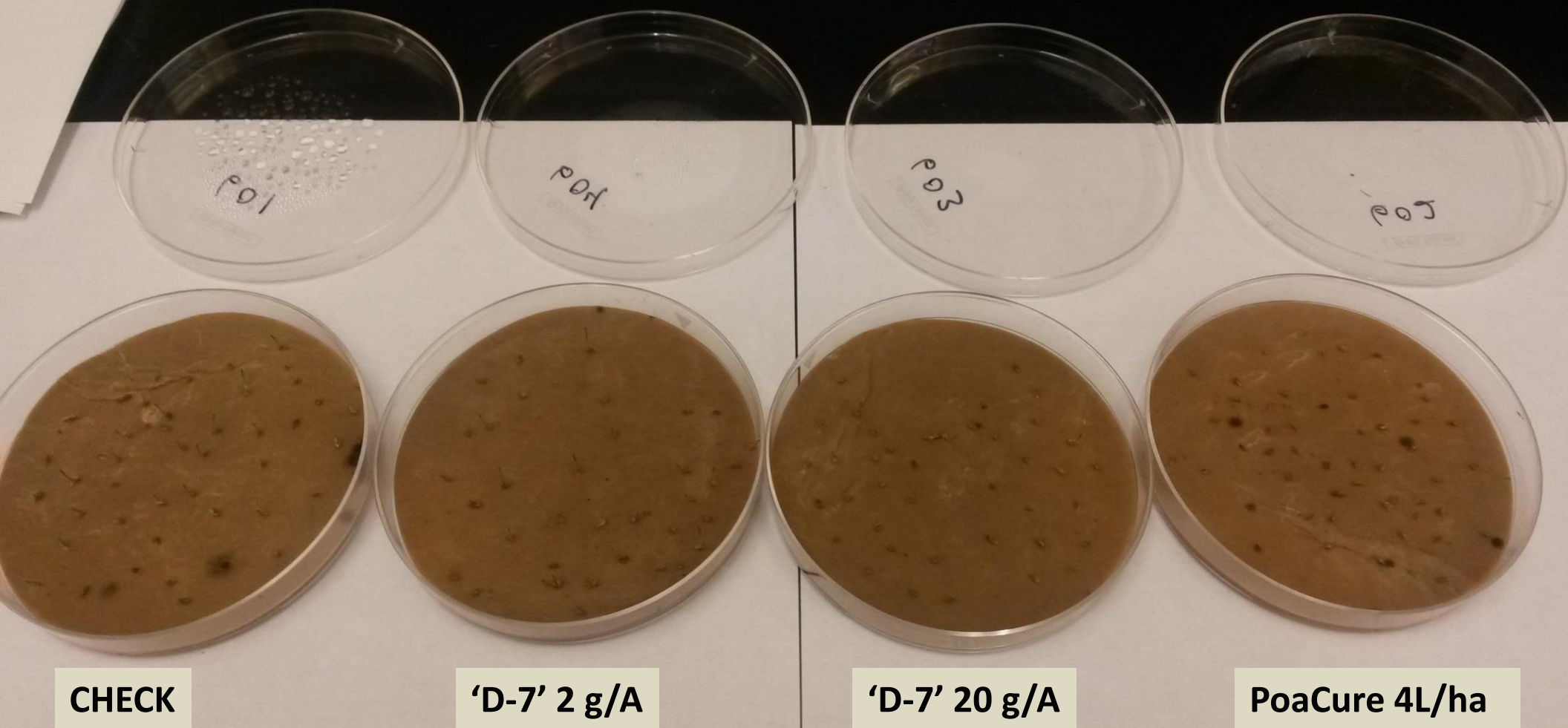
65% Poa

3 applications @1.2 fl oz/1000 ft² (4 L/ha)
at 2 week intervals; Fall 2011

Check

Colfax Golf Course
Picture taken 9-28-12

Annual Bluegrass Germination Test with 'D-7' and PoaCure



Annual Bluegrass Emergence Test with 'D-7' and PoaCure 25 days after planting



CHECK

'D-7' 2 g/A

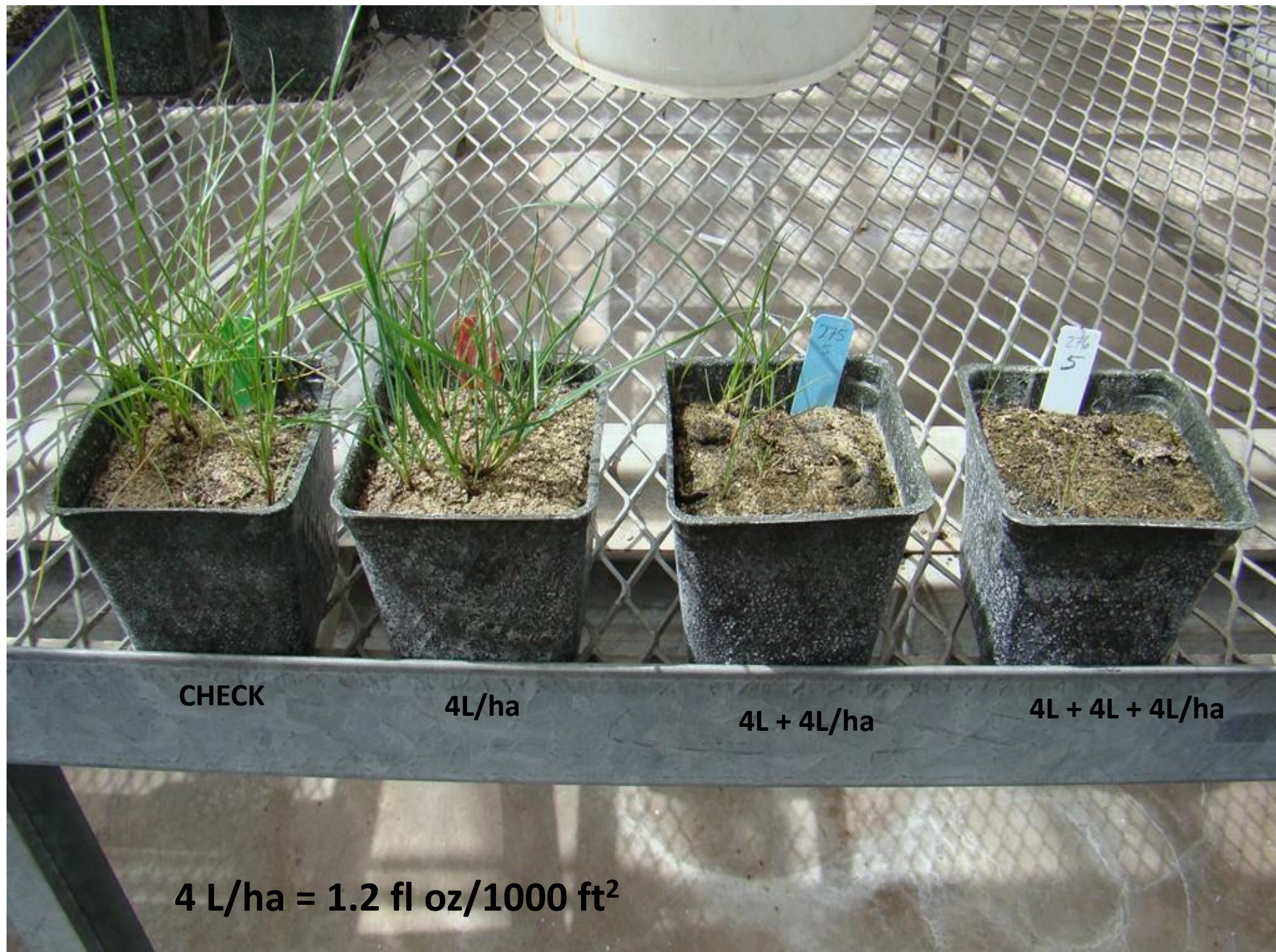
'D-7' 20 g/A

PoaCure 4L/ha

Methiozolin Residual Soil Activity Study 2012



Perennial ryegrass 'Top Gun II' planted 6/27/13 (20 weeks) after last PoaCure application.
Picture taken at the 4 week emergence count: 7/24/13.



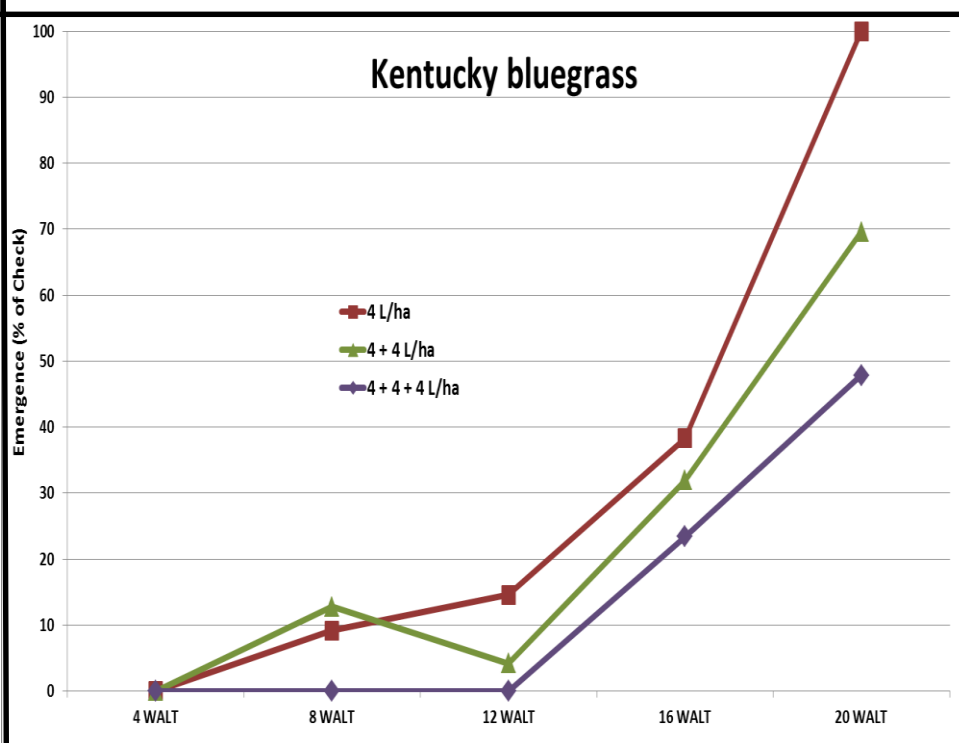
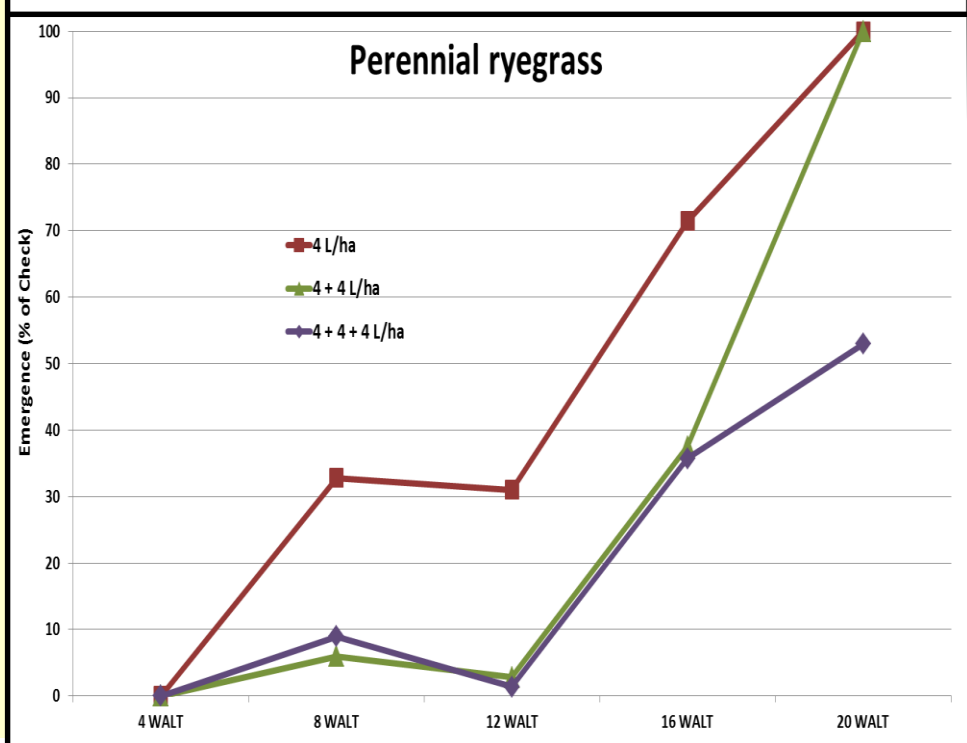
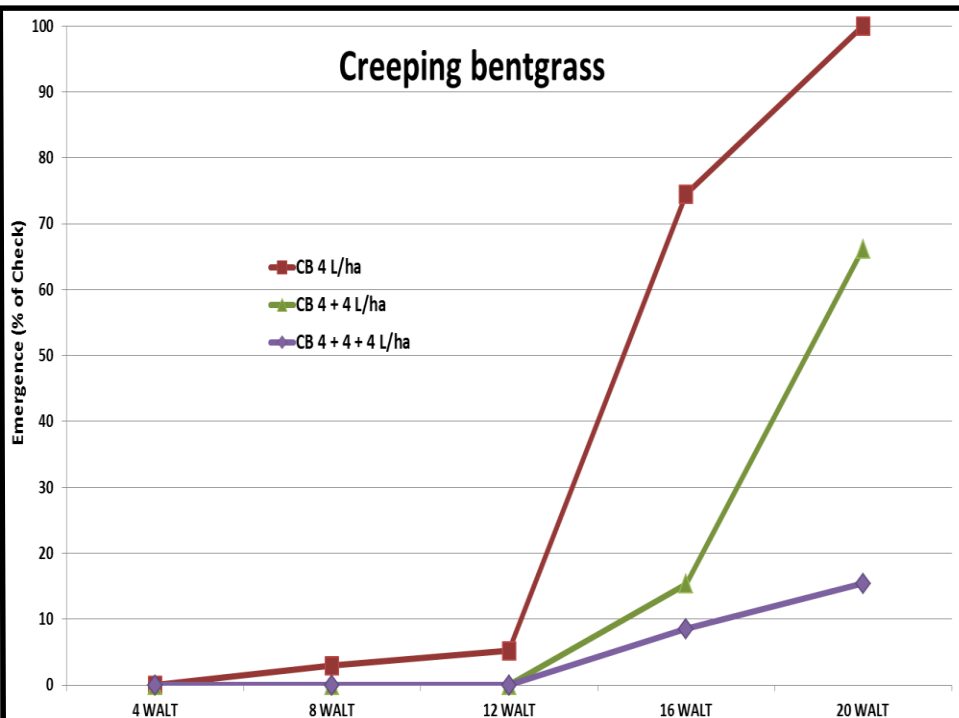
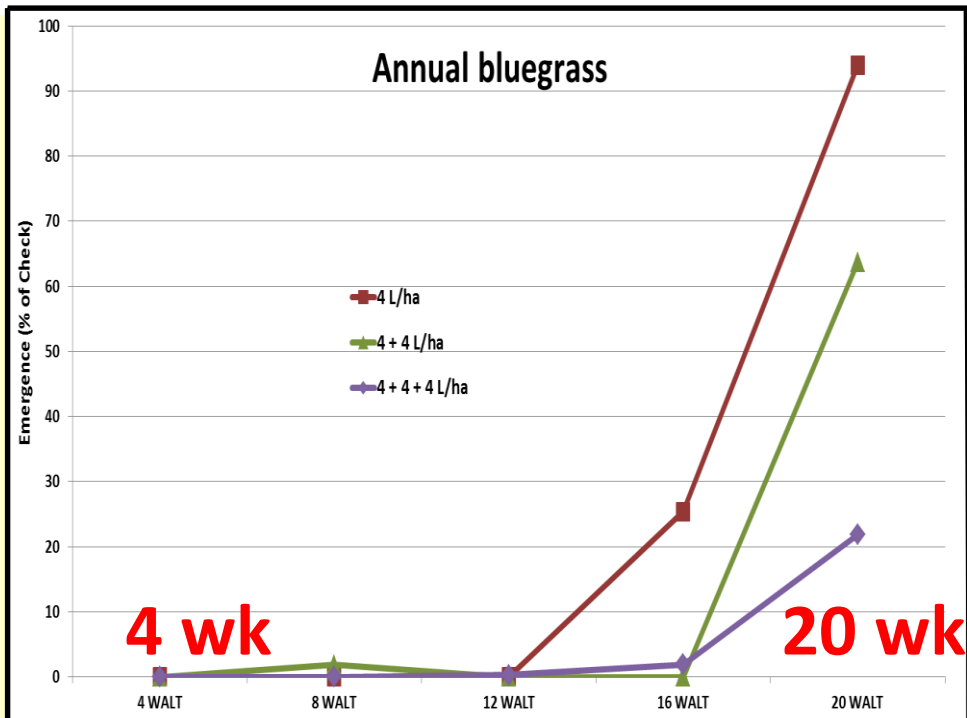
CHECK

4L/ha

4L + 4L/ha

4L + 4L + 4L/ha

4 L/ha = 1.2 fl oz/1000 ft²



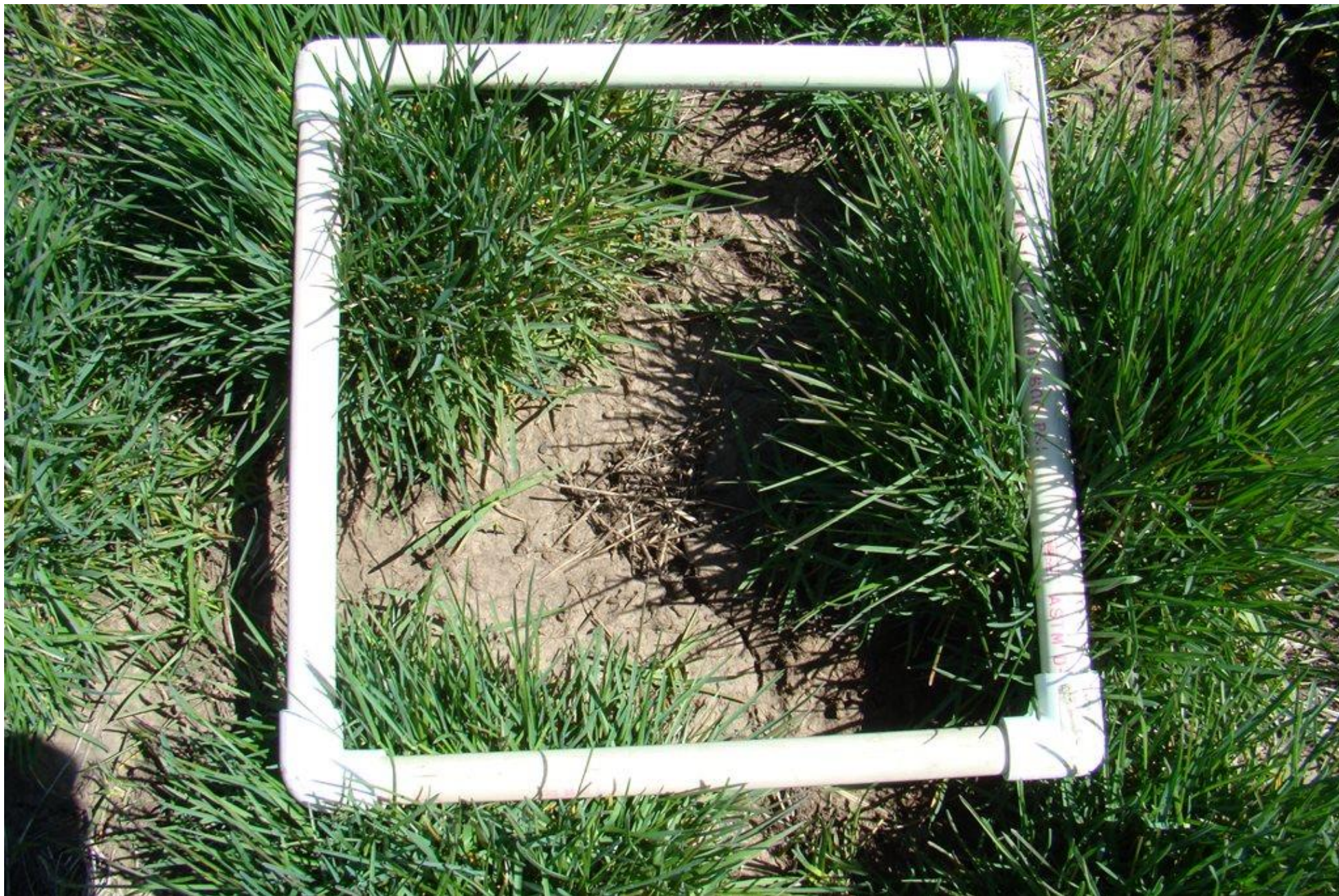
Fall Applied PoaCure to Control *Poa annua* in KBG Seed Fields

PI 371775 KBG Seed Increase TARC Plot 12. 5-6-13.



Fall Applied PoaCure to Control Poa in KBG Seed Fields

PI 371775 KBG Seed Increase TARC Plot 12. 5-6-13.



All PoaCure treatment - 2L, 4L, 2L + 2L, or 4L + 4L/ha controlled *Poa annua*
Fall 2012

PoaCure Questions?

**More WSU turfgrass information:
TURF.WSU.EDU**

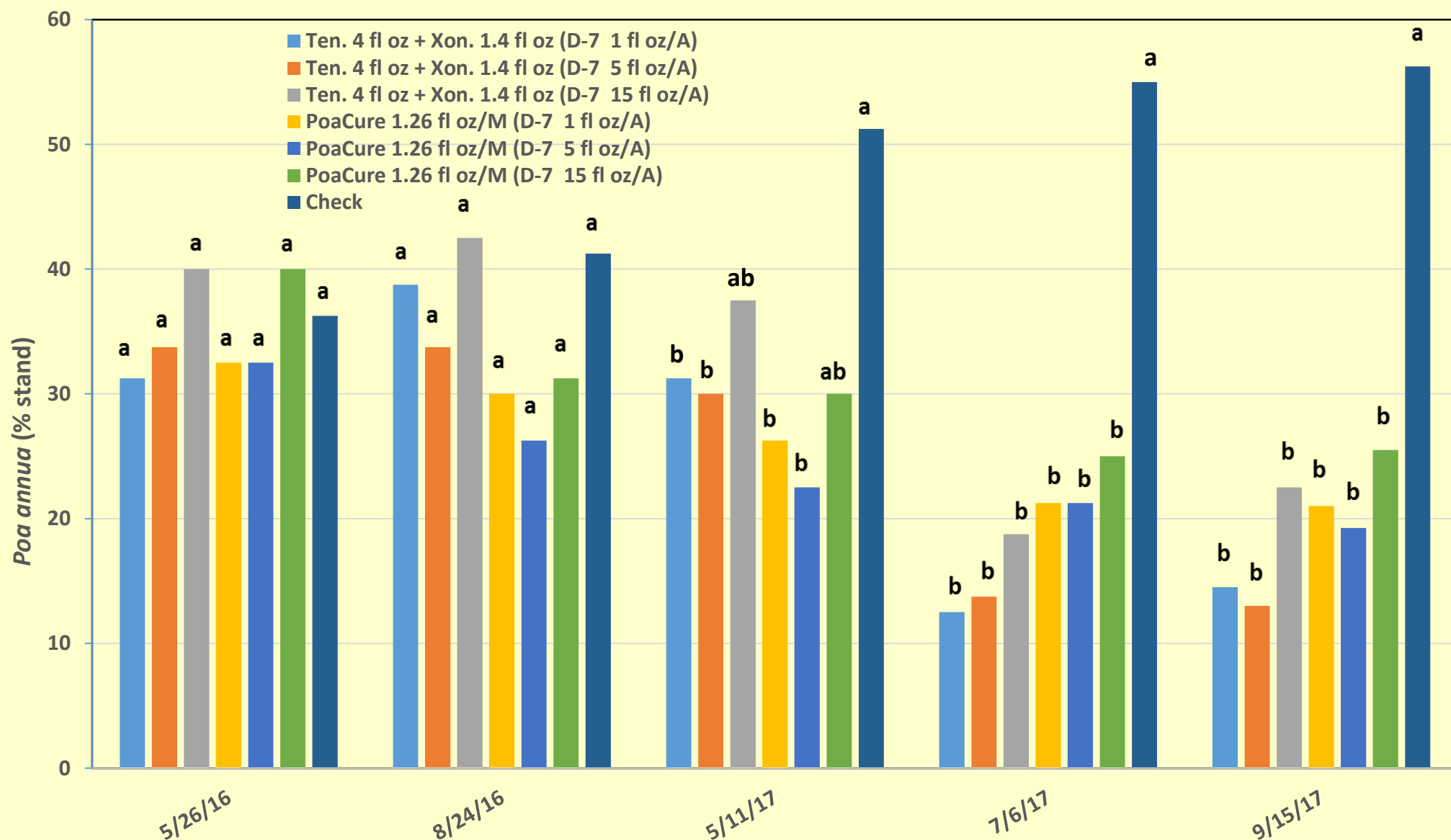
Updates on PoaCure research from different regions:

- www.moghu.com/en/index
- Twitter @PoaCure, @MoghuUSA

Other questions regarding PoaCure, contact:
PoaCure Development Manager - Kyung Han

- kyungmhan@moghu.com
717-350-9829

3-year Chemical/Biocontrol @ Palouse Ridge G C



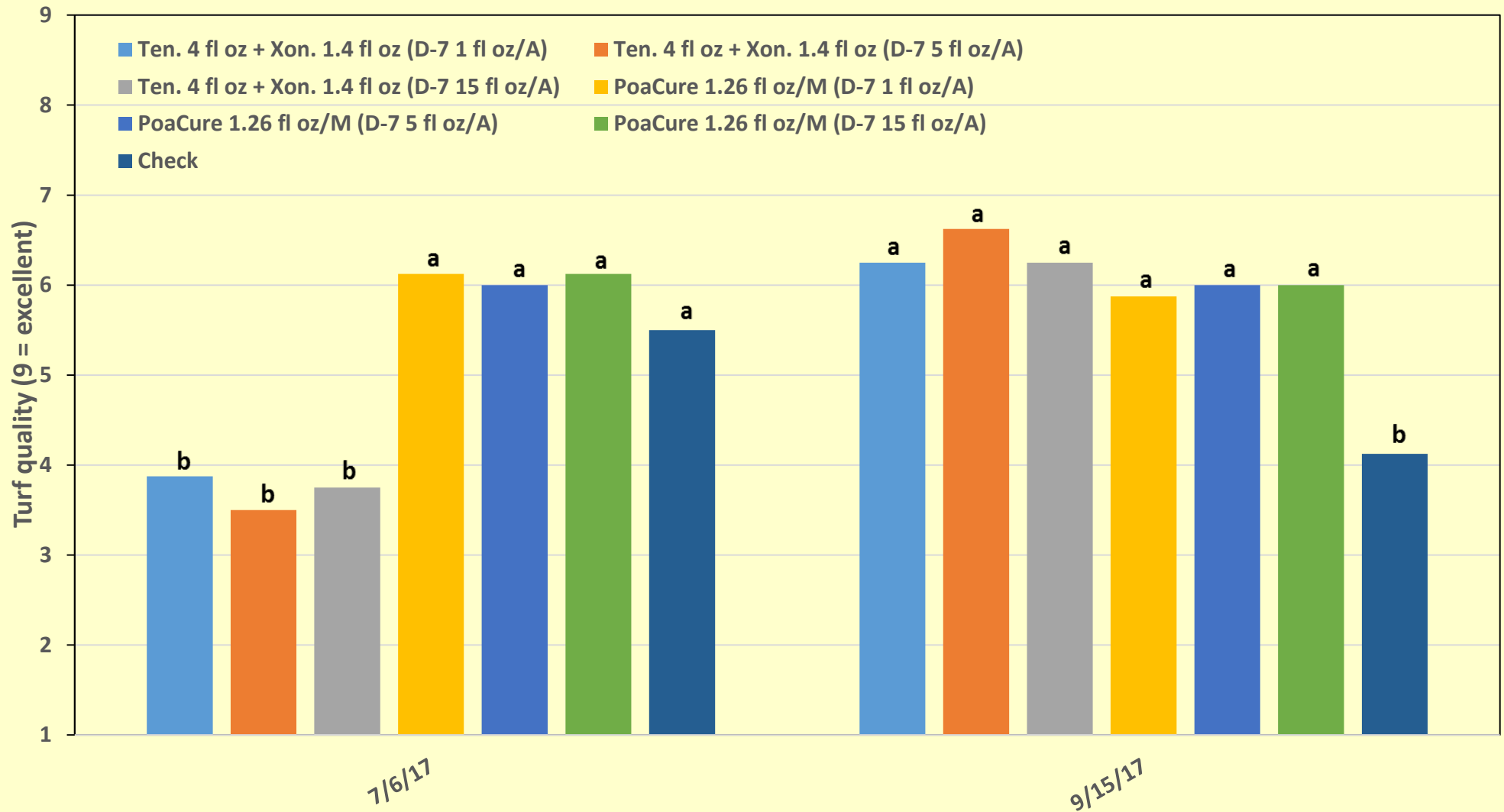
Sp '16
PC 3 apps

Fall '16
PC 3
T+X 3
D7 1 app

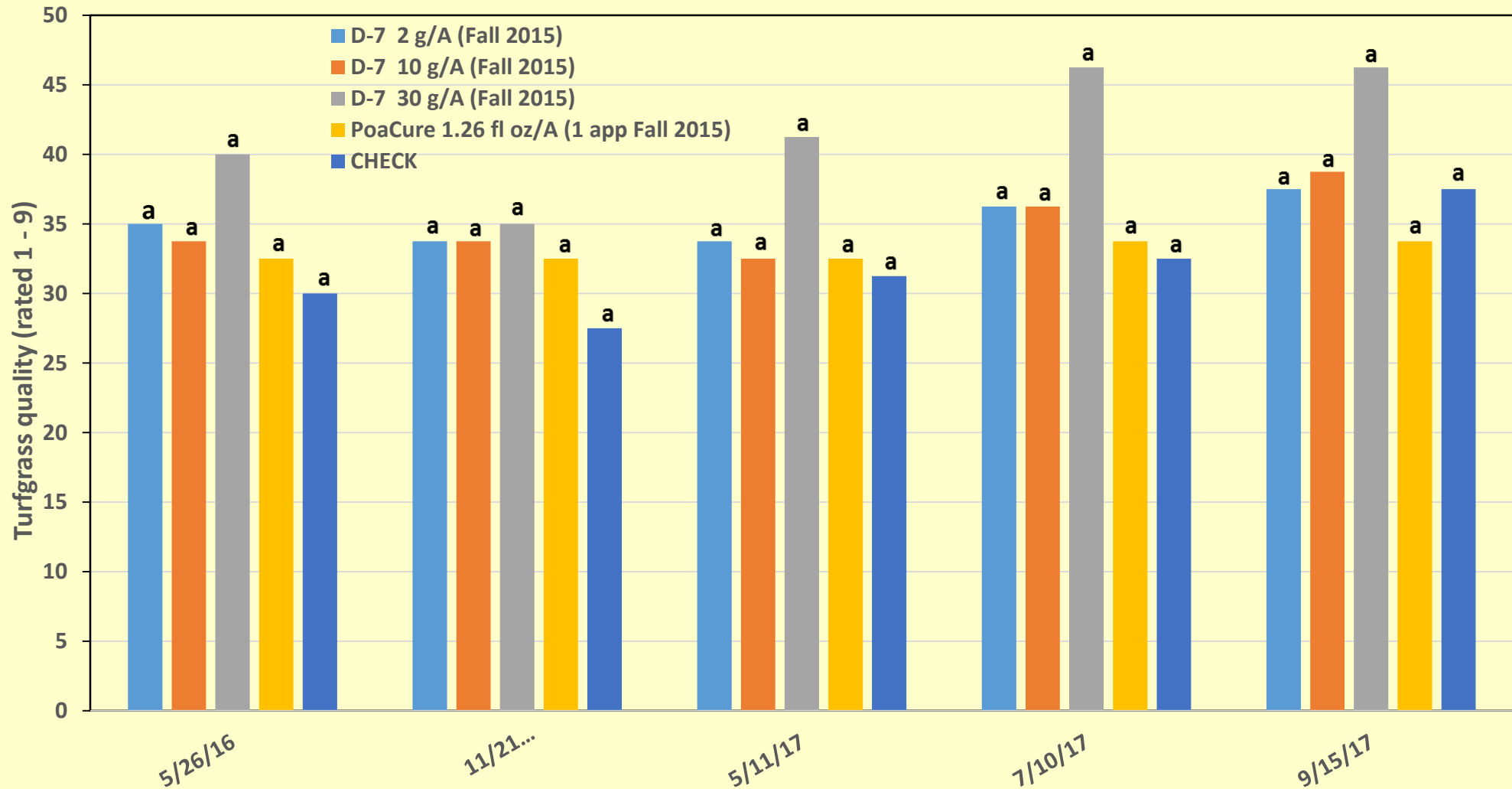
Sp '17
PC 3 apps
T+X 3 apps

Fall '17
PC 3
D7 1

3-year Chemical/Biocontrol @ Palouse Ridge G C

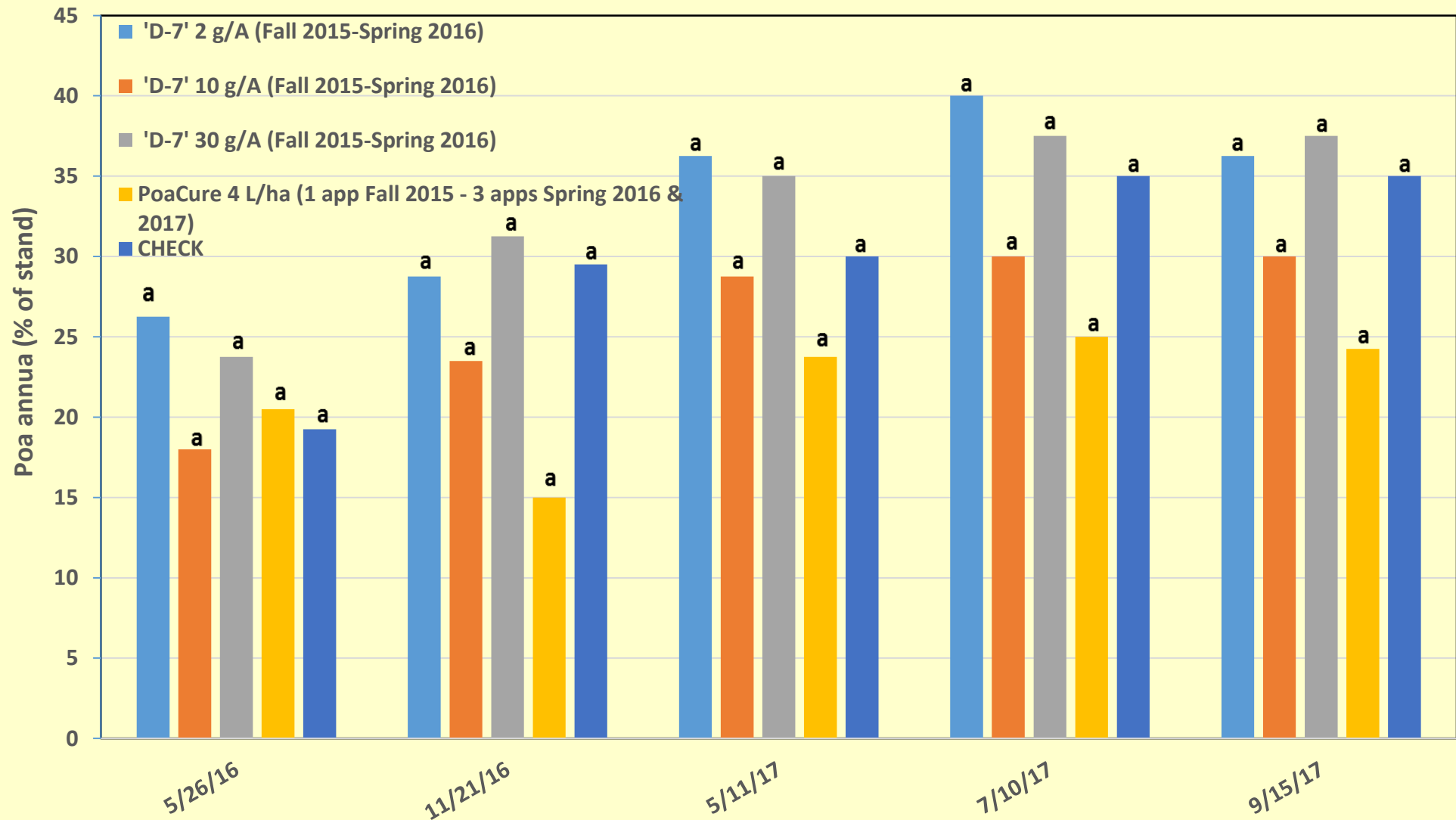


D7 or PoaCure (Fall 2015) @ Palouse Ridge G C



To do: PoaCure 3 apps fall 2017 and fall 2018

D7 or PoaCure (Fall 2015 – Spring 2016) @ Palouse Ridge G C



To do: PoaCure 3 apps fall 2017, spring2018, and fall 2018

3-year Study; chemical/biocontrol

CHECK

A white trapezoid is drawn on a green lawn. The top horizontal edge is labeled 'CHECK'. There are four blue markers at the corners of the trapezoid: one at the top-left, one at the top-right, one at the bottom-left, and one at the bottom-right.

7/6/17

3-year Study; chemical/biocontrol
PoaCure 1.26 fl oz/M
(3 apps Spring, Fall 2016 and Spring 2017)
D-7 15 fl oz/A (1 app Nov. 2016)



7/6/17

**3-year Study; chemical/biocontrol
Tenacity 4 fl oz/A + Xonerate 1.4 fl oz/A
(3 apps Fall 2016 and Spring 2017)
D-7 15 fl oz/A (1 app Nov. 2016)**



7/6/17

3-year Study; chemical/biocontrol

CHECK

9/22/17



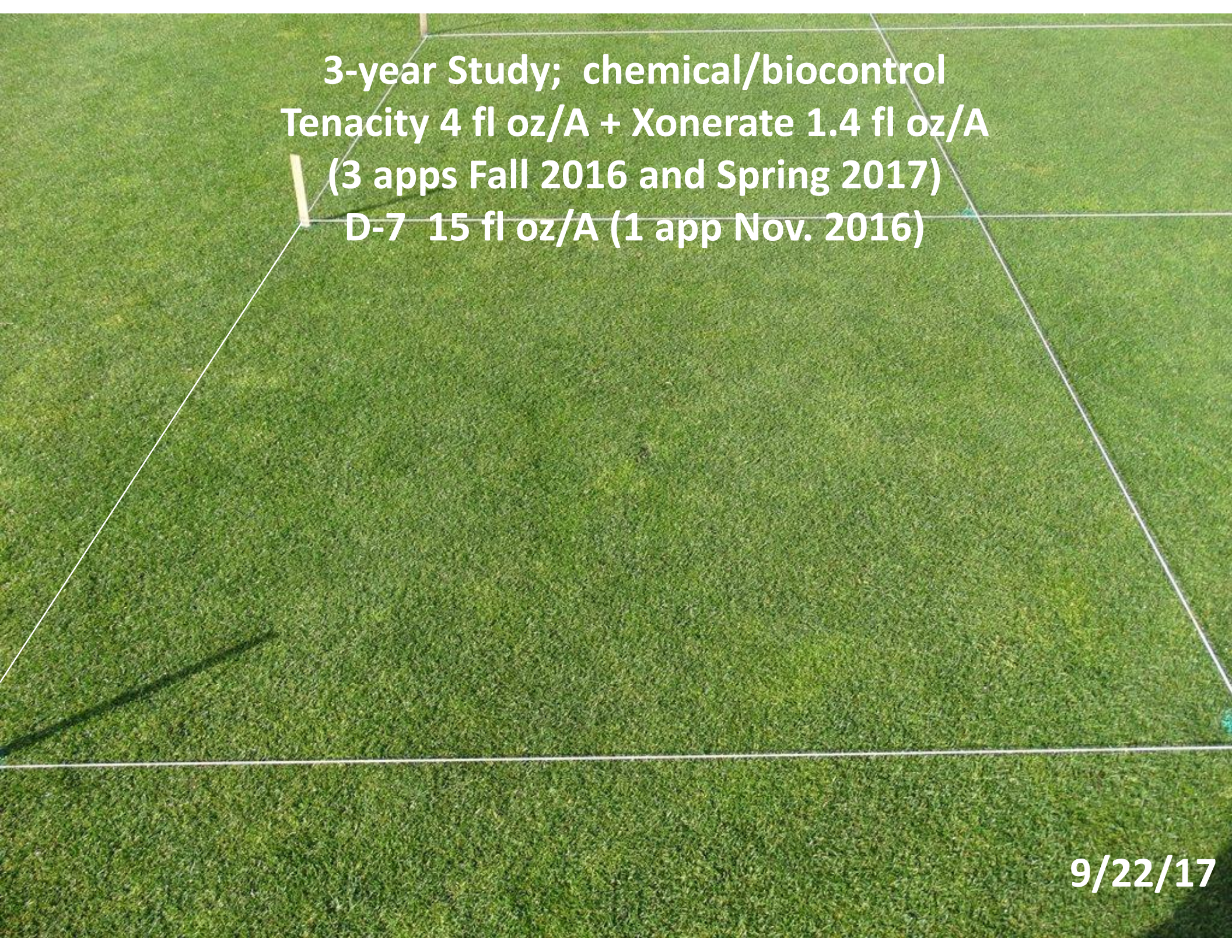
3-year Study; chemical/biocontrol

PoaCure 1.26 fl oz/M

(3 apps Spring and Fall 2016 and Spring 2017)

D-7 15 fl oz/A (1 app Nov. 2016)

9/22/17



3-year Study; chemical/biocontrol
Tenacity 4 fl oz/A + Xonerate 1.4 fl oz/A
(3 apps Fall 2016 and Spring 2017)
D-7 15 fl oz/A (1 app Nov. 2016)

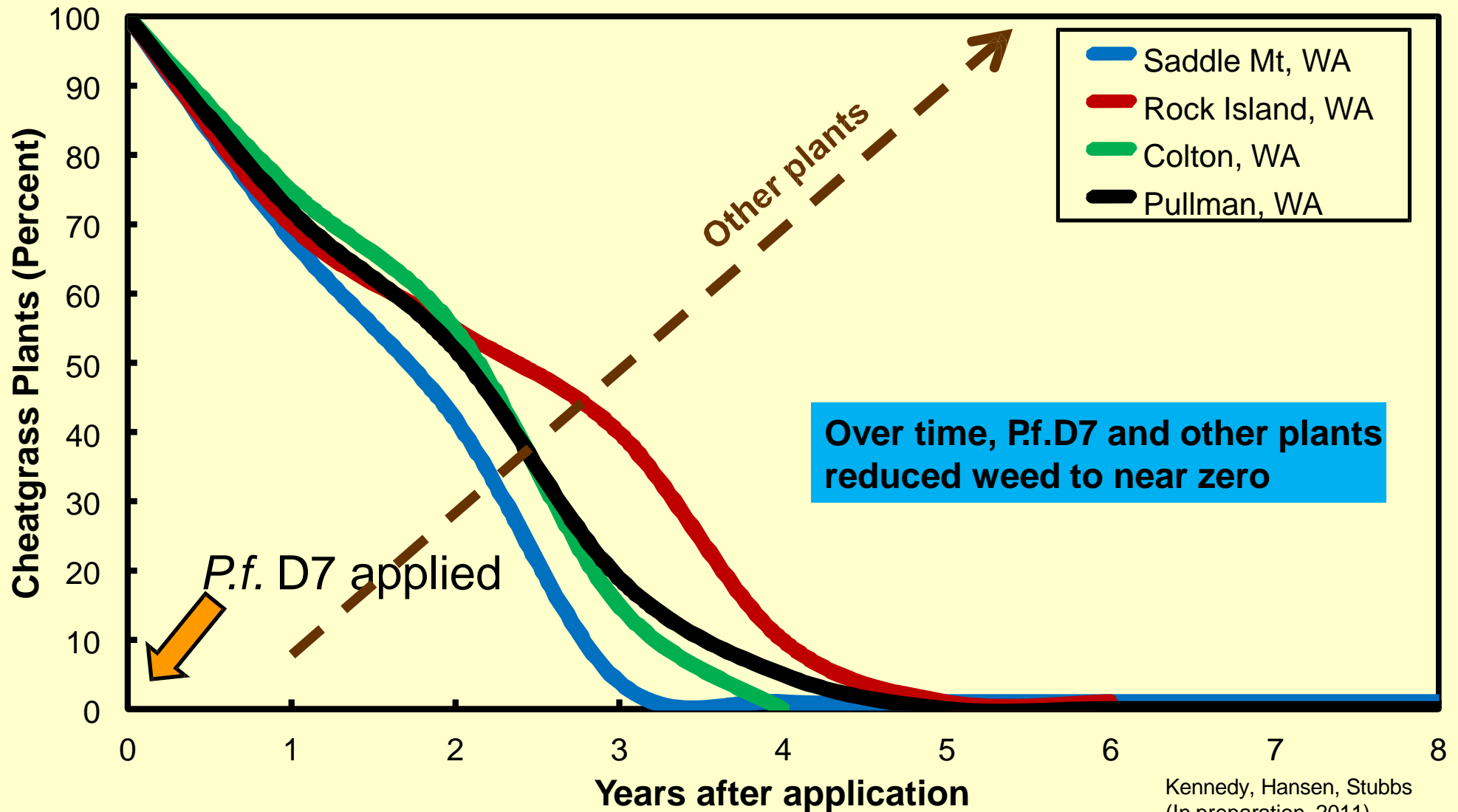
9/22/17

2018



Fading interest in D7 for *Poa annua* control in turf

Cheatgrass Reduction with *P.f.* D7



5 replicate plots @ each site; $P=0.05$ for all years except $t=0$

Kennedy, Hansen, Stubbs
(In preparation, 2011)



New biocontrol product for testing:

Three *Pseudomonas fluorescens* strain mixture

**Excellent control on *Poa annua* root growth
(agar, greenhouse, and field trials)**

**Excellent control on *Poa annua* germination
(antidotal?)**

New formulation

**WSU will continue current ongoing D7 and chemical
studies fall 2017 and through 2018**

Root growth inhibition

Strain

A	B	C
	%	
<i>Poa annua</i>	100	98
<i>Poa trivialis</i>		94
Creeping red fescue	10	10
Tall fescue	10	
Creeping bentgrass		
Kentucky bluegrass		
Perennial ryegrass		
Downy brome	30	

No effect on dicots (32 evaluated)

2018 research protocol:

Effect on germination

Effect on seedling growth (growth chamber/green house

Effect of strain ratios other than 1:1:1

Effect on mature *Poa annua* on golf course field sites

WSU turf position – Status update

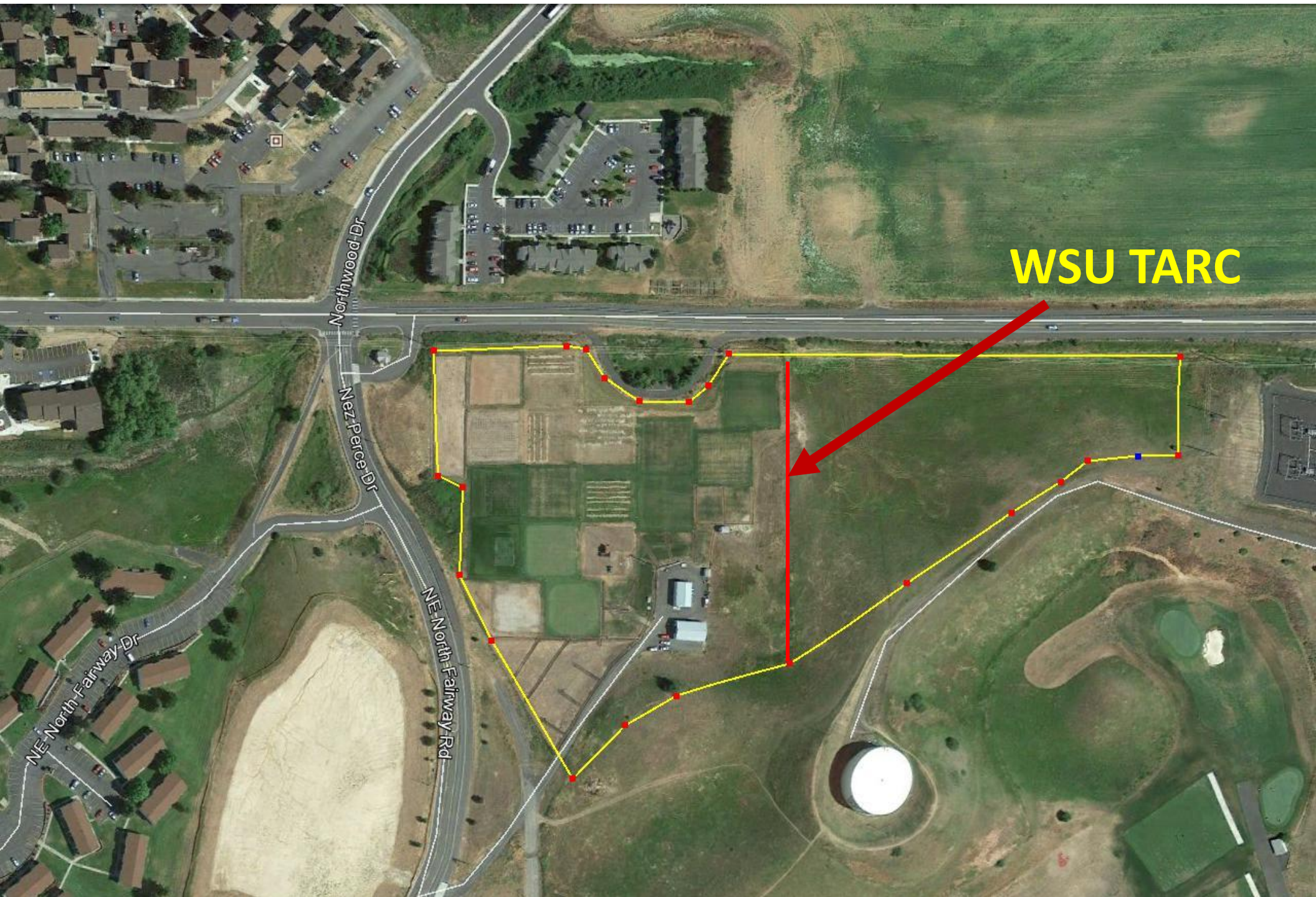
1. Grass Ecology position

- a. Turf**
- b. Seed**
- c. Currently on hold; budget crisis at WSU**
- d. Teaching – all current students have had
all 3 turf courses**
- e. Research - Charles Golob and I continue onward**
- f. State funding of technicians ended July 1, 2017**

2. Turf Plots

“Moving again”; 3rd time in one career

Grass Ecology Research & Teaching Laboratory



WSU TARC





© 2017 Google

Google Earth

Pullman-Moscow Hwy

270

1996

Imagery Date: 6/30/2015 46°43'26.22" N 117°08'18.23" W elev 2569 ft eye alt 4966 ft



Interacting with the
NTA has been a great.

All the best!

Thanks for the
mentoring, support,
and friendship.

