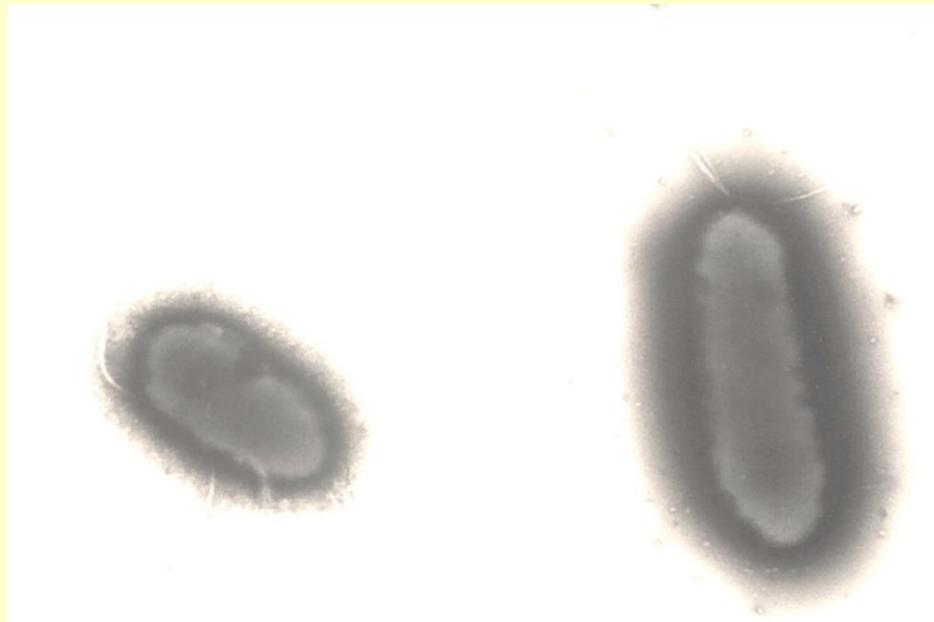
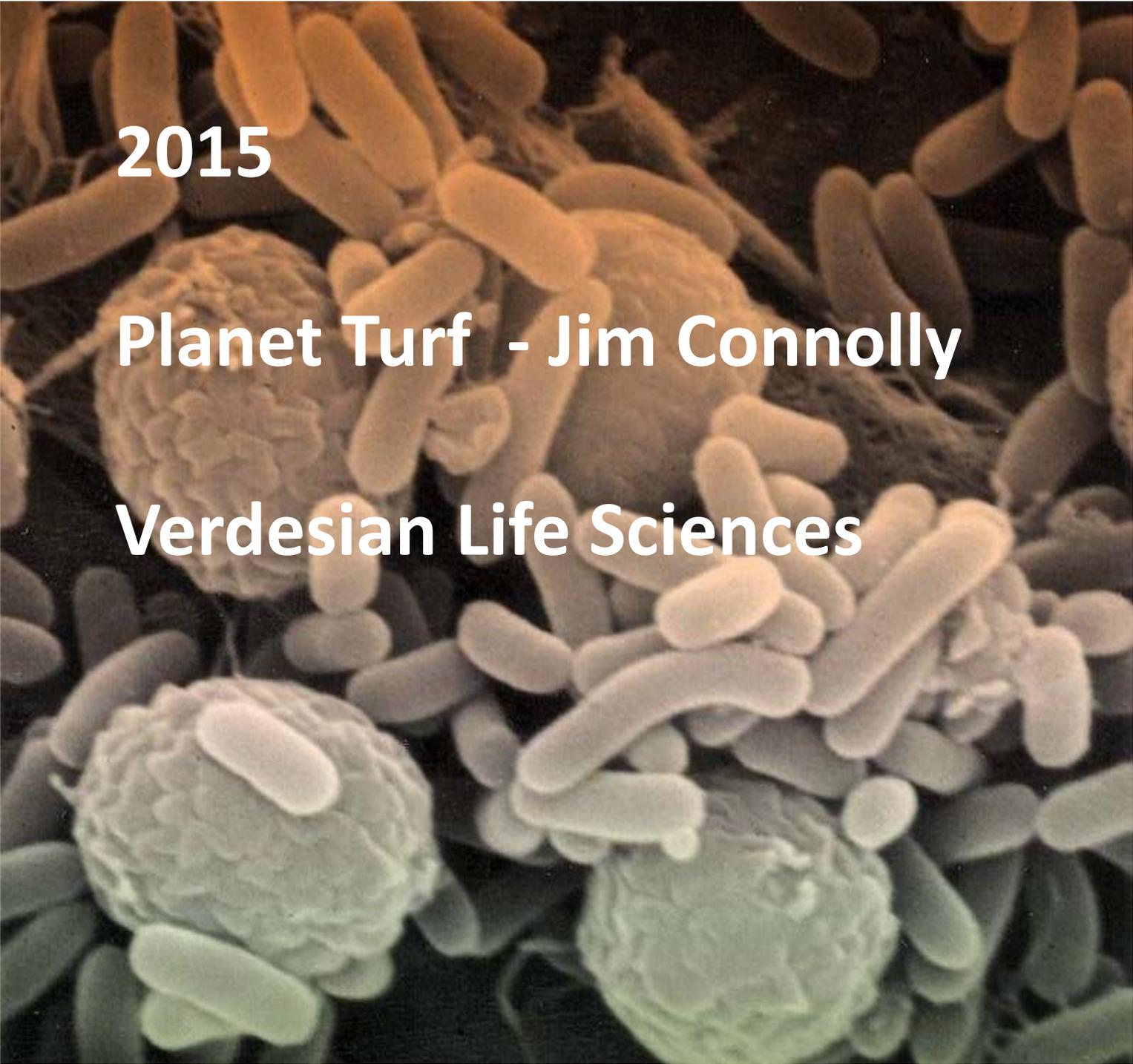


Bio Control of *Poa annua*

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

**NTA Conference
Bandon, OR
Oct. 30 – Nov. 1, 2016**



A scanning electron micrograph (SEM) showing a dense community of microorganisms on a turf surface. The image features several large, spherical, textured structures, likely fungal hyphae or spores, surrounded by numerous smaller, rod-shaped bacteria. The overall appearance is a complex, three-dimensional microbial network. The text is overlaid on the left side of the image.

2015

Planet Turf - Jim Connolly

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.”

'D7' biocontrol – How it all started

Poor growth of winter wheat in spring

(Lloyd Elliott)

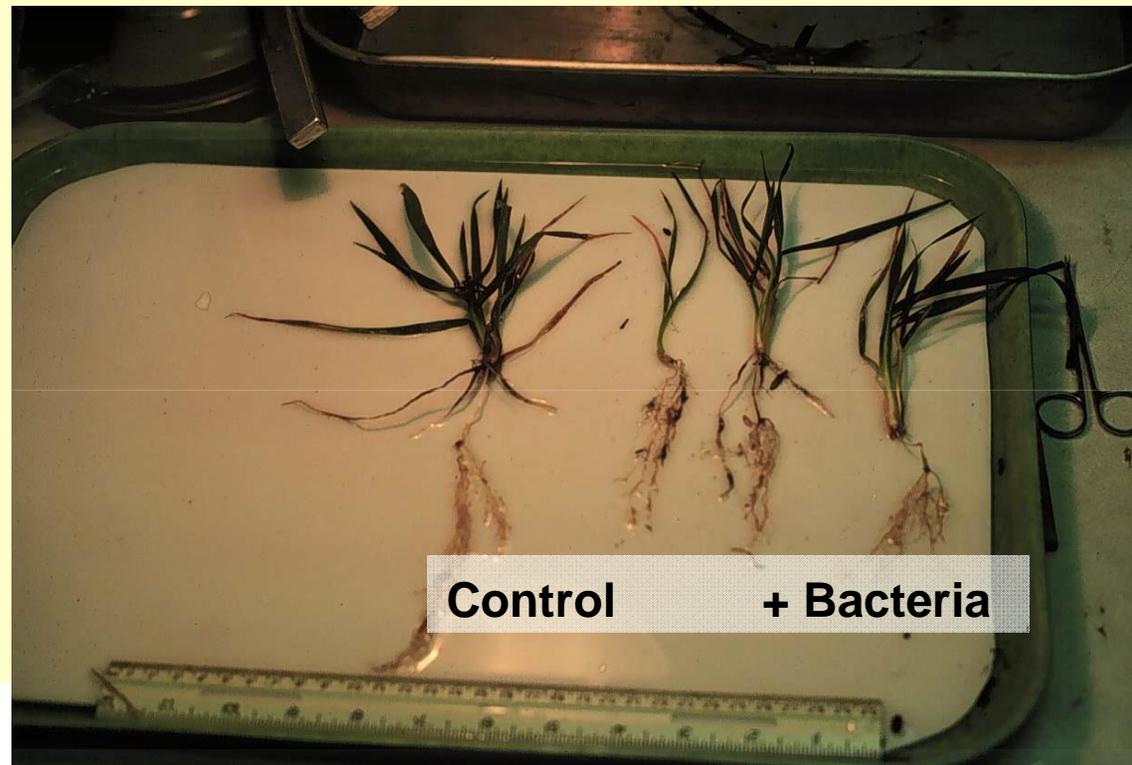


Poor growth of winter wheat in spring

High numbers of *Pseudomonas* on roots

Toxin was selective against cultivars (Elliott)

- **What
about
grass
weeds?**



Weed-Suppressive Bacteria

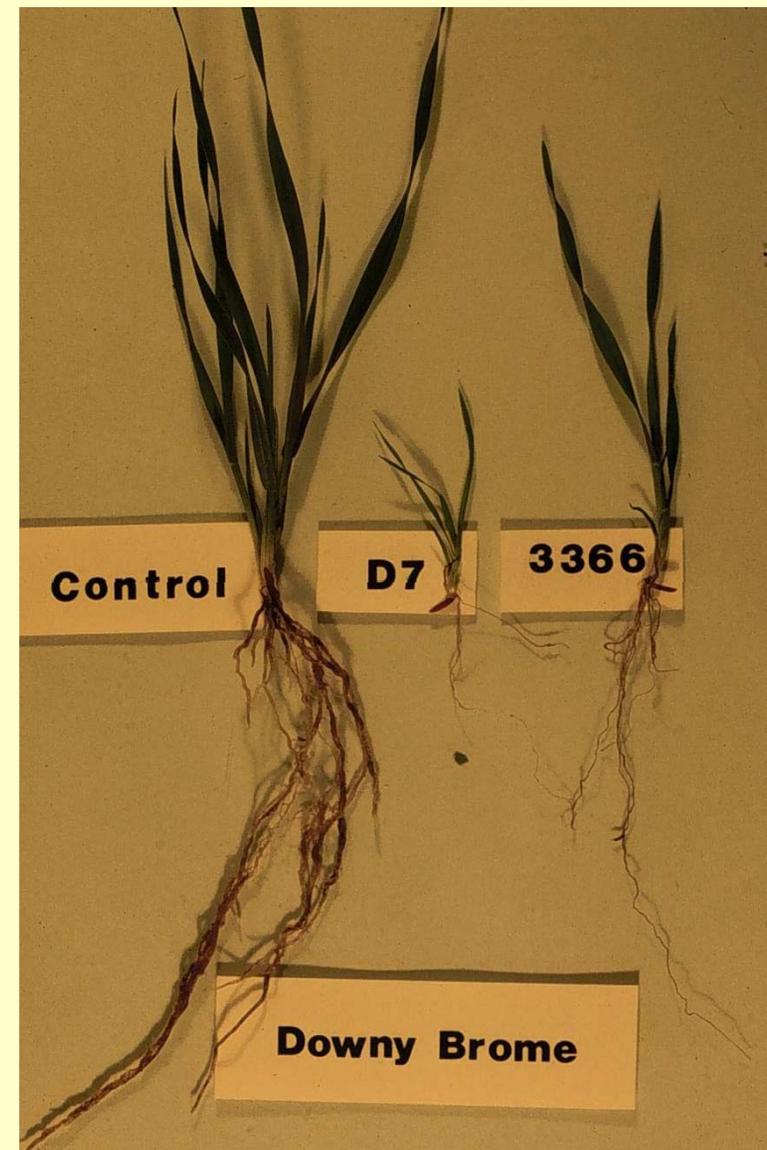


- Colonize residue/root
- Survive well at low temperatures
- Not competitive at warm temperatures
- Go dormant during hot, dry summer
- Produce plant-suppressive compounds
- Members of the genus *Pseudomonas*

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):

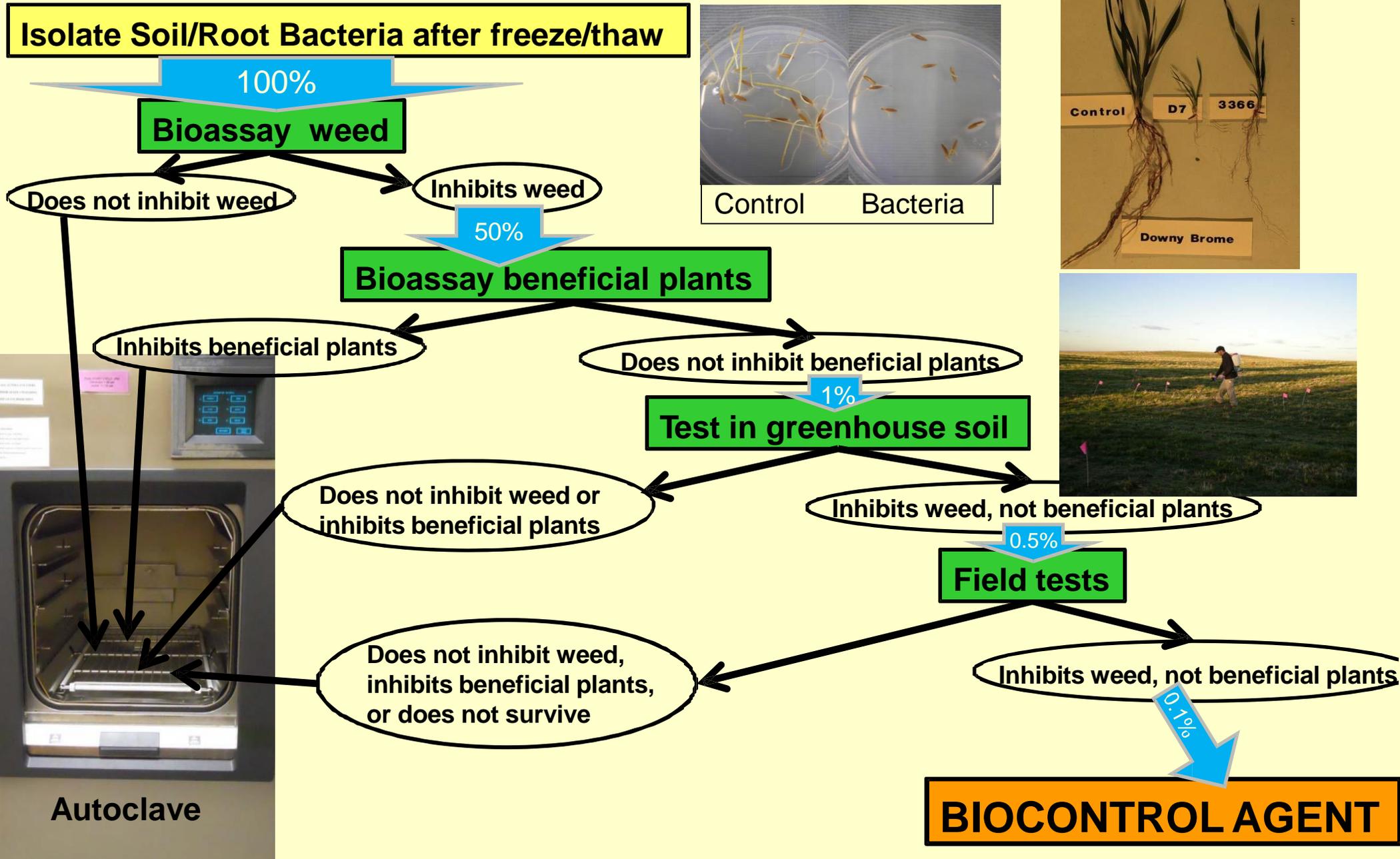
Chromopeptide, peptides, fatty acid esters & polysaccharides

All must be present for activity

Reduces lipopolysaccharide production - No cell elongation

Genes: Multiple loci (very unlikely to mutate)

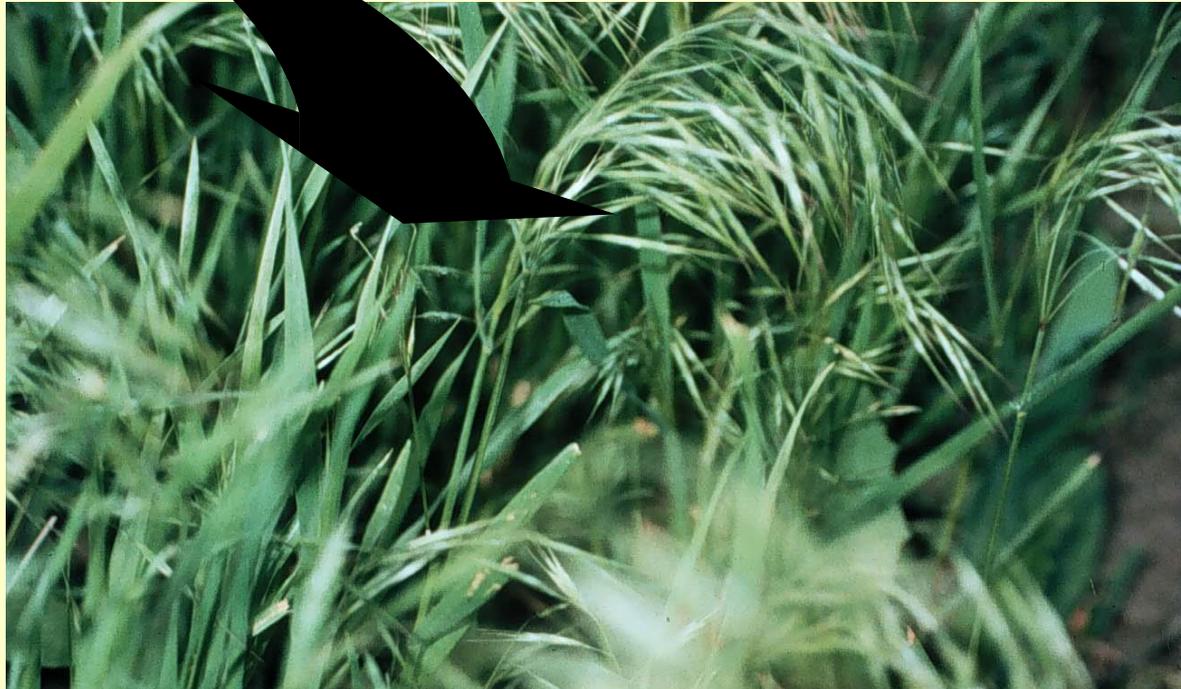
SCREENING >10,000+ isolates



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:

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





Control Plot

Downy brome was inhibited by bacteria in the field

Field Studies

Winter wheat no-till planted

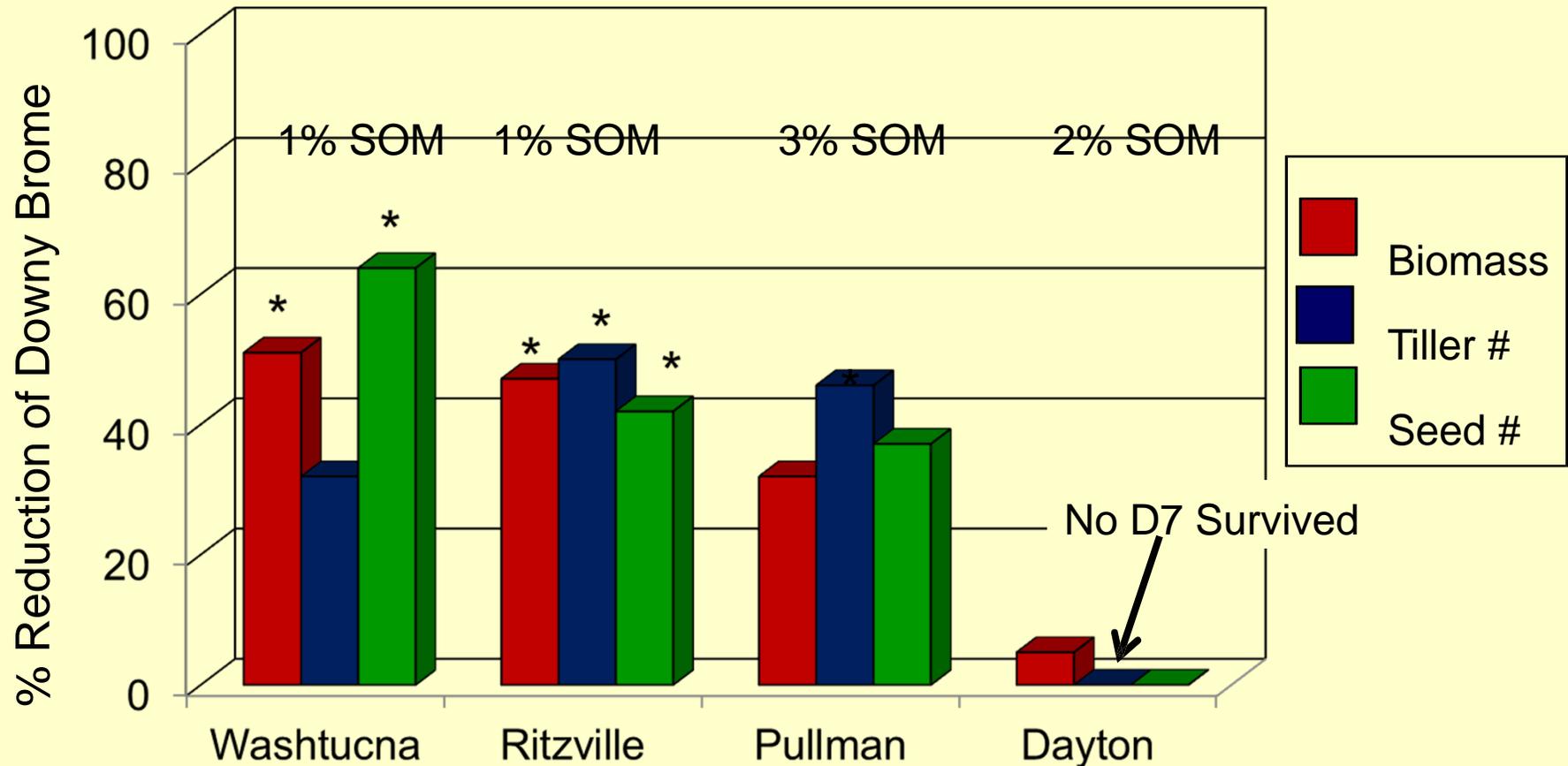
**Natural infestation of downy brome;
Benge, WA**

Inoculated Plot



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 cheatgrass and no cheatgrass in fields



Pasture Field Trials, Pullman, WA

P.f. D7 applied as spray in fall

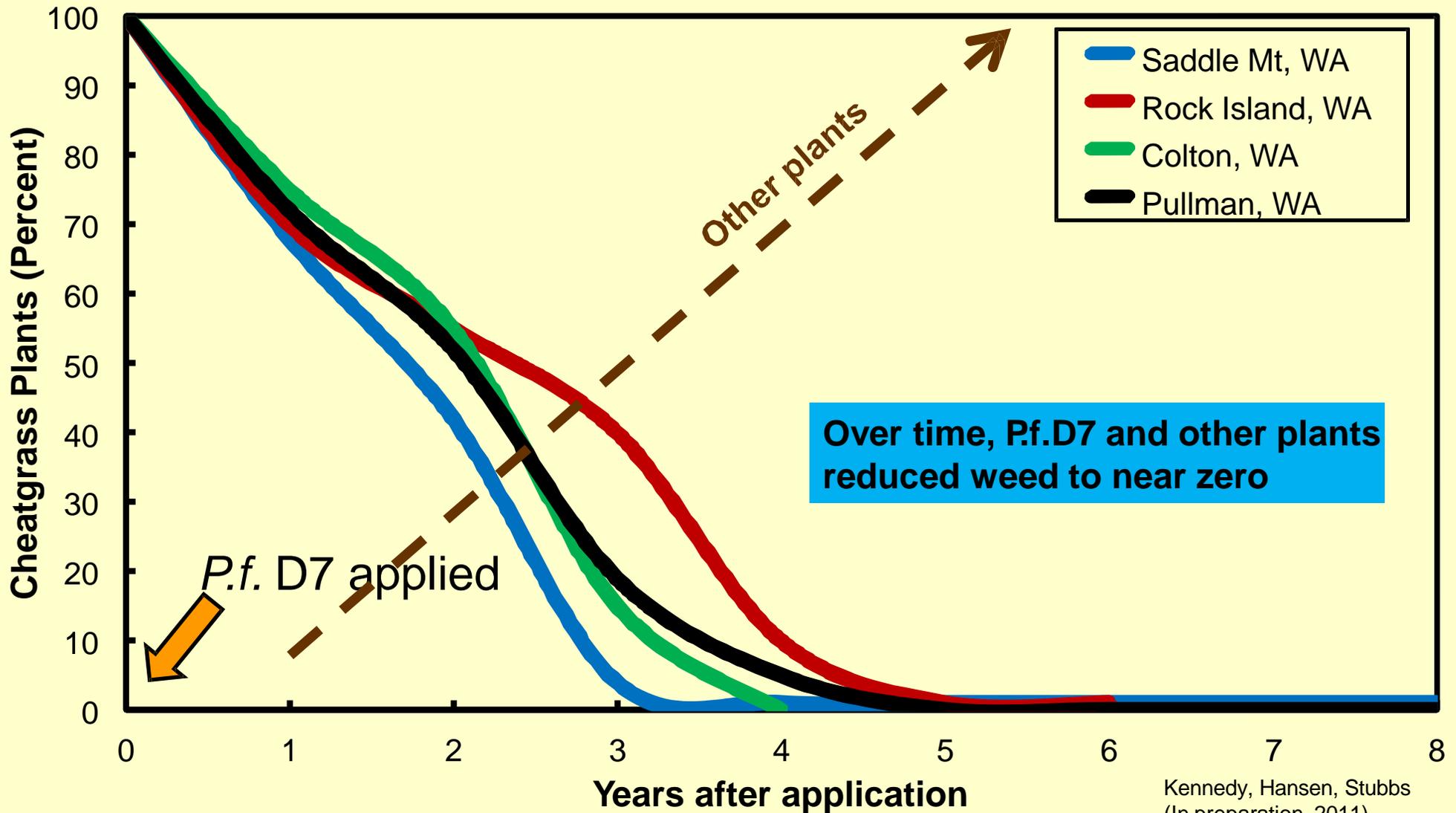
Control

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)



SCALE UP - Fermentors



Shelf Life



Freeze-Dried Bacteria



Vacuumed-Packed Bacteria

Vacuum packed/frozen – many years
Vacuum packed/refrigerated – 1 year
Not vacuumed pack – 3 months



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 #

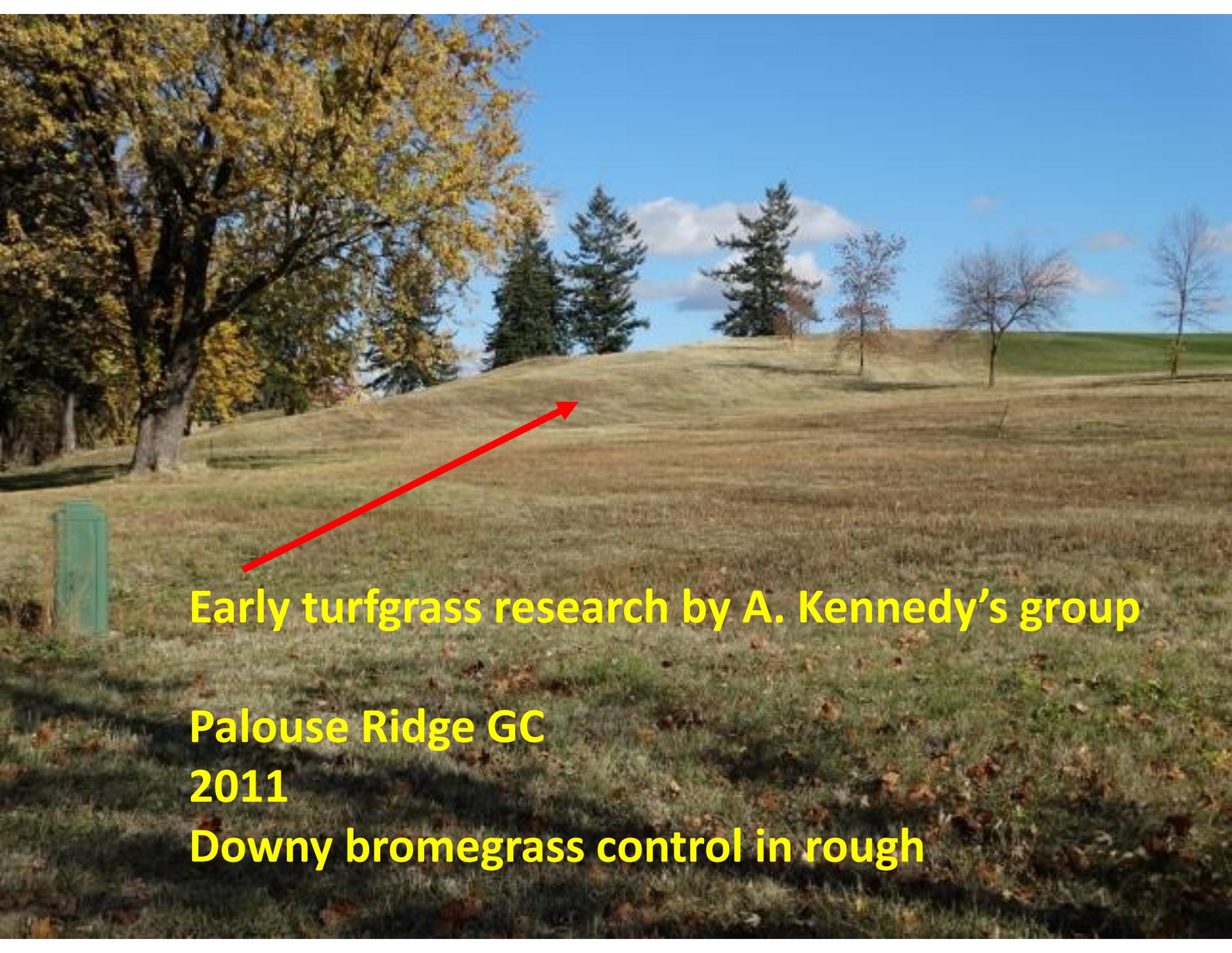
Northwest Agricultural Products
P.O. Box 3453
Pasco, WA 99302
(509)547-8234





VERDESIAN

**Jim Connolly - planet turf
Verdesian Life Sciences**

A photograph of a golf course rough. The foreground is a mix of green grass and brown, fallen leaves. A red arrow points from the bottom left towards a small, rounded mound of grass in the middle ground. To the left, there are several trees with yellow and orange autumn foliage. In the background, there are more trees, including some evergreens, and a clear blue sky with a few clouds. A green trash can is visible on the left side of the image.

Early turfgrass research by A. Kennedy's group

Palouse Ridge GC

2011

Downy brome grass control in rough



2016 NTA Proposals:

1. Biological Control of *Poa annua* in Fairways

2. *Poa annua* Control in Fairways – Chemical Programs

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

3-yr Study

**Chemical followed by
Biocontrol**

**Fall
Biocontrol vs. Chemical**

**Fall – Spring
Biocontrol vs. Chemical**

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



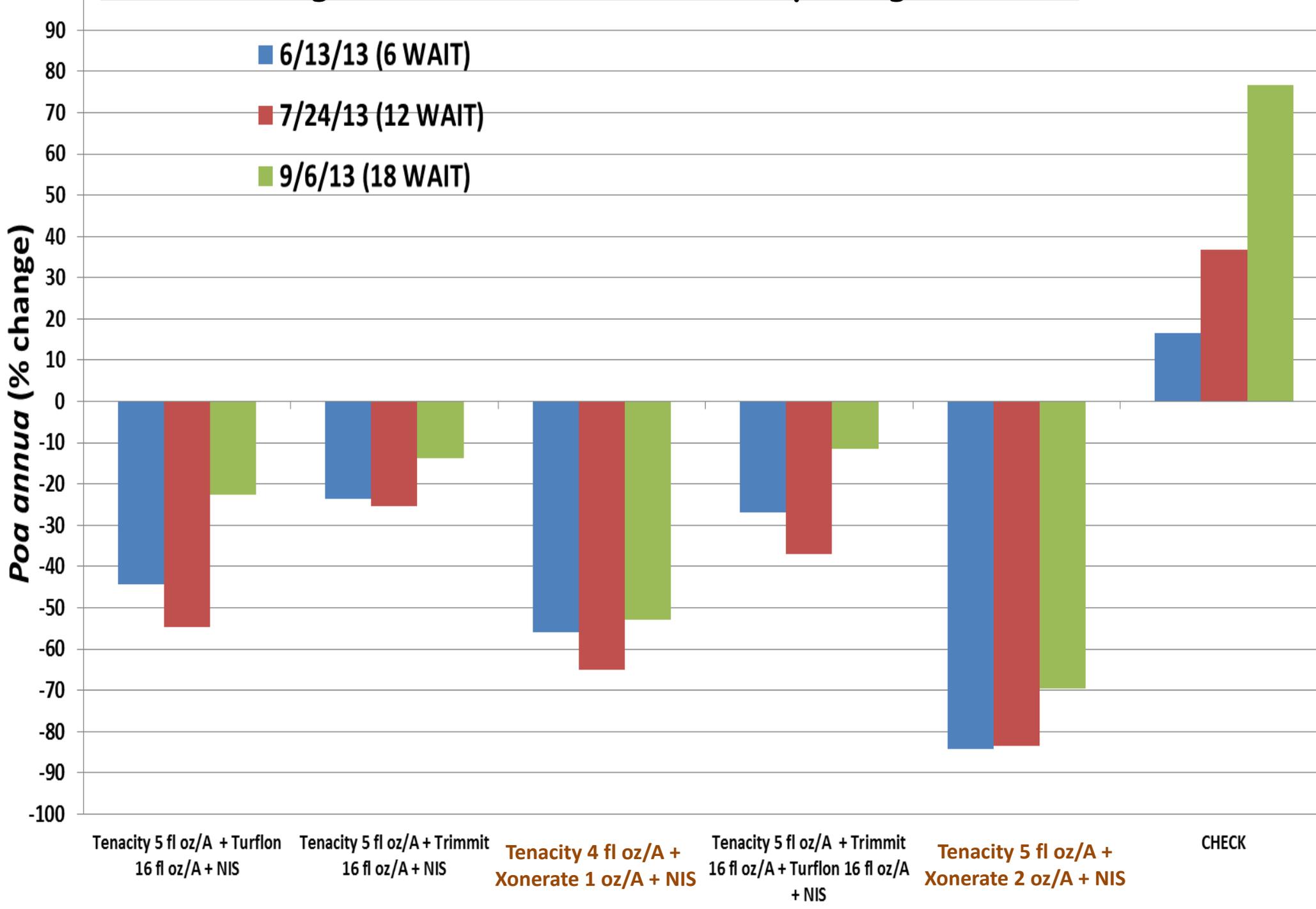
3-year Biocontrol/Chemical Control Study @ Palouse Ridge G C

**D-7 1 app fall 2016; to be applied 11/15/16 @ 3 rates
(2, 10, and 30 g/A)**

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

PoaCure; 3 apps spring 2016, 2 so far in fall 2016 @ 1.26 fl oz/M

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



18 WAIT (September 6)

CHECK

**Tenacity 5 fl oz/A + Trimmit 16 fl oz/A +
Turflon Ester Ultra 16 fl oz/A + NIS**

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

CHECK

Herbicides applied May 2, May 23 and June 13

18 WAIT (September 6)

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

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

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

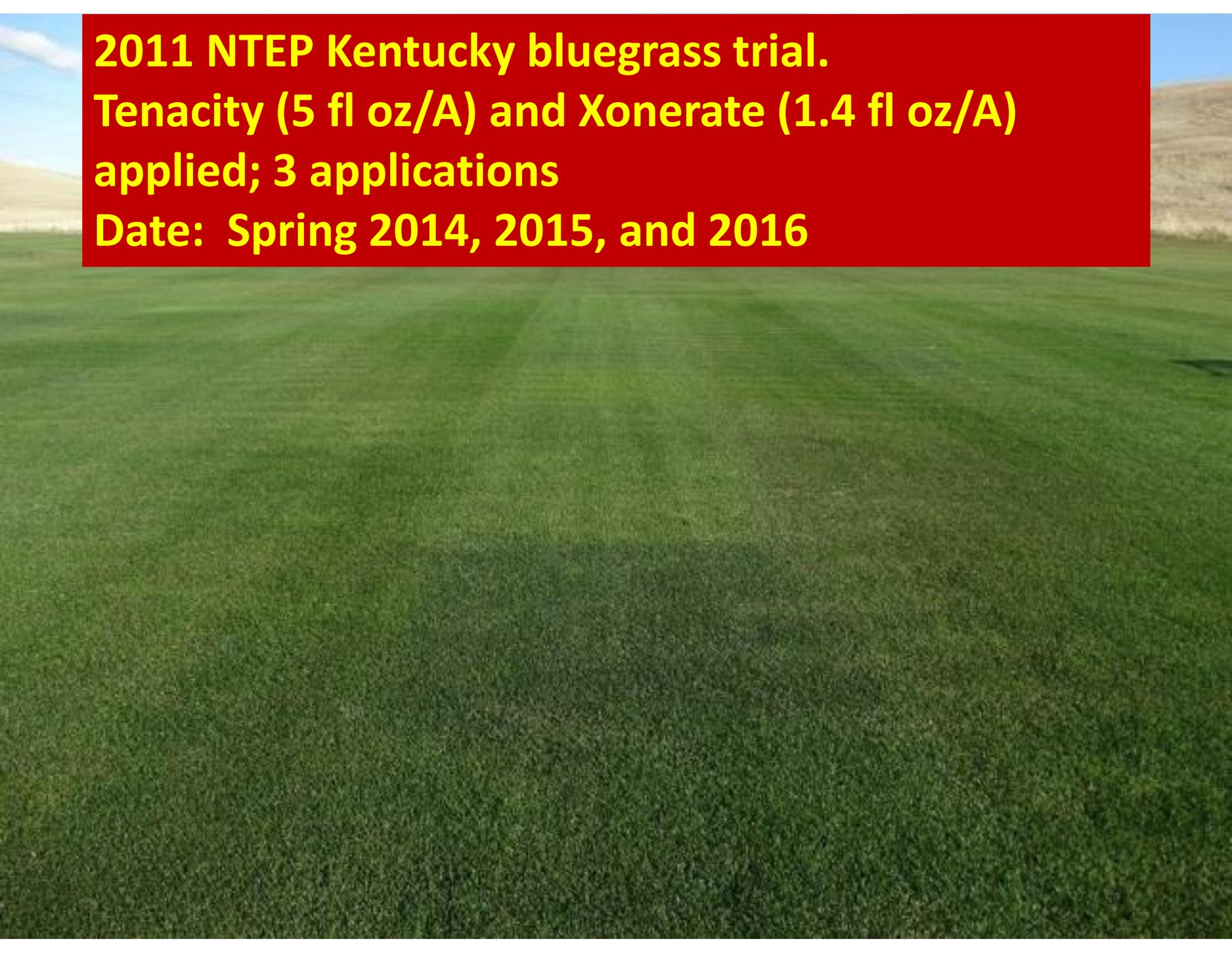
Tenacity 5 fl oz/A + Trimmit 16 fl oz/A + Turflon + NIS

Herbicides applied May 2, May 23 and June 13

2011 NTEP Kentucky bluegrass trial.

**Tenacity (5 fl oz/A) and Xonerate (1.4 fl oz/A)
applied; 3 applications**

Date: Spring 2014, 2015, and 2016



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.



Methiozolin

Moghu Research Center

South Korea

**Registered for turf in
Korea**

April 2010 'PoaCure'

Pine Ridge Country Club, South Korea



Long Island National Golf Club, NY



Photo taken 5/16/15

Poa annua control with PoaCure on bentgrass greens

5% Poa

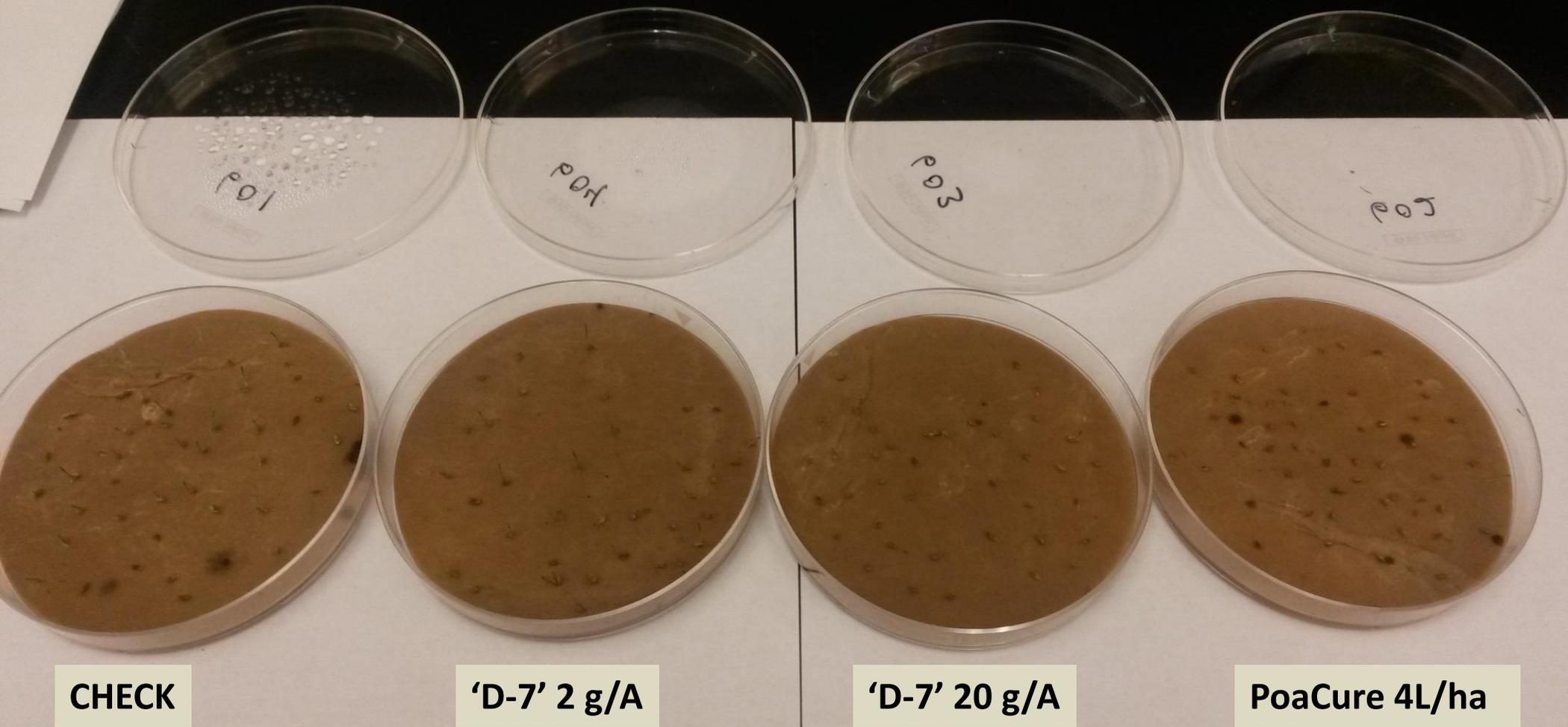
65% Poa

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
9 days after planting**

201



CHECK

202



'D-7' 2 g/A

203



'D-7' 20 g/A

204



PoaCure 4L/ha

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



CHECK

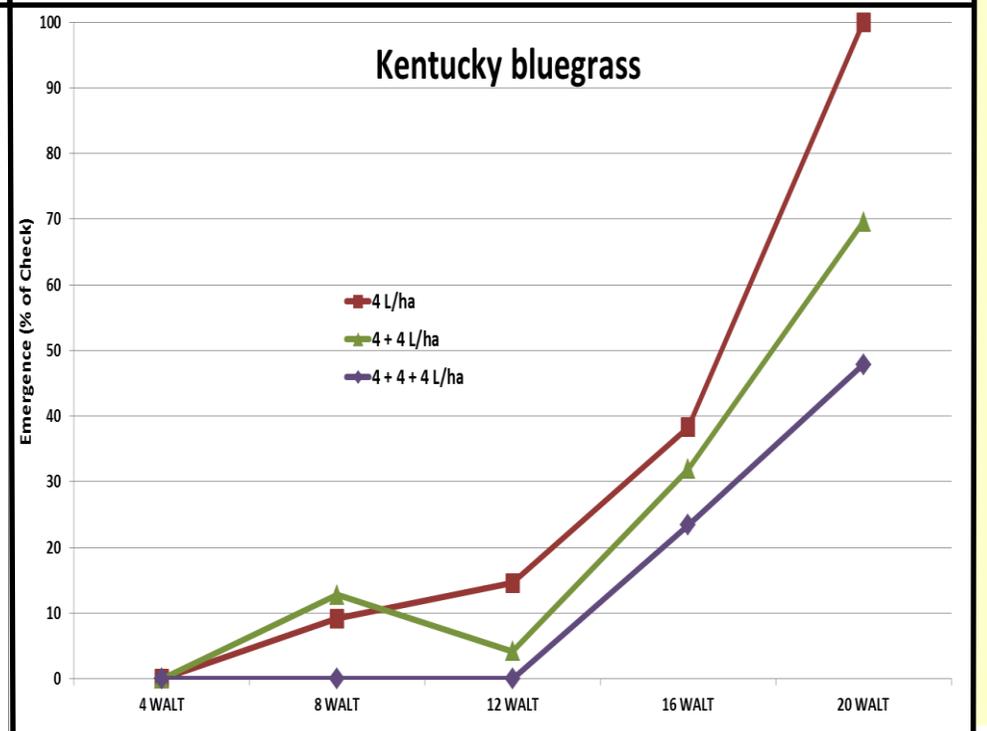
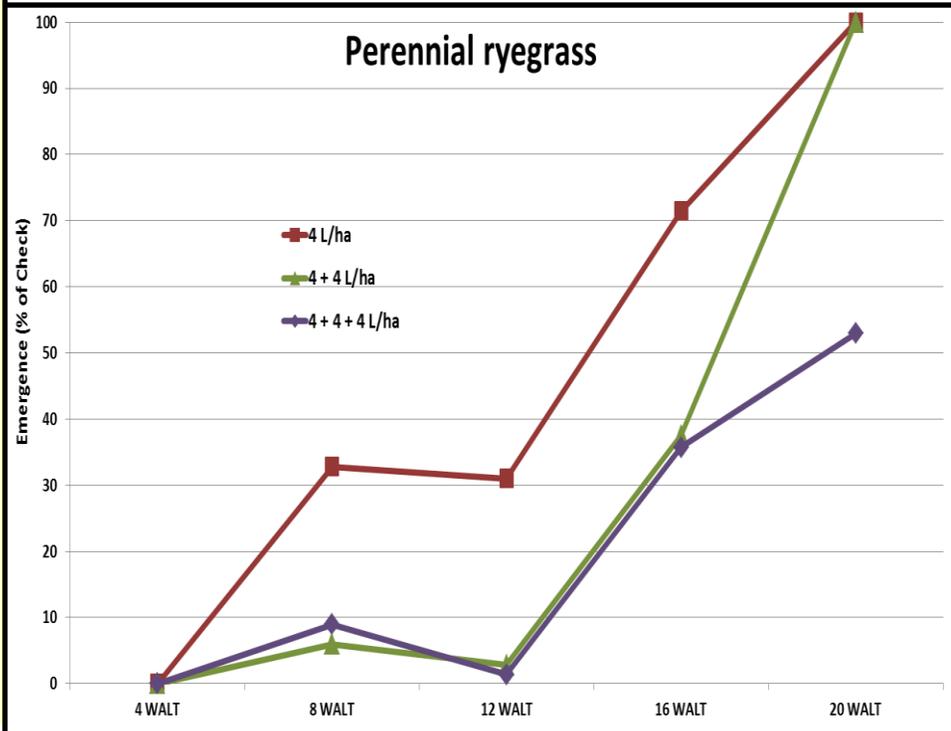
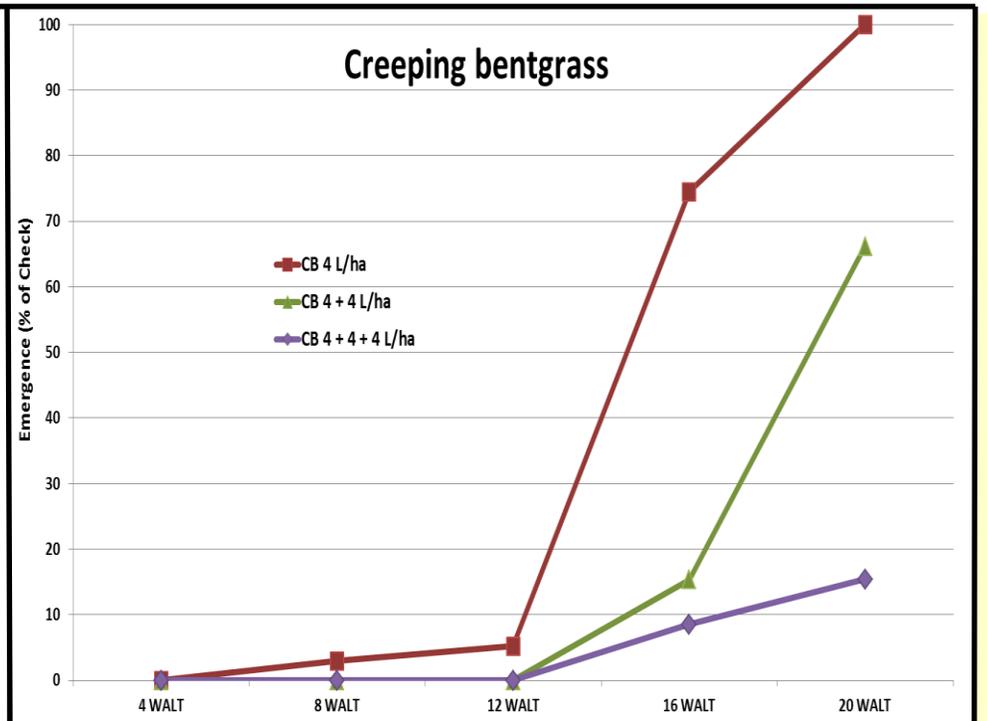
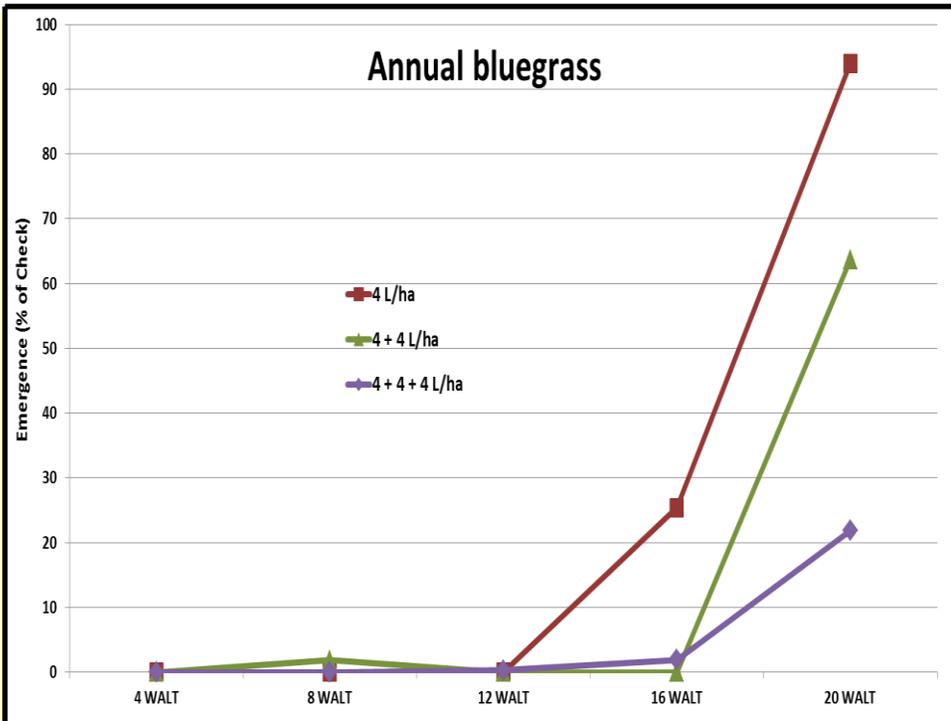
'D-7' 2 g/A

'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 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

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

WSU turf position – Status update

1. Grass Ecology position

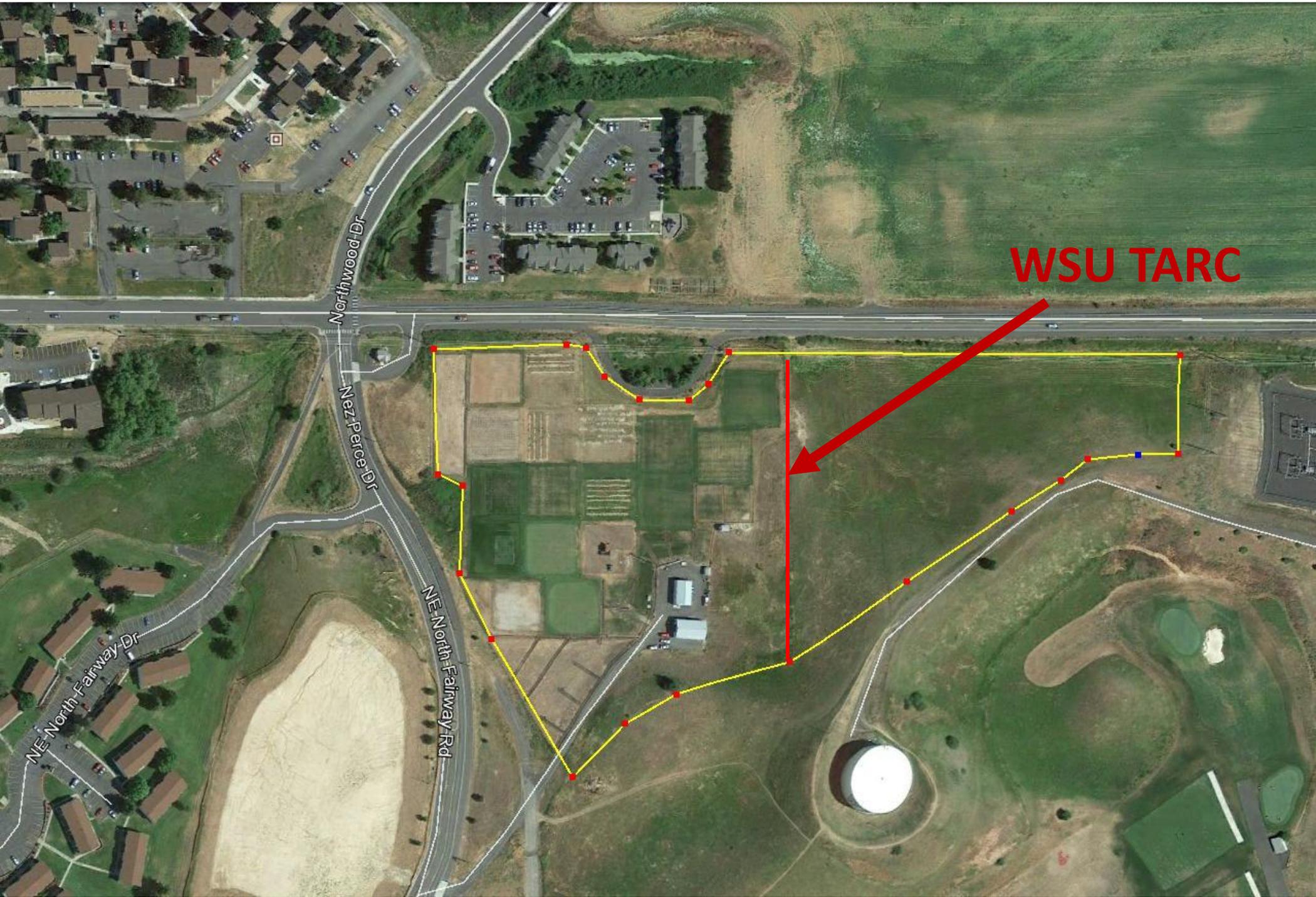
a. Turf

b. Seed

2. Turf Plots

“Moving again”; 3rd time in one career

Grass Ecology Research & Teaching Laboratory



WSU TARC





Proposed site at the Palouse Ridge GC

Facilities Services GIS
Real Estate

Measuring Tools
Area Line Radius Lat/Long

The Area is:
In Square Feet: 200716.77
In Square Meters: 18667.04
In Square Miles: 0.01
In Acres: 4.61
In Hectares: 1.86
Perimeter in Feet: 2675.58

Basemap Layers
Work Canvas
Measure Draw
Settings Export

Antelope Dr
Animal Sciences Bldg
Antelope Dr
Antelope Dr

esri



Interacting with the NTA has been a great.

All the best!

Thanks for the mentoring, support, and friendship. And one last – Go Cougs!

