



Sikrere vinteroverlevelse av gress på golfbaner: Forbedringer i plantemateriale og skjøtsel

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Low-Input grass for kaldt klima





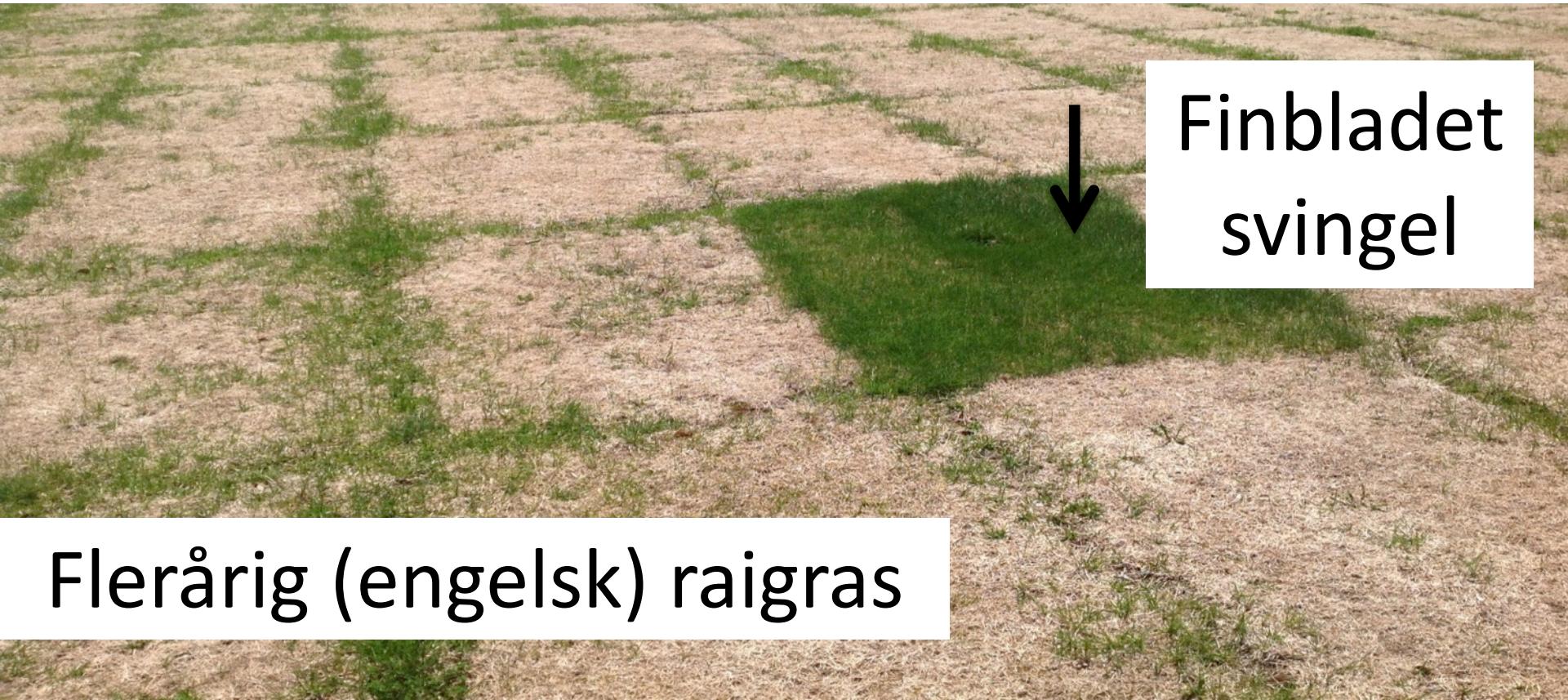
photo: Dr. Lindsey Hoffman

Winter survival

Environmental
factors

Genetic factors

Direkte frostskađe



Flerårig (engelsk) raigras

Finbladet
svingel

Uttørking om vinteren



Isdekke



Photo courtesy: Eric Counselman

Vannopptak i og rundt vekstpunktet



Photo courtesy of Dr. Frank Wong

Overvintringssopp



Spørreundersøkelse blant golfbaner i Norden

	Denmark	Finland	Iceland	Norway	Sweden
Number of golf courses (approx.)	150	160	60	170	470
Number of respondents	77	24	40	80	125
Average number of replies	45	19	25	59	102
Response rate, %	30	12	41	35	22

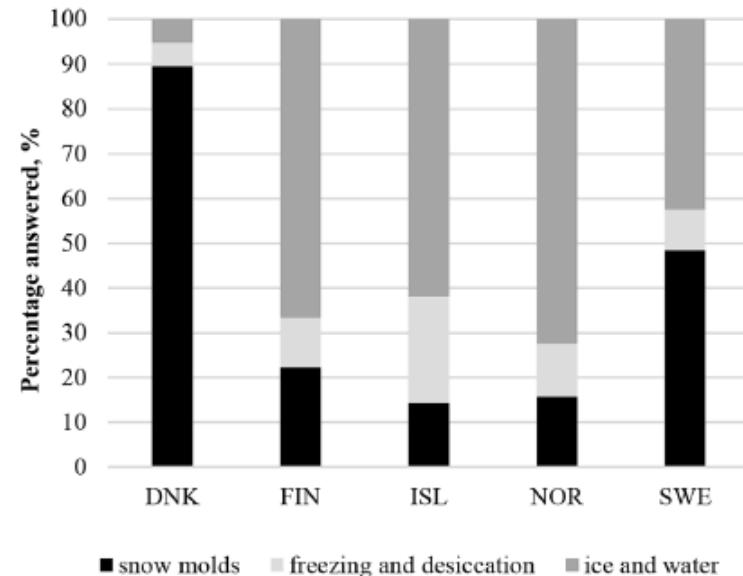
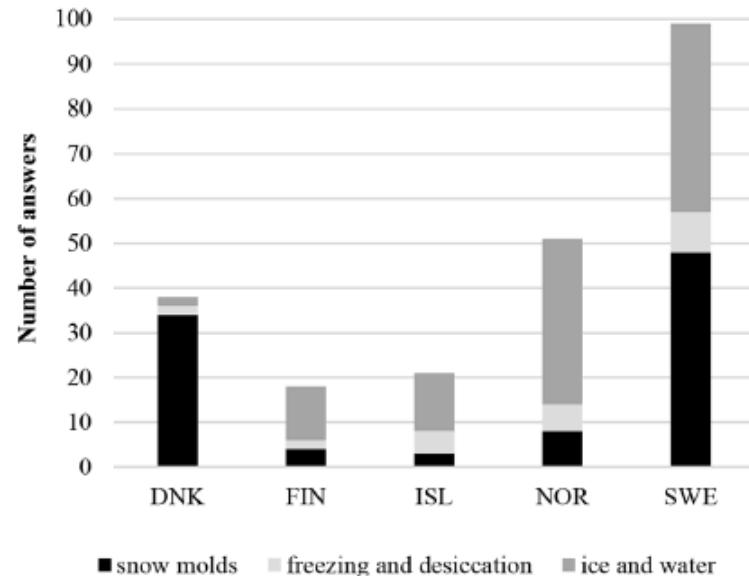


Fig. 1. The most economically important causes of winter injury on greens in the five Nordic countries, based on the data from 227 golf courses. Actual numbers on the left; relative numbers on the right. Country codes: DNK, Denmark; FIN, Finland; ISL, Iceland; NOR, Norway; SWE, Sweden.

Gress-skjøtsel

- Valg av gressart – og sort
- Vinterforberedelser
- Skjøtsel gjennom vinteren
- Reparasjon etter vinterskader

Finbladet svingel

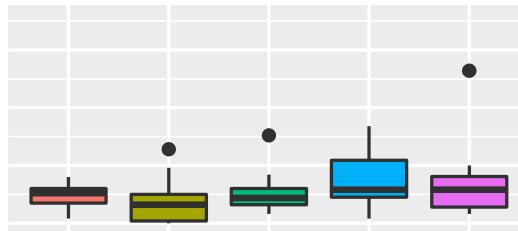
Latinsk navn	Norsk navn
<i>Festuca rubra</i> ssp. <i>rubra</i>	Rødsvingel med lange utløpere
<i>Festuca rubra</i> ssp. <i>litoralis</i>	Rødsvignal med korte utløpere
<i>Festuca rubra</i> ssp. <i>commutata</i>	Rødsvingel uten utløpere
<i>Festuca trachyphylla</i>	Stivsvingel
<i>Festuca ovina</i>	Sauesvingel / fåresvingel

Overvintringssopp

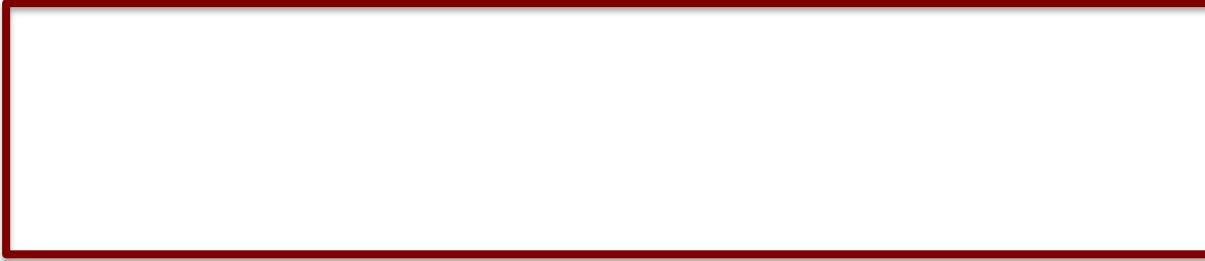


photo credit: Paul Koch, U. of Wisconsin

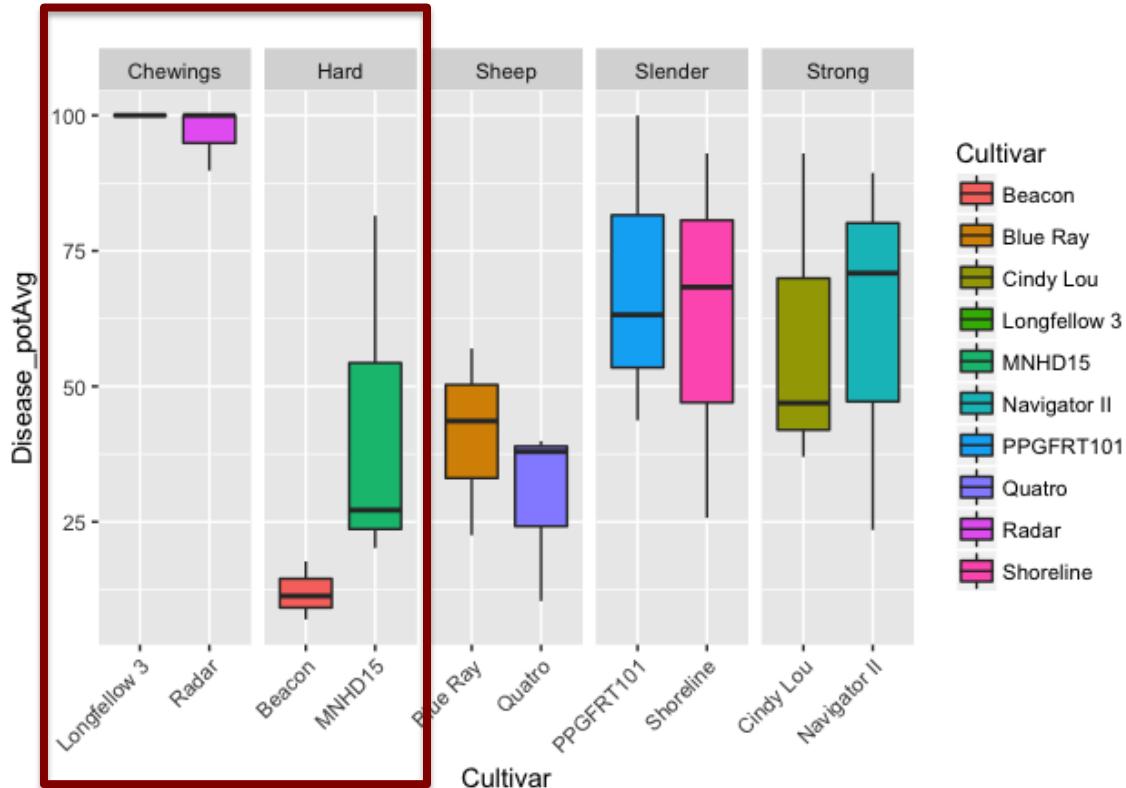
Hvit trådkøllesopp i finbladet svingel



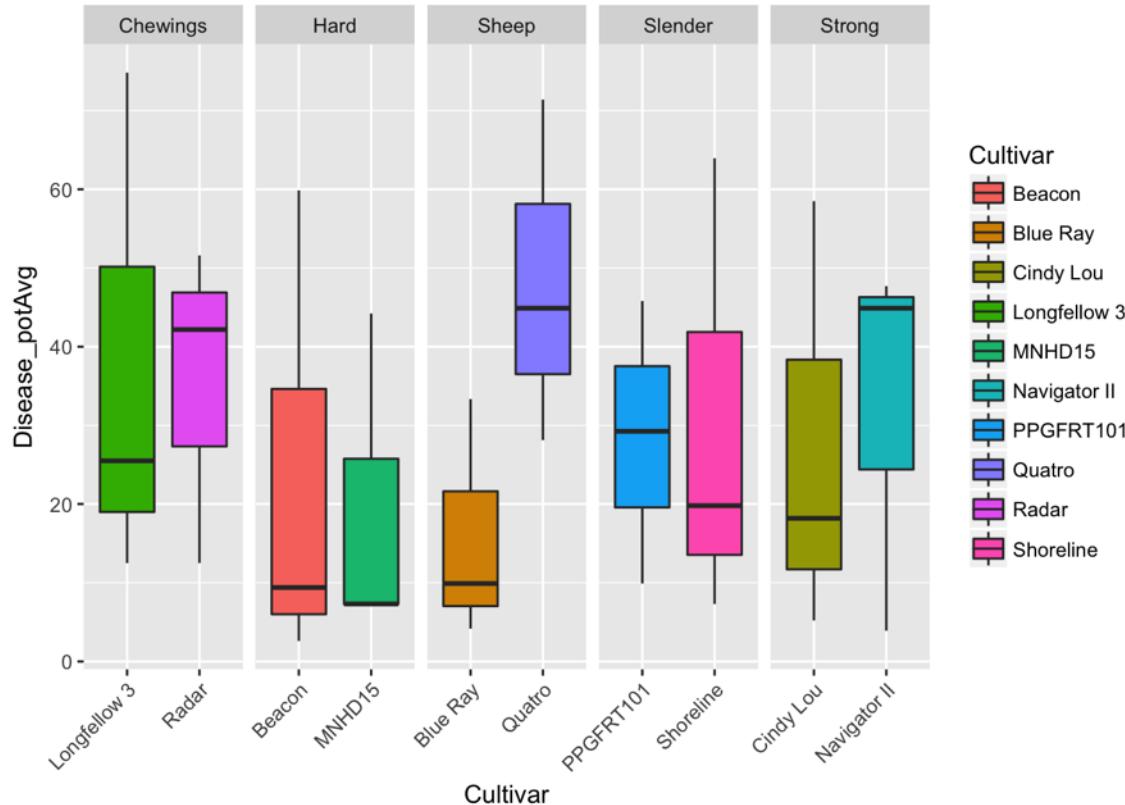
T. ishikariensis



Microdochium i finbladet svingel



Rød trådkøllesopp i finbladet svingel



Foredling for resistens mot overvintringssopp



Snømugg 2010 in Minnesota

rank	entry	s.mold 9=best		rank	entry	s.mold 9=best
1	09-81	8.0		54	P301 x SPR	6.3
2	09-248	8.0		63	Brightstar SLT	6.0
3	09-376	7.7		66	Citation Fore	6.0
4	09-195	7.7		87	Quebec	4.0
5	09-339	7.7		88	68-10 LP	4.0
6	09-20	7.7		89	Apple GL	4.0
7	09-90	7.7		90	Headstart 2	4.0
8	09-8	7.3		91	Affirmed	4.0
9	09-364	7.3		92	2TPR	3.7
10	09-225	7.3		93	06-B LP	3.7
11	09-290	7.3		95	Grey Goose	3.3
12	09-344	7.3		96	2RDY	2.7
13	09-31	7.3		97	2TQL	2.3
14	09-226	7.3			LSD _{0.05}	1.0

Isdekke

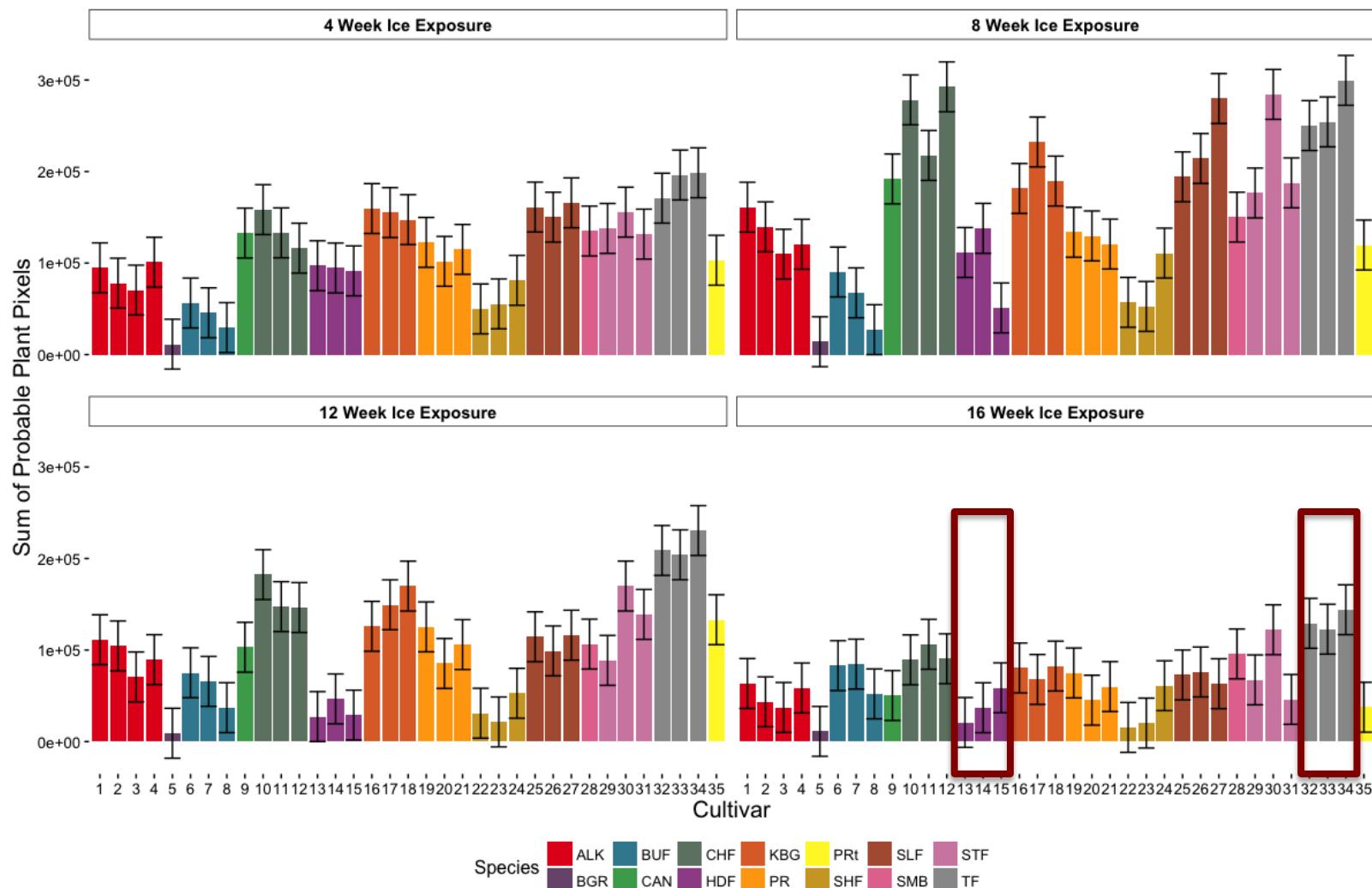


Isdekke

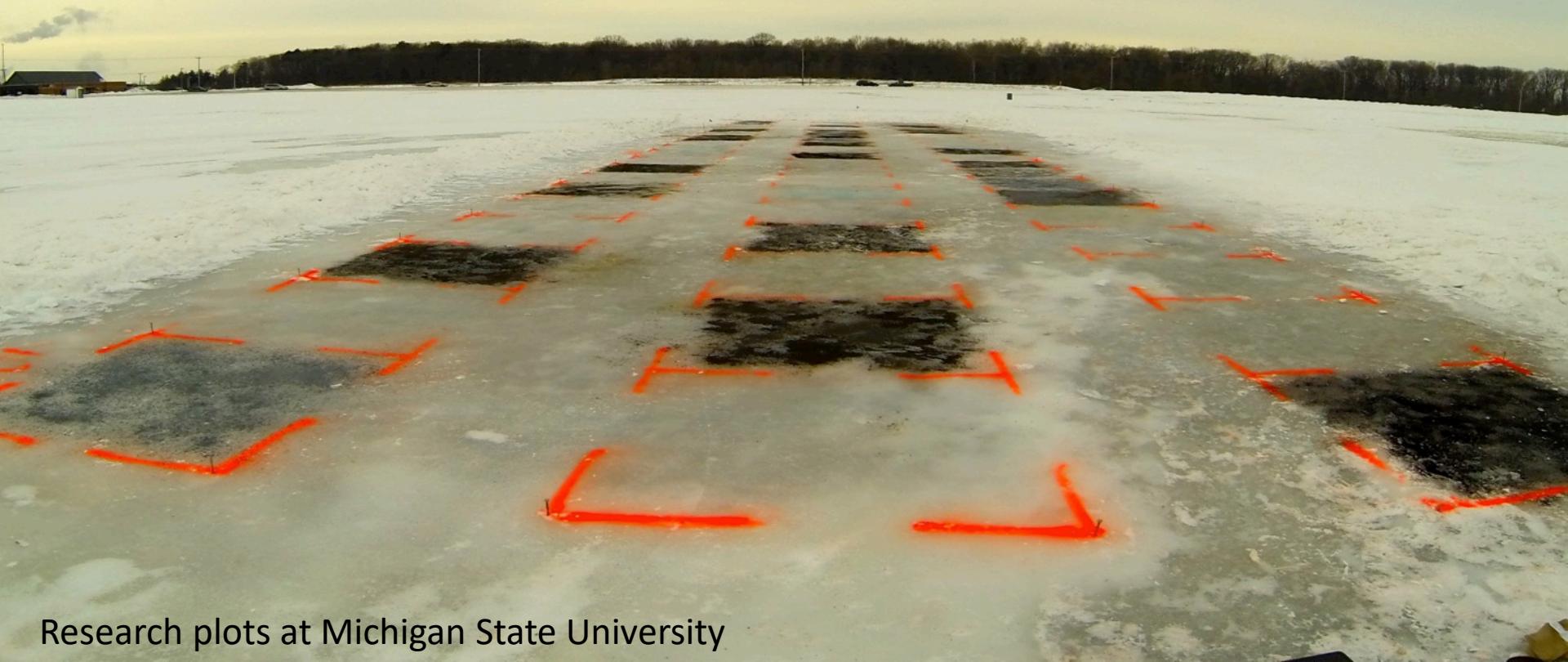


Forsøk i kontrollert klima





Fjerning av is



Research plots at Michigan State University

Fjerning av is

- Langvarig isdekke er et problem for gress på golfbaner
- Isfjerningsmilder kan tilføres
- Kjemiske isfjerningsmidler kan skade gresset
- Produkter som gir bedre oppfanging av solenergi gir bedre vårvekst



Ice Removal Treatments (1st trial)

- Kontroll (inge behandling)
- Mekanisk isfjerning
- Sort sand(1.5t/ha)
- Grønn sand (1.5t/ha)
- Milorganite 6-2-0
- Sustane 10-2-10
- Humate
- Urea flytende (50kg/ha)
- Urea granular (50kg/ha)
- CaCl
- Green maling
- Sort maling



Tidspunkt for tilførsel



24 timer etter tilførsel



48 timer etter tilførsel



Hva er sikkert for ikke å skade gresset ?

Table 1. Application rates for chemical de-icing products in phytotoxicity trials conducted on native soil and USGA *Agrostis stolonifera* 'L-93' putting greens at the University of Minnesota Turfgrass Research, Outreach and Education Center (St. Paul, MN) in March 2014 and March 2015.

Treatment	Rate	
	Product g m ⁻²	Nitrogen kg ha ⁻¹
(NH ₄) ₂ SO ₄ †	136.3 (1.00×), 68.2 (0.50×)	284.8, 142.4
CaCl ₂ ‡	136.3 (1.00×), 68.2 (0.50×)	0.0
CaMg ₂ (CH ₃ COO) ₆ §	136.3 (1.00×), 68.2 (0.50×)	0.0
MgCl ₂ ¶	136.3 (1.00×), 68.2 (0.50×)	0.0
Paw Thaw#	136.3 (1.00×), 68.2 (0.50×)	?
KCl †	136.3 (1.00×), 68.2 (0.50×)	0.0
CH ₃ COONa ‡	136.3 (1.00×), 97.6 (0.72×), 73.2 (0.54), 48.8 (0.36), 24.4 (0.18)	0.0
NaCl §§	136.3 (1.00×), 68.2 (0.50×)	0.0
EnviroMelt ¶¶	136.3 (1.00×), 68.2 (0.50×)	623.8, 311.9
Safe Paw##	136.3 (1.00×), 68.2 (0.50×)	<623.8, <311.9
Tenderfoot ††	136.3 (1.00×), 68.2 (0.50×)	<623.8, <311.9

Table 2. Application rates for solar absorption products in a trial conducted on native soil and USGA *Agrostis stolonifera* 'L-93' putting greens at the University of Minnesota Turfgrass Research, Outreach and Education Center (St. Paul, MN) in March 2014 and March 2015.

Treatment	Rate [†]		
	Bulk density g cm ⁻³	Product g m ⁻²	Water soluble N kg ha ⁻¹
BioDact + DeFrost§	0.750	228.4	0.0 0.0
BioDac + DeFrost + Colorant	0.760	231.4	0.0 0.0
Black sand	1.605	488.7	0.0 0.0
Eon 75¶	0.755	229.9	0.0 0.0
Milorganite#	0.893	271.9	163.1 67.9
Sustane††	0.647	197.0	98.5 29.6
Top Cut SGN§§ 200	0.850	258.8	103.5 19.4
Top Cut SGN 90	0.840	256.7	102.7 19.3
Top Cut + DeFrost	0.850	258.8	103.5 19.4



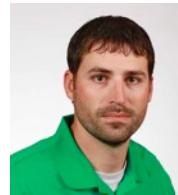


Sammendrag - isfjerning

- Isfjerning er viktig
- Sorte granulater er mest effektive for å smelte is – best å unngå kjemikalier
- Raskere green-up om våren etter bruk av sorte granulater og produkter som inneholder N. Problem med avherding ?
- Produkter som inneholder urea kan føre til sviskader (tilføres ofte i store doser)

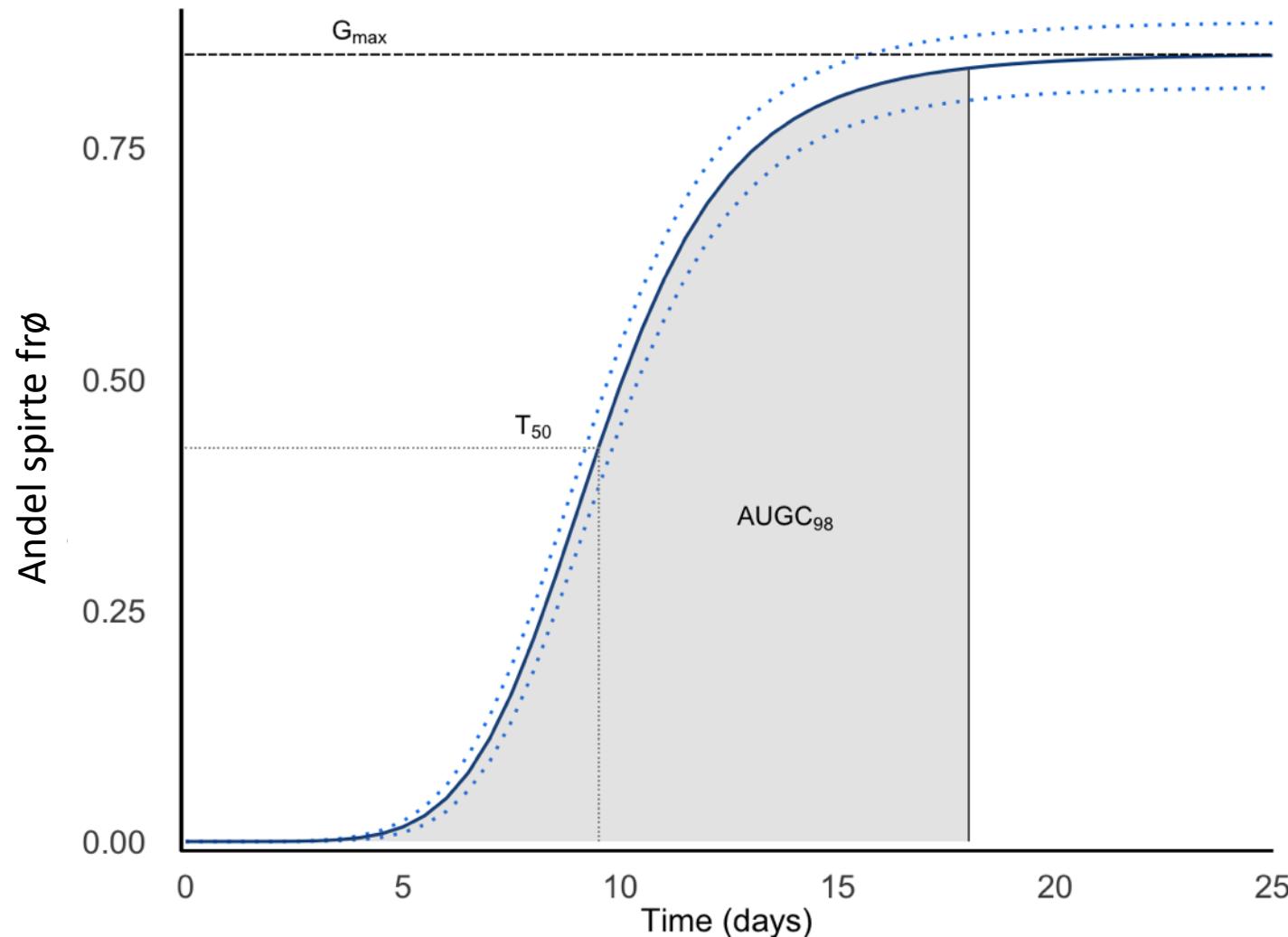
Frøspiring ved lav temperatur

- Greener med mye vinterskade må resås om våren
- Sein spiring ved lav temperatur
- Har krypkveinsortene ulik evne til å spire ved lav temperatur ?

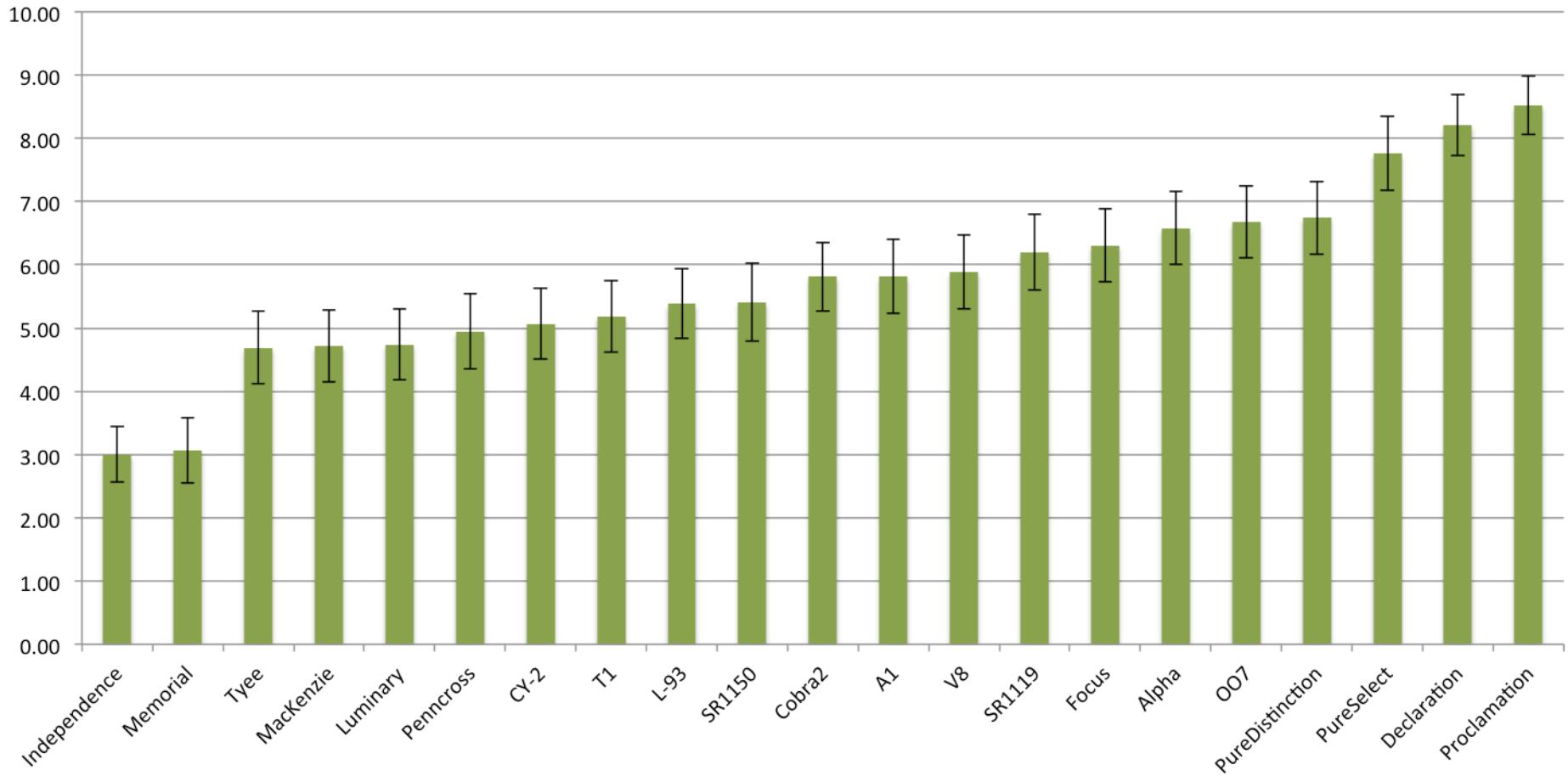


Metoder

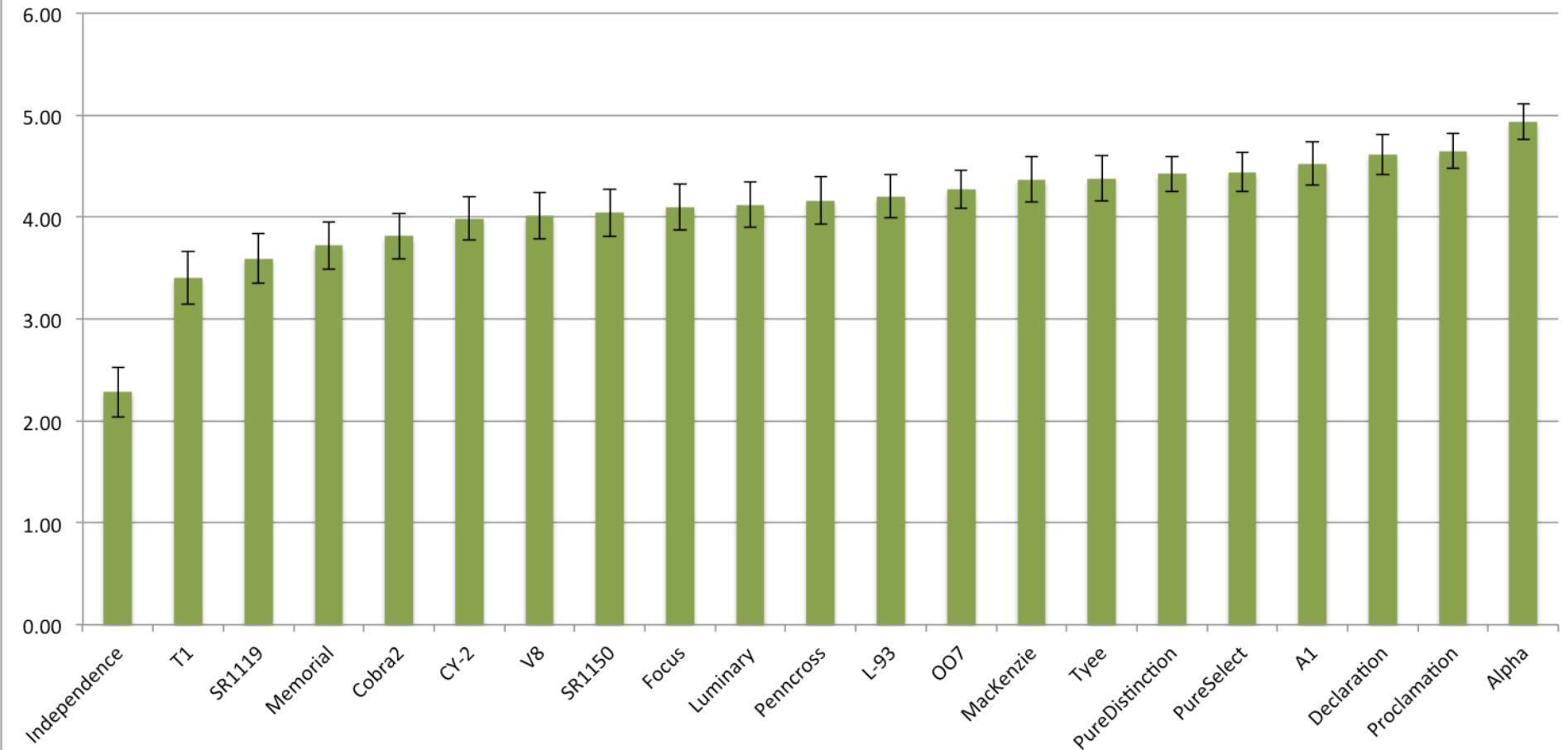
- 22 krypkveinsorter
- 100 frø pr sort lagt ut på spirepapir i petri-skåler (4 gjentak)
- Skålene plassert i vekstrom med temperatur som i jorda om våren i Minnesota (45 °F, 50 °F, 60 °F) (7.2°C, 10 °C, 15.6 °C)
- Regelmessig telling av antall spirte frø

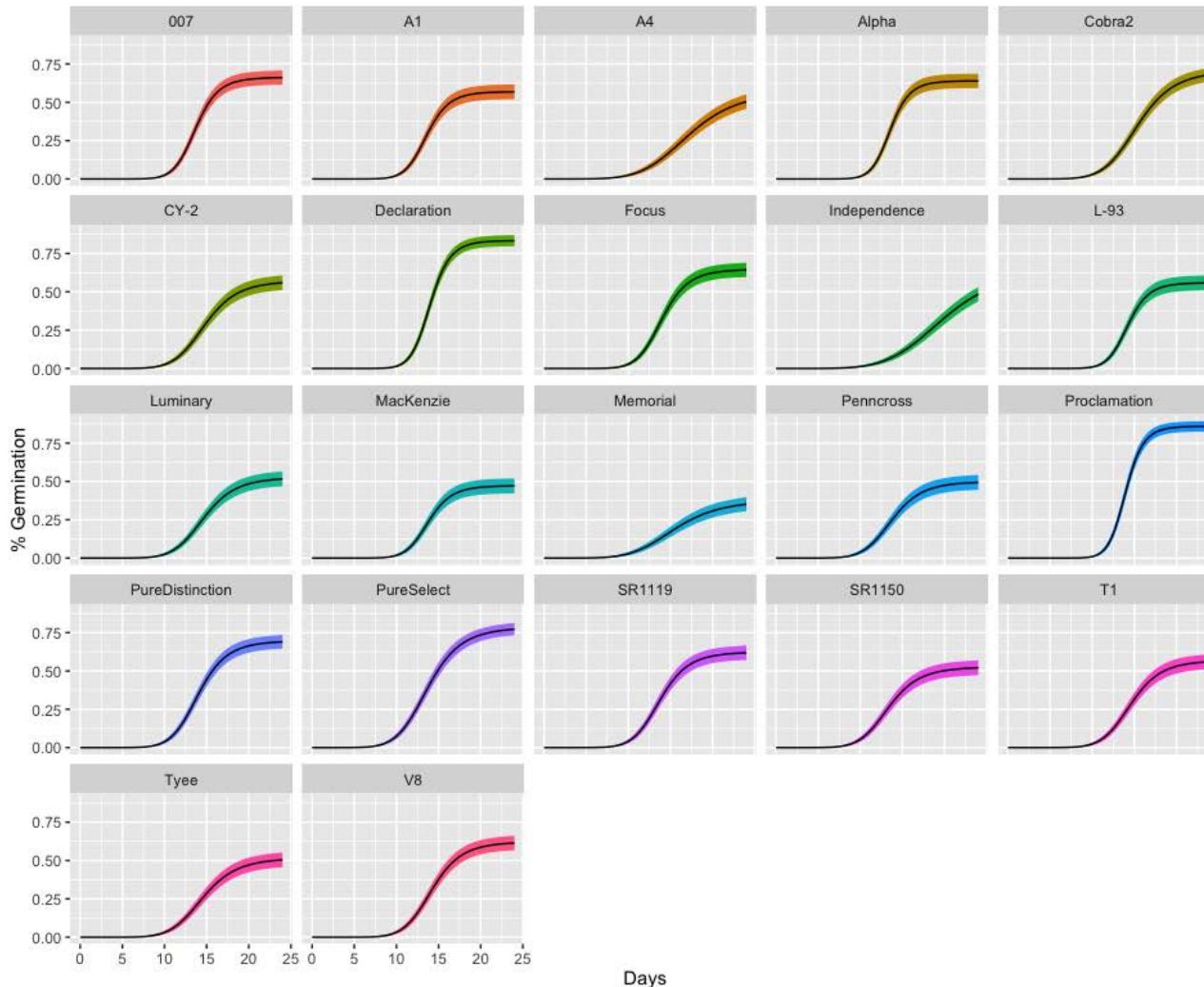


Areal under spirekurven ved 15,6 °C



Areal under spirekurven ved 7,2 °C





45°F (7.2°C)

cultivar	007	MacKenzie
A1	0.55	0.50
A4	0.55	0.50
Alpha	0.60	0.55
Cobra2	0.60	0.55
CY-2	0.55	0.50
Declaration	0.55	0.50
Focus	0.55	0.50
Independence	0.55	0.50
L-93	0.55	0.50
Luminary	0.55	0.50
MacKenzie	0.55	0.50
Memorial	0.55	0.50
Penncross	0.55	0.50
Proclamation	0.55	0.50
PureDistinction	0.55	0.50
PureSelect	0.55	0.50
SR1119	0.55	0.50
SR1150	0.55	0.50
T1	0.55	0.50
Tyee	0.55	0.50
V8	0.55	0.50

Foredling av nye sorter



Foredling av nye sorter

- Bedømming i felt
- Bedømming i kontrollert klima
- Metabolomics-assistert foredling
- Samspill mellom planter og mikroorganismer
- Bedre gress til veiskråninger

Bedømming i felt



Bedømming i felt

country	tiller survival
Norway	4.1
Sweden	4.1
Italy	1.8
France	1.6
Denmark	1.3
Algeria	1.1
Wales	1.1
<i>LSD0.05</i>	0.8
1=dead; 9=best	
sample from 300 accessions and 8 standard cultivars	

Fryseforsøk

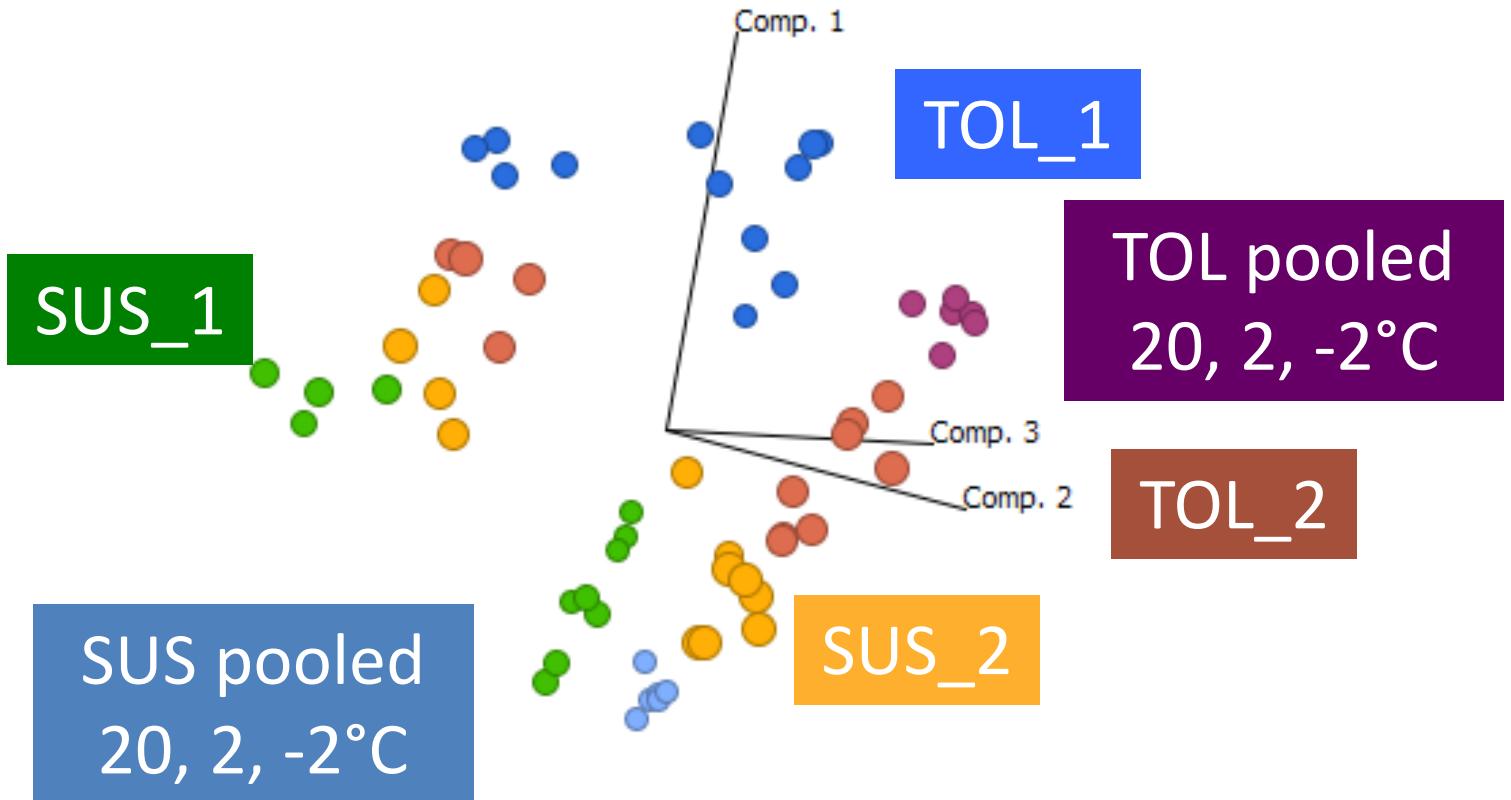
Table 2 LT₅₀ and mean tiller survival of perennial ryegrass accessions ranked by increasing LT₅₀

Accession	Country of origin	Field ^a		Controlled freezing											
		Tiller survival ^b		LT ₅₀ , whole plant basis ^c				Tiller survival ^b							
		2005	2006	95% LB	θ	95% UB	-2°C ^d	-4°C	-6°C	-8°C	-10°C	-12°C	-14°C	-16°C	
		Score	°C	Score											
PI 598433	Italy	7.0	5.5	-14.58	-13.95	-13.37	9.0	9.0	9.0	9.0	8.3	6.2	2.2	1.0	
PI 610806	Romania	4.9	4.9	-14.20	-13.61	-13.04	9.0	9.0	9.0	9.0	8.3	5.4	1.9	1.0	
PI 502412	Russia	7.2	5.2	-14.19	-13.40	-12.70	9.0	9.0	9.0	8.7	7.8	5.7	2.3	1.0	
PI 610820	Romania	7.2	4.6	-13.93	-13.38	-12.82	9.0	9.0	9.0	8.9	8.3	4.8	1.6	1.0	
PI 577266	Romania	6.5	5.8	-14.39	-13.31	-12.42	9.0	8.5	9.0	9.0	8.4	6.2	1.6	1.0	
PI 628717	Bulgaria	1.9	3.3	-13.87	-13.24	-12.61	9.0	9.0	9.0	9.0	8.8	4.9	2.1	1.0	
PI 611044	Russia	6.7	6.8	-13.74	-13.12	-12.51	9.0	8.9	9.0	9.0	8.4	4.9	1.9	1.0	
PI 598453	Romania	6.9	5.2	-13.44	-12.87	-12.31	9.0	8.6	9.0	9.0	8.1	4.0	1.4	1.0	
31480-03	Italy	3.7	4.0	-13.39	-12.86	-12.36	9.0	9.0	9.0	8.9	6.6	3.4	1.4	1.0	
NK 200	Check Fore	4.8	6.0	-13.42	-12.77	-12.10	8.9	9.0	9.0	8.9	8.2	3.6	1.4	1.0	
31531-03	France	3.3	2.3	-13.34	-12.75	-12.16	9.0	8.9	8.6	9.0	7.5	4.1	1.4	1.0	
PI 231565	Libya	1.3	5.0	-13.24	-12.64	-12.03	9.0	9.0	9.0	9.0	7.8	3.4	1.1	1.0	
PI 418717	Italy	6.5	6.5	-13.33	-12.61	-11.91	8.9	9.0	9.0	9.0	7.5	3.7	1.7	1.0	
Citation	Check Fore	3.2	2.7	-13.07	-12.50	-11.93	9.0	8.9	9.0	9.0	7.4	4.1	1.1	1.0	

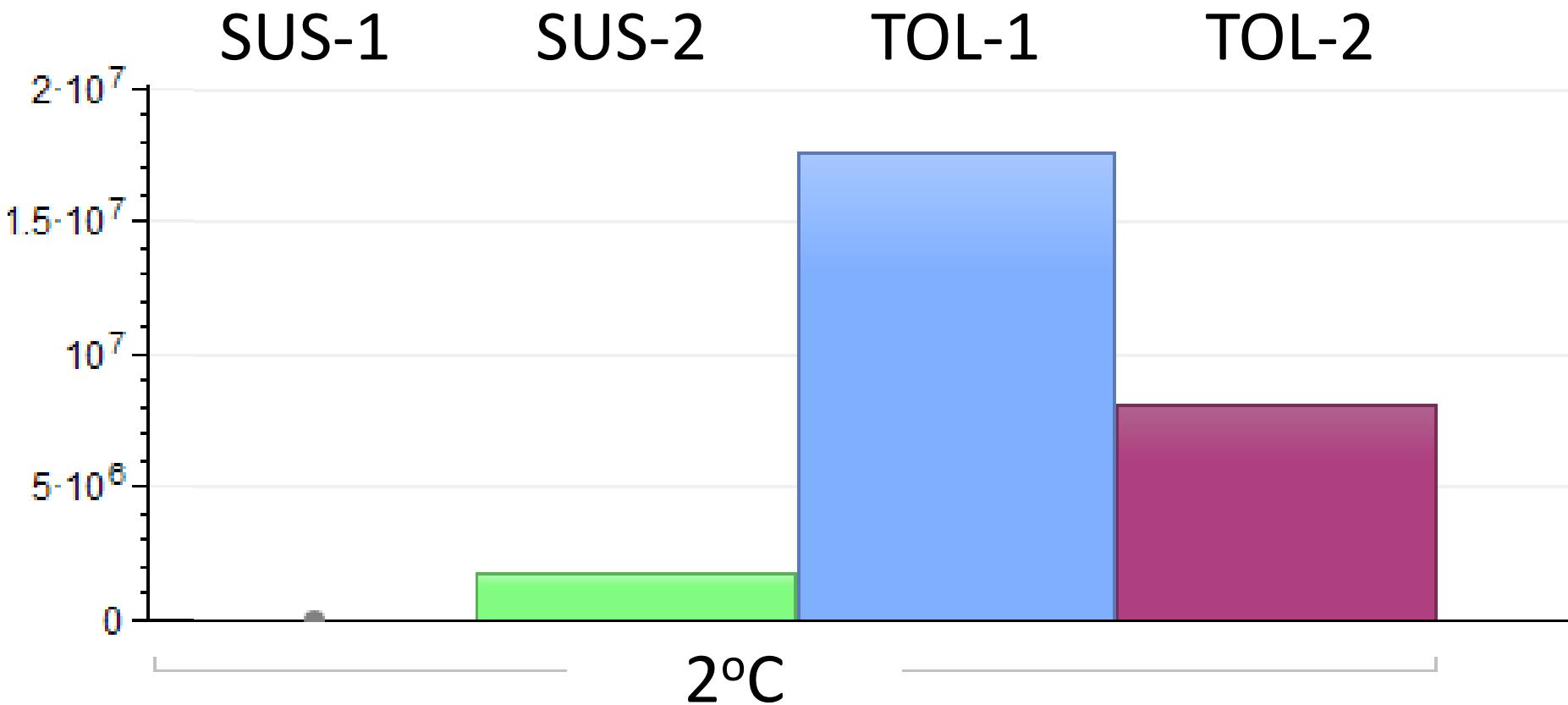
Metabolomics-Assisted Breeding

- Four perennial ryegrass accessions identified as either TOL or SUS based on previous research
 - TOL-1: LT_{50} of -14.0 °C
 - TOL-2: LT_{50} of -13.5 °C
 - SUS-1: LT_{50} of -10.7 °C
 - SUS-2: LT_{50} of -10.3 °C
- Accessions were subjected to one of 3 acclimation temperatures for 2 weeks (20°C, 2°C, -2°C)
- Leaf material was harvested after each 2 week period, lyophilized, and stored at -80°C until analysis
- Metabolic profiles (LC-MS) were developed for each accession under each temperature treatment

Partial Least Squares: Negative Ion Mode



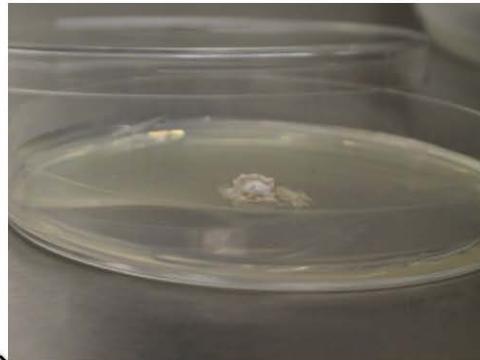
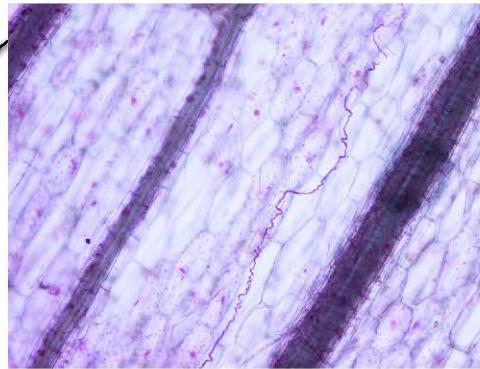
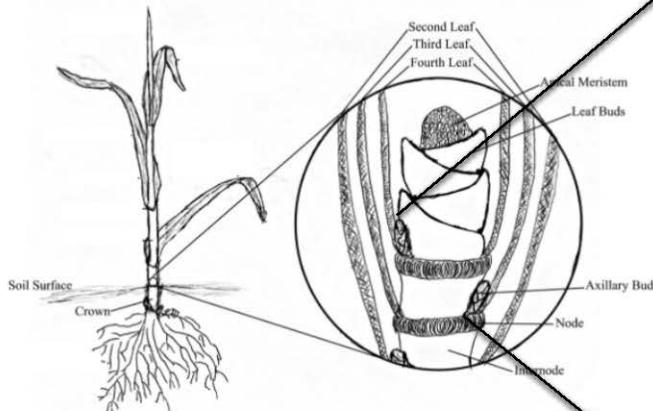
Potential Metabolite Marker: m/z 815.51



Metabolomics—Next Steps

- Identify compounds associated with freezing tolerant accessions
- Confirm the presence of the metabolites in a wide array of freezing-tolerant germplasm
- Utilize the metabolic traits as biomarkers for screening large populations of perennial ryegrass plants

Plant-Microbe Interactions



Phenotype

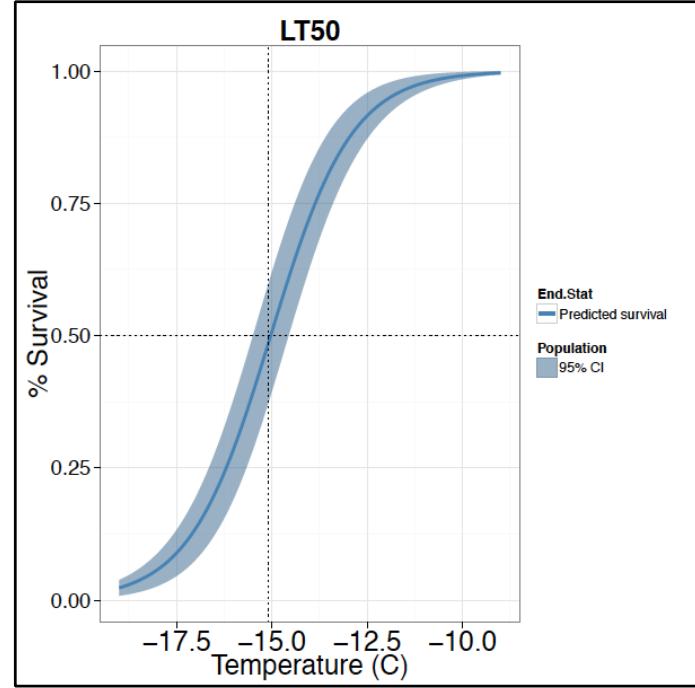
=

Host Genotype + Microbe Genotype + Environment + Host Genotype*Microbe Genotype*Environment

Plant survival is measured
on a binomial scale

1



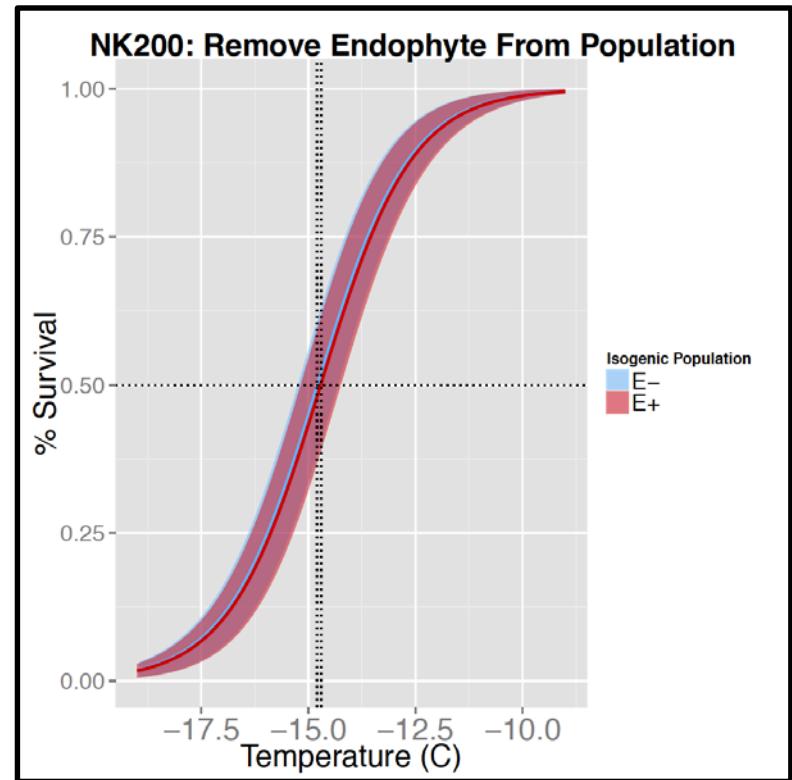
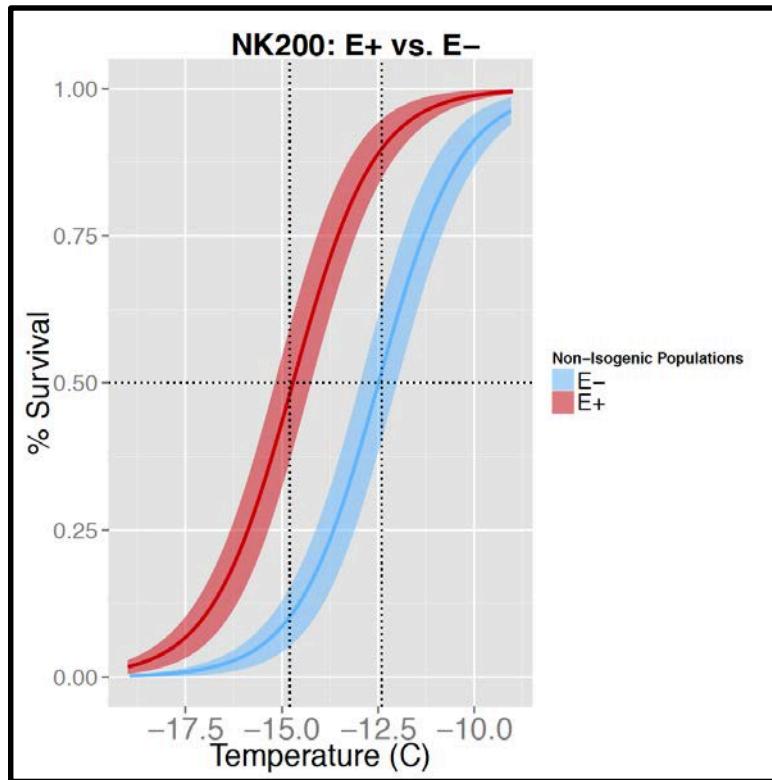


Graphical representation of population survival over freezing temperatures

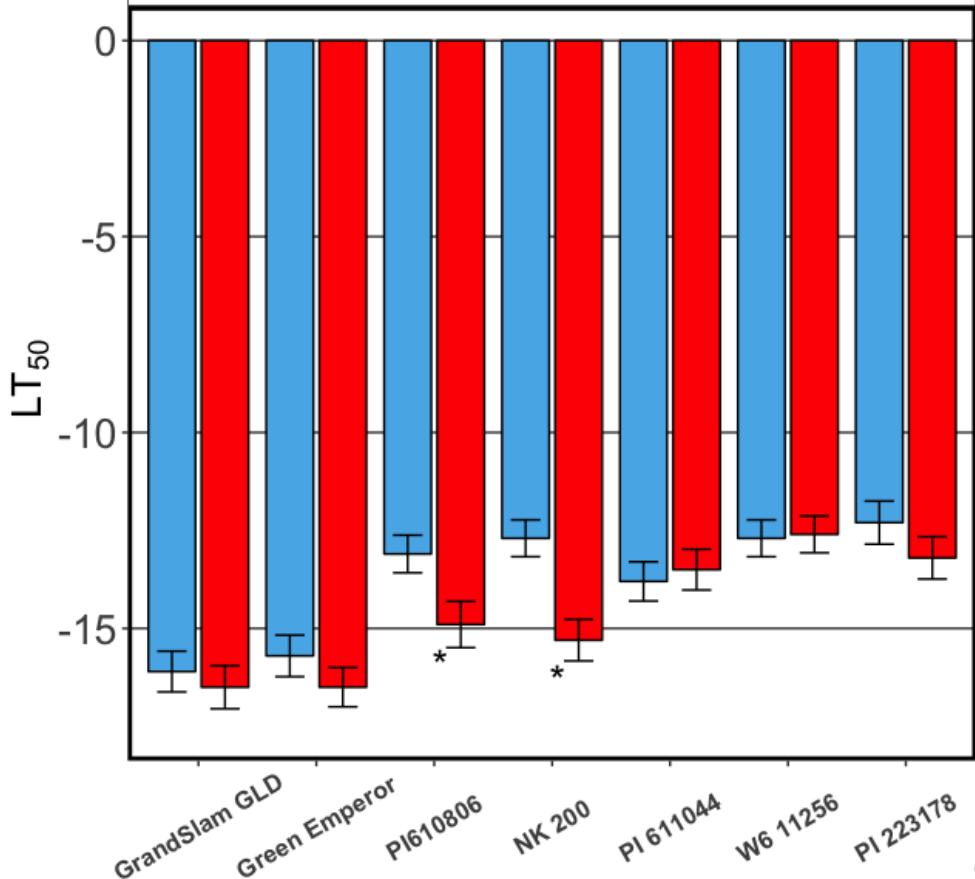
Solid line is
predicted survival

0

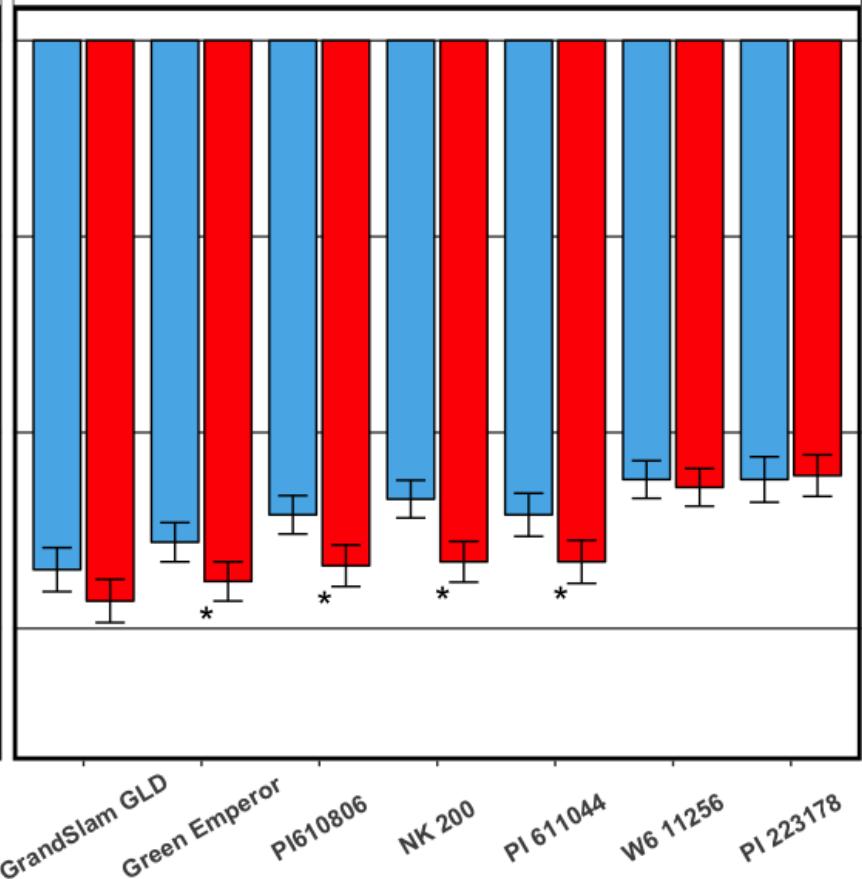
Endophyte Effects on Freezing Tolerance; Preliminary study



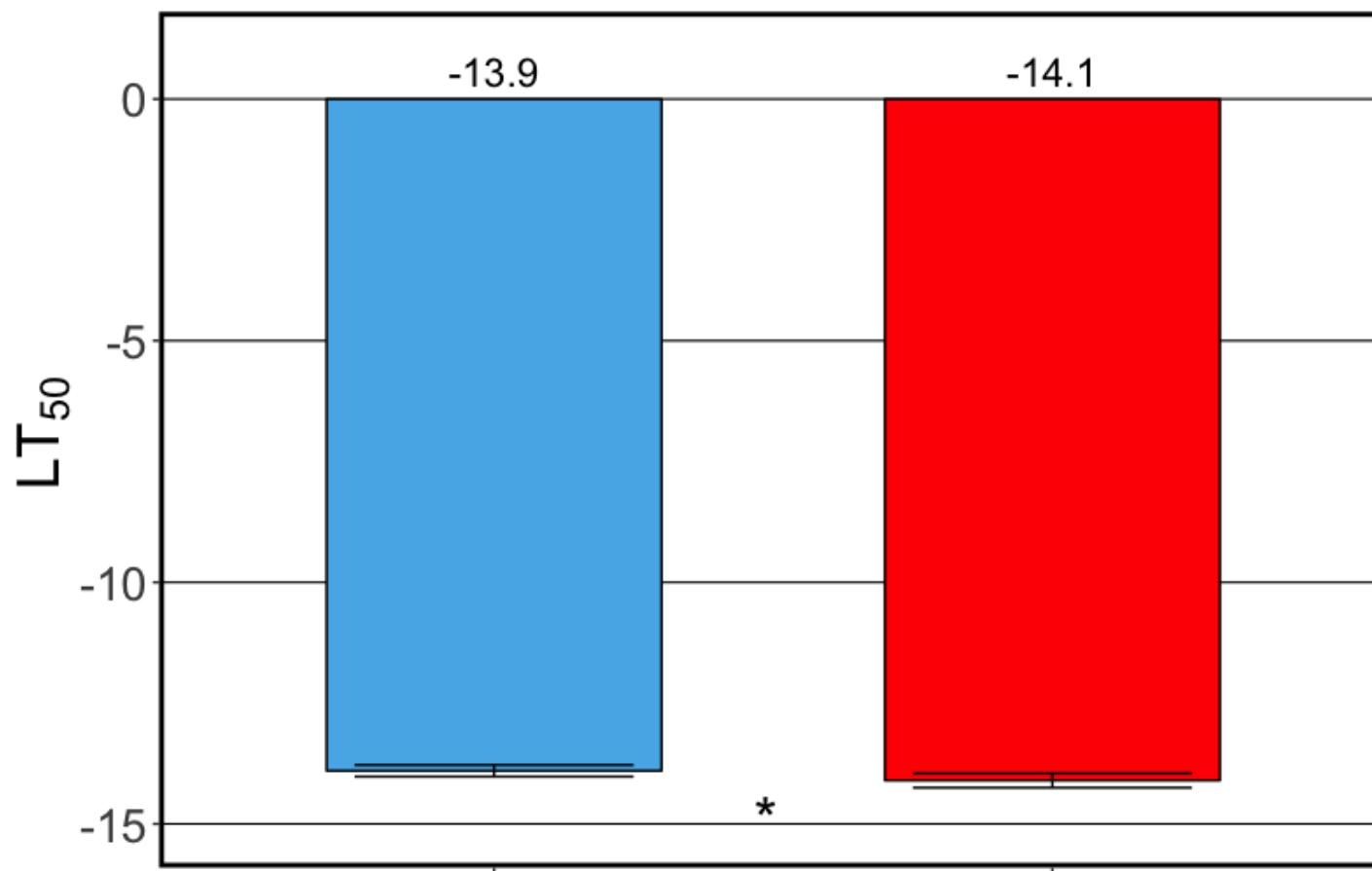
Trial One



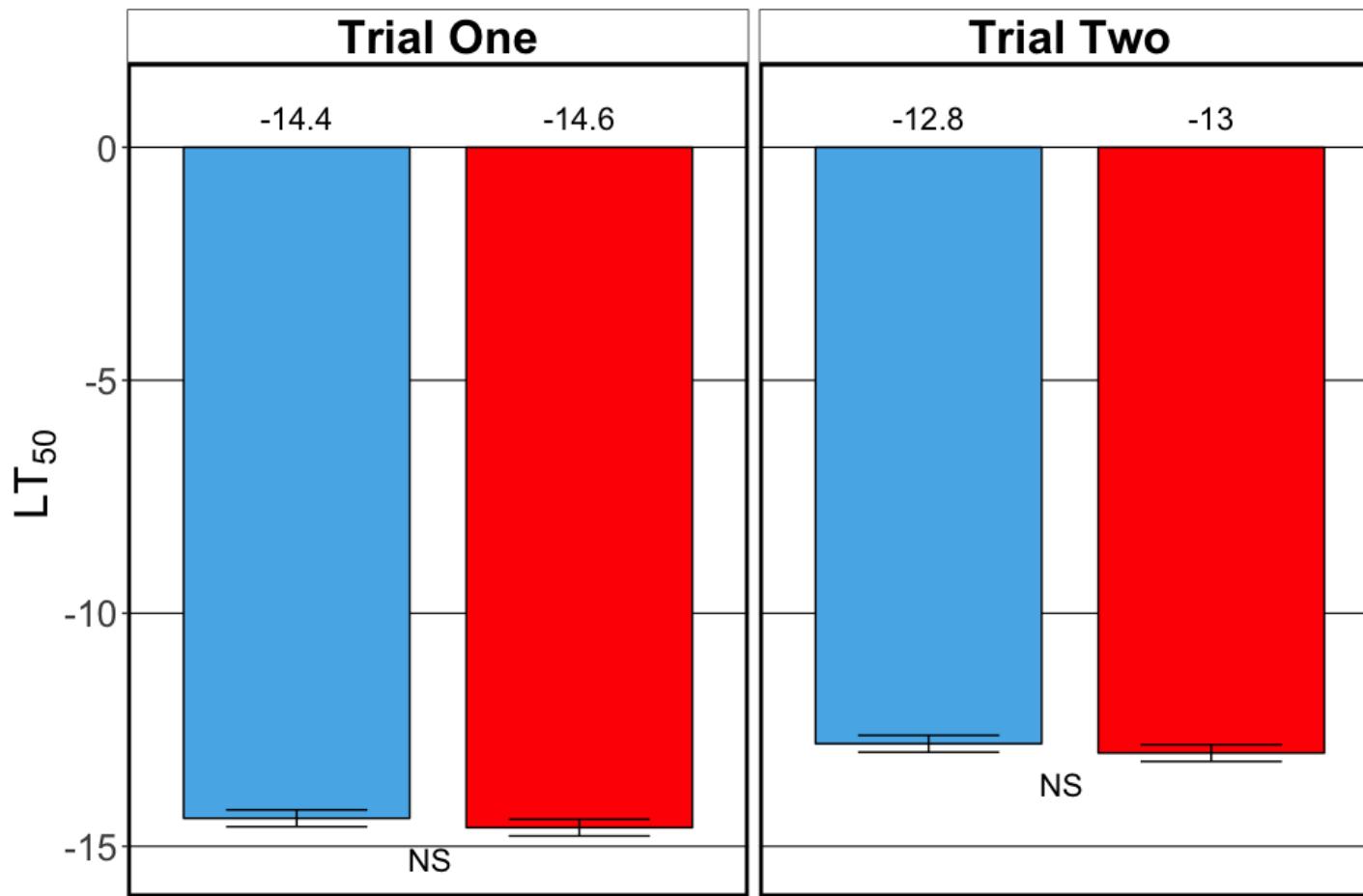
Trial Two



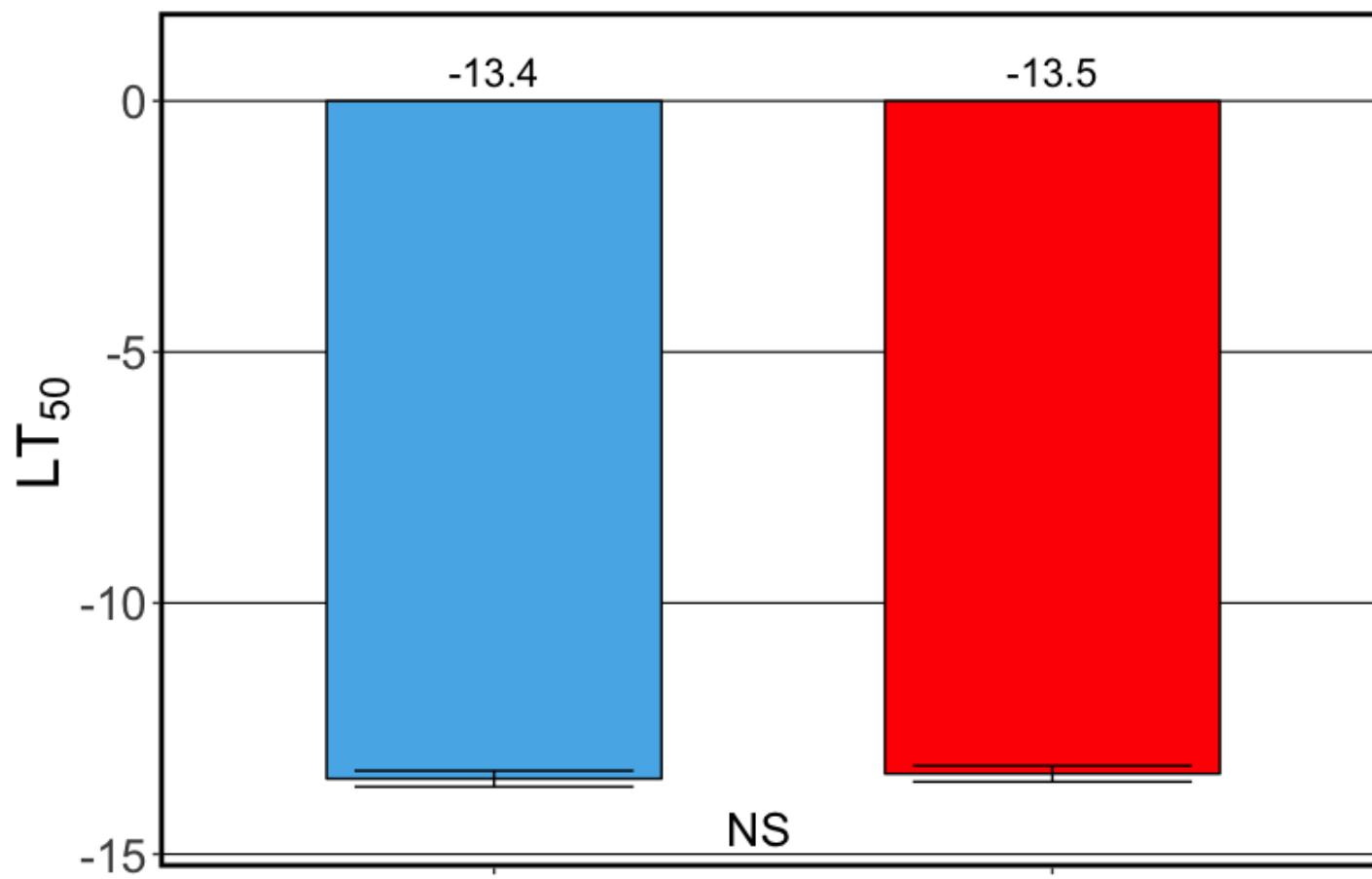
Non-Isogenic E+/- Populations: ■ E- congenital ■ E+



Large Non-Isogenic $E^+/-$ Populations: ■ E^- Congenital



Isogenic E+/- Populations: ■ E- fungicide ■ E+

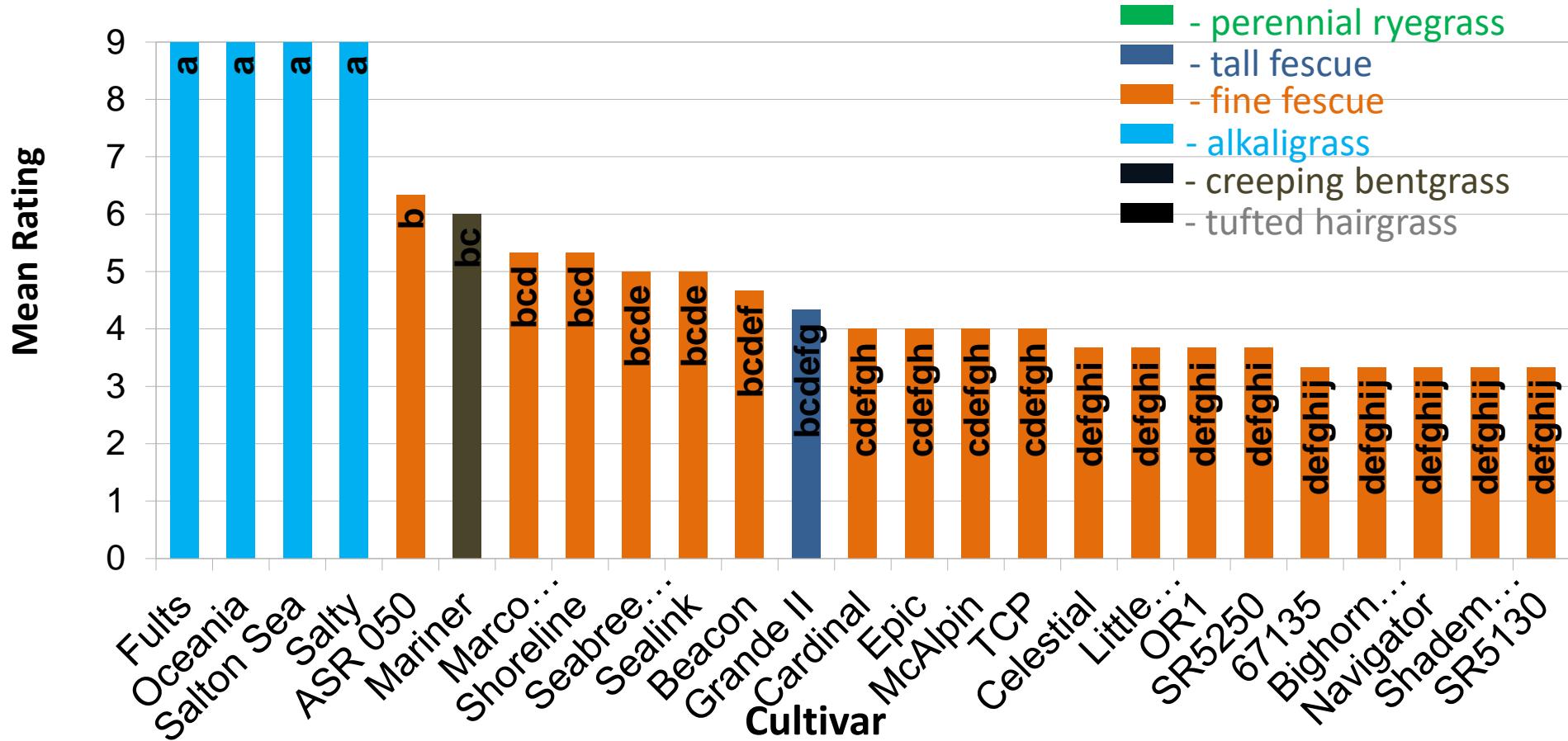


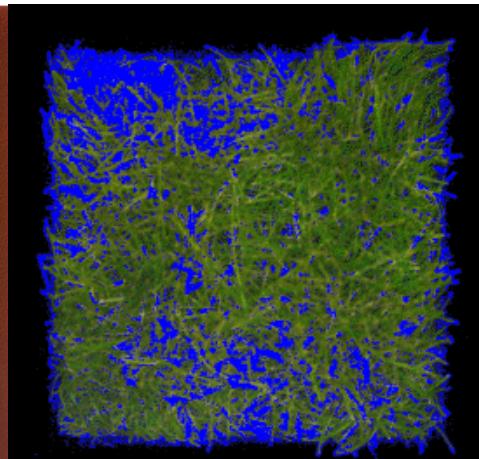
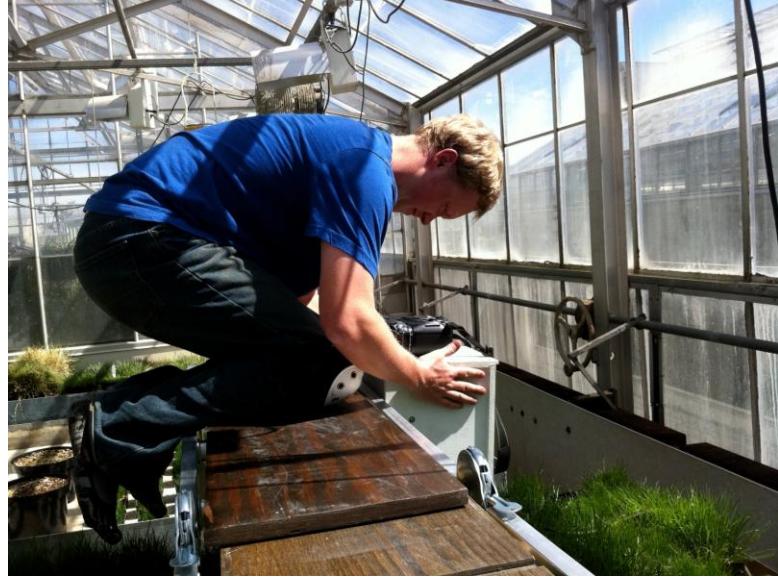
Isofrequent E+/- Populations: ■ E- ■ E+

Improving Roadside Grasses



Spring Survival: MnROAD





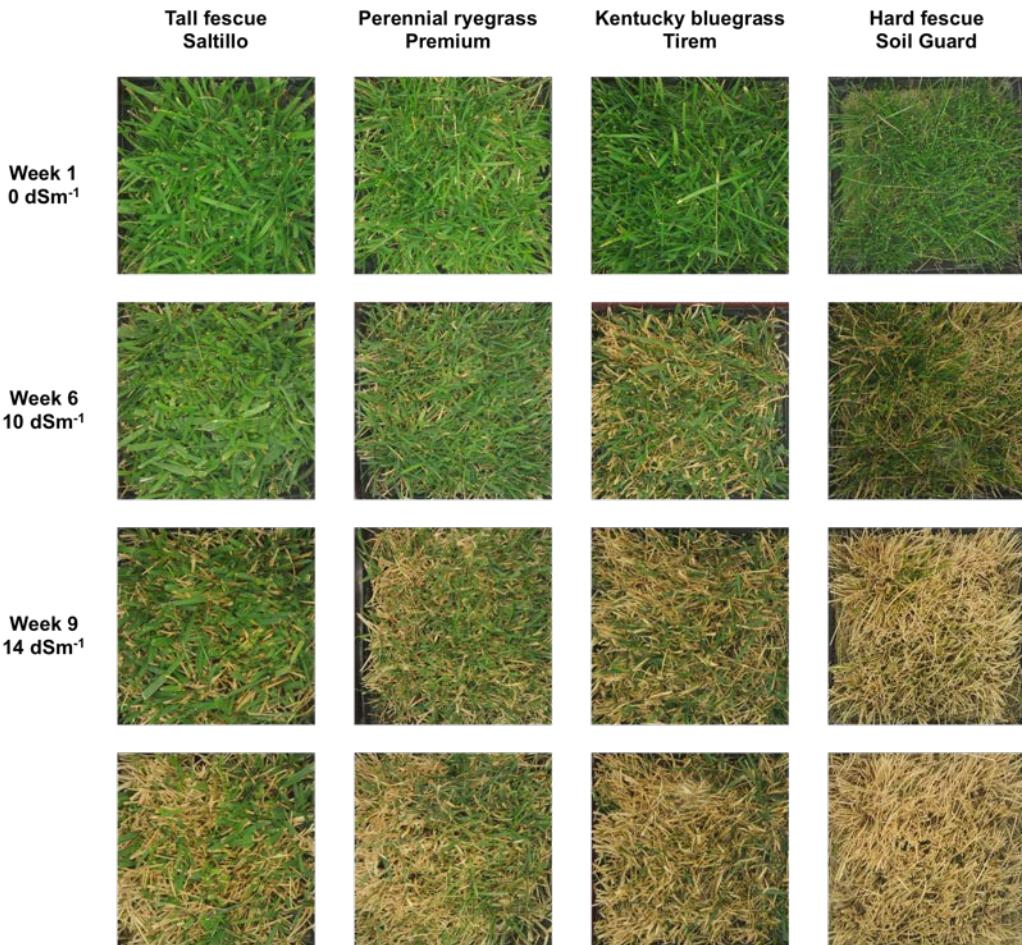
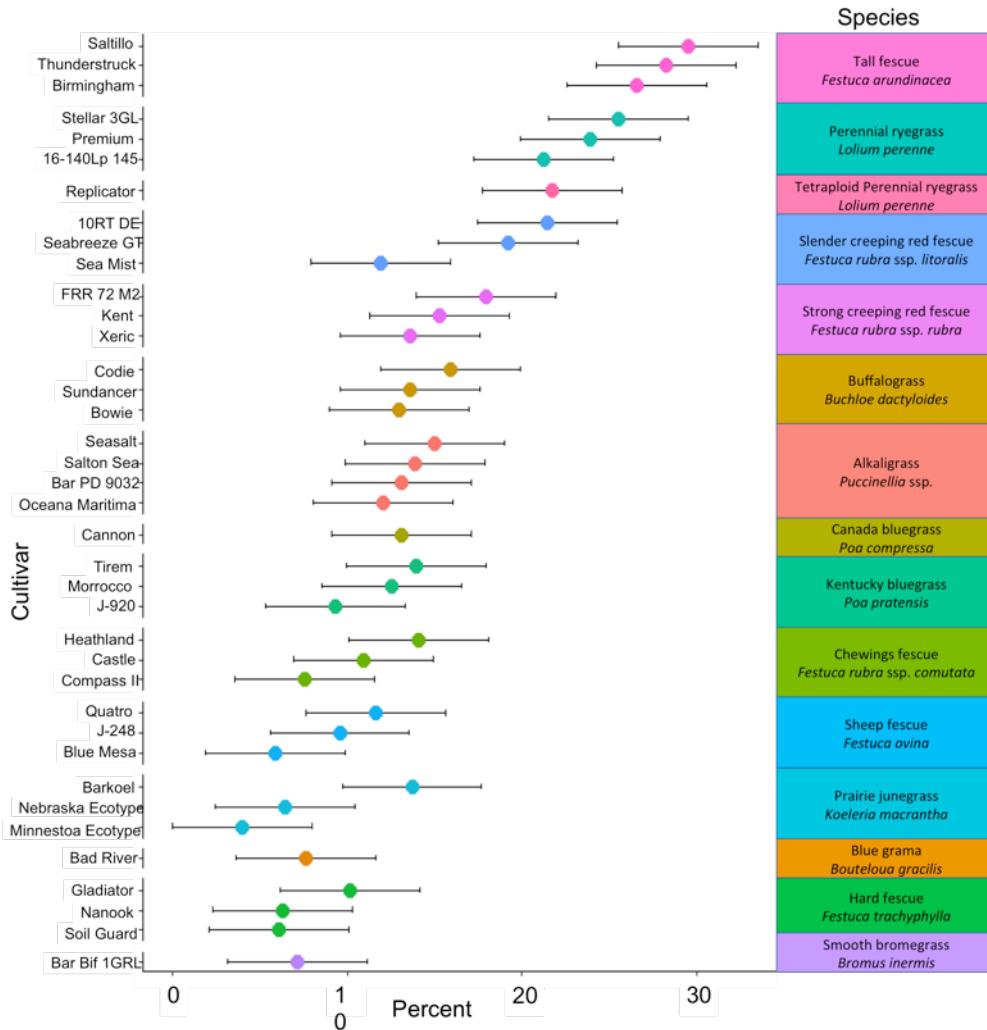


Figure 2. Example images of 4 species and how they performed over time. Week 1 was at the beginning of the experiment before any salt exposure. Week 6 was a cumulative exposure of the previous concentration of 10 dSm⁻¹, and 14 dSm⁻¹. Week 12 was cumulative exposure of previous concentrations and 18 dSm⁻¹.

Percent Cover after 6 Weeks of Salt Stress



Identifying Best Mixtures



Table 5

Regression coefficients from the logistic regression model of grid count data from spring 2013. Coefficients denote the effect on log-odds of retaining greater than 60% survival based on inclusion of each species in the roadside turfgrass mixture experiment.

Species ^a	Coefficient	Std. error	Pr (> z) ^b
SLCRF	1.05	0.67	0.12
SHF	0.96	0.54	0.08
HDF	0.95	0.58	0.10
CHF	0.52	0.76	0.49
CBG	0.47	0.51	0.36
KBG	0.18	0.58	0.76
STCRF	-0.24	0.68	0.73
TF	-1.79	0.69	0.01
ALK	0.61	0.64	0.35

^a STCRF, strong creeping red fescue; ALK, alkali grass; KBG, Kentucky bluegrass; CBG, creeping bentgrass; SHF, sheep fescue; HDF, hard fescue; SLCRF, slender creeping red fescue; TF, tall fescue; CHF, Chewings fescue.

^b Listed *p*-values are for comparison of each coefficient to zero (no effect) after accounting for all other variables in the model.

Final Thoughts

- Grass species is always important!
- Cultivar is often important
- Tools exist to better manage winter stress
- Advances in breeding and genetics should help to more quickly develop cultivars with enhanced winter survival
- Winter survival = genetics + management

Acknowledgements

- University of Minnesota Turfgrass Science Team
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 - Minnesota Department of Transportation
 - Minnesota Turf and Grounds Foundation
 - Minnesota Golf Course Superintendents Association



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Thank You

