Germination thresholds of species in the Mixed-grass Prairie as affected by global climate change: A FACE study

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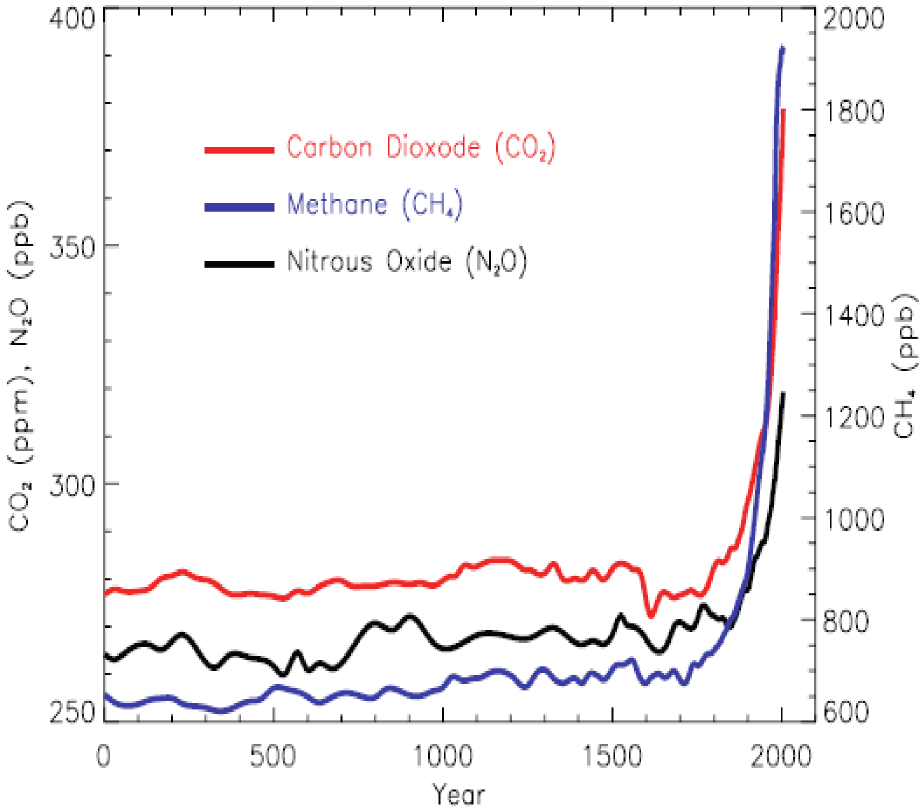
Outline

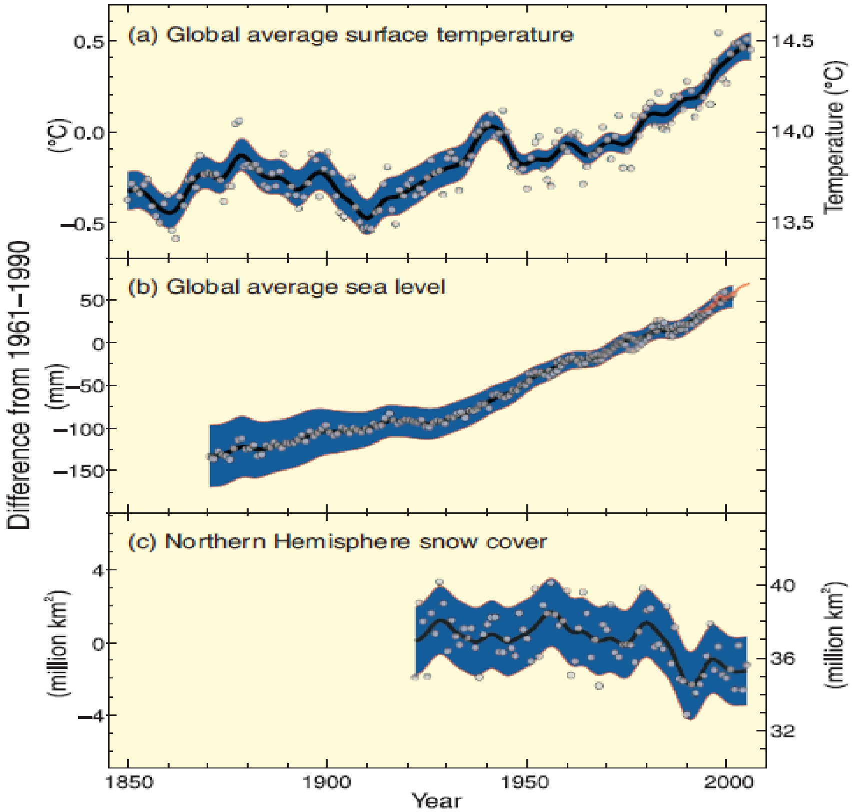
- Introduction
  - Global climate change
  - Effects on plant reproduction
- Objectives of my project
- Materials and methods
  - PHACE Project
- Data analysis
  - Thermal time model
- Results
  - Seed quality
  - Seed germinability
- Conclusions

Introduction

* Global climate change
  - ✓ CO_2 concentration: from 290 to 385 to 740 ppm
  - ✓ Temperature: ↑ 2 to 6.4° C by the end of century

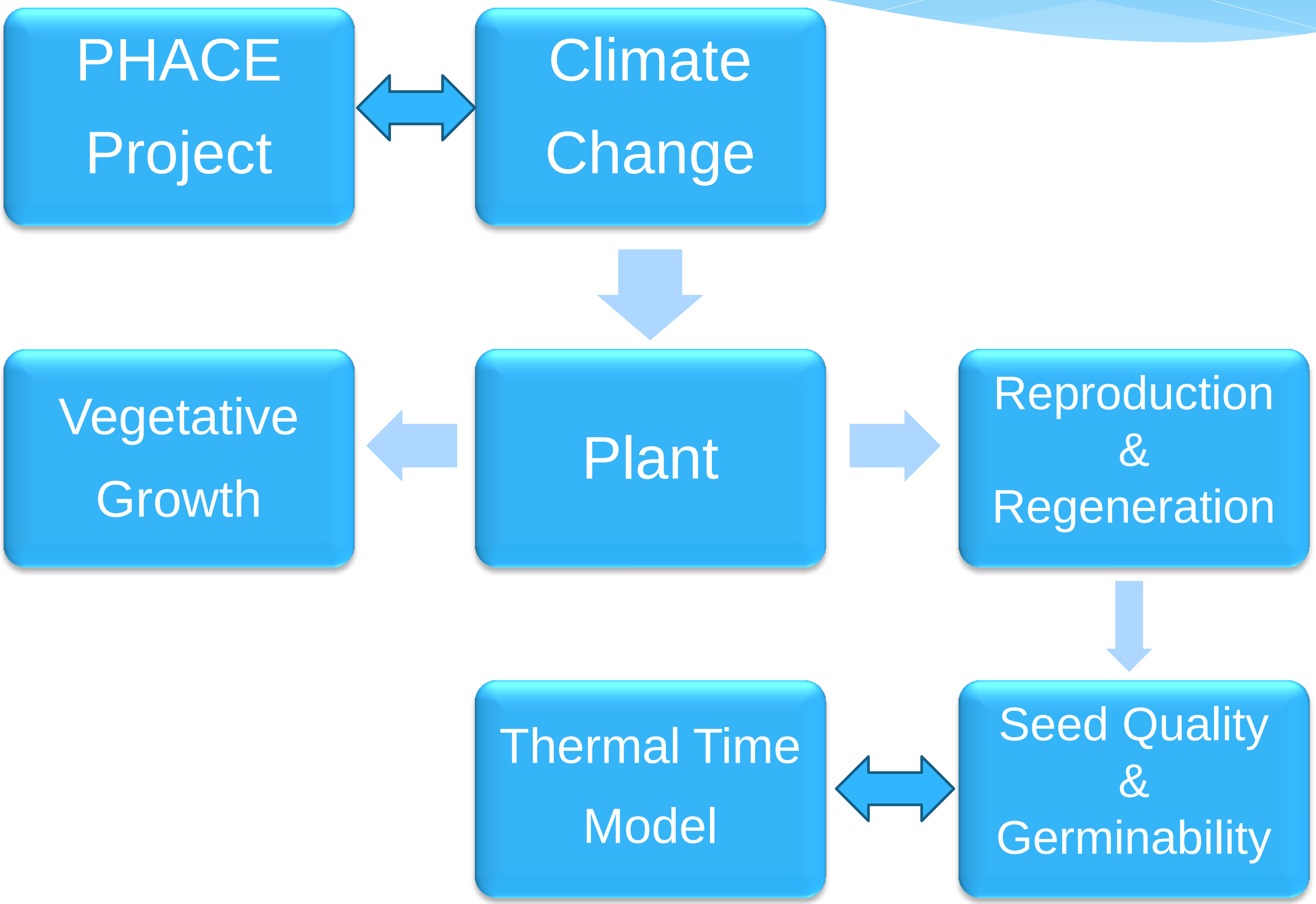


Concentrations of Greenhouse Gases from 0 to 2005 (IPCC, 2007)



Changes in temperature, sea level and Northern Hemisphere snow cover

Introduction (cont.)



Objectives

* To identify germination thresholds
* To identify physiological mechanisms
* To extend results to functioning groups
* To make general predictions

Materials and Methods

* PHACE Project = the Prairie Heating and CO_2 Enrichment

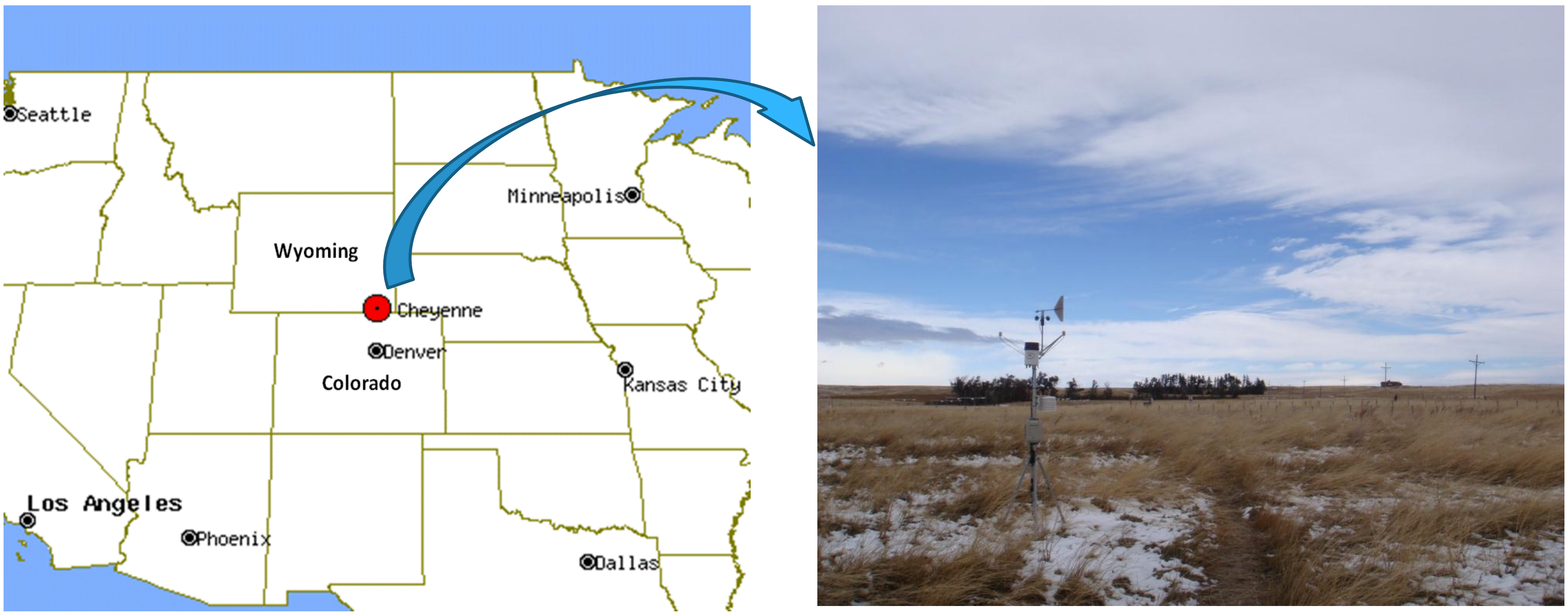
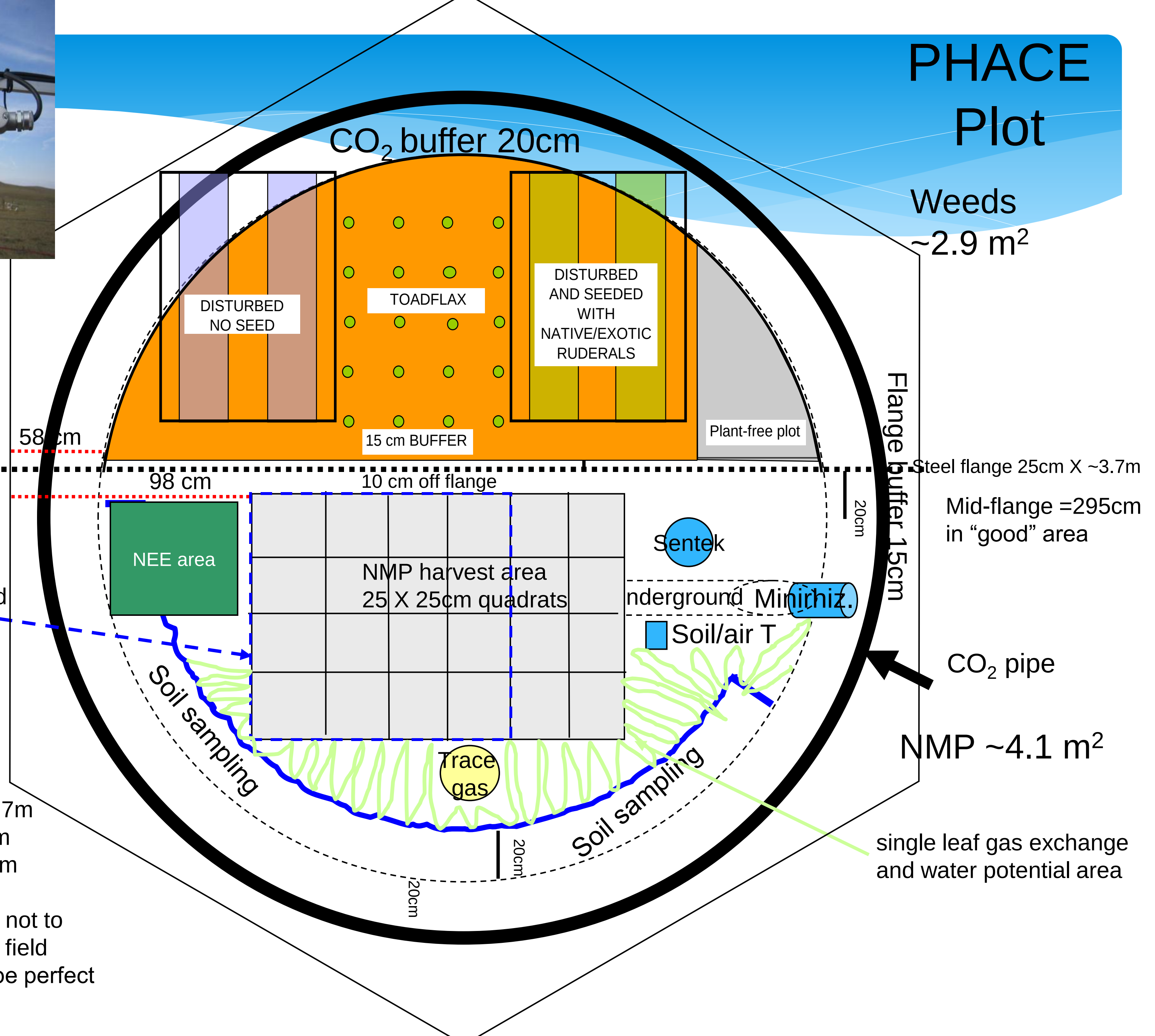


Figure 1. Location of United States Department of Agriculture – Agricultural Research Service, High Plains Grasslands Research Station, Cheyenne, Wyoming, USA (41º11' N, 104º54' W).



PHACE
Plot
Weeds
~2.9 m^2
IR lamp
Over top
CO_2 buffer 20cm
DISTURBED
NO SEED
TOADFLAX
DISTURBED
AND SEEDED
WITH
NATIVE/EXOTIC
RUDERALS
Plant-free plot
15 cm BUFFER
58 cm
Split oriented in
Windy direction
280 degrees
98 cm
10 cm off flange
Steel flange 25cm X ~3.7m
Flange buffer 15cm
20cm
Mid-flange =295cm
in “good” area
NEE area
NMP harvest area
25 X 25cm quadrats
Sentek
nderground
Minirhiz.
Soil/air T
photography and
phenology area
one meter^2
CO_2 pipe
Soil sampling
Trace
gas
Soil sampling
NMP ~4.1 m^2
20cm
20cm
single leaf gas exchange
and water potential area
Flange diameter 3.7m
Ring diameter 3.4m
Useable space diam
eter 3.0m
NOTE: objects are not to
exact scale: actual field
dimensions won’t be perfect

Treatment Design

- CO_2:
  - Ambient = 375 ppm CO_2
  - Elevated = 600 ppm CO_2
- Warming:
  - Infra-red heating = 1.5/3.0ºC warmer day/night
  - No heating
- Irrigation:
  - Shallow irrigation = 20 mm, frequent
  - Deep irrigation = early and late season application
- 6 treatments * 5 replicates = 30 plots

Treatment Design (cont.)

Symbol	Treatment
ACI-d	ambient CO_2, control temp, irrigated (deep, one in early spring and one in later summer)
ACI-s	ambient CO_2, control temp, irrigated (shallow)
ACN	ambient CO_2, control temp, non-irrigated
AHN	ambient CO_2, infra-red heating, non-irrigated
ECN	elevated CO_2, control temp, non-irrigated
EHN	elevated CO_2, infra-red heating, non-irrigated

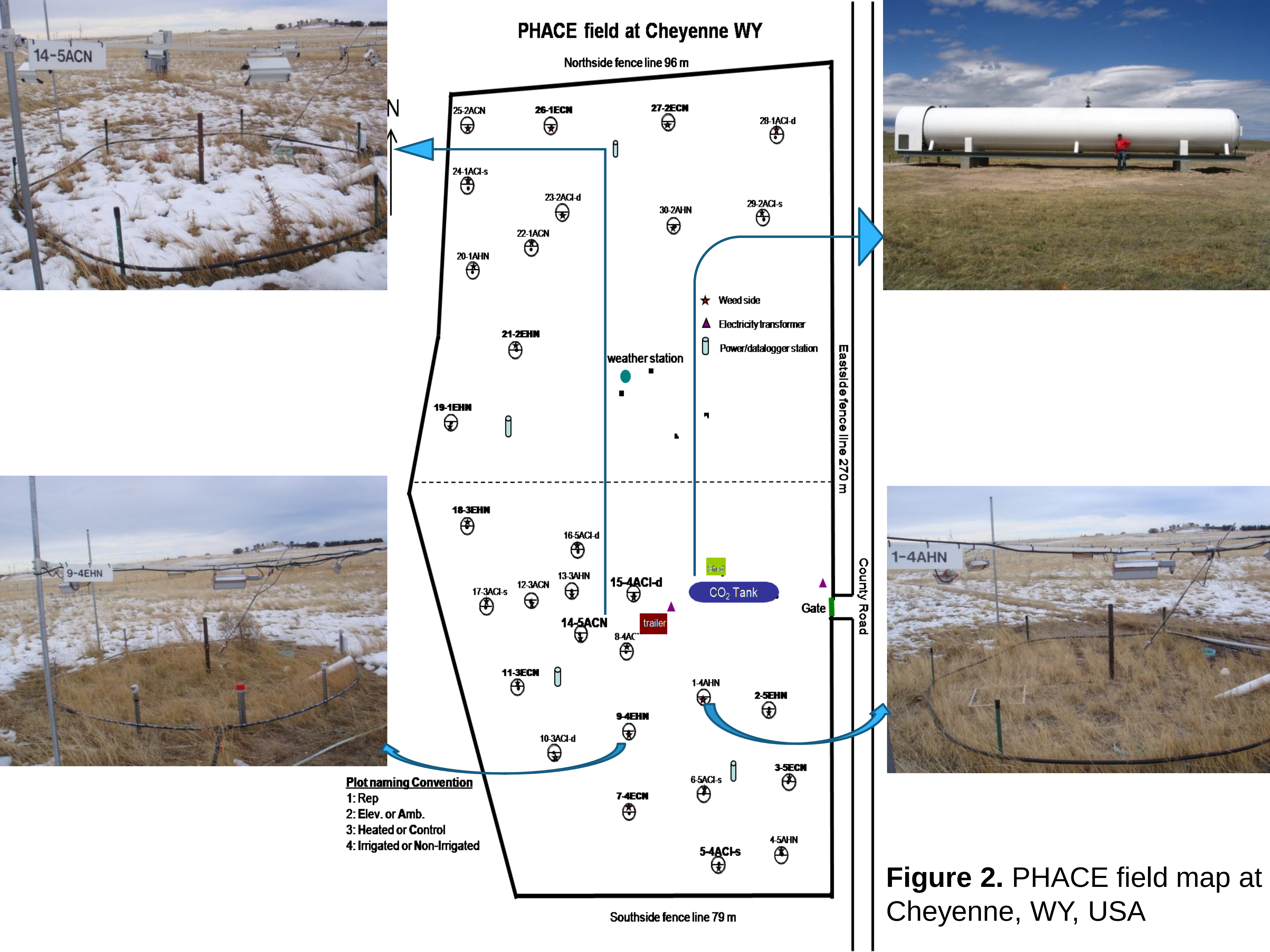


Figure 2. PHACE field map at Cheyenne, WY, USA

Seed collection and germination test

- Seeds collected from PHACE
  - ✓ Native species:
    - Perennial C4 – *Bouteloua gracilis* (Blue grama)
    - Perennial C3 – *Koeleria macrantha* (June grass)
    - Perennial C3 – *Stipa comata* (Needle-and-thread)
  - ✓ Native VS Invasive species:
    - Annual C3 – *Chenopodium leptophyllum* (Narrowleaf goosefoot)
    - Annual C4 – *Salsola iberica* (Russian thistle)




Seed collection and germination test

- Temperature regimes for germination test

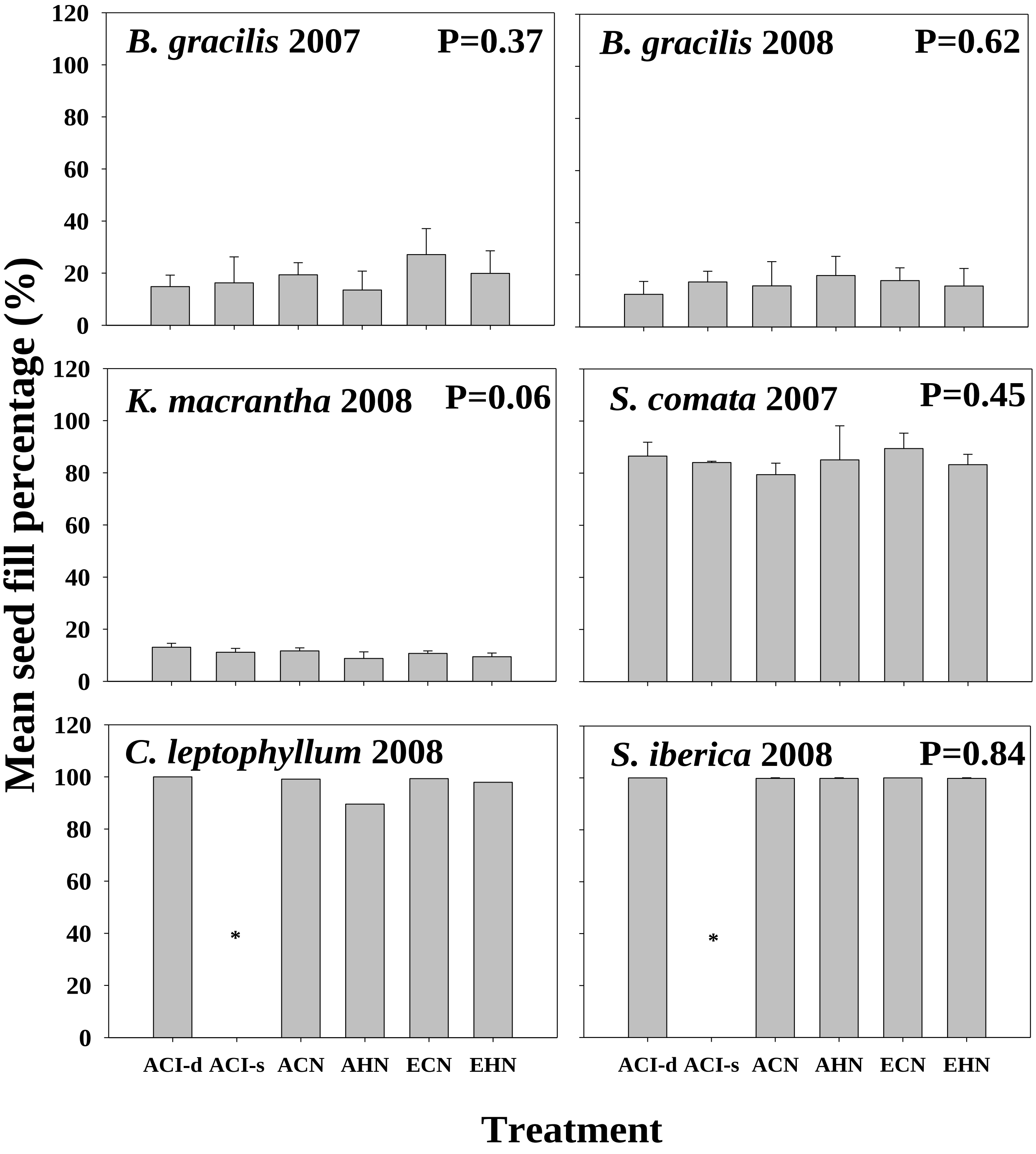
Species / Year	Alternating Temperature (° C)					
	10/0	15/5	20/10	25/15	30/20	35/25
B. gracilis 2007&2008	×	×		×		×
K. macrantha 2008	×	×	×	×		
S. comata 2007		×	×	×		
C. leptophyllum 2008	×		×		×	
S. iberica 2008	×		×		×	

Data analysis

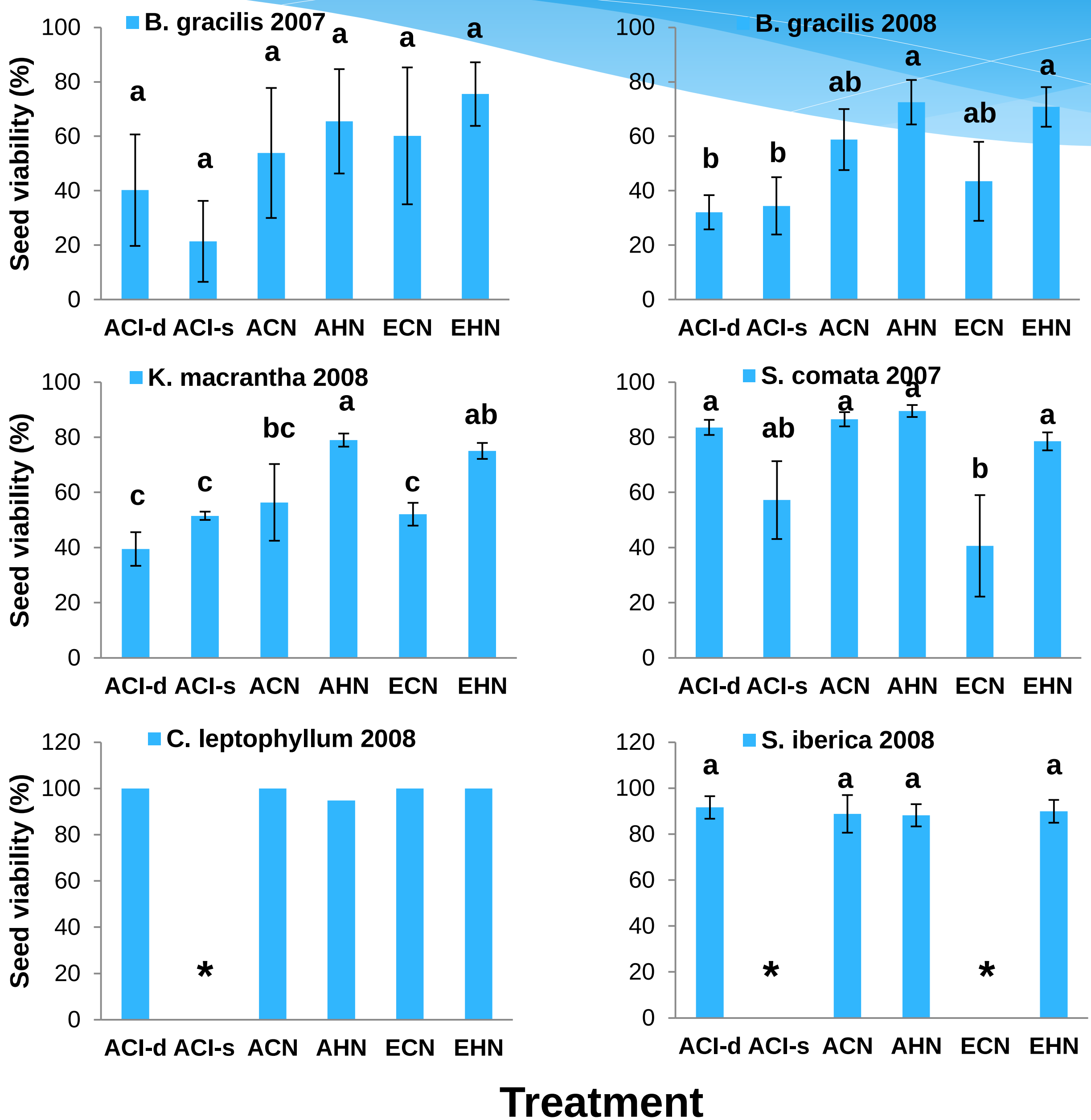
- Seed fill percentage (%) and viability
- Final germination percentage
- Base temperature (T_b) and thermal time requirement (θ_{50})
  - ✓ Chapman-Richards growth function → germination time courses: $g=a[1-\exp(-bt(g))]\ c$
  - ✓ Subpopulations of 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, and 90% of each germination unit: Probit (g) = $\{\log [(T-T_b)\ t_g - \log[\theta_{T(50)}]\}/\sigma_{\theta T}$
  - ✓ Thermal time requirement: $\theta_{T(g)}=(T-T_b)t_g$
- ANOVA and GLM regression in SAS
  Means: LSD
  Significance: 5%

Results

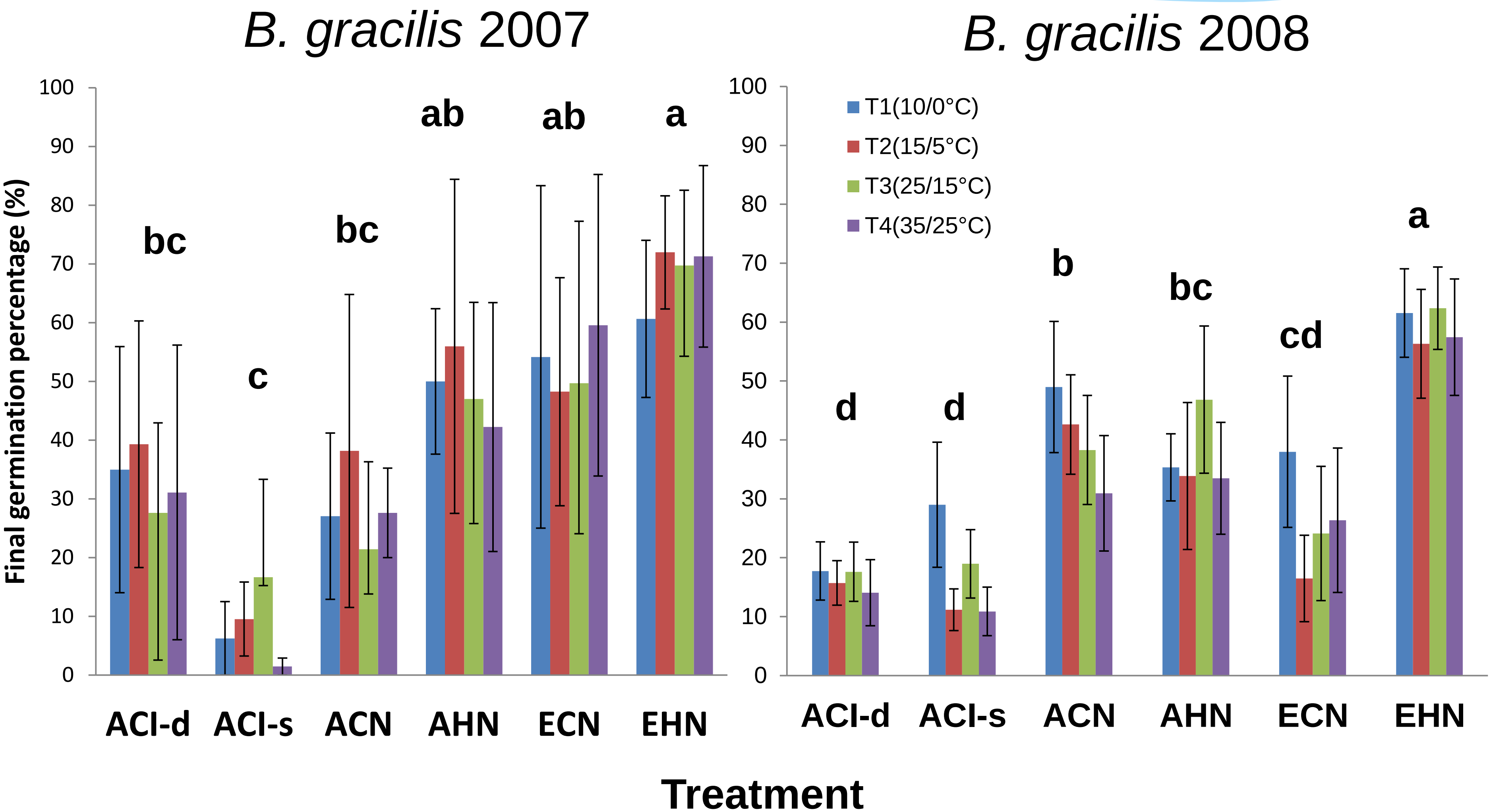
* No treatment effect on seed fill percentage



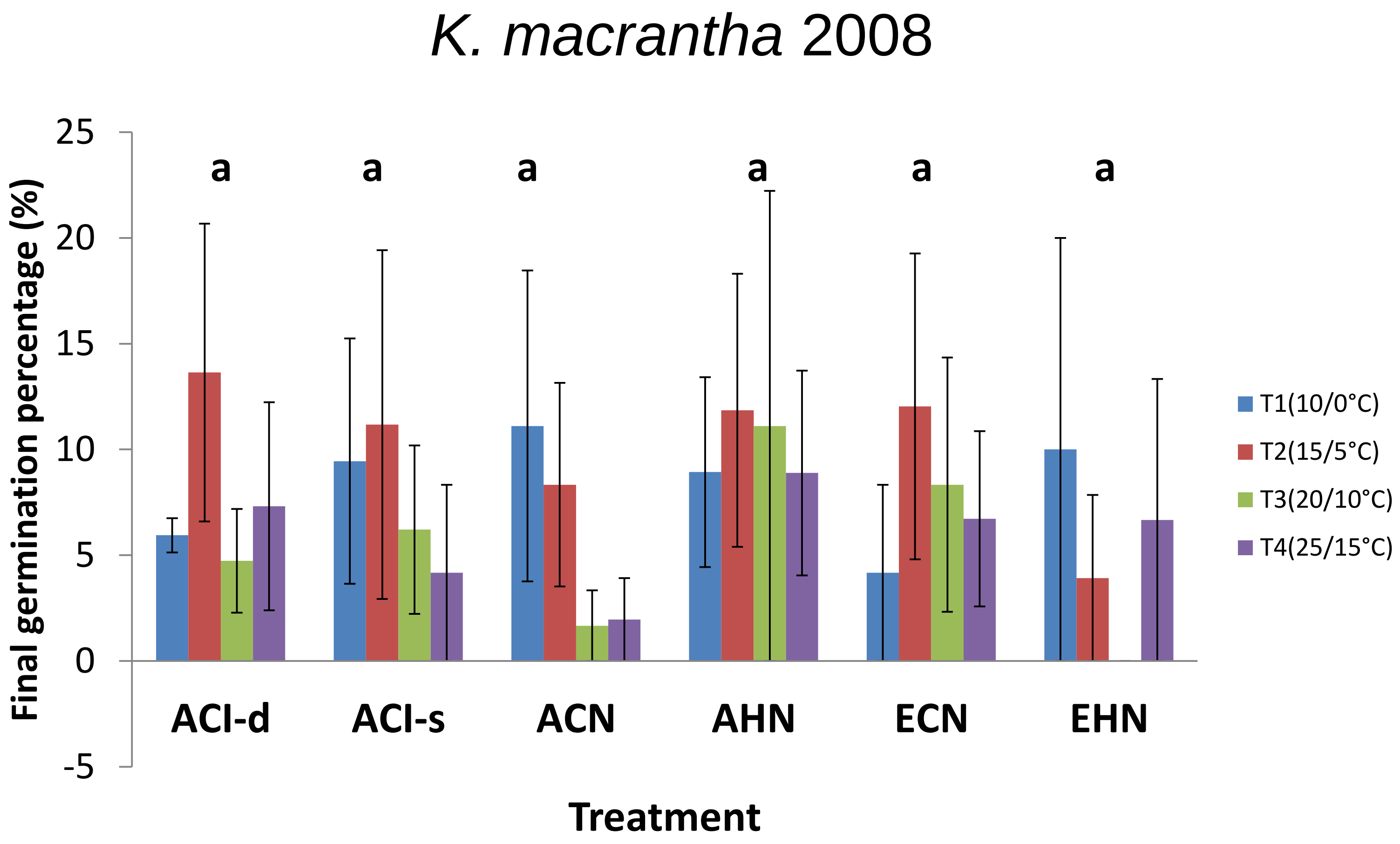
Seed viability



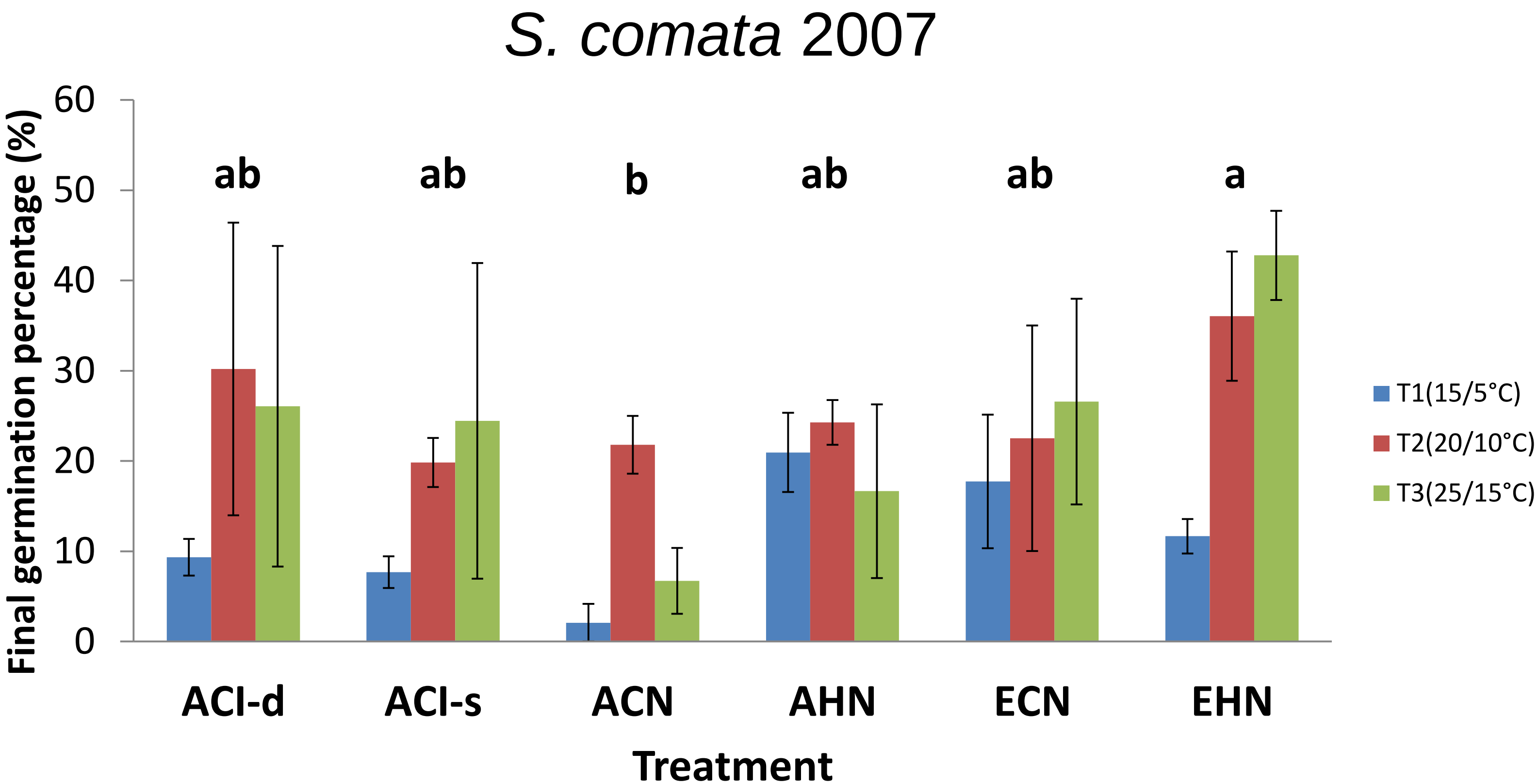
Treatment effects on final germination percentage



Treatment effects on final germination percentage



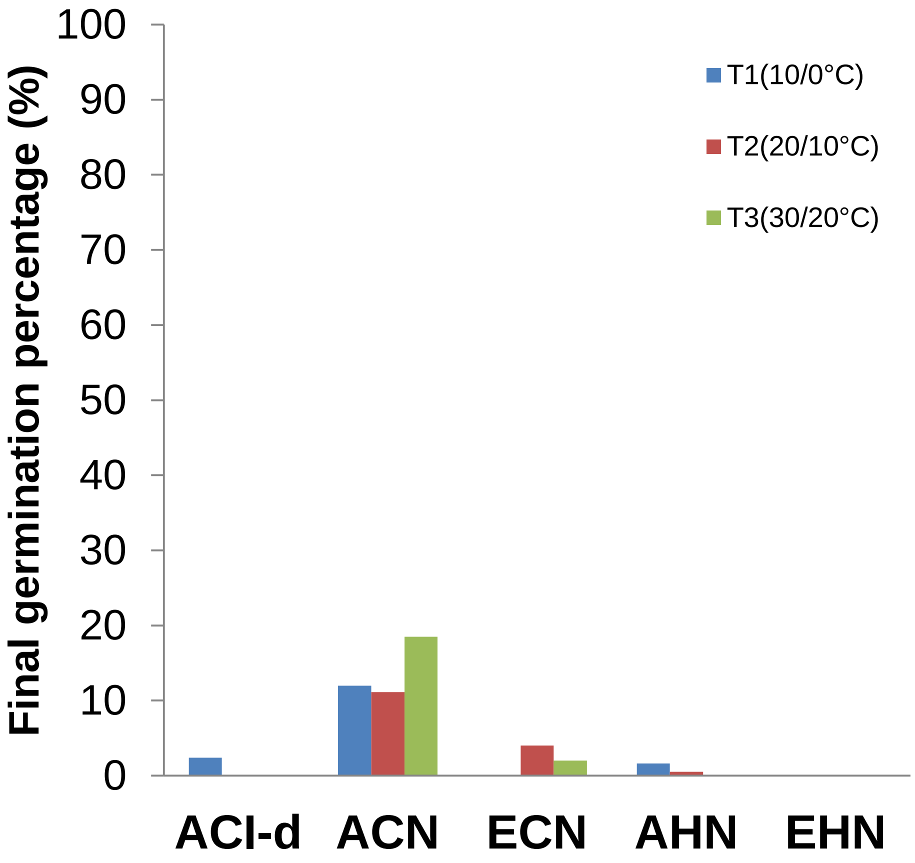
Treatment effects on final germination percentage



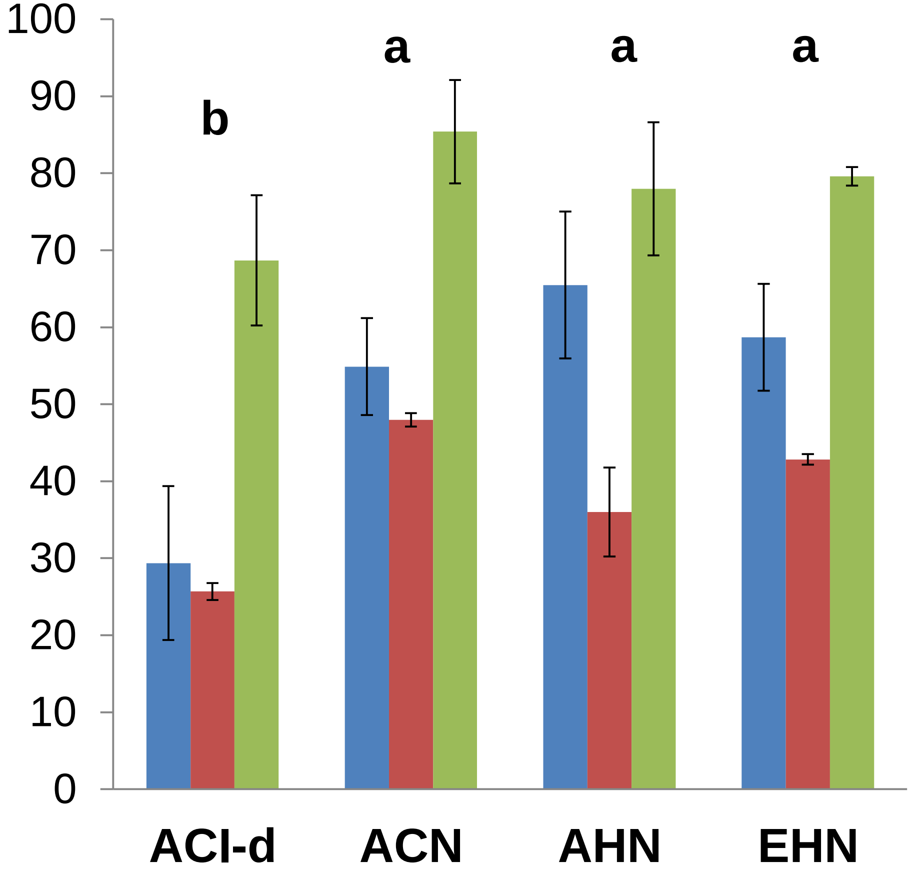
- Higher temperature favors germination (T3a, T2a > T1b)

Treatment effects on final germination percentage

C. leptophyllum 2008

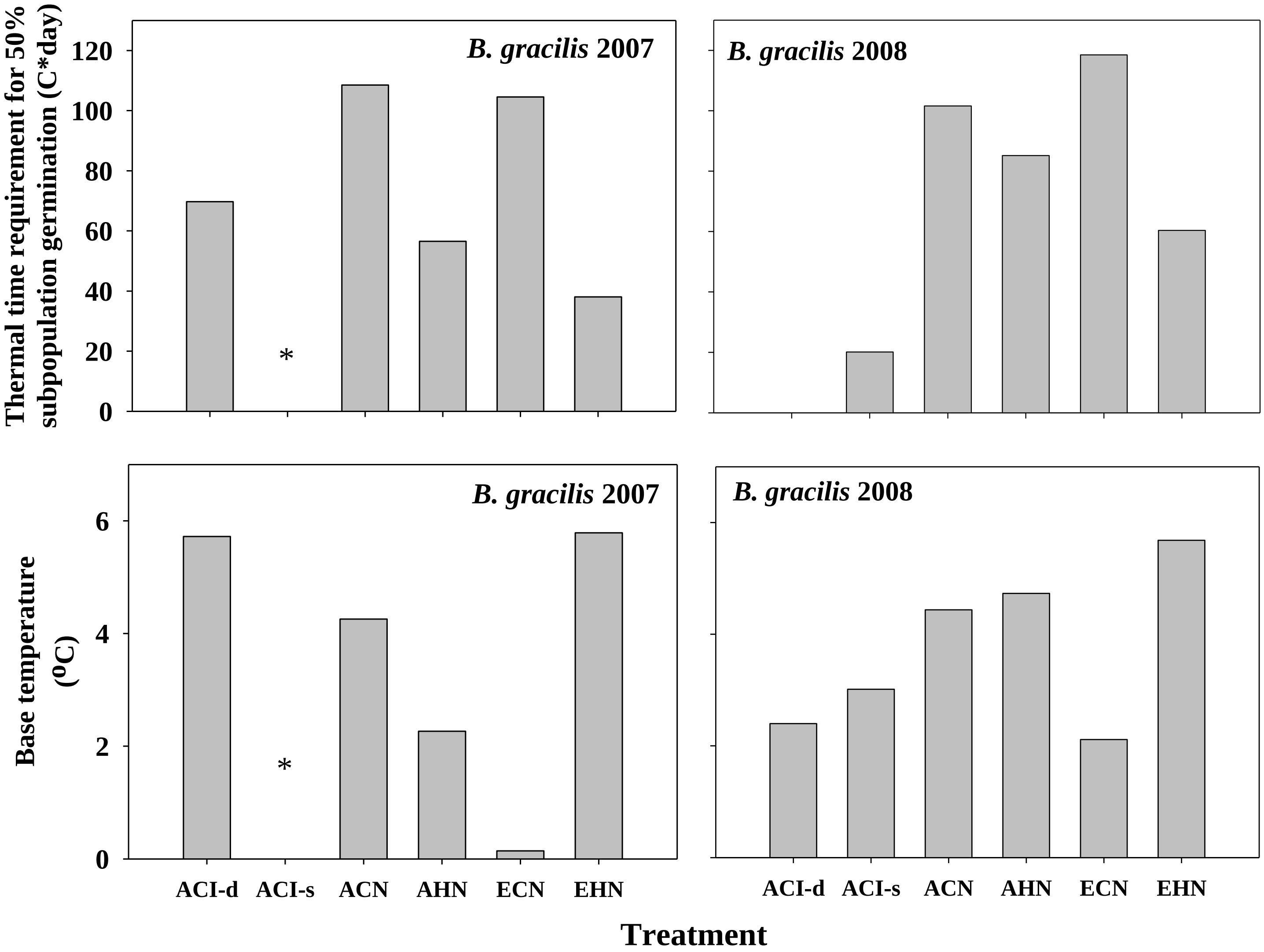


S. iberica 2008

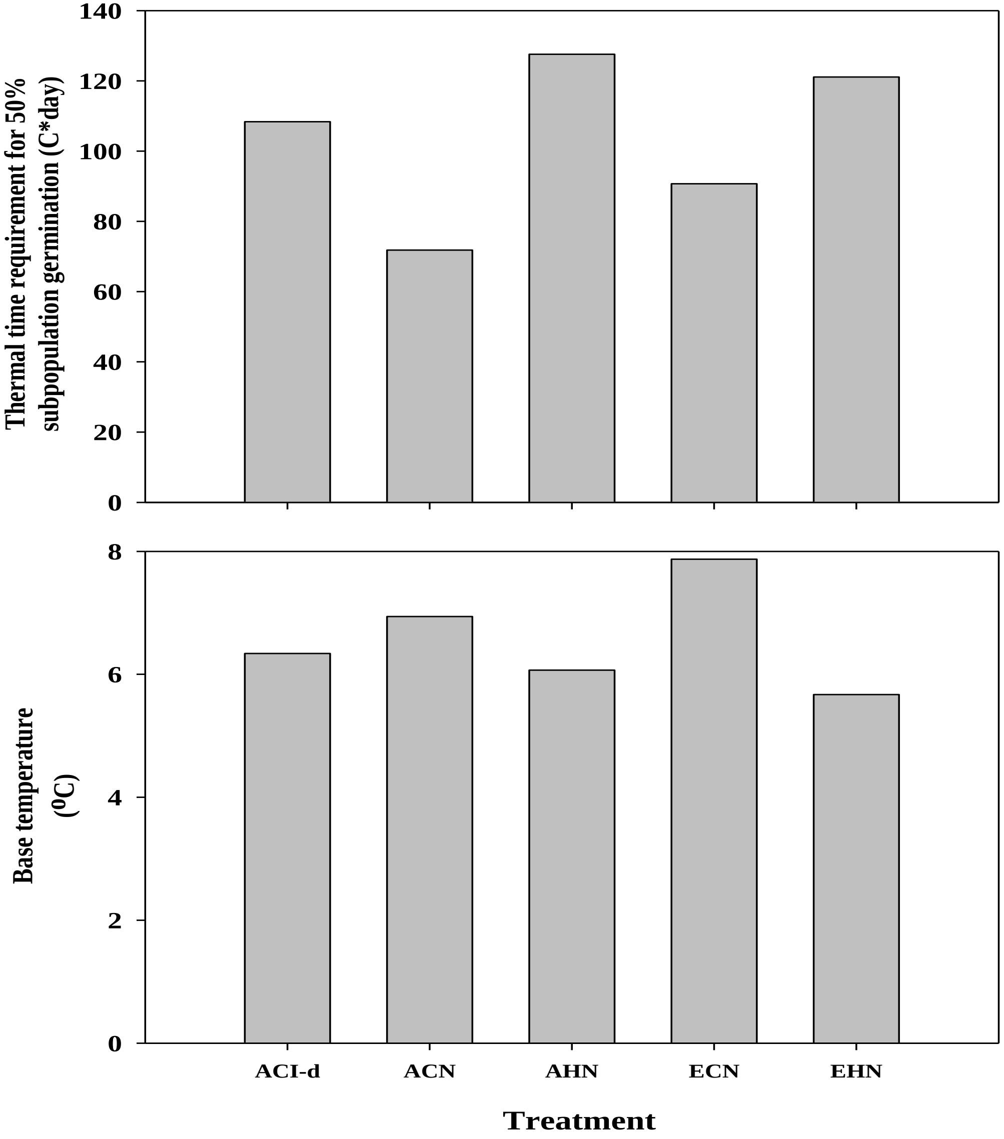


Higher temperature favors germination (T3a > T2b > T1c)

T_b, and θ_{50} for *B. gracilis* 2007 & 2008



T_b, and θ_{50} for *S. iberica* 2008



Conclusions

- No treatment effect on seed fill percentage of all species studied
- Heating increased while irrigation treatments decreased seed viability of three native species when soil moisture was not limited
- EHN had the highest as well as increased final germination percentage of the most species studied
- Heating treatments increased T_b but decreased θ_{50} in *B. gracilis* (C4) and *S. iberica* (C4) while ECN had the opposite effect
- Species specific changes in seed quality and germinability as affected by climate change conditions
- The distribution and abundance of *C. leptophyllum* may be reduced while *S. iberica* and *B. gracilis* may be favored by global climate change

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FAQ's


SASKATOON
TRANSPORTATION OF THE FUTURE
DUE TO GLOBAL WARMING, SASKATOON IN THE FUTURE HAS AN AVERAGE DAILY TEMPERATURE OF 20°C, YEAR ROUND. THE LACK OF SNOW AND ICE EASES TRAFFIC FLOW. ALL CARS, TRUCKS, VANS, MOTORBIKES, & BUSES ARE POWERED BY HYDROGEN FUEL CELLS AND/OR DEEP RECHARGEABLE BATTERIES. TO AVOID TRAFFIC CONGESTION, PERSONAL VEHICLES ARE NOT ALLOWED IN THE CITY'S INNER CORE, BUT ONLY IN OUTLYING SECTORS. DOWNTOWN, RAPID LIGHT-RAIL ELECTRIC AND MAGNETIC LEVITATION TRAINS CARRY CITIZENS SWIFTLY TO THEIR DESTINATIONS.
GEHRY-DESIGNED SOUTH DOWNTOWN TRANSPORTATION MUSEUM AND CONCERT HALL.
EVERY HOUSE AND BUILDING CITY IS EQUIPPED WITH SOLAR ELECTRIC & HOT-WATER HEATING MODULES AND RAIN-COLLECTING SYSTEMS.
SASKSOLAR
SASK BIOFUEL CORP
WELLNESS FACILITY
SASKPLORATORIUM
ONLY PEDESTRIANS AND BICYCLES ARE ALLOWED ON THIS BRIDGE.
URBAN RIVER VALLEY FOREST IS EXPANDED DUE TO NARROWING OF THE SASKATCHEWAN RIVER.
THE SOUTH SASKATCHEWAN RIVER IS SLOWER, NARROWER, AND ONLY ONE METRE DEEP, DUE TO DISAPPEARING GLACIERS AND HIGH-VOLUME WATER SALES TO THE USA. THE RIVER BOTTOM IS DREDGED FLAT AND THE WEIR HAS BEEN REMOVED. LOW-DISPLACEMENT-HYDROGEN-FUEL-CELL-POWERED RAPID-TRANSIT HOVERCRAFT ARE NOW ABLE TO TRAVEL NORTHWARD TO PRINCE ALBERT AND POINTS BEYOND. LOCKS AT THE GARDINER DAM, AS WELL AS CANALS FURTHER TO THE WEST, ALLOW FOR HOVERCRAFT TRIPS TO CALGARY.
THE ONLY PERSONAL CONVEYANCES ALLOWED IN THE DOWNTOWN CORE ARE BICYCLES, SCOOTERS, ELECTRIC SKATEBOARDS, AND MICRO-MINI SOLAR ELECTRIC CARTS.