Management of Bentgrass Cultivars for Improved Resistance to Microdochium Patch under Climate Change Conditions

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Agriculture and Agri-Food Canada

Climate Change

- Predictions of future climate change:
  - Increases in greenhouse gasses
  - Increase Earth's average temperature
  - Influence precipitation patterns
  - Reduce ice and snow cover
  - Increase the frequency, intensity, and/or duration of extreme events
  - Impact plant diseases?

Engabreen Glacier-1917

Engabreen Glacier-1979

Engabreen Glacier- 2001

http://glacier.nve.no/viewer/GPP/no/nve/GlacierPictureInfo

Engabreen Glacier- 2015

http://glacier.nve.no/viewer/GPP/no/nve/GlacierPictureInfo

“Better living conditions”

http://www.dagbladet.no/nyheter/sinte-snomenn-demonstrerte-for-kulde/66293013

Microdochium nivale

- Hosts include barley, oats, wheat, and cool-season turfgrasses
- Pink Snow Mold after snowmelt
- Fusarium Patch/Microdochium Patch

Guelph Turfgrass Institute, 2015

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Stricker, 2016

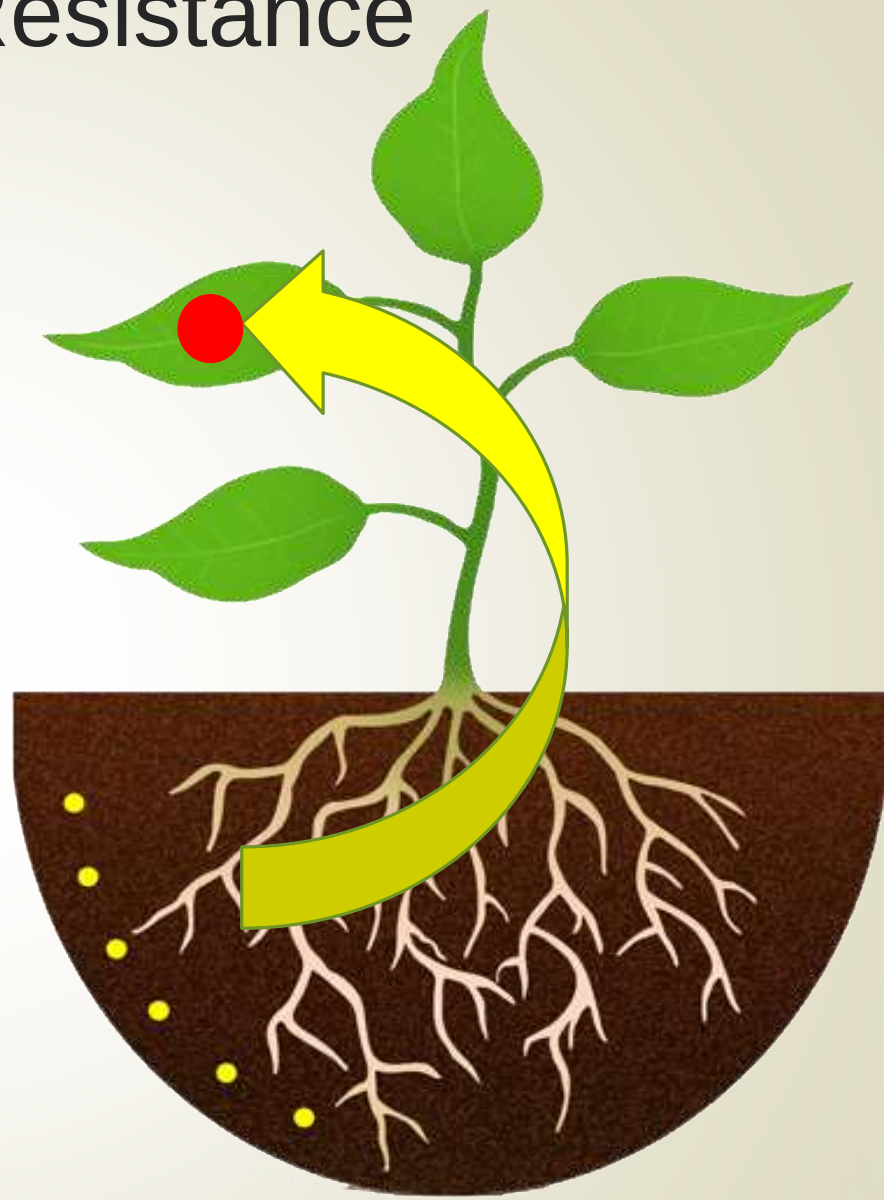
Hsiang, 2007

Canadian pesticide regulations

- Canadian pesticide regulations more vigorous than those in USA
- Ontario's *Cosmetic Pesticide Ban*, 2009
  - Prohibits use of pesticides in public spaces and for personal use (sports fields exempted)
- Quebec's *Pesticide Code,* 2006
  - prohibits the use of more than 100 pesticide products registered for use in the rest of Canada
  - Québec golf courses that apply pesticides are required to submit a pesticide reduction plan every three years.

Induced Systemic Resistance

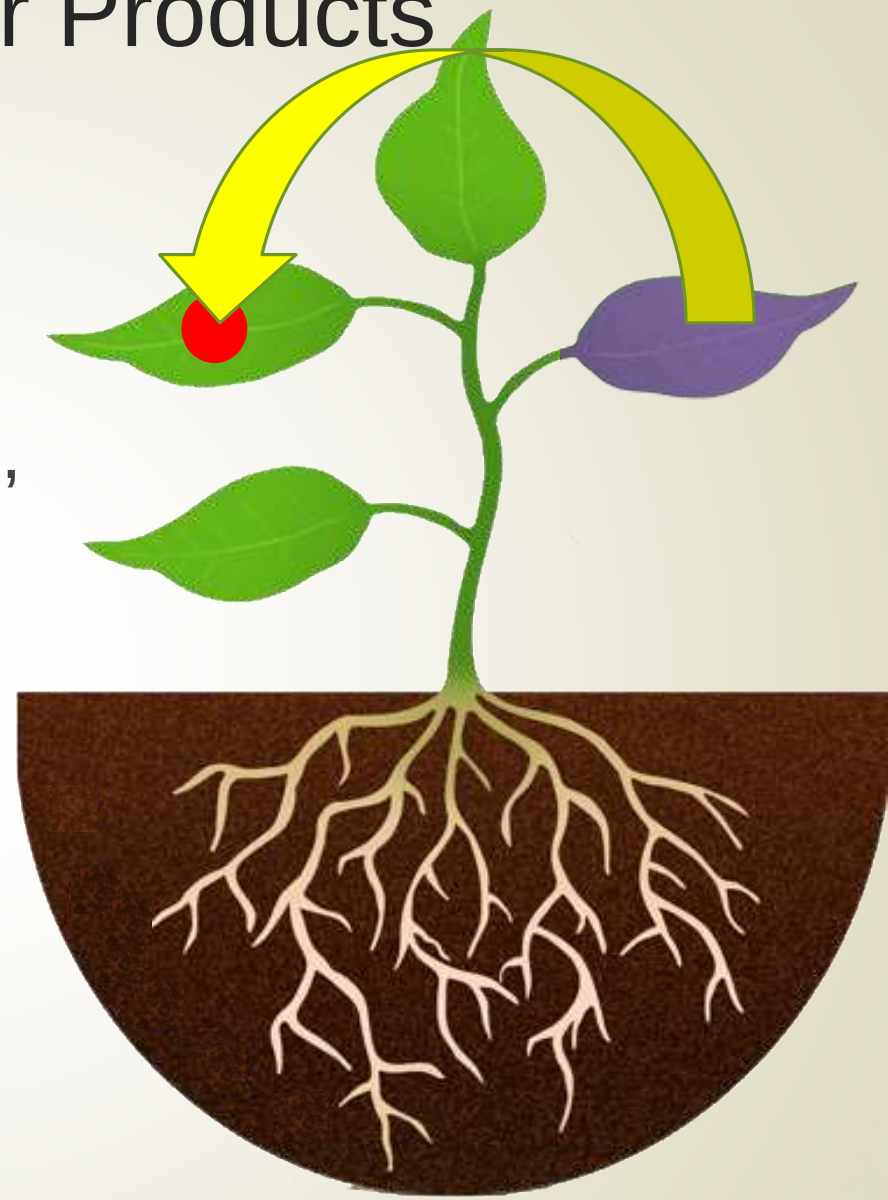
- First discovered with rhizobacteria
- Using a plant's natural resistance responses against:
  - Abiotic stresses
  - Insects
  - Diseases
- Speed of recognition and response is key



Resistance Activator Products

- A synthetic chemical that is non-toxic to plants and fungi that, when applied to a plant, activates natural resistance responses

- New plant tissue is protected systemically



Civitas + Harmonizer™

- Developed by Petro-Canada
  - Civitas: Food-grade isoparaffins
  - Harmonizer: Pigment dispersal product containing chelated copper
- Civitas increases the expression of resistance genes for efficacious control of diseases caused by:
  - *Microdochium nivale*
  - *Rhizoctonia solani*
  - *Sclerotinia homoeocarpa*

(Cortes et al. 2010)

Main Questions

- How will disease severity of bentgrass cultivars be affected by climate change?
  - Specifically increased CO_2
- How will the efficacy of Civitas + Harmonizer™ be affected by elevated CO_2?

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CO_2 Growth Chambers

- Soils and Crops Research and Development Centre Québec City, Québec

Agriculture and Agri-Food Canada

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Seeding

Creeping bentgrass (*A. stolonifera*)

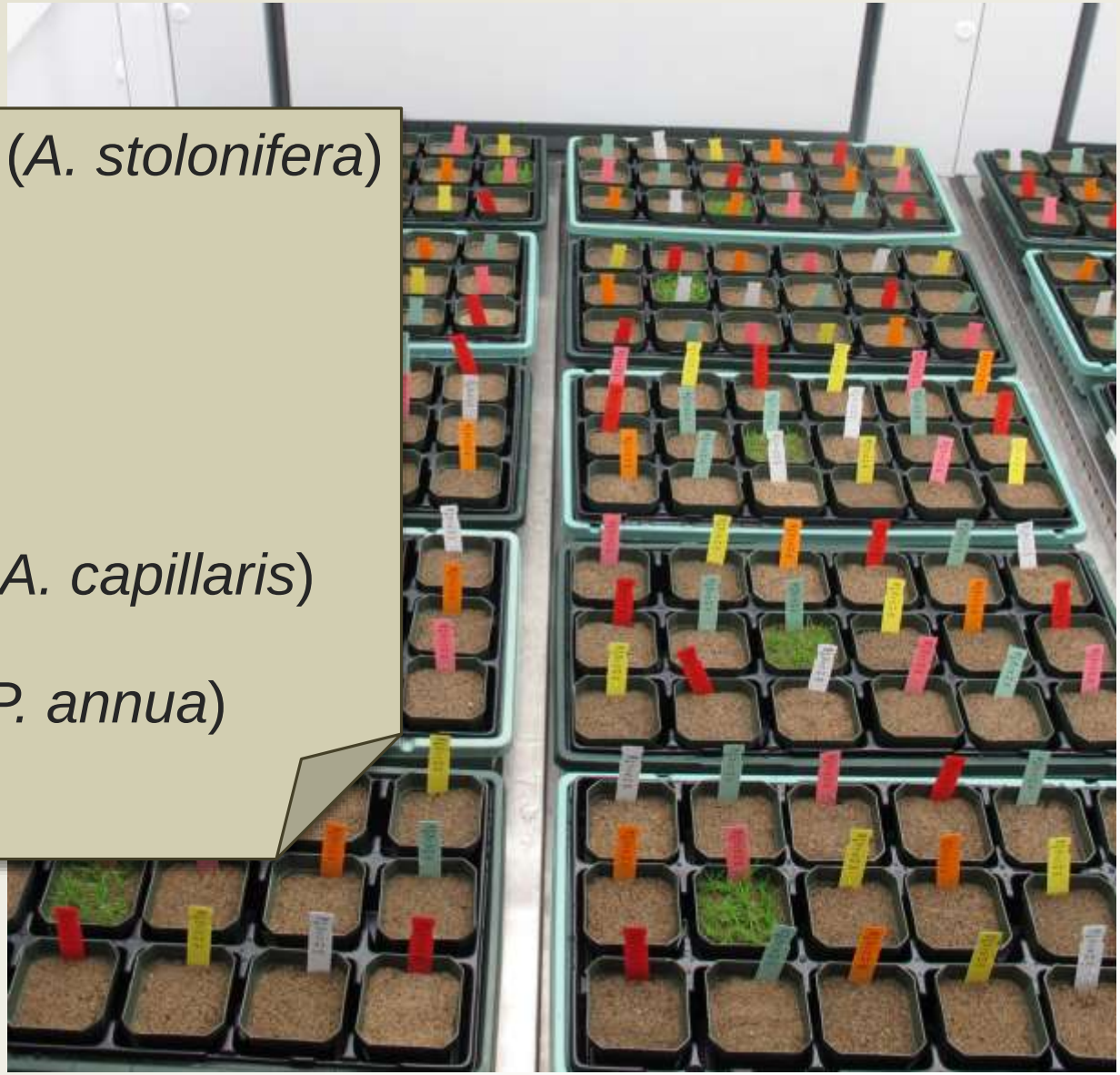
- Alpha
- Penncross
- Tyee
- T1
- Focus
- Independence

Colonial bentgrass (*A. capillaris*)

- Leirin

Annual bluegrass (*P. annua*)

- LaBelle (propagated)



NIBIO
NORSK INSTITUTT FOR BIOØKONOMI

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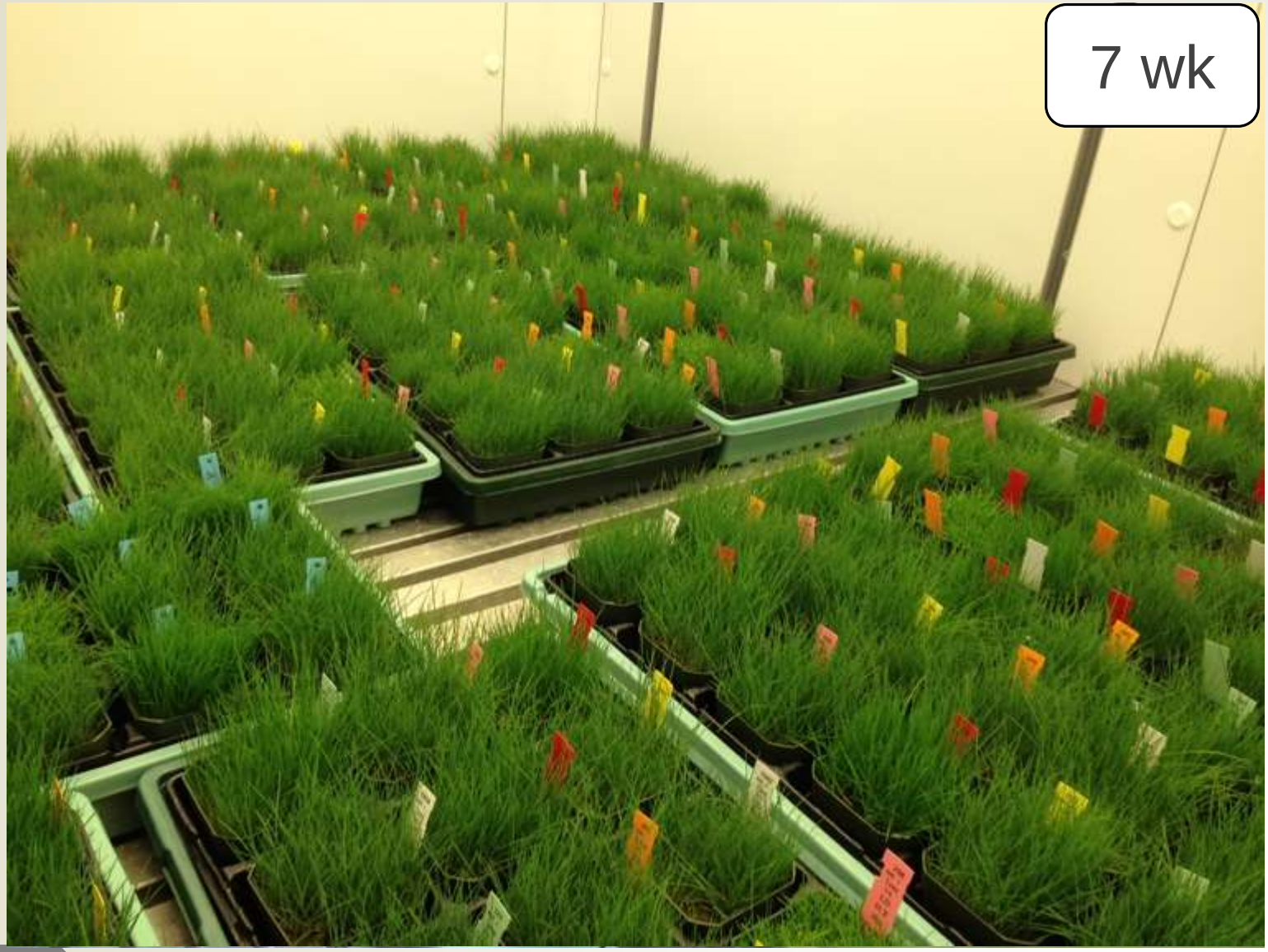
Growth- 20°C day / 15°C night



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Growth- 15°C day / 10°C night

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Sampling

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Activator Treatment

10 wk

Tissue samples were collected and frozen 1 wk later before inoculation

Activator Treatment

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Inoculation

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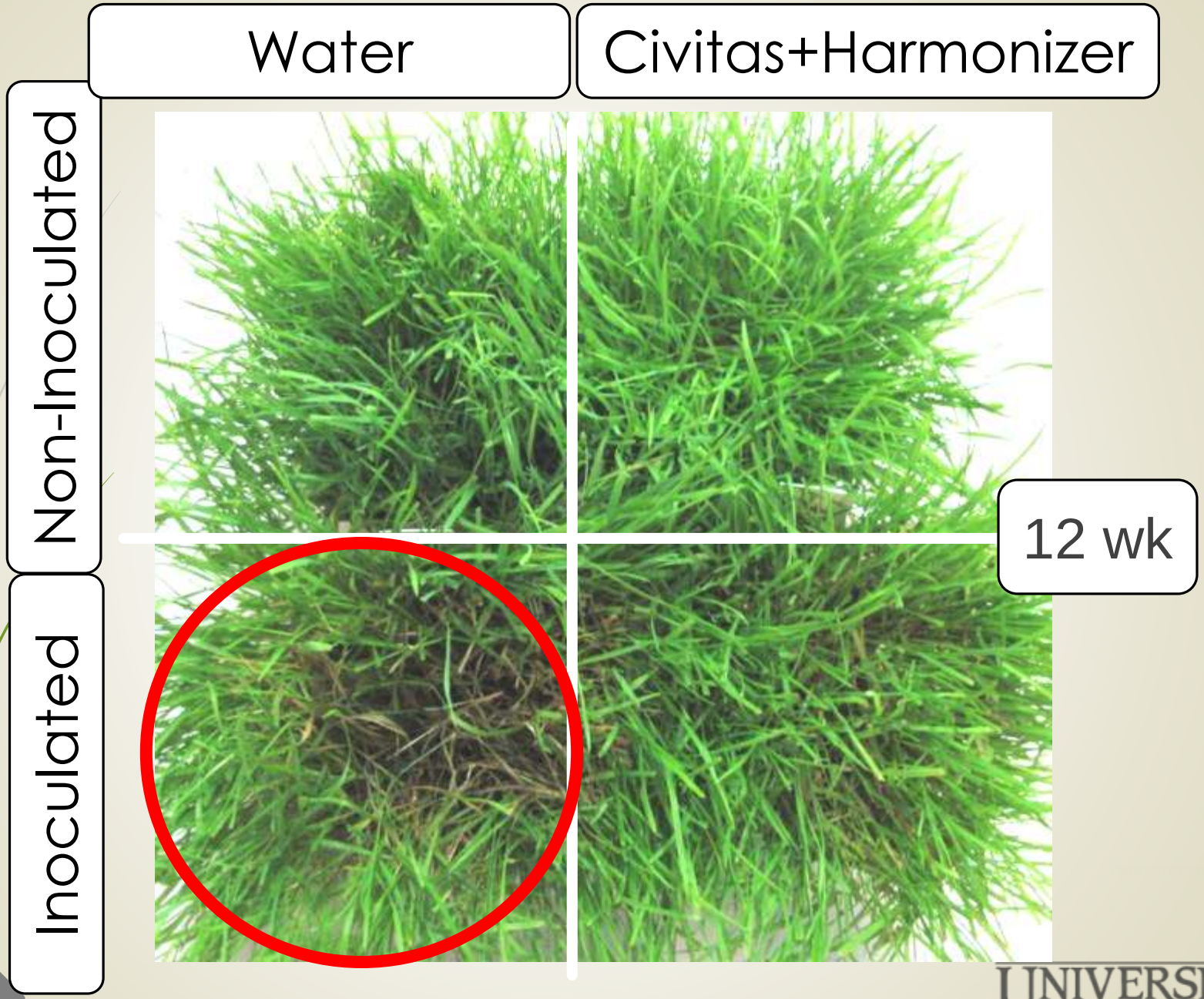
Inoculation

Agriculture and Agri-Food Canada



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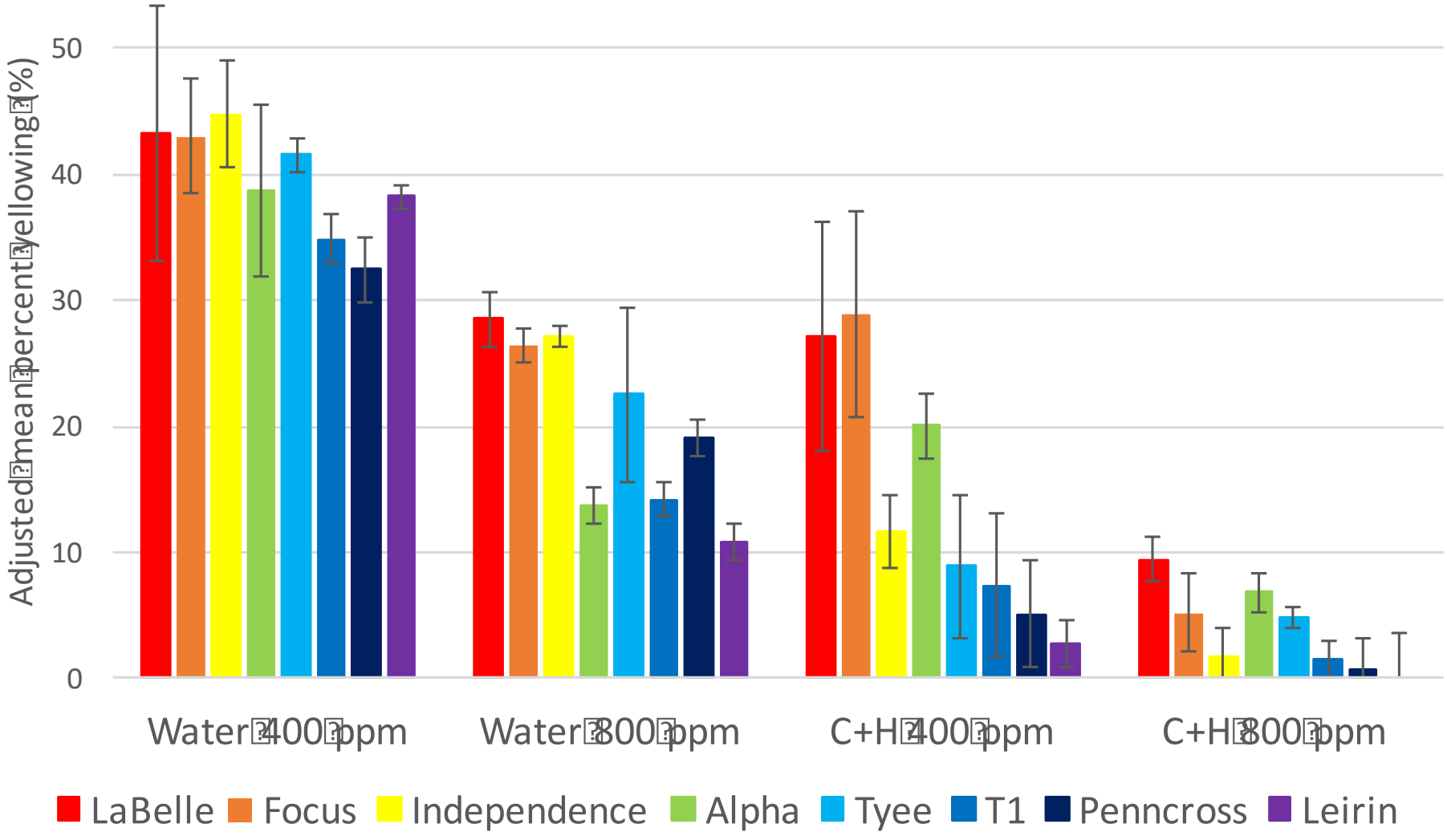
Percent yellowing of turfgrasses by treatment 15 days post inoculation with *M. nivale*



Results- Disease Suppression

Mean percent disease suppression where Civitas+Harmonizer was first applied and then *M. nivale* was inoculated 7 d later, and yellowing was rated several days after inoculation (dpi) at two CO_2 concentrations

	400 ppm				800 ppm			
Cultivar	7 dpi	9 dpi	15 dpi	21 dpi	7 dpi	9 dpi	15 dpi	21 dpi
Alpha	-10[a]	-21	48 [b]	38	0	53	50	10
Focus	11	15	33	6	36	72	80	66
Independence	-10	-23	73	23	18	46	94	-115
LaBelle	12.0	69	37	40	40	56	67	-58
Leirin	-17	32	92	21	5.9	-15	151	48
Penncross	-76	80	84	34	34	56	96	-30
T1	-112 [b]	74	79	45	4.2	38	89	21
Tyee	15	30	79	28	23	-16	79	51
Average	2	32	68	29	20	36	88	-0.8
Cultivar LSD (*p=0.05*)	94	82	38	102	58	76	37	85

[a] Means were calculated as (Water treatment yellowing – CH treatment yellowing)/(Water treatment yellowing) where yellowing was adjusted for basal yellowing in the non-inoculated control, and are based on up to 8 replications for 7, 8 and 15 and 4 replications for 21 dpi

[b] Red shaded boxes are significantly less than 0, and Green shaded boxes are significantly more

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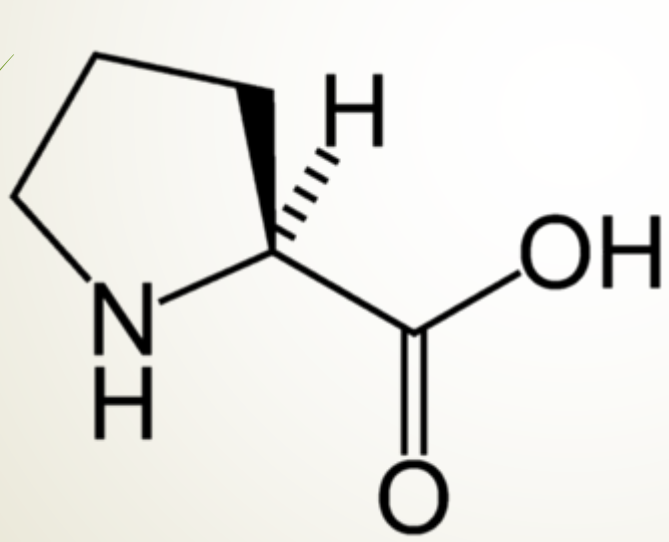
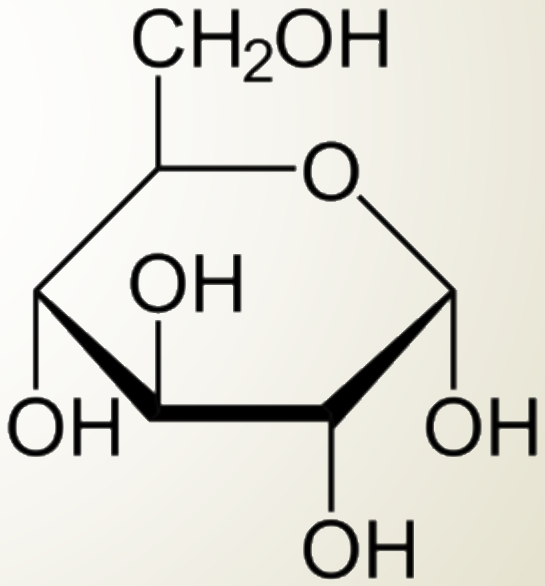
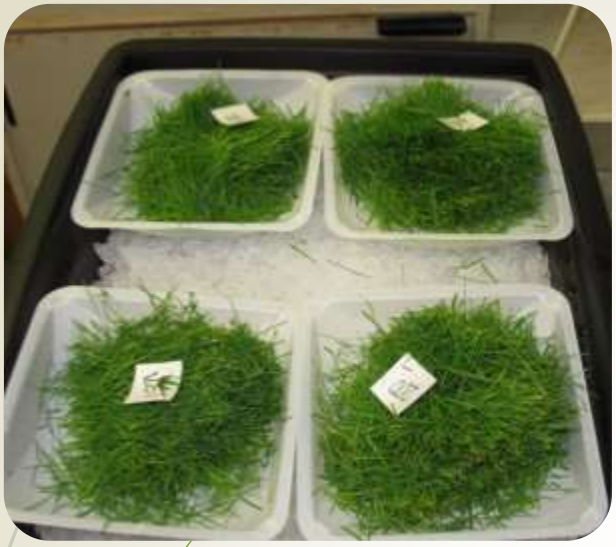
More Questions

- Does elevated CO_2 and Civitas + Harmonizer have an impact on free amino acid and soluble sugar composition of grasses?





Waters ACQUITY UPLC analytical system



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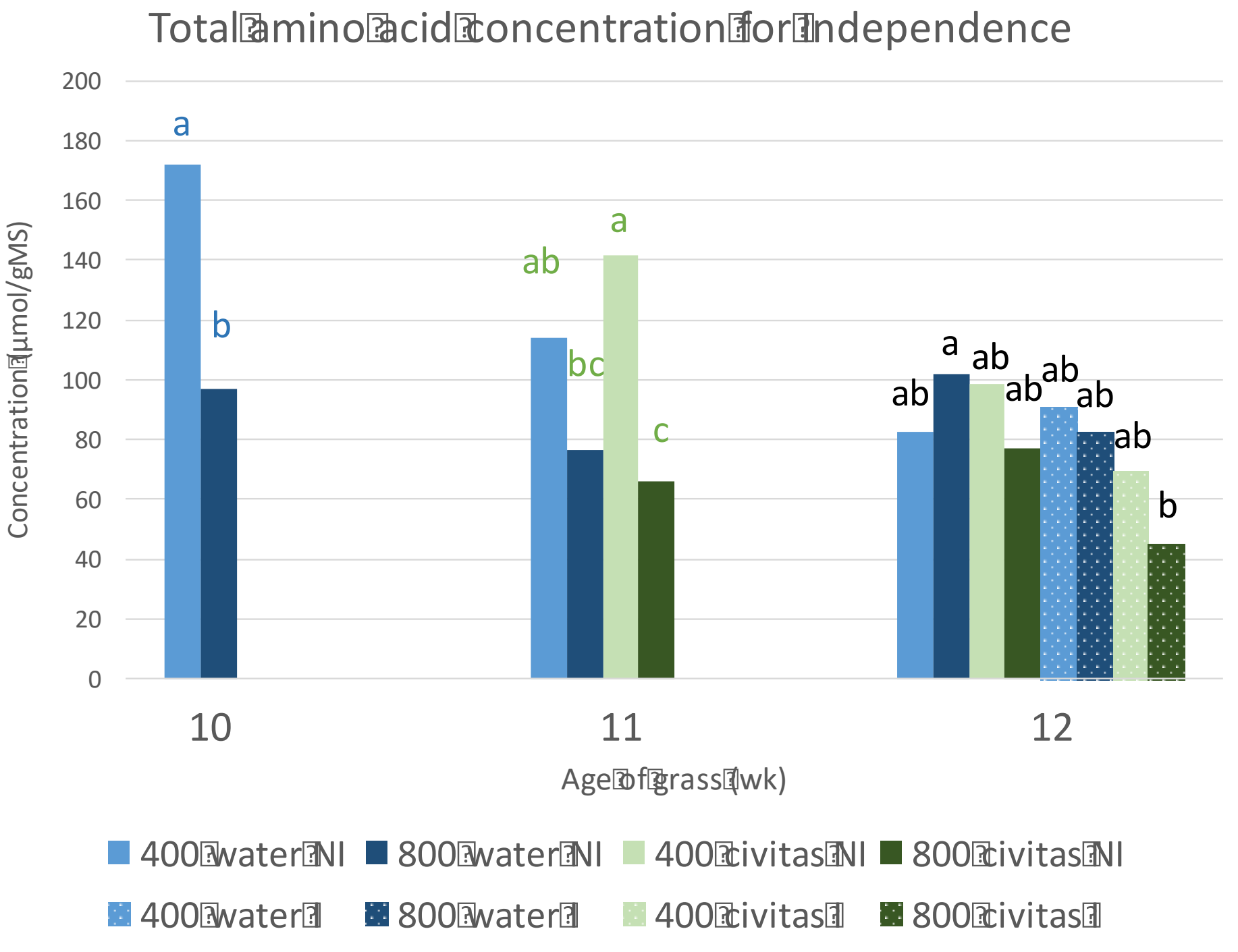
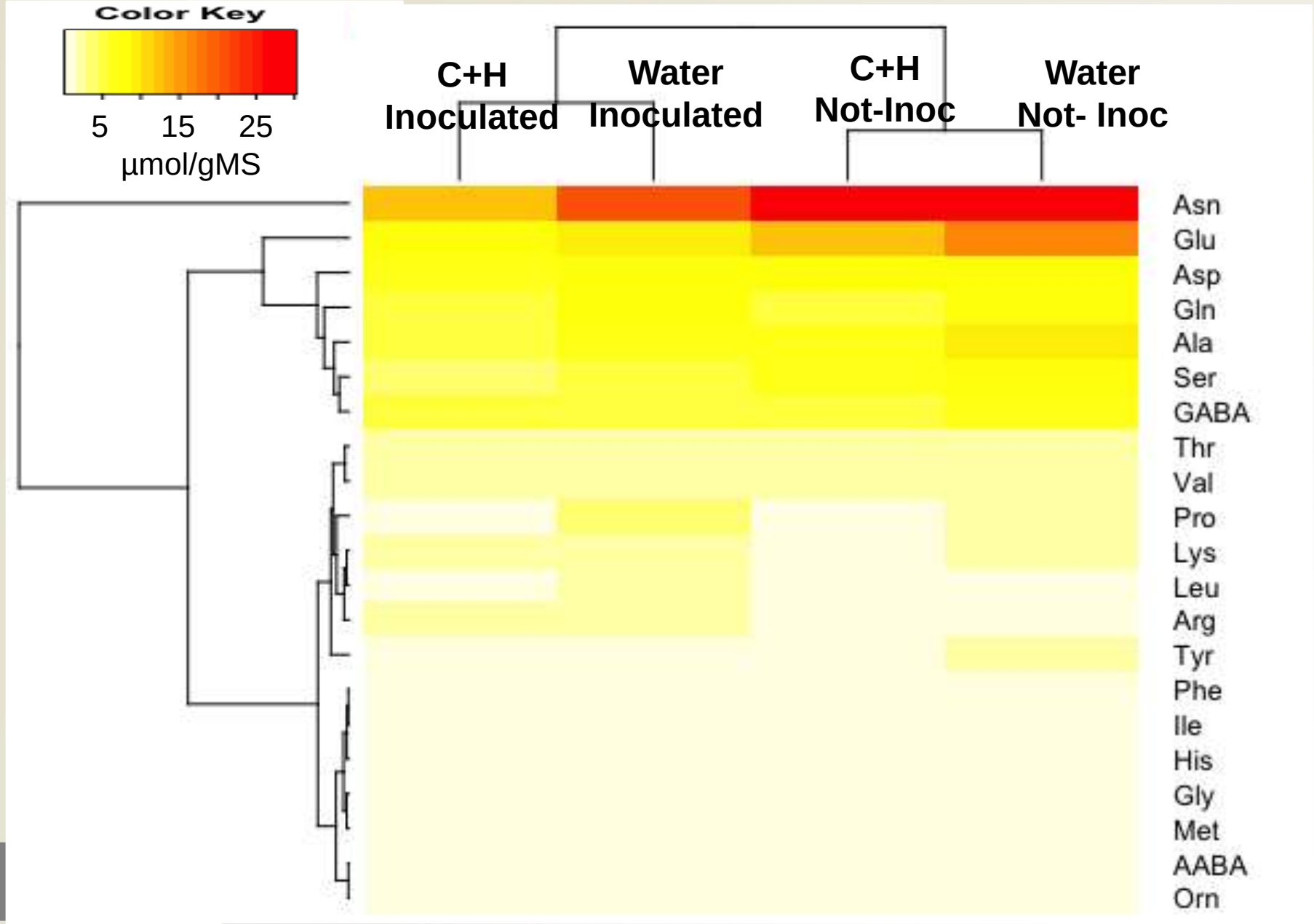

Total amino acid concentration for Independence
Concentration (µmol/gMS)
200
180
160
140
120
100
80
60
40
20
0
a
b
ab
bc
a
c
ab
a
ab
ab
ab
ab
b
10
11
12
Age of grass (wk)
400 water NI
800 water NI
400 civitas NI
800 civitas NI
400 water I
800 water I
400 civitas I
800 civitas I

Amino acid concentrations by treatment



CO_2 Chambers Results-Carbohydrates

Carbohydrate content (mg/gDW) of creeping bentgrass cultivars under two CO_2 concentrations after 12 weeks of growth

		400 ppm				800 ppm			
		Independence		Focus		Independence		Focus	
	Sugar	Non	Inoc	Non	Inoc	Non	Inoc	Non	Inoc
Water	Sucrose	5.9	6.7	9.6	6.5	16	4.4	9.4	5.2 *
	Glucose	4.3	8.8 *	6.4	8.0	6.2	4.8	6.6	6.7
	Fructose	3.7	6.1	4.9	4.7	5.3	3.1	4.7	4.0
	Total SS	14	22	21	19	28	12	21	16
	HPF	0.7	2.1	0.8	1.0	1.2	1.9	3.4	1.7
	TNC	15	24	22	20	29	14	24	18
C+H	Sucrose	5.3	7.2 *	14	17	7.0	4.5 *	6.9	5.2
	Glucose	4.4	8.7	7.2	8.9	5.3	4.4	6.2	5.1
	Fructose	2.9	5.2	4.7	5.9	3.7	3.2	4.8	3.3 *
	Total SS	13	21	26	32	16	12	18	13
	HPF	0.5	3.2	1.0	2.4	2.3	3.7	3.2	1.8
	TNC	13	24 *	27	35	18	16	21	15

*indicates significance at $p<0.05$ between NI and I treatments
SS= soluble sugars, HPF= high degree of polymerization fructans,
TNC= total nonstructural carbohydrates

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Conclusions: Disease symptoms

- For most cultivars, C+H efficiently reduced disease symptoms after 15 days
- The positive effect on disease suppression by C+H was higher under elevated CO_2
- Inter- and intraspecific differences in turfgrass response to C+H and CO_2 concentration.
  - Cultivar selection could be part of Integrated Pest Management (IPM) practices to reduce Microdochium patch disease both under current and future conditions.

Conclusions: Biochemical responses

- Overall decrease in amino acids and carbohydrates over time
- Elevated CO_2 decreases free amino acids
- Inoculation decreases free amino acids while effect of sugars is varied
- When treated with C+H (Focus low response, Independence high response) at 800 ppm we observed:
  - An increase in proline (53%) in Independence when inoculated, yet no change for Focus
  - No difference in carbohydrates when treated with C+H

Future Work

- The mechanism of disease suppression by C+H could not be explained by single metabolic changes
  - Further metabolomics studies are needed
- Analysis of RNA expression in creeping bentgrass inoculated with *M. nivale*

Acknowledgements

Funding

- Petro Canada
- Canadian Turfgrass Research Foundation
- Natural Sciences and Engineering Research Council of Canada

People

- Hsiang Lab
- Bertrand Lab
- GTI Staff

Any Questions?

Thank you for your time

Takk for tiden din!

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