Understanding Turfgrass Crown Survival of Winter Conditions

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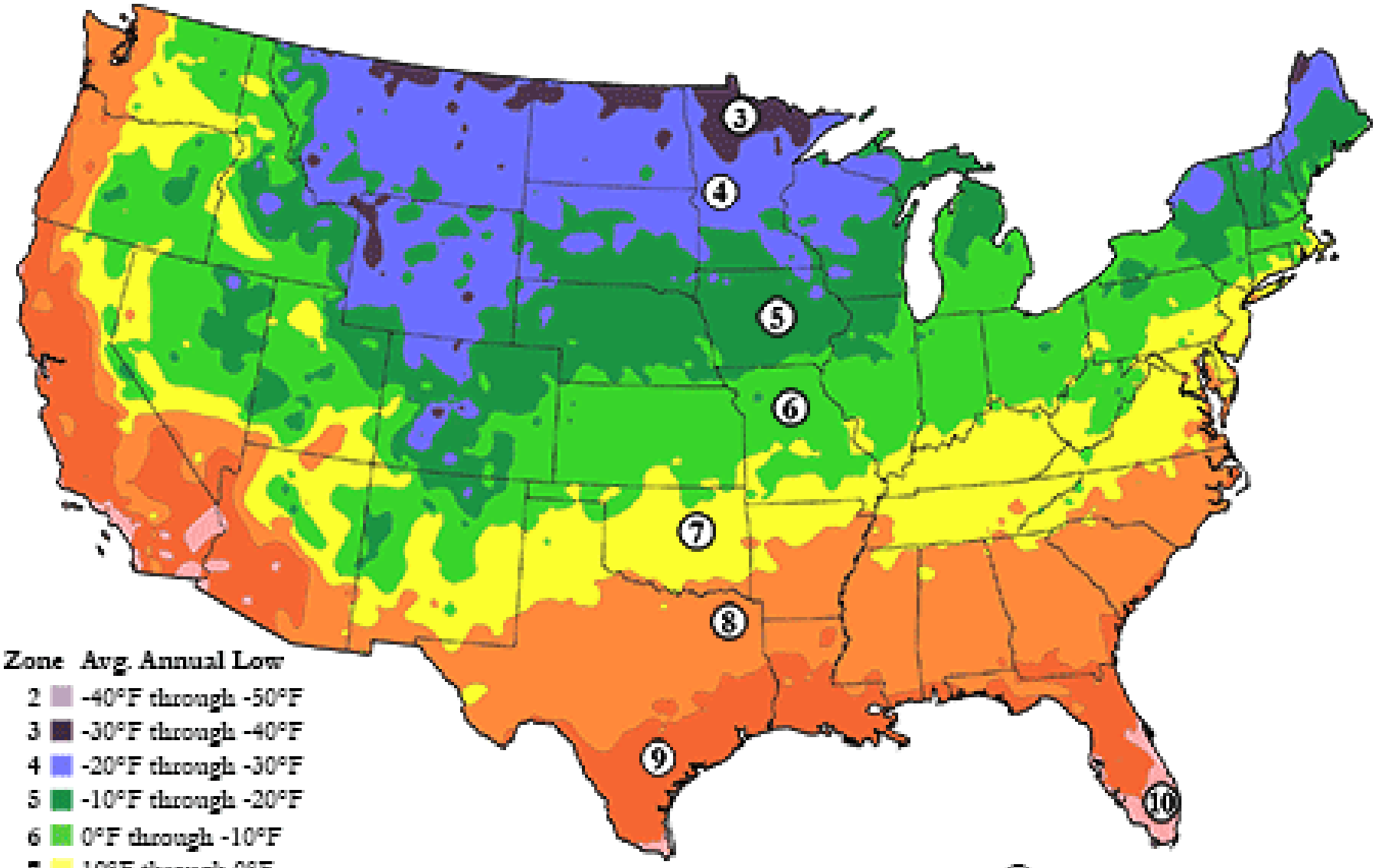
ICEBREAKER Seminar Nov 3, 2023



Zone	Avg. Annual Low	
2	-40°F through -50°F	-40 - -46 °C
3	-30°F through -40°F	-34 - -40 °C
4	-20°F through -30°F	-29 - -34 °C
5	-10°F through -20°F	-23 - -29 °C
6	0°F through -10°F	-18 - -23 °C
7	10°F through 0°F	-12 - -18 °C
8	20°F through 10°F	- 7 - -12 °C
9	30°F through 20°F	- 1 - - 7 °C
10	40°F through 30°F	- 1 - 4 °C

Michigan hardiness zones

- 4a (-30 to -25 °F/-34.4 to -31.7 °C)
- 4b (-25 to -20 °F/-31.7 to -28.9 °C)
- 5a (-20 to -15 °F/-28.9 to -26.1 °C)
- 5b (-15 to -10 °F/-26.1 to -23.3 °C)
- 6a (-10 to -5 °F/-23.3 to -20.6 °C)
- 6b (-5 to 0 °F/-20.6 to -17.8 °C)

Winterkill Research - Ice Encasement

Winter 2013 - 2014

Hancock Turfgrass Research Center, Michigan, USA

Factors that influence overwintering structures - Crown tissue


Credit KWF -April 21, 2014

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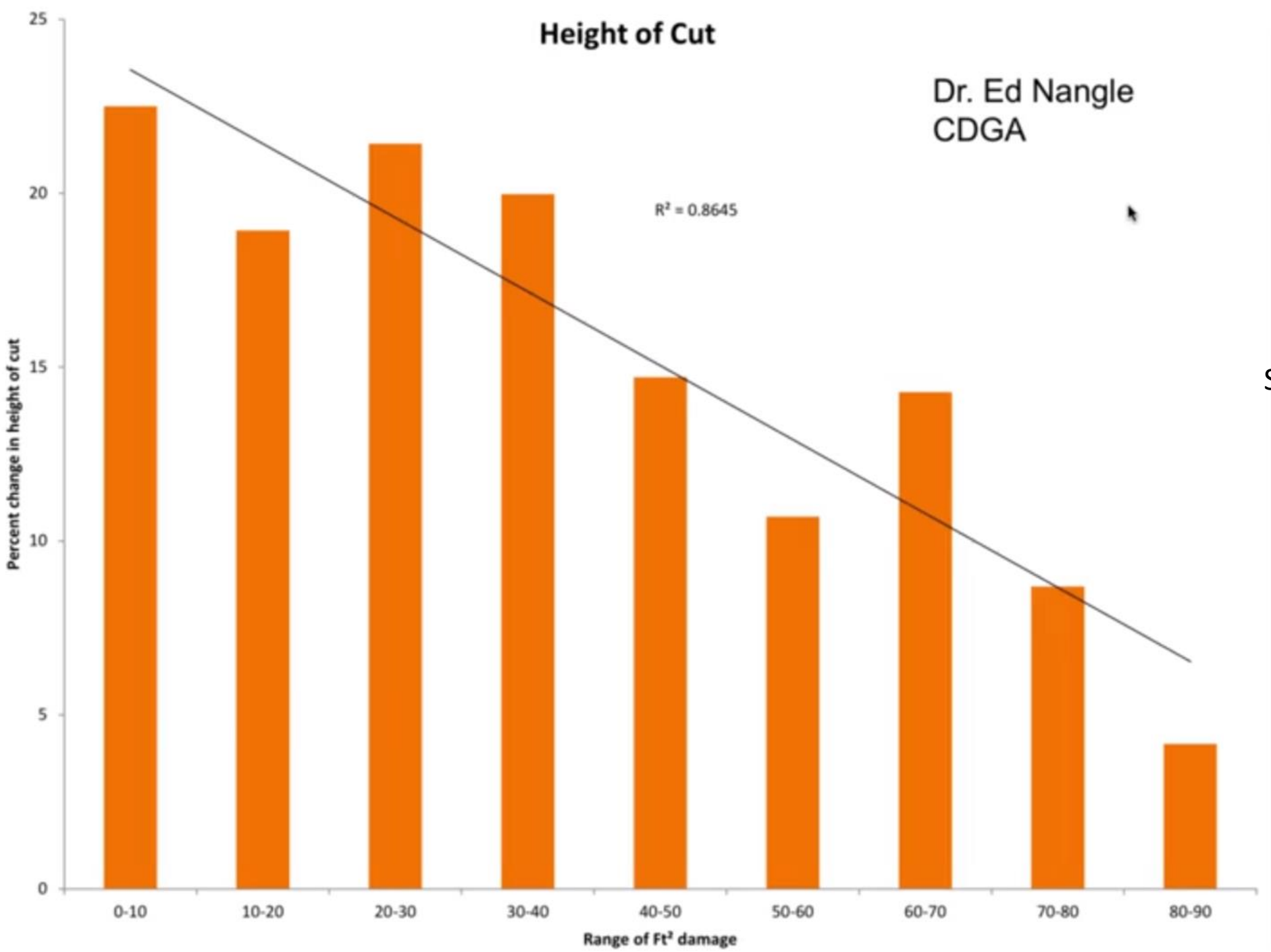


Survey in 2014


TORO
MULTI PRO

1. Water

2. Mowing Height

3. PGR use

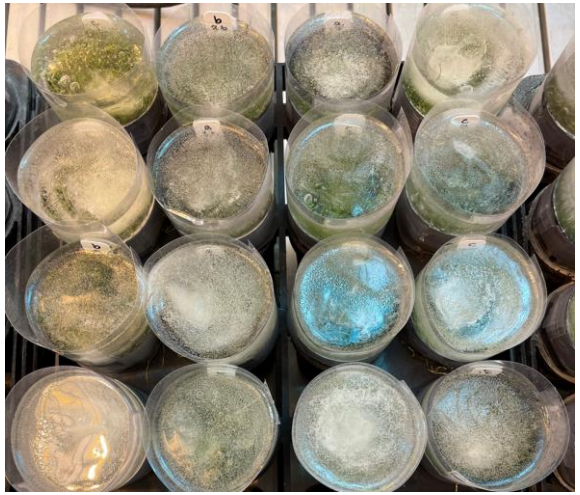
4. Covers

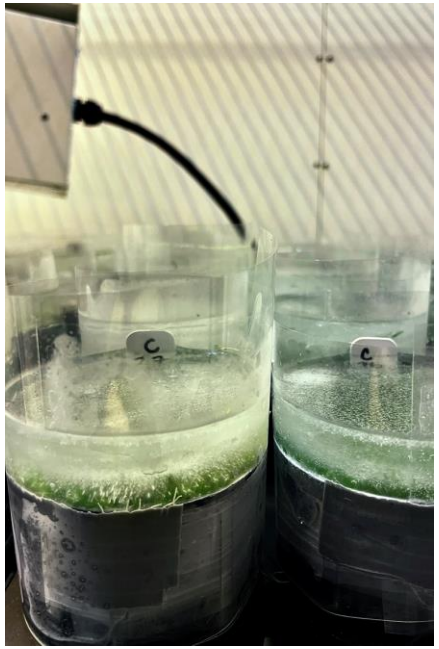
Plant cold acclimation

Dry out	Antifreeze	Store/reduce use	Protect	Keep energized
Dry out cells	Increase free small sugars	Store enough starch reserves (bigger sugars) or minimize respiration	Protect against light while preparing to sleep	Keep membranes as normal and as functional as possible
water	Growth rate/Sugars/respiration (CO2/O2)		Light	Membranes

Water

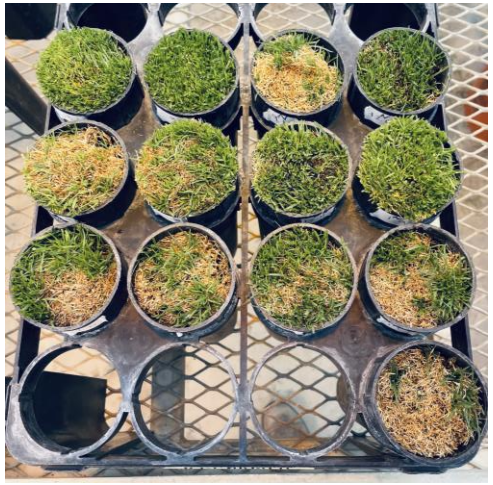
Cold acclimation Incremental decrease in temps from 20˚C to 4˚C





8% soil volumetric water content (VWC)
12% VWC
20% VWC

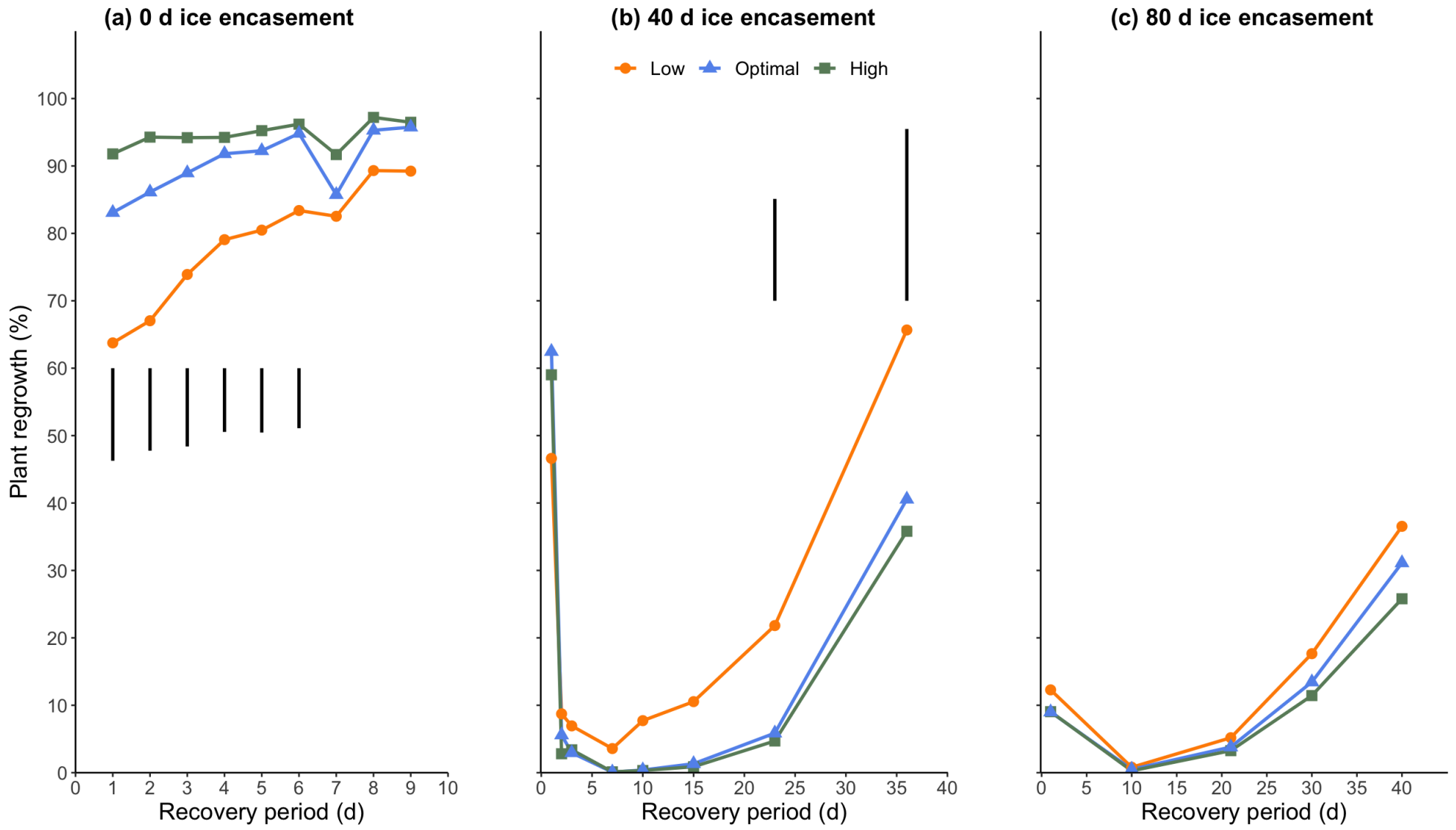
De-acclimation temps and greenhouse recovery



Plant tissues were harvested and separated

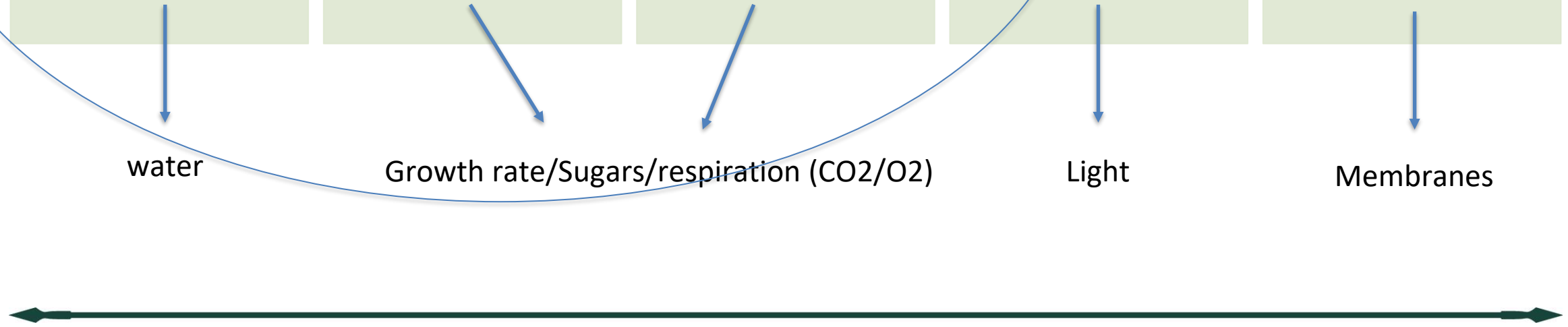
Leaves Stems Roots

Ice encasement (-3˚C) for (0, 40, or 80 days)


(a) 0 d ice encasement
(b) 40 d ice encasement
(c) 80 d ice encasement
Low
Optimal
High
Plant regrowth (%)
Recovery period (d)
Recovery period (d)
Recovery period (d)

Plant cold acclimation

Dry out	Antifreeze	Store/reduce use	Protect	Keep energized
Dry out cells	Increase free small sugars	Store enough starch reserves (bigger sugars) or minimize respiration	Protect against light while preparing to sleep	Keep membranes as normal and as functional as possible



Any management strategies to keep conditions drier during the fall/winter/spring may promote turfgrass survival

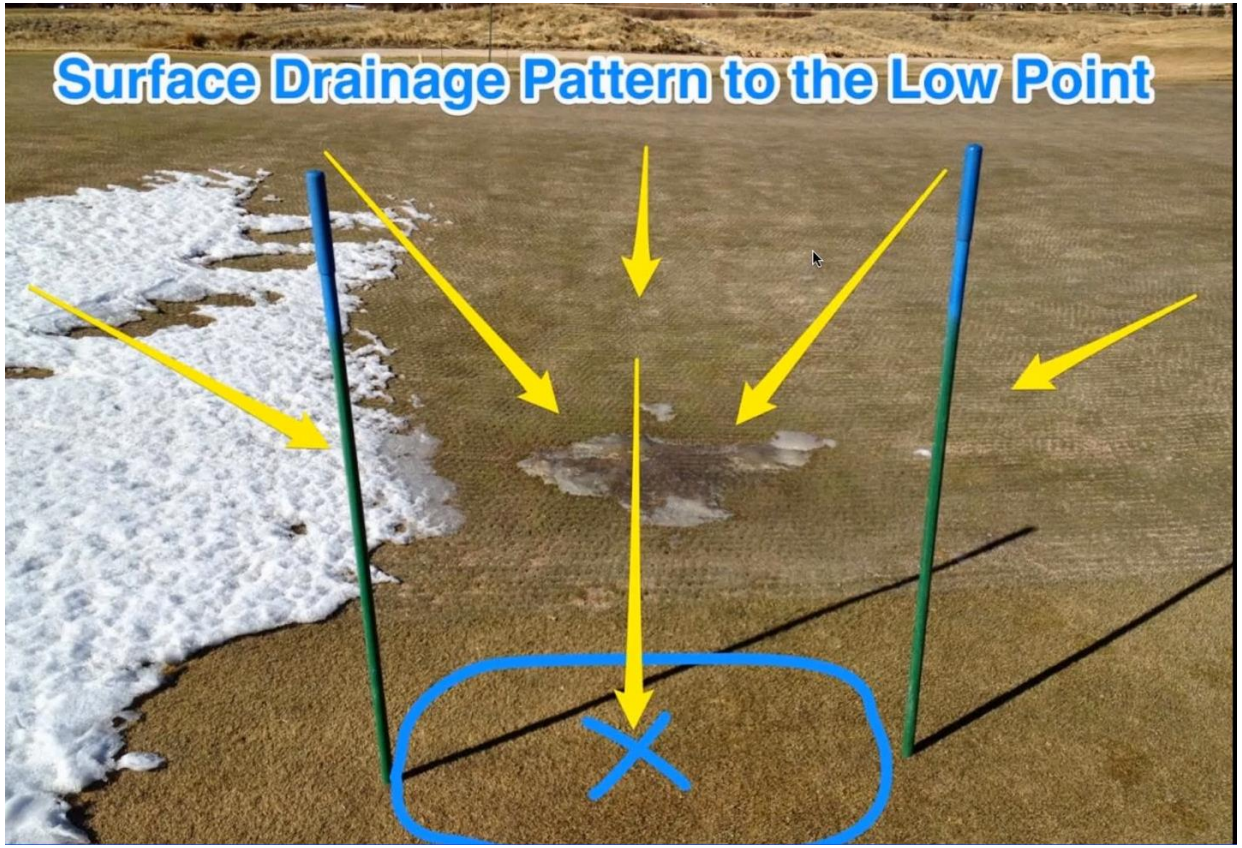
Fall aeration

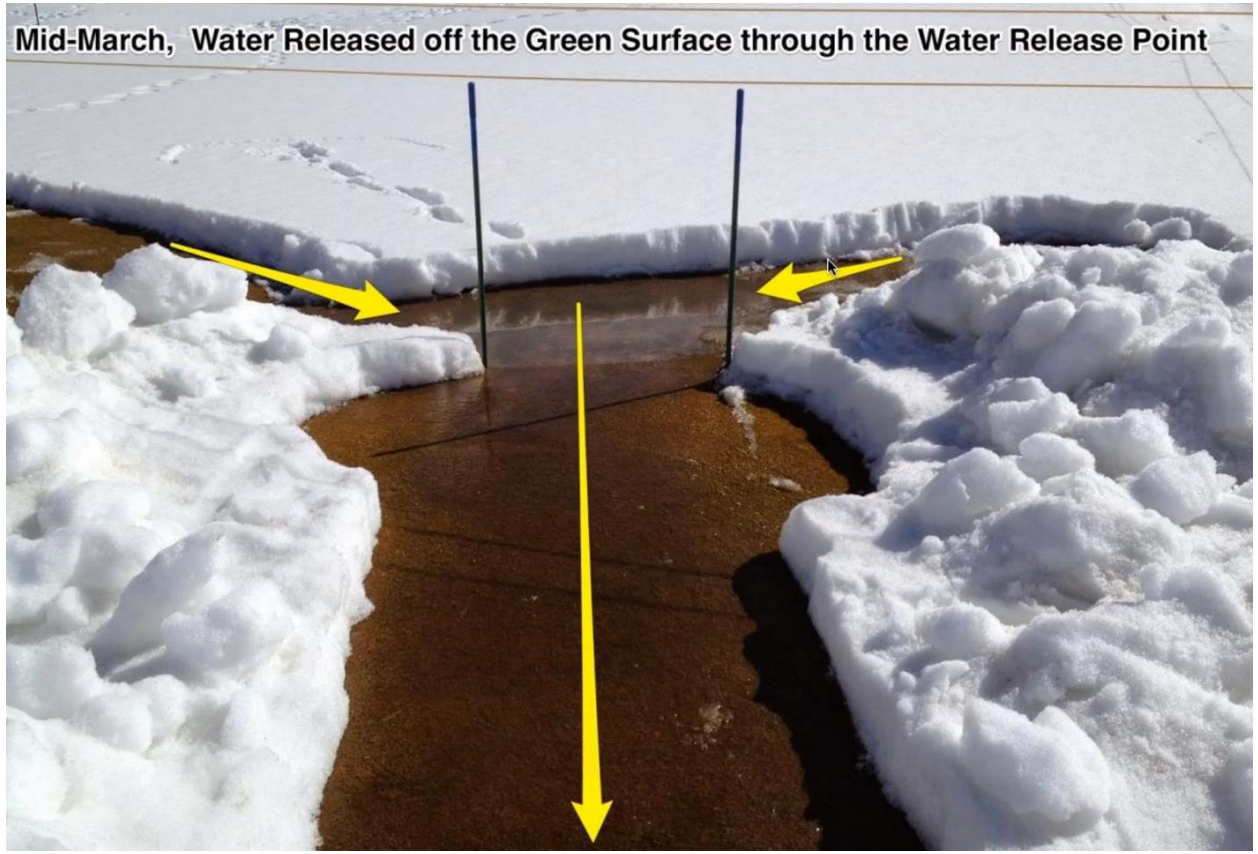

Kevin Frank

USGA, 2017


Kevin Frank

Kevin Frank


Surface Drainage Pattern to the Low Point


Mid-March, Water Released off the Green Surface through the Water Release Point

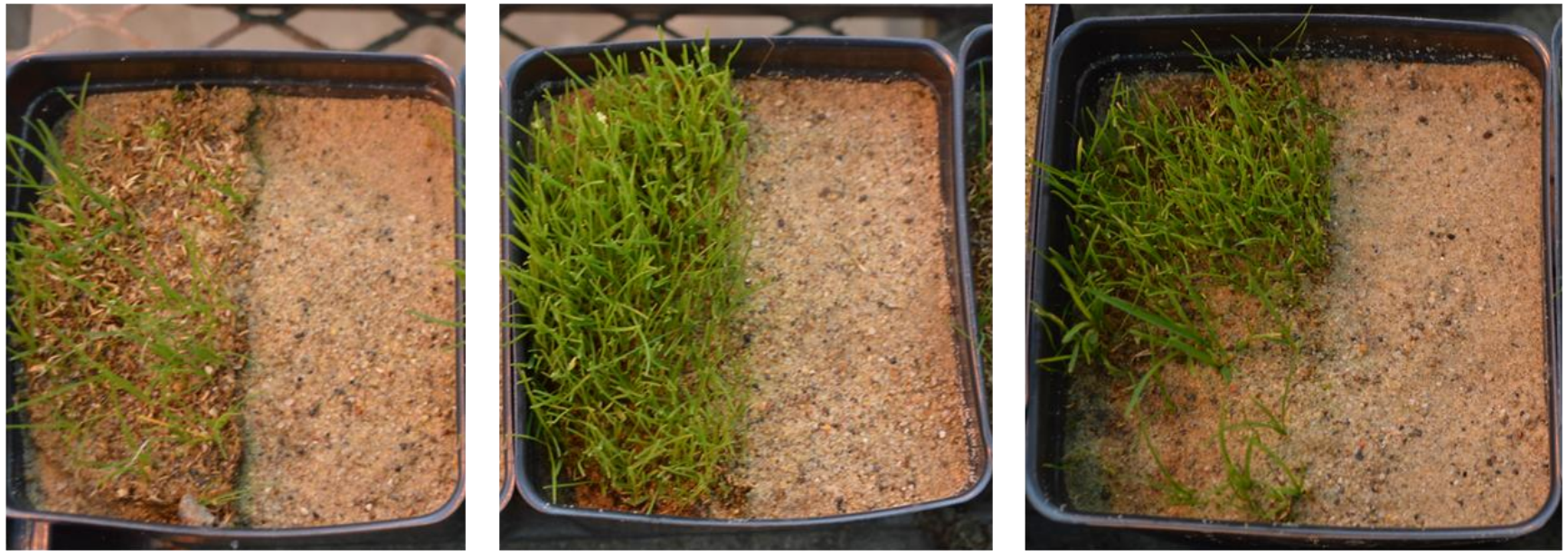

Jan. 15, 2016
Native Soil
USGA
Native Soil
80-10-10
Native Soil
USGA
Kevin Frank

PGRs

MICHIGAN STATE UNIVERSITY

Exercise caution with some plant growth regulators

2015 40 day under ice

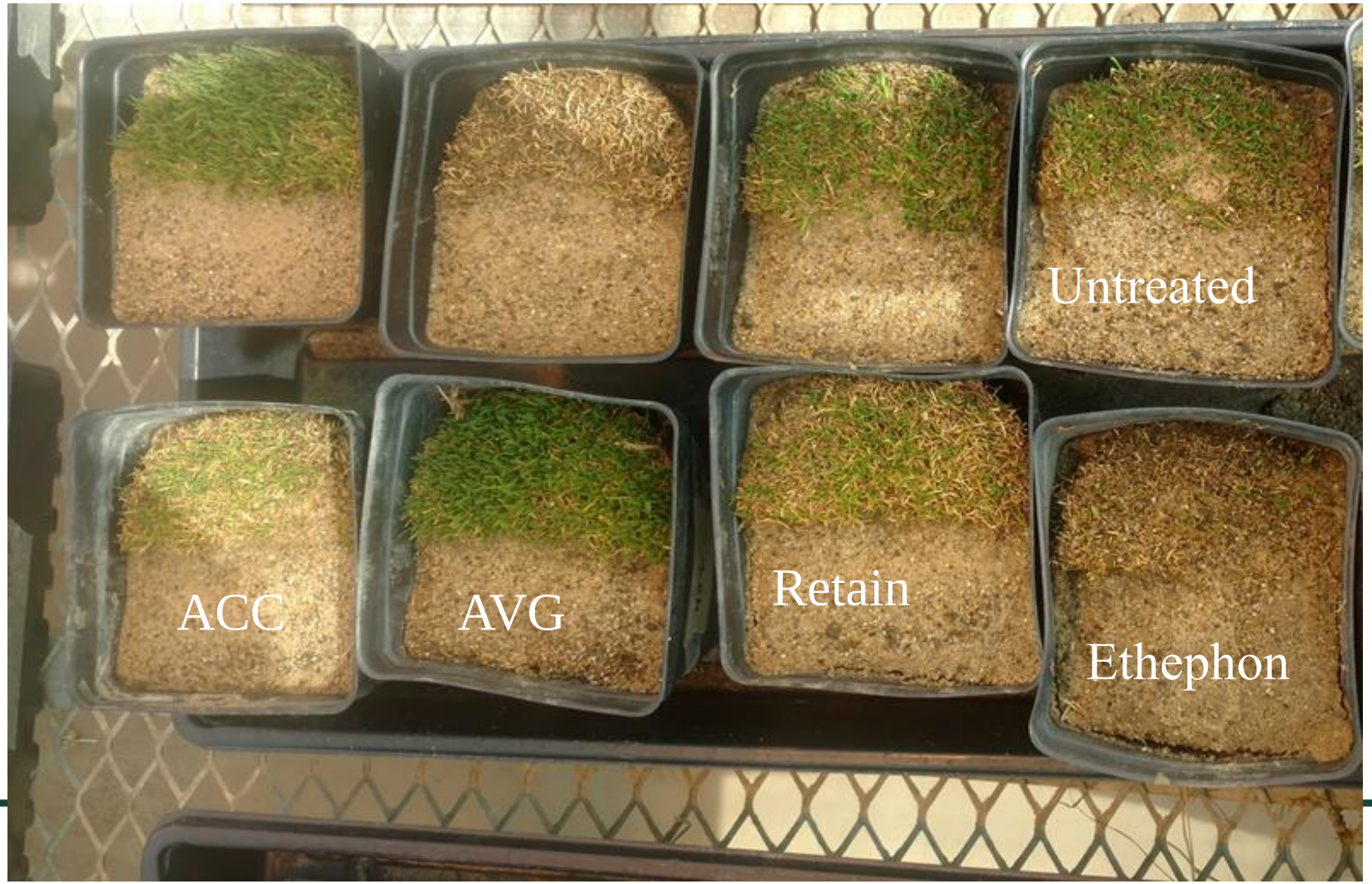


Trinexapac-ethyl

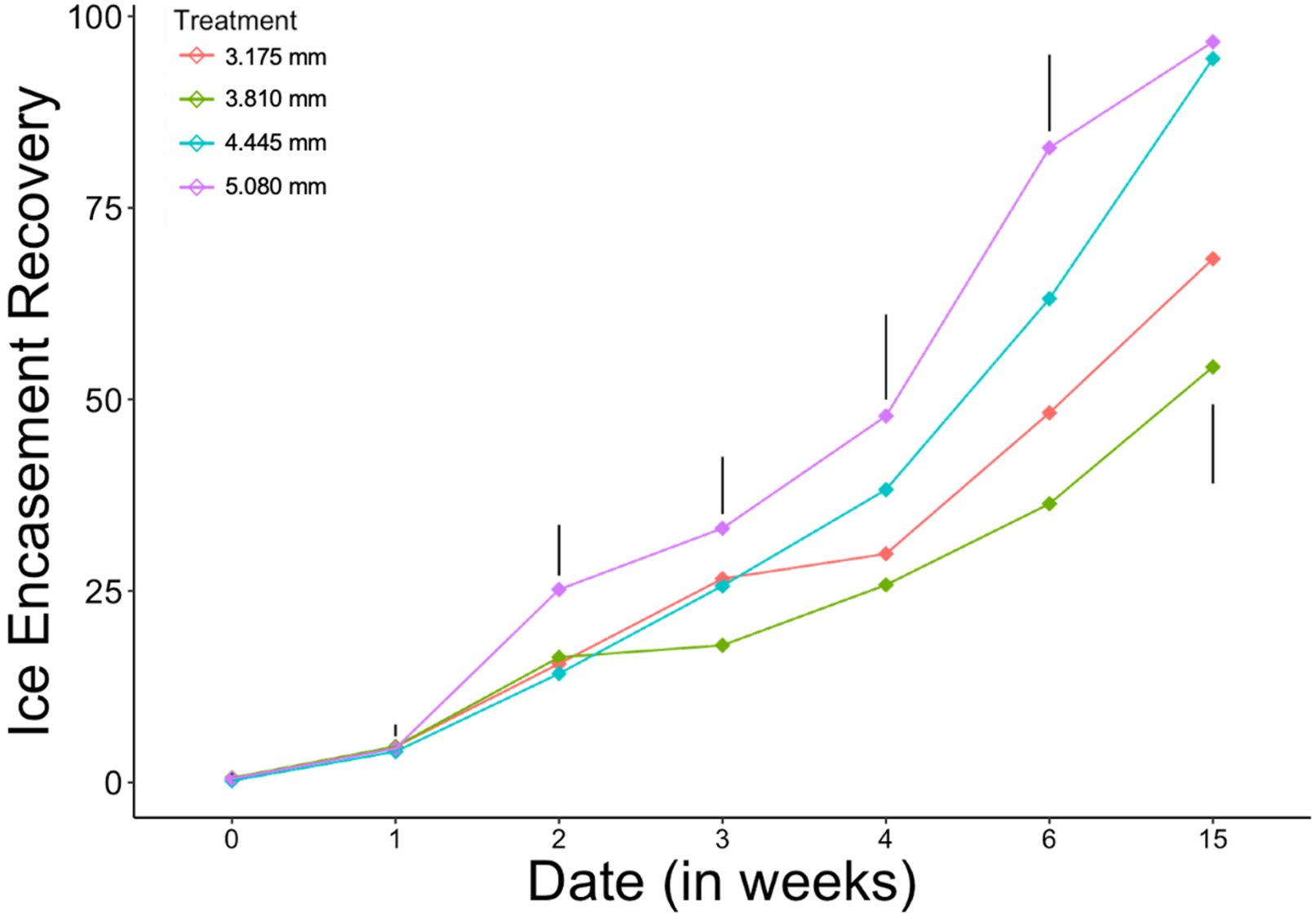
Civitas One

Untreated control

Ethylene based regulators

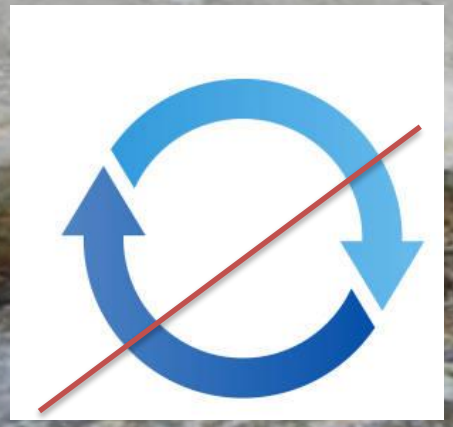


Mowing height studies



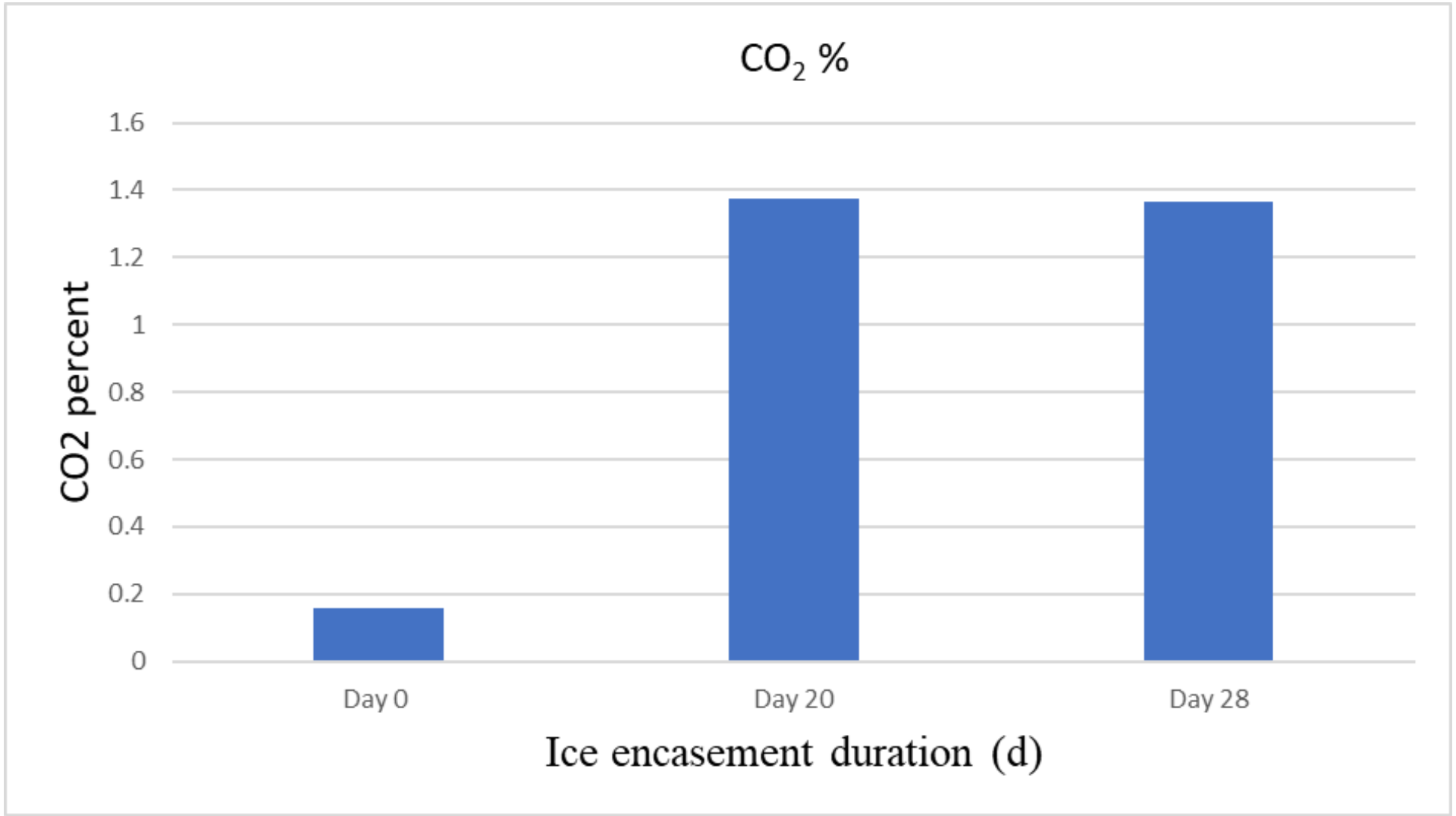
- Improvement in recovery after 20 d or 40 d of ice encasement
- Evidence to support crown carbohydrates are higher

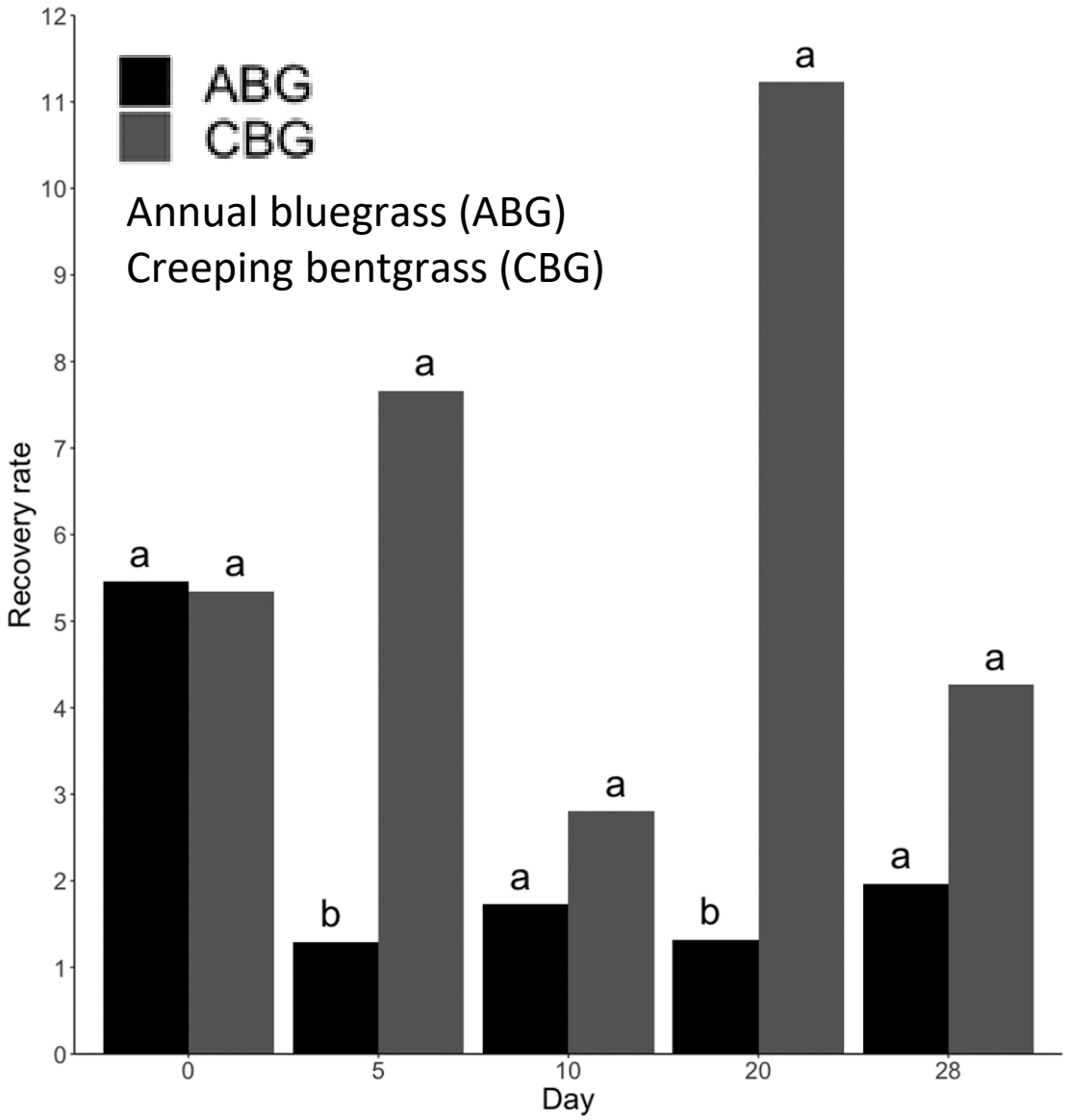
Ice directly on grass structures

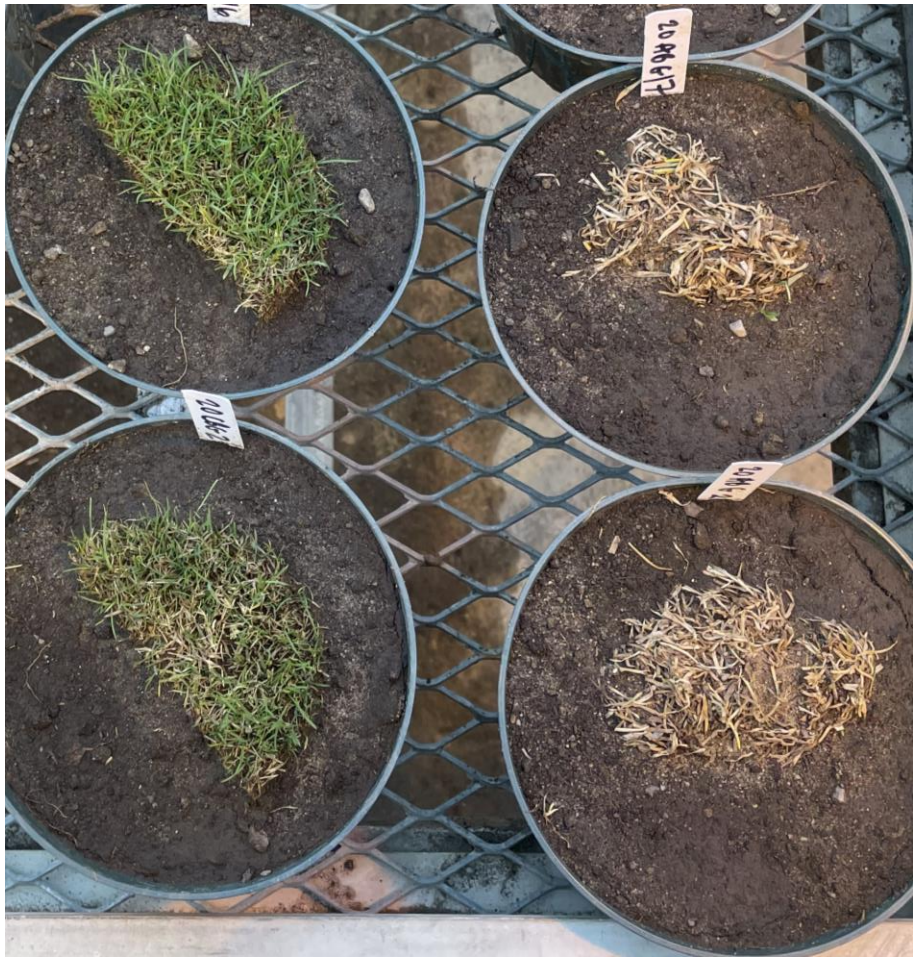


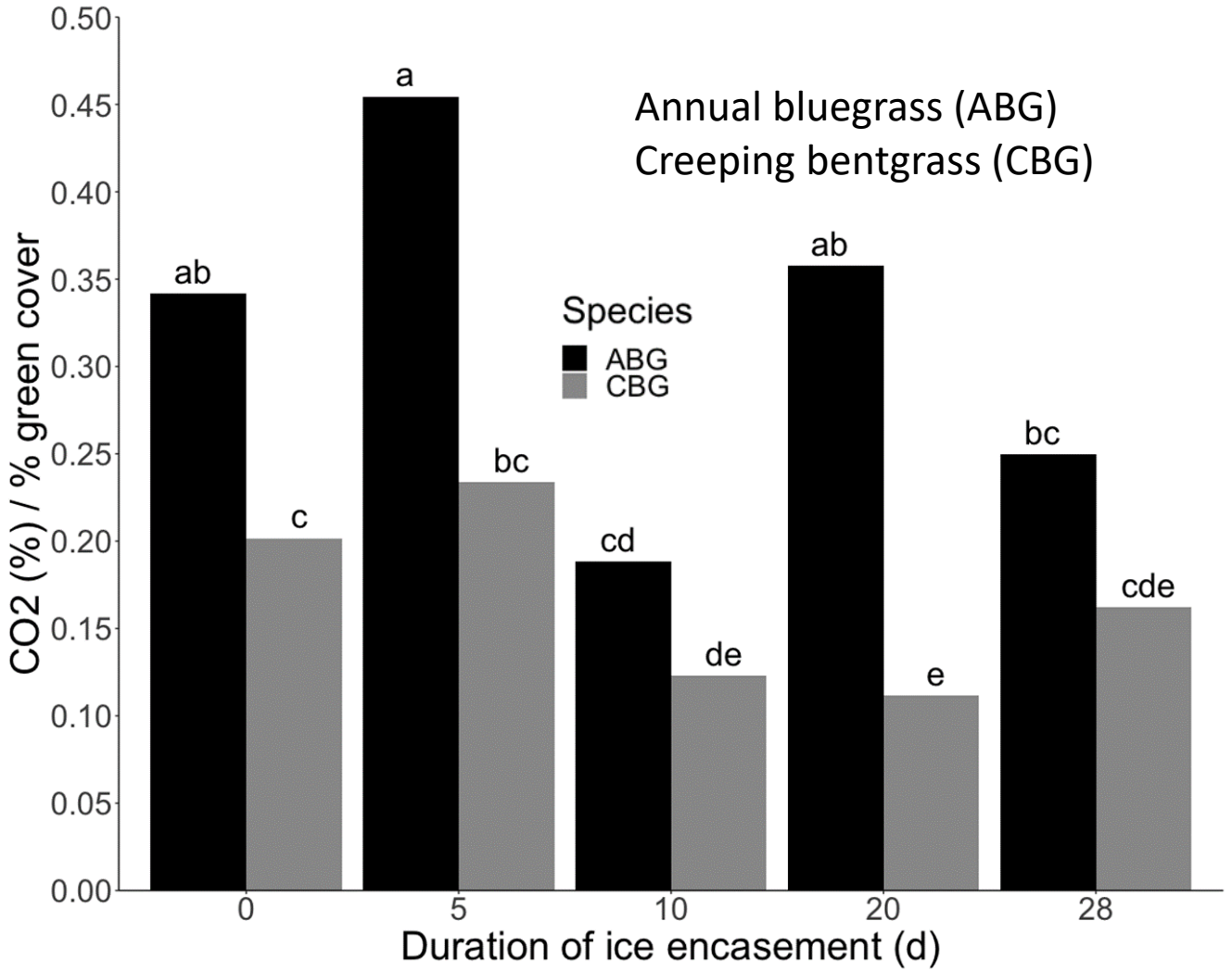
Ice encasement: O2 is used up by respiration and CO2 builds up

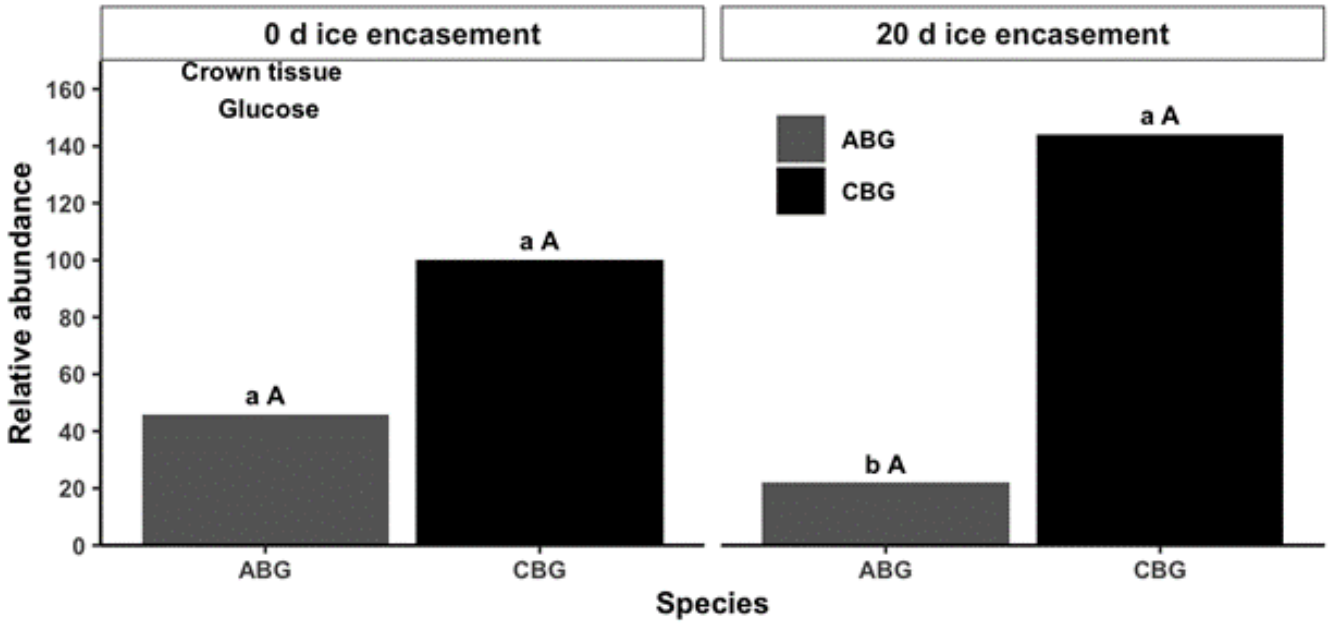
Frank, 2014

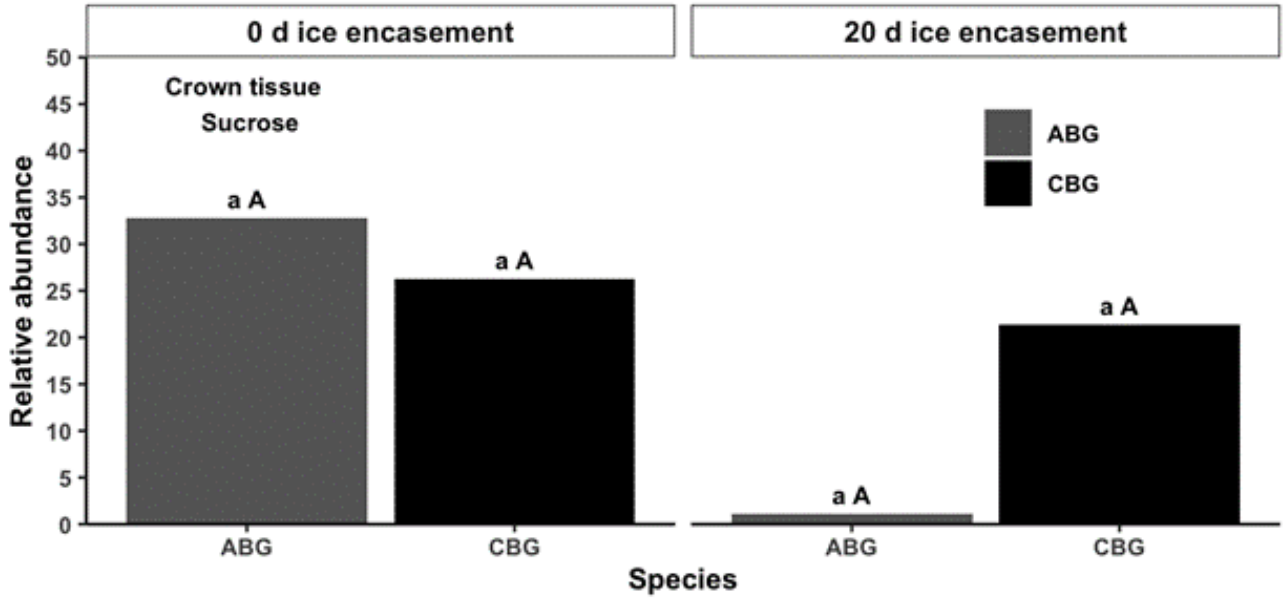

CO_2 %
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
CO2 percent
Day 0
Day 20
Day 28
Ice encasement duration (d)


ABG
CBG
Annual bluegrass (ABG)
Creeping bentgrass (CBG)
Recovery rate
Day
0
5
10
20
28
a
a
b
a
a
b
a
a
a
a

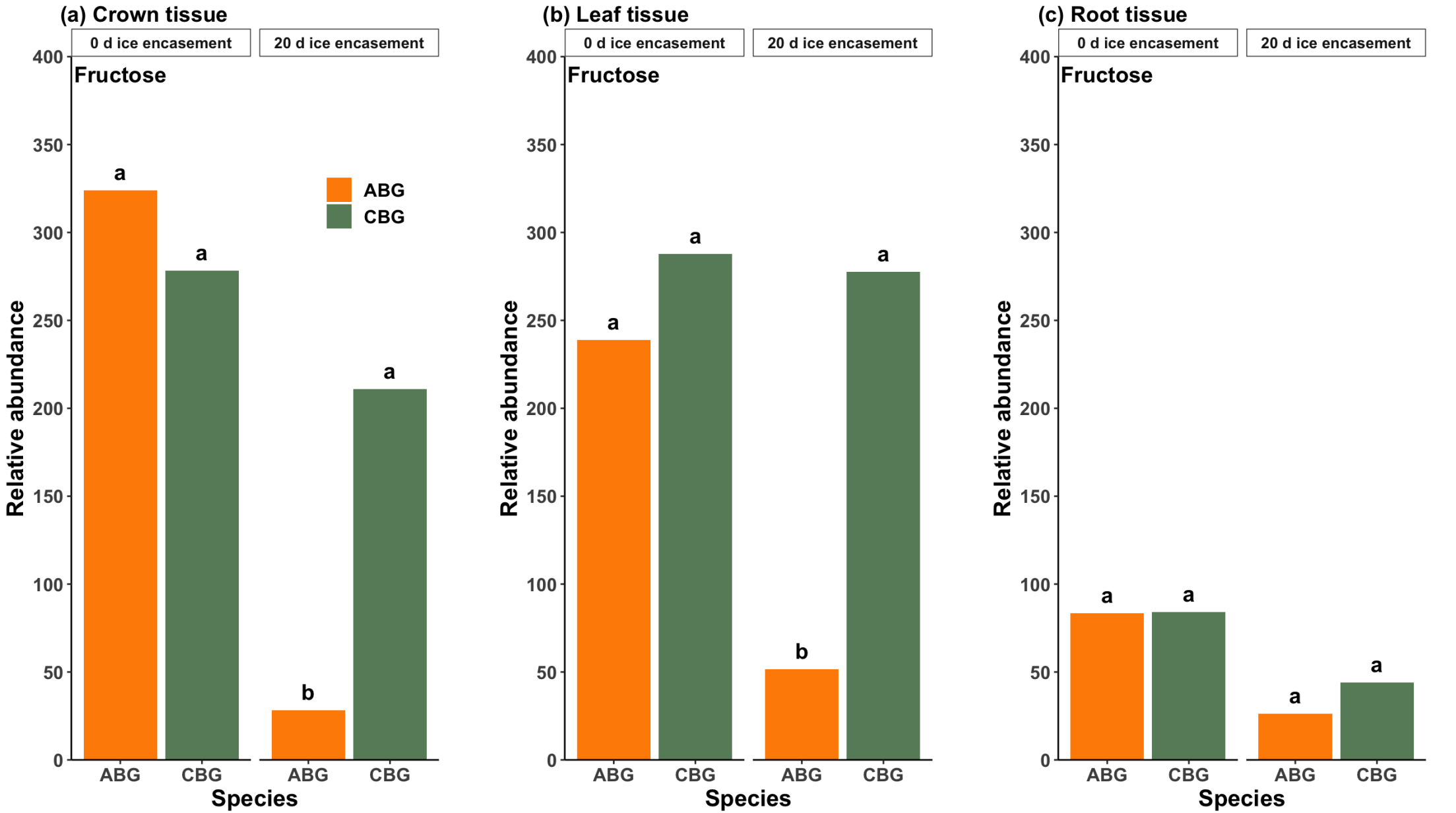


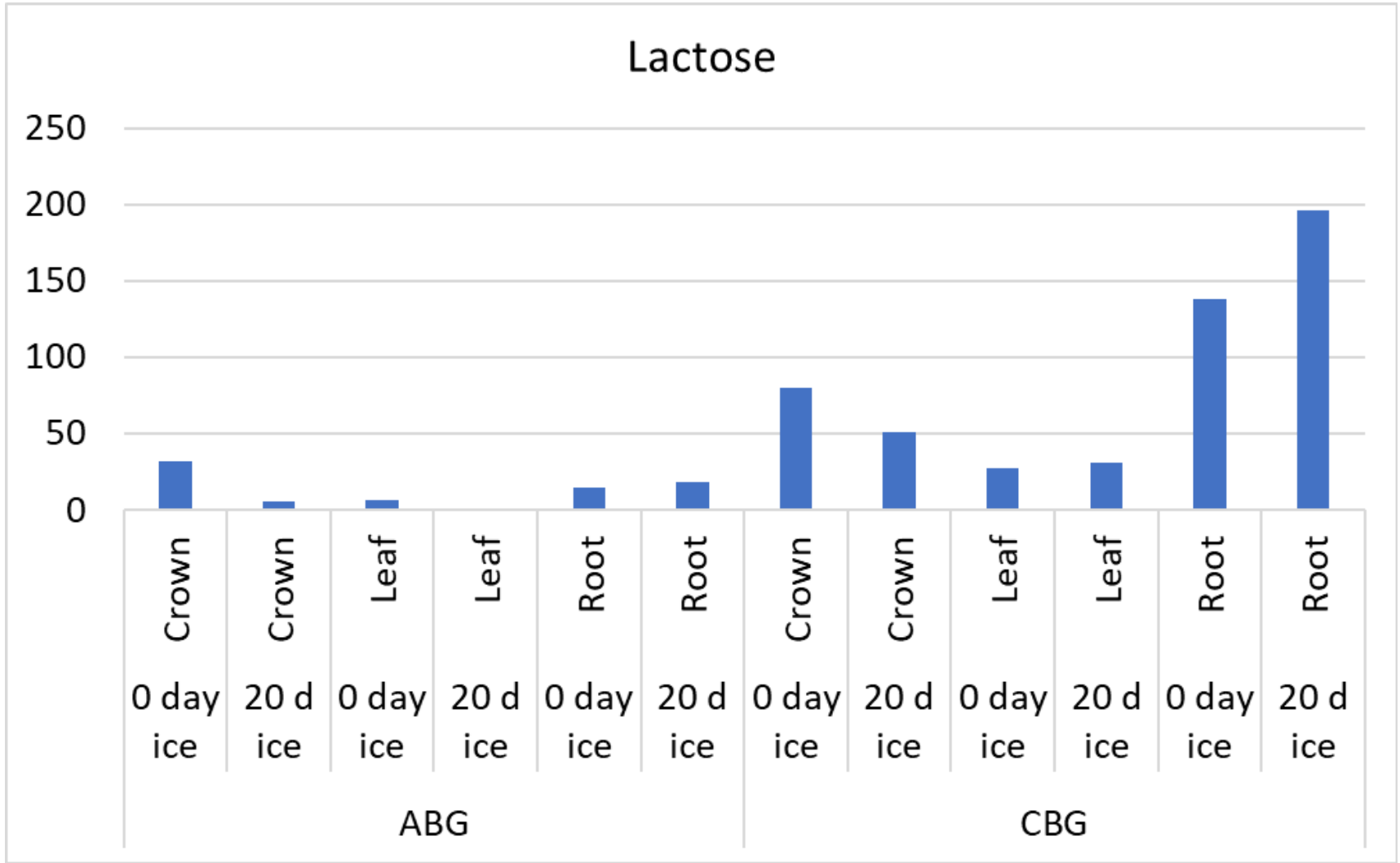

Annual bluegrass (ABG)
Creeping bentgrass (CBG)
CO2 (%) / % green cover
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Species
ABG
CBG
ab
c
a
bc
cd
de
ab
e
bc
cde
0
5
10
20
28
Duration of ice encasement (d)

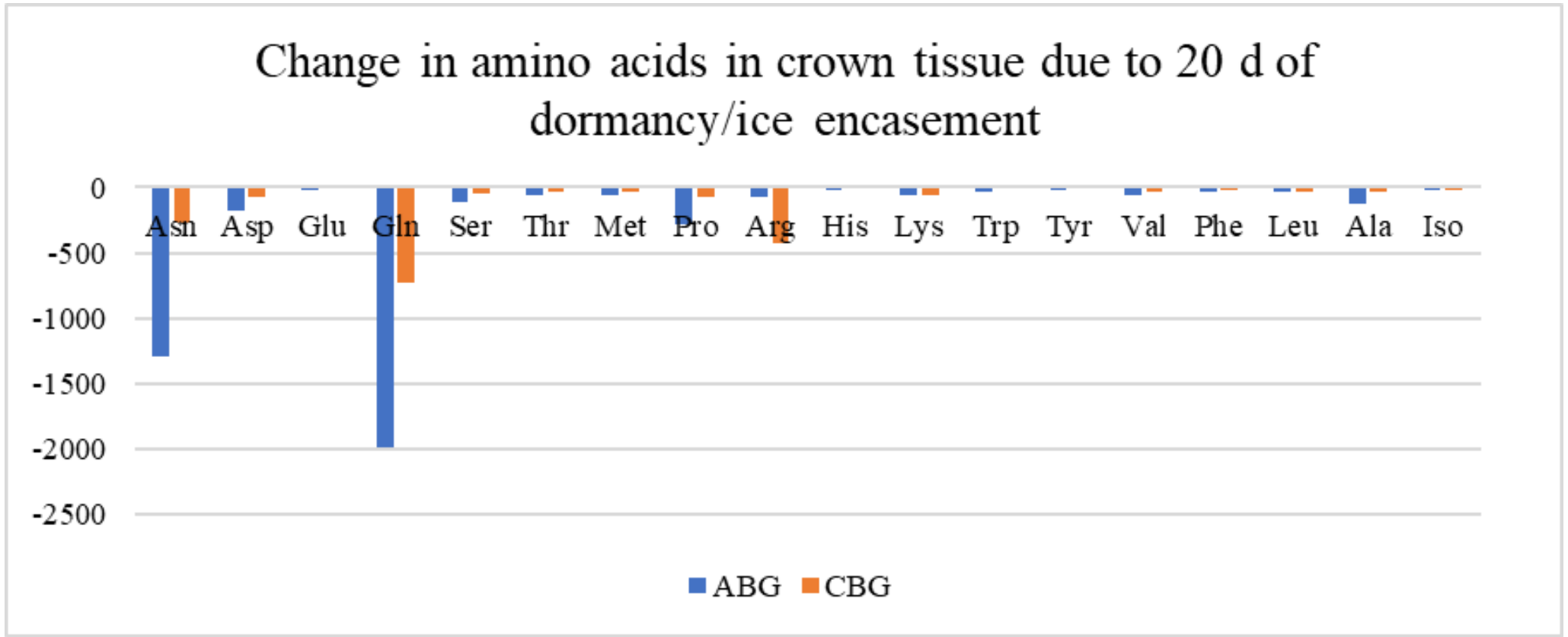


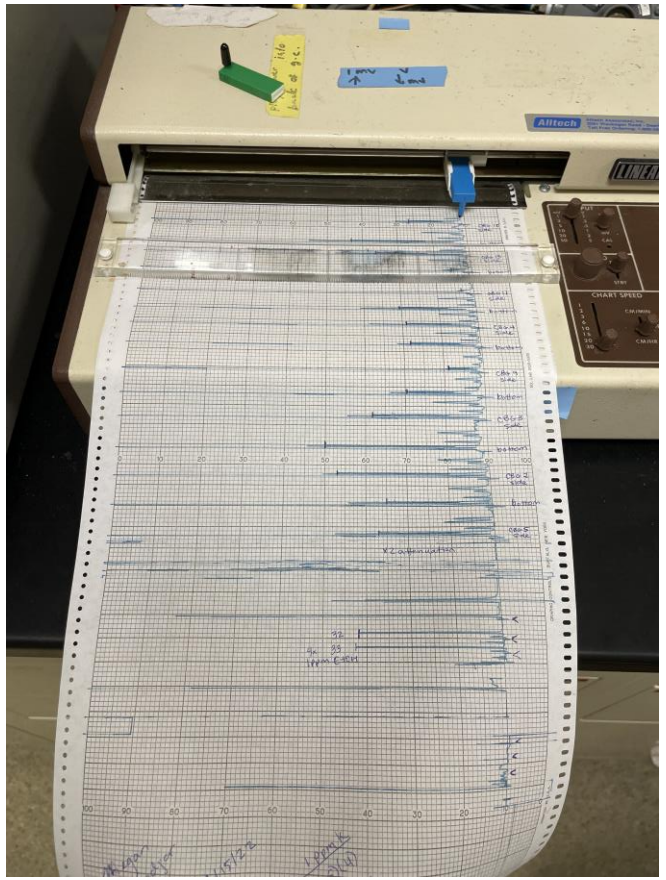


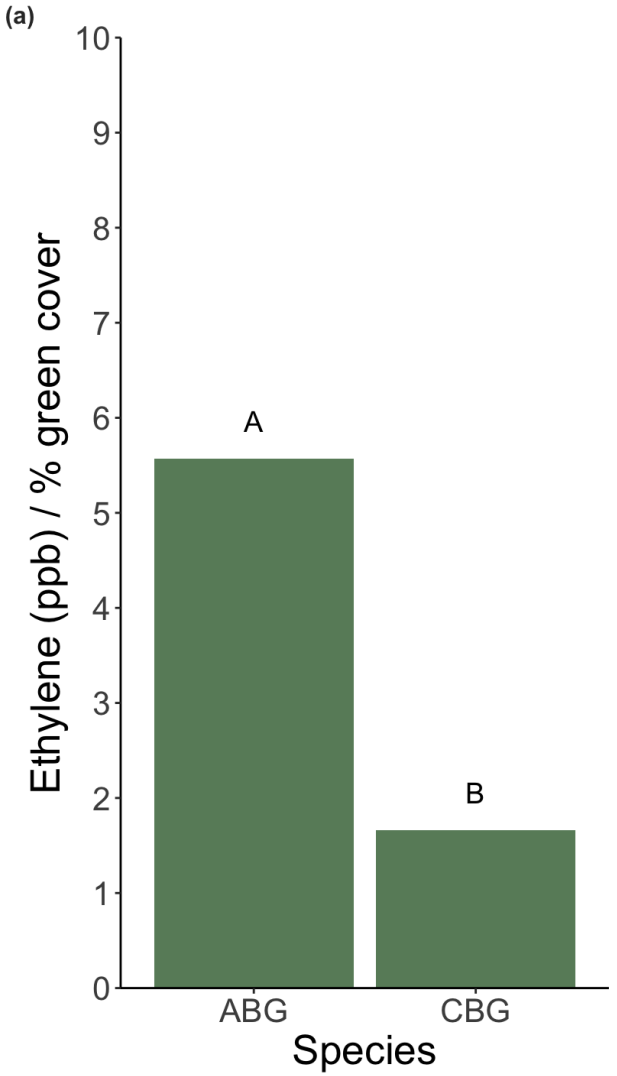
Plant sugar reserves

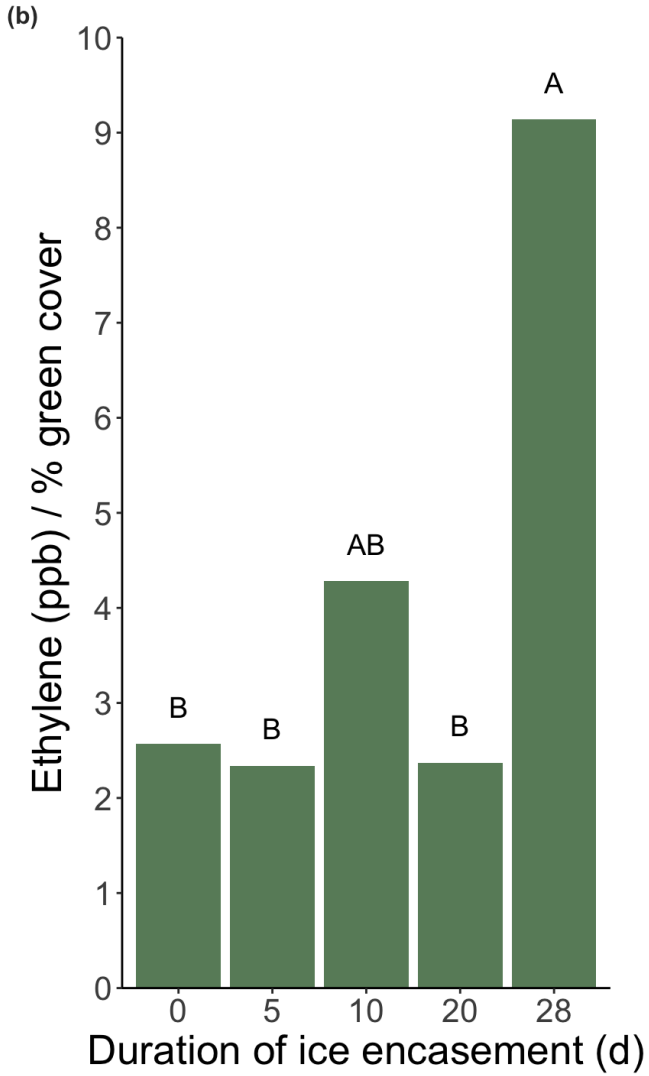

(a) Crown tissue
(b) Leaf tissue
(c) Root tissue
0 d ice encasement
20 d ice encasement
Fructose
ABG
CBG
Relative abundance
Species
0
50
100
150
200
250
300
350
400
a
b


Lactose
250
200
150
100
50
0
Crown
Crown
Leaf
Leaf
Root
Root
Crown
Crown
Leaf
Leaf
Root
Root
0 day ice
20 d ice
0 day ice
20 d ice
0 day ice
20 d ice
0 day ice
20 d ice
0 day ice
20 d ice
0 day ice
20 d ice
ABG
CBG


Change in amino acids in crown tissue due to 20 d of dormancy/ice encasement
0
-500
-1000
-1500
-2000
-2500
Asn
Asp
Glu
Gln
Ser
Thr
Met
Pro
Arg
His
Lys
Trp
Tyr
Val
Phe
Leu
Ala
Iso
ABG
CBG



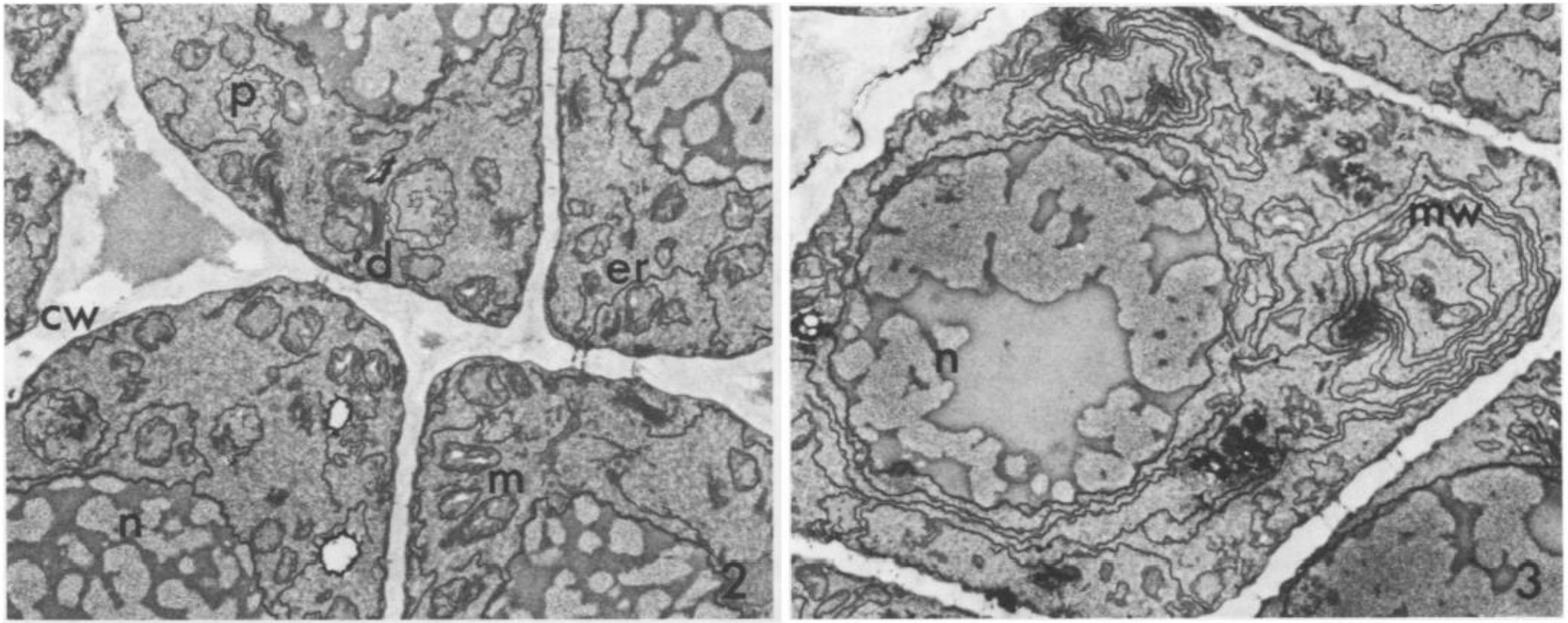

(a)
Ethylene (ppb) / % green cover
0
1
2
3
4
5
6
7
8
9
10
A
B
ABG
CBG
Species


(b)
Ethylene (ppb) / % green cover
0
1
2
3
4
5
6
7
8
9
10
B
B
AB
B
A
0
5
10
20
28
Duration of ice encasement (d)

Sugar/Energy crisis coupled with having to get rid of toxins

No Ice

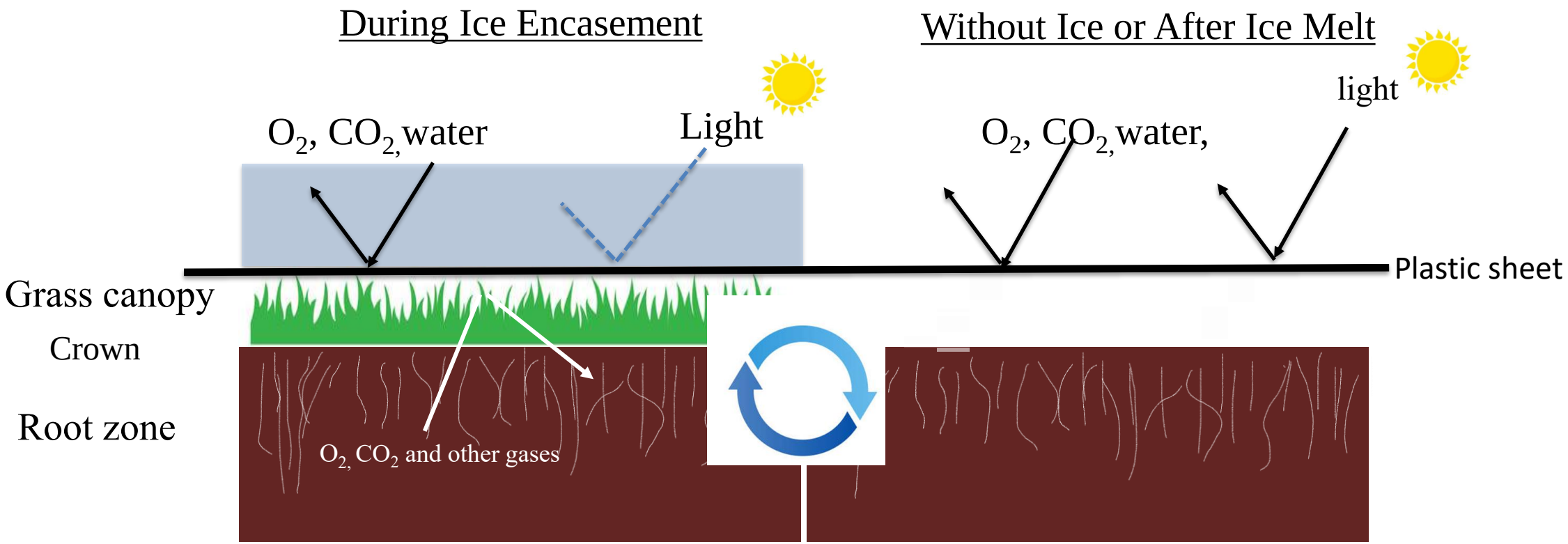
Ice encasement of wheat



https://www.ncbi.nlm.nih.gov/pmc/articles/PMC543037/pdf/plntphys00129-0129.pdf

Improve drainage but even the best draining soils do not drain when they are frozen.

Addition of impermeable plastic to the system



Soil heat may be lost more readily under ice alone

	Thermal Conductivity ($Wm^{-1}\,°C^{-1}$)	Good Insulator?
Air	0.023	Yes
Snow	0.024	Yes
Water	0.54	yes
Ice	2.22	No
Polyethylene	0.40	yes

Soil microbial activity is higher under plastic and may provide oxygen to turfgrass structures

Impermeable plastic use has risks

When to remove? How much light? Risk of hypoxia? Other concerns?

Popular covers are low-density polyethylene film

Table 1

Mean production rates of CH_4 and C_2H_4 from a variety of plastics incubated in water under ambient solar radiation (light) and dark conditions.

Plastic type	Source	CH_4 (pmol $g^{-1}d^{-1}$)		C_2H_4 (pmol $g^{-1}d^{-1}$)	
		light	dark	light	dark
Polycarbonate (PC)	www.amazon.com/dp/B000FP83PO/ref=biss_dp_t_asn	10 ± 2	NS	24 ± 5	NS
Acrylic (AC)	www.minplastics.biz/acrylic_products.html	30 ± 3	NS	24 ± 1	20 ± 1
Polypropylene (PP)	www.amazon.com/dp/B000ILG19U/ref=biss_dp_t_asn	170 ± 10	NS	50 ± 1	NS
Polyethylene Terephthalate (PET)	www.amazon.com/dp/B0015H4BIE/ref=biss_dp_t_asn	500 ± 20	50 ± 10	64 ± 11	NS
Polystyrene* (PS)	commercial.owenscorning.com/products/foam/	730 ± 110	120 ± 30	910 ± 10	60 ± 5
High-density Polyethylene (HDPE)	www.amazon.com/dp/B000ILG0TQ/ref=biss_dp_t_asn	90 ± 10	NS	190 ± 20	NS
Low-density Polyethylene (LDPE)	www.amazon.com/dp/B000ILG118/ref=biss_dp_t_asn	4100 ± 200	NS	5100 ± 400	NS

Relevant information regarding the polymer sources is also included. The errors represent the standard deviation of triplicate samples.

NS: final concentrations not significantly different from those in the control treatment (t-test, P>0.05).

*: Polystyrene incubations lasted for 14 days and were conducted in MilliQ water.

Royer SJ, Ferrón S, Wilson ST, Karl DM. Production of methane and ethylene from plastic in the environment. PLoS One. 2018 Aug 1;13(8):e0200574. doi: 10.1371/journal.pone.0200574. PMID: 30067755; PMCID: PMC6070199.

USGA, 2017

Thank you!!!

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