Progress Report on NSERC/CTRF/PetroCanada Funded Project by Tom Hsiang, December 2015
(Funding from Jan 1, 2015 to December 31, 2017)

TITLE: Management of bentgrass cultivars for improved resistance to Fusarium patch under climate change

Atmospheric CO_2 concentrations are expected to reach between 500 to1000 ppm by the end of the century and, as a consequence, Canada and other northern countries may experience a seasonal temperature increase between 1.5 and 4°C. These changes will affect the survival of turfgrasses and fungi as well as affecting their interactions, with a potential for greater disease severity. From among widely used bentgrass cultivars worldwide, or those with particular potential for cold environments, we plan to screen for ones which show the greatest resistance to Microdochium patch. We will study the turfgrass and fungal interactions under current and predicted future climatic conditions (CO_2 and temperature increases). In addition, we will test the efficacy of resistance activators such as Civitas/Harmonizer which are sustainable alternatives to chemical fungicides, under altered climatic conditions in atmosphere-control growth chambers and in the field. The grass cultivars will first be tested in the lab, and a select few will be tested in the field in both Canada and Scandinavia. Cultivars that perform well in one or both locations will be further analyzed for their pathogen-associated and activator-induced molecular responses under current climatic and some predicted future climatic conditions, to shed light on the genes and pathways that may be involved. The project will provide recommendations for turfgrass managers on the choice of cultivars and on improved management practices to face the challenges and opportunities of climate change. This research will also generate new scientific information of great interest for stakeholders represented by the Turf Research Association partner, CTRF, which includes turgrass seed companies and turfgrass managers, and of benefit to the other industry partner, PetroCanada, for commercial and R&D purposes.

MILESTONE 1 - Recruit HQP (one post-doc and one graduate student)
Dates: upon NSERC approval of funding to 31 March 2015 DONE (but post-doc just left in Jan 2016)

MILESTONE 2- Select and obtain seed of top selling/widely used/cold environment adapted bentgrass cultivars in Canada (up to 10) and Norway (up to 2) (Growth room tests, ONTARIO & NORWAY) Dates: 1 October 2014 - 30 April 2015 DONE

RESULTS: These species and cultivars have been used in the various tests (red* were sent from Norway).

Agrostis stolonifera (creeping bentgrass)

Alpha	Mackenzie
Cato	007
CY-2*	Penn A4
Declaration*	Penncross
Focus	T1
Independence*	Tyee
Kingpin	

Agrostis capillaris (colonial bentgrass)

Greenspeed* Leirin*

Agrostis canina (velvet bentgrass)

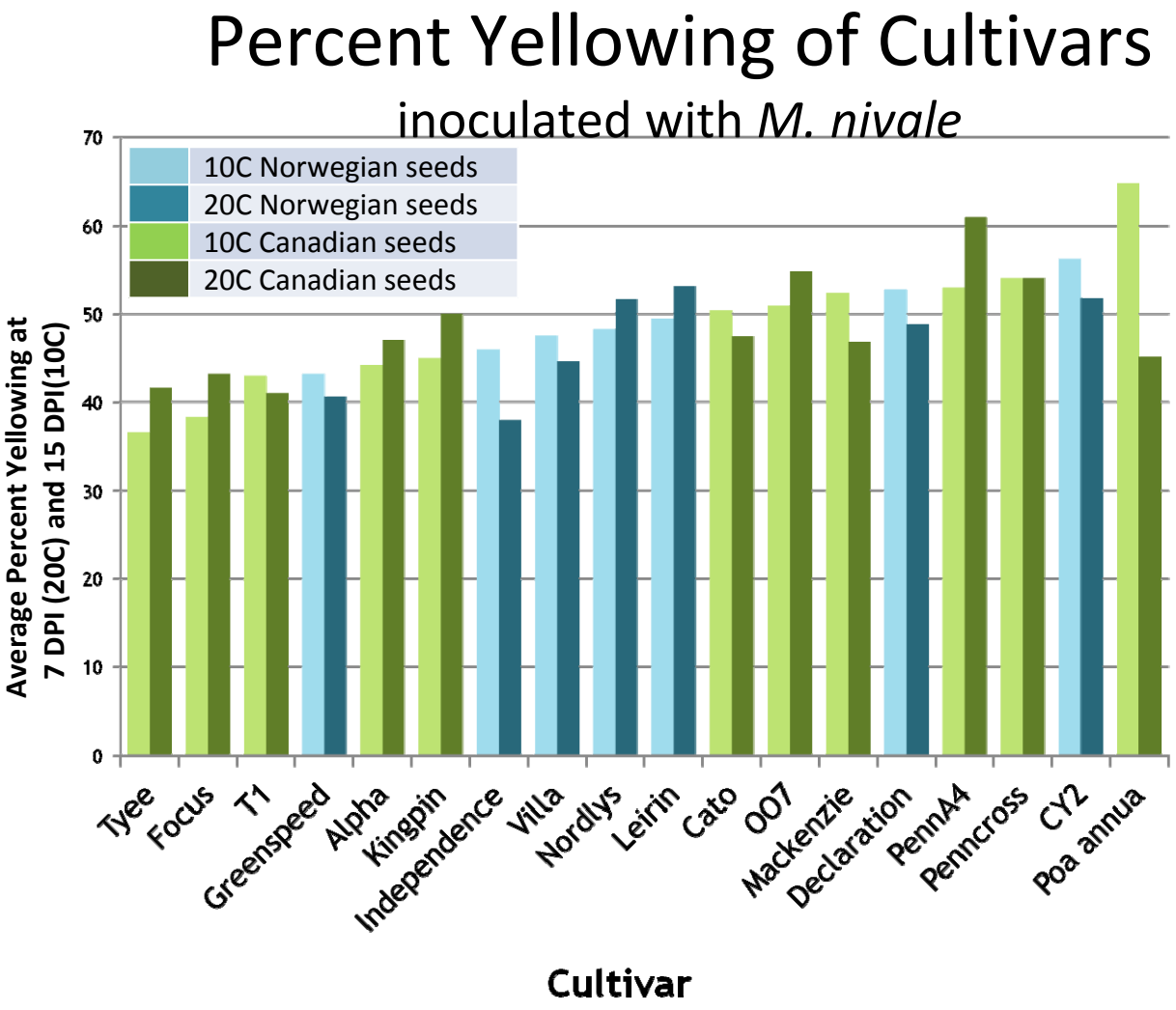
Nordlys* Villa*

Poa annua
wild seed lot, Labelle

MILESTONE 3- Preliminary test for growth response of creeping bentgrass 'Penncross' under high/current CO2 and high/current temperature conditions. In addition, two ecotypes of annual bluegrass (*Poa* annua) that combine resistance to snow mold and high level of freezing tolerance as determined previously (Bertrand et al. Crop Science 2009 49:589-599) can also be included in these trials (growth room test, QUEBEC)
Dates: 1 October 2014 - 30 June 2015 DONE

RESULTS: This was a preliminary test where Vesper velvet bentgrass, and creeping bentgrasses T1, 007 and Penncross were grown at 20/15C under 400 and 800 ppm CO2. All grasses were stimulated (more foliar growth) by higher CO2 and higher temperature. (more data in final report)

MILESTONE 4- Screen top selling/widely used/cold environment adapted bentgrass cultivars in Canada and Northern Europe for Microdochium patch resistance, and identify resistant cultivars at room temperature and cold (10C) conditions (Lab screening, ONTARIO & NORWAY).
Dates: 1 October 2014 - 31 August 2015 DONE (may be repeated)



RESULTS:
- Cultivars with significantly less yellowing at 10C (37-51% at 15 DPI) were less yellowed at 20C (41-61% at 10 DPI)
- Some cultivars exhibited differential yellowing (some higher at 20C, some higher at 10C)
- Norwegian cultivars as a group were not significantly different than Canadian cultivars as a group

MILESTONE 5- Establish plots/pots of the cultivars (selected from MILESTONE 3) and test resistance under field conditions in Canada and Scandinavia (Field trials, ONTARIO, NORWAY)
Dates: 1 May 2015 - 30 June 2016 (winter field season 1) IN PROGRESS

MILESTONE 6- Investigate the underlying mechanisms of creeping bentgrass resistance to *Microdochium nivale* under both current and future climatic conditions using metabolic analysis (QUEBEC) and gene expression studies by RNA-Seq and RT-qPCR analyses (Lab tests, ONTARIO, QUÉBEC).
Dates: 1 May 2015 - 31 August 2017. JUST STARTED

MILESTONE 7- Assess the impact of elevated CO_2 and temperature in growth chambers on 1) the disease severity of Microdochium patch on select grass biotypes of differing resistance; 2) the efficiency of Civitas/harmonizer (Growth chamber trials, QUÉBEC).
Dates: 1 May 2015 - 30 September 2017. DONE

Effect of Cultivar, CO_2 and C/H on Yellowing

Average trial-long yellowing of bentgrass cultivars inoculated with *M. nivale* by CO2 concentration & C/H (high=more yellow)

	400 ppm CO2		800 ppm CO2	
Cultivar	C/H	Water	C/H	Water
Focus	525	620	232	586
Tyee	435	619	216	518
Independence	285	594	256	483
Penncross	325	553	240	354
T1	378	682	227	337
Alpha	376	552	258	273
Leirin	289	423	166	270
Labelle	240	323	195	225
LSD (p<0.05)	235	221	126	239

*Yellowed cells indicate higher amount of disease in column
*Non-inoculated data not shown

RESULTS
- there are varietal differences in resistance (differences between varieties)
- in general, increased CO2 leads to decreased symptoms (by 34%)
- disease decrease at higher CO2 was greater for C/H treated plants (37%) than water treated (30%)

MILESTONE 8- Assess the efficiency of Civitas/Harmonizer and select activators on creeping bentgrass cultivars contrasting in their resistance to Microdochium patch in the field (ONTARIO, NORWAY)
Dates: 31 May 2015 - 30 June 2016 (winter field season 1) IN PROGRESS

MILESTONE 9- Validate the resistance of the cultivars (selected from MILESTONE 3) under field conditions in Canada and Scandinavia (Field trials, ONTARIO, NORWAY)
Dates: 1 May 2016 - 30 June 2017 (winter field season 2) FUTURE

MILESTONE 10- Assess the efficiency of Civitas/Harmonizer and select activators on creeping bentgrass cultivars contrasting in their resistance to Microdochium patch in the field (ONTARIO, NORWAY)
Dates: 1 May 2016 - 30 June 2017 (winter field season 2) FUTURE

MILESTONE 11- Annual meetings of the collaborators whether by teleconferencing or in person in Northern Europe or Canada. Dates: 2015 and 2016 and 2017 NOW (2015 meeting on Nov 12), and FUTURE

Deliverables:
a) Identification of creeping bentgrass cultivars with greater resistance to Microdochium patch that can be directly used by turf managers or available to breeders for the development of cultivars adapted to current and predicted future climatic conditions.
b) Identification of cultivars which show greater responsiveness to resistance activators such as Civitas and Harmonizer for immediate use by turf managers or as germplasm available to breeders for improvement. Use of such cultivars with resistance activators would allow for disease management with reduced applications of chemical fungicides.
c) New knowledge on mechanisms of resistance of creeping bentgrass at molecular and genetic levels.
d) New knowledge on the mechanism of action of Civitas/Harmonizer on turfgrass.
e) New knowledge on the responses by turfgrass cultivars to changing environmental conditions.

Team expertise:
Dr. Tom Hsiang is the lead Principal Investigator on this project, and administers the project funding.
Graduate Student Sara Stricker, University of Guelph
Technician Jie Chen, University of Guelph
Post-Doc (in between post-docs right now), University of Guelph

Collaborators on this project include the following:
Dr. Annick Bertrand, Agriculture & Agrifood Canada, Québec City, Molecular physiology and biology.
Dr. Yves Castonguay, Agriculture & Agrifood Canada, Québec City, Molecular physiology and biology.
Dr. Trygve Aamlid, Bioforsk Øst Landvik, N-4886 Grimstad, Norway. Turfgrass agronomy.
Dr. Tatsiana Espevig, Bioforsk Øst Landvik, N-4886 Grimstad, Norway. Turfgrass pathology.
The collaborators will receive funding from their own sources, but some of the research will be done in parallel (especially field studies for Canada and Norway).