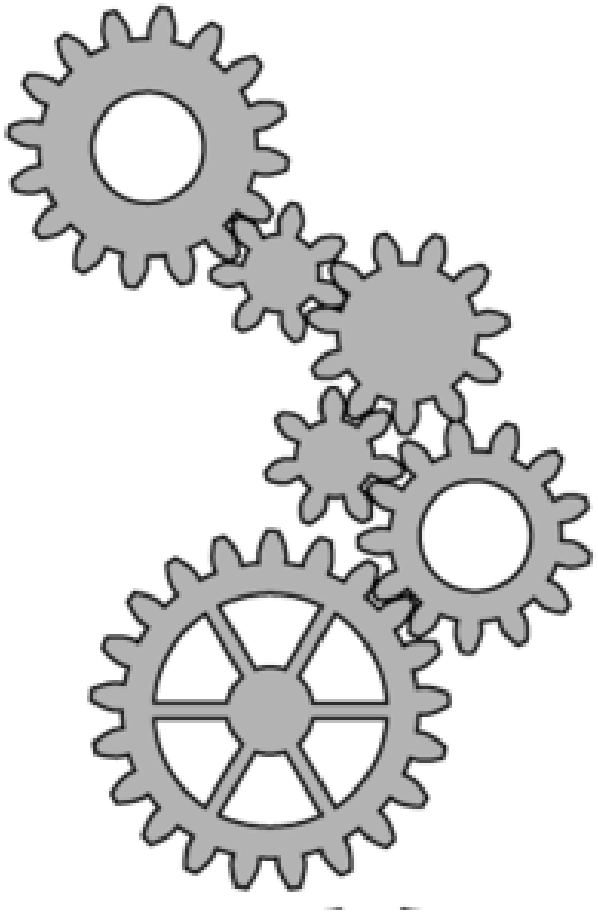
Profit from Data?

Midwest Winter Production Conference
February 12, 2019; Jefferson City, MO

Matt Kleinhenz
Extension Specialist

THE OHIO STATE UNIVERSITY
COLLEGE OF FOOD, AGRICULTURAL, AND ENVIRONMENTAL SCIENCES



- location
- typical weather
- tunnel (+ other?)
- decisions
- microclimate in tunnel
- crop genetics

crop and farm outcomes

Liebig's Law of the Minimum

One factor most limits growth.

… the factor varies

… may be possible to identify and alter

http://en.wikipedia.org/wiki/Liebig%27s_law_of_the_minimum

Microclimate Management/ Season Extension

… limit "governors" of growth

… raise stave height, barrel capacity

Temperature? Light?

Farms and crop plants are manufacturing sites with required inputs, expected outputs and conditions that affect performance.

- photosynthesis (+)
- respiration (-)
- partitioning or allocation (distribution of what remains)

plant factory: triumph of engineering; much greater yield and C footprint than field production (Japan tripling its investment in plant factories)


indoor and soil-less

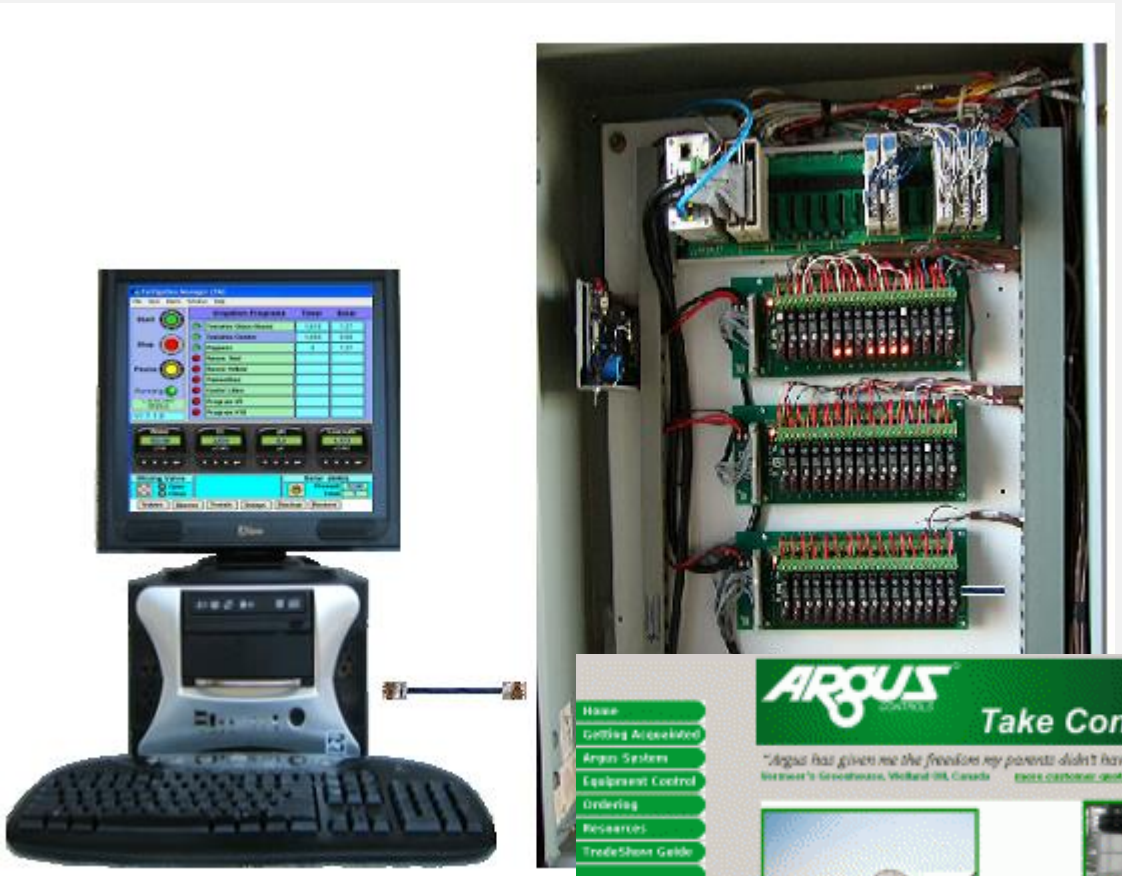

indoor, soil-less, vertical


MODINE


WiSensys


Link4


iGrow 1400
Link4




autopilot
Environmental Control Systems
Greenhouse Master Controller


ARGUS
Take Control With Ar
Home
Getting Acquainted
Argus Systems
Equipment Control
Ordering
Resources
TradeShow Guide
Contact Us
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- data-driven
- predictable outcomes


loss of control, predictability; increase in risk
plant factories and fully climate-controlled greenhouses
high tunnel systems

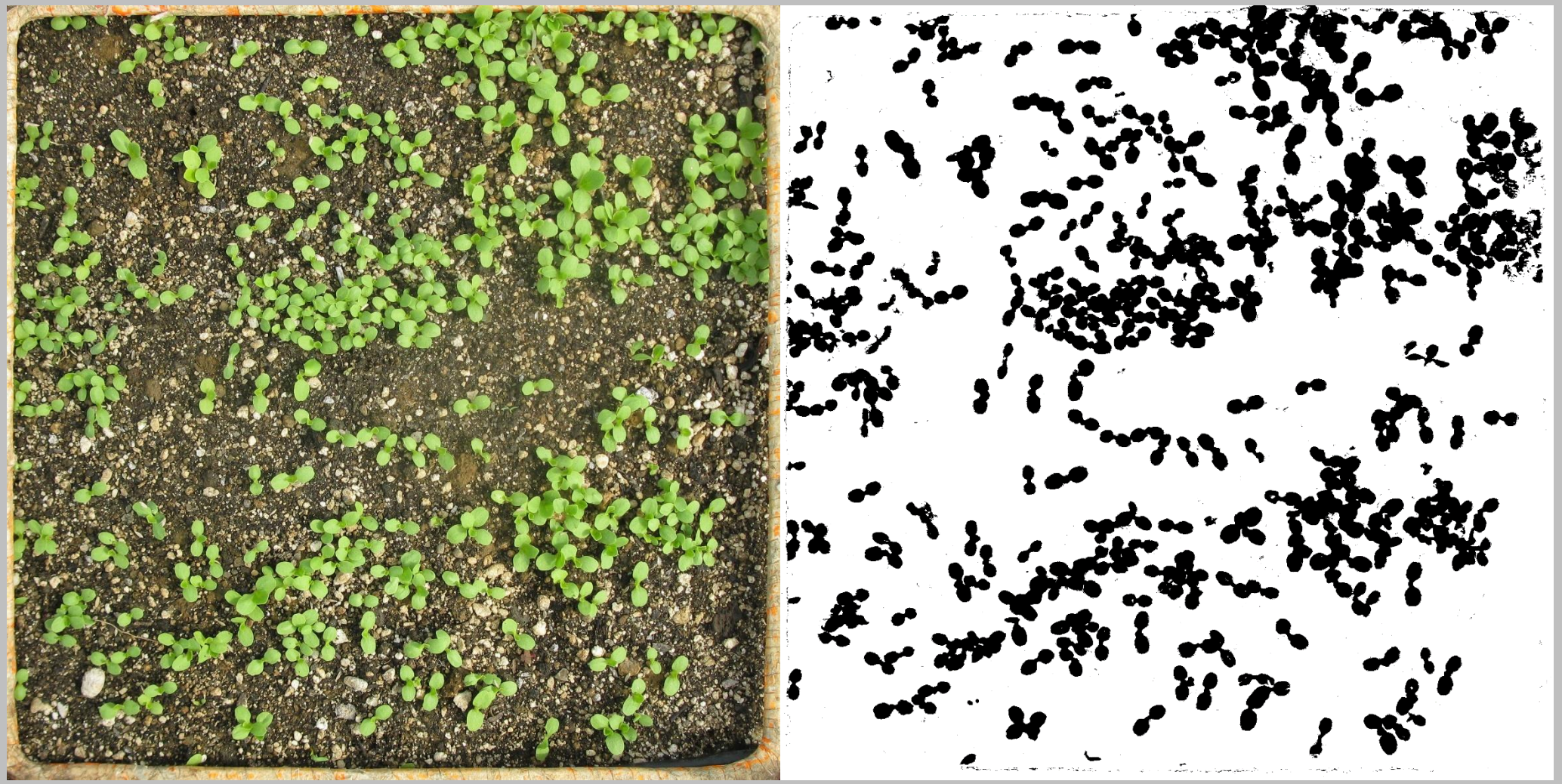
(High) Tunnel Systems

- design, components for, and use of are not fully set (may never be)
- additional options (materials, other inputs) and resources are needed

… foundation for some are available today

track yield and quality

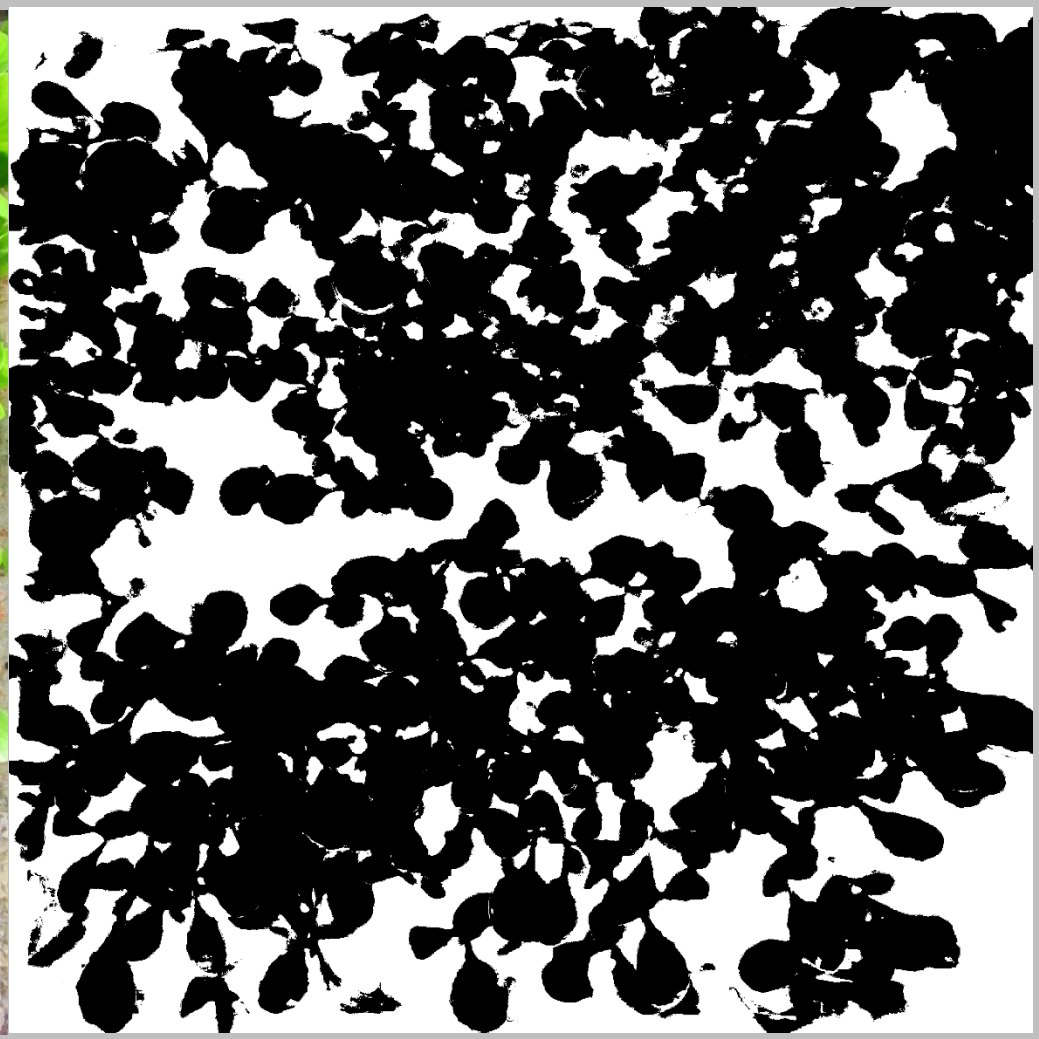
Canopy analysis



Sept 25, 2015

20.39% canopy cover

Canopy analysis



Oct. 6, 2015

63.98% canopy cover

Outredgeous Lettuce seeded 10/16/14

top row (unheated soil); bottom row (heated soil)

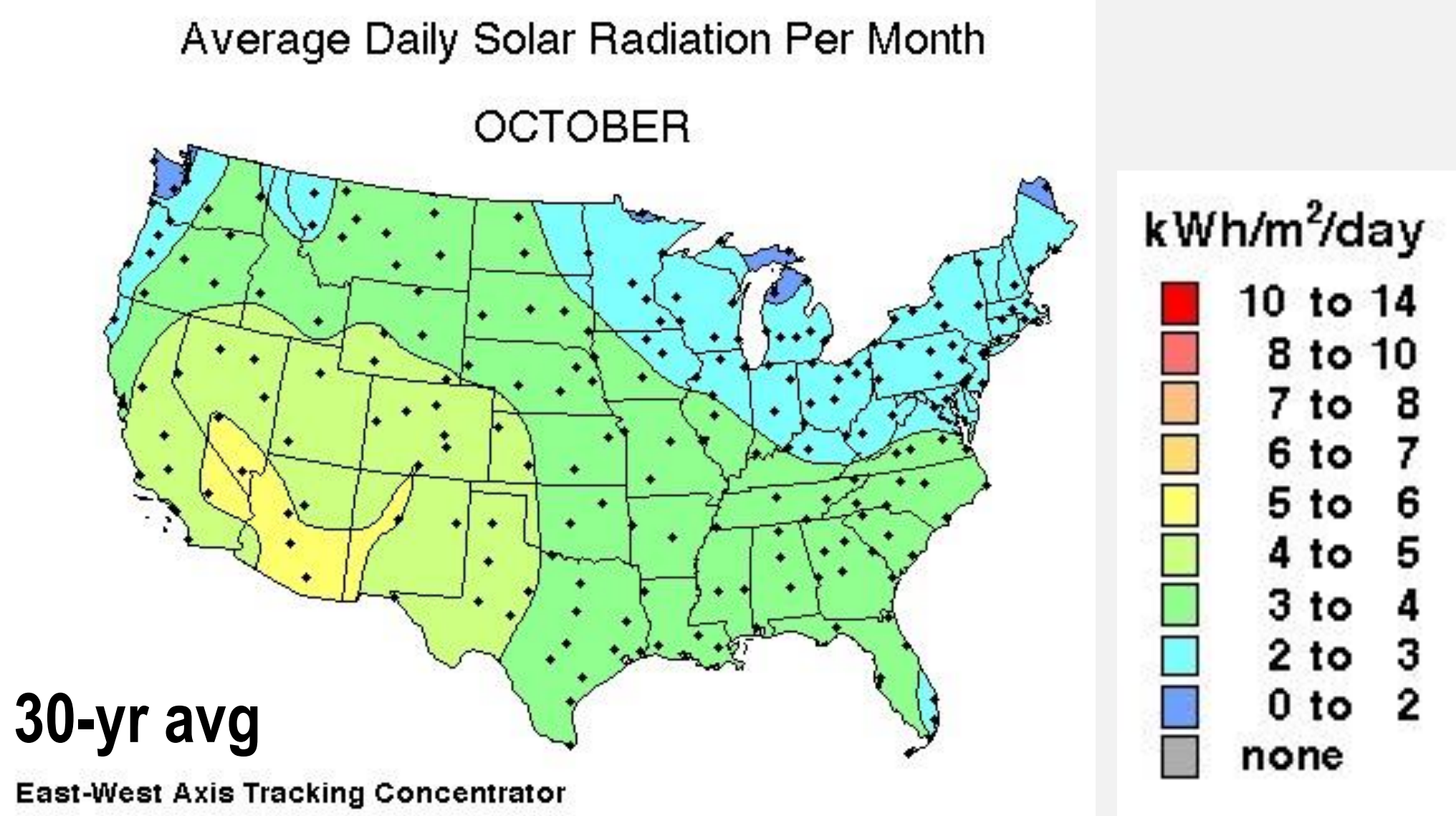
10/21

10/31

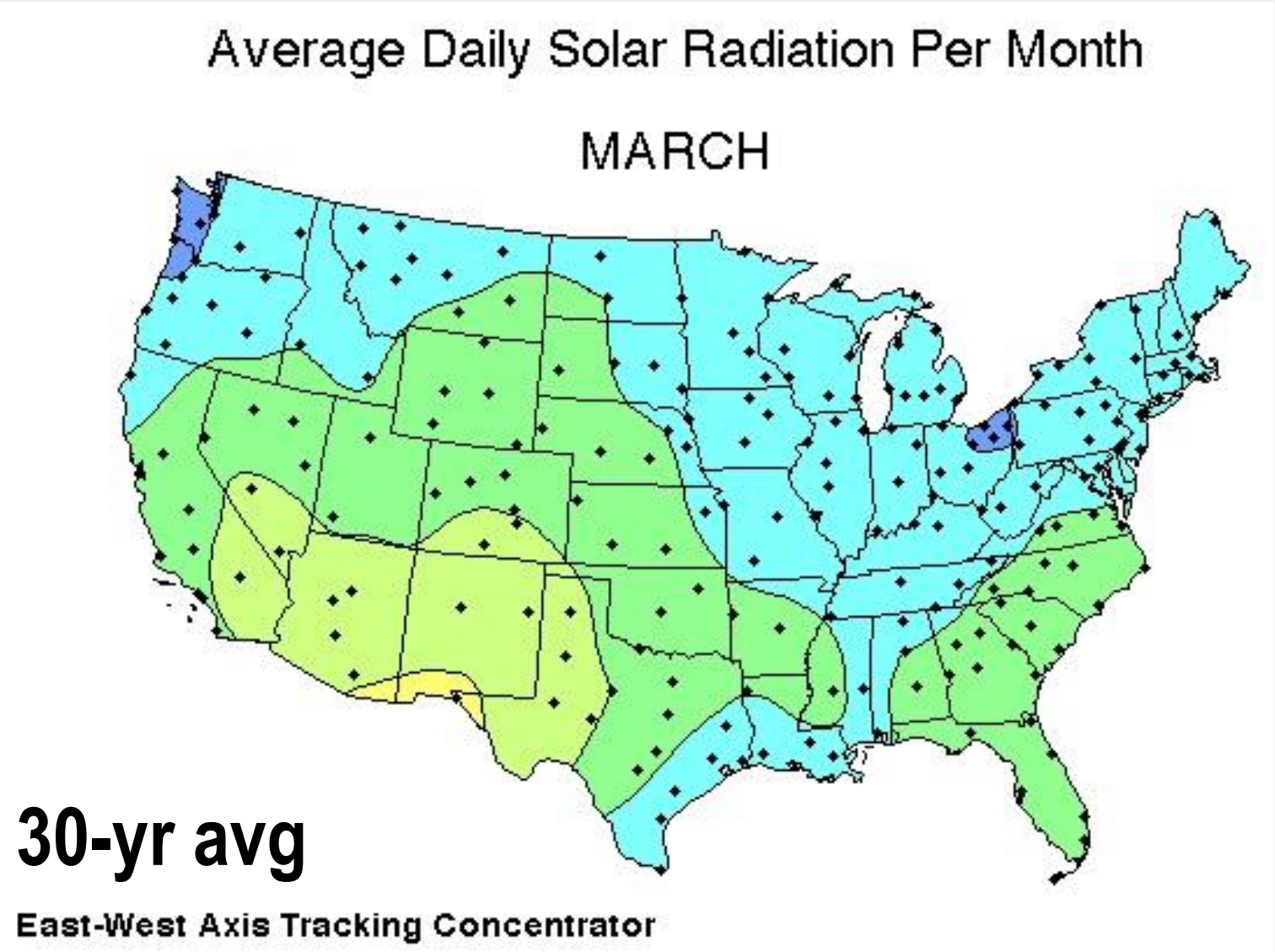
11/13

12/12

11/26

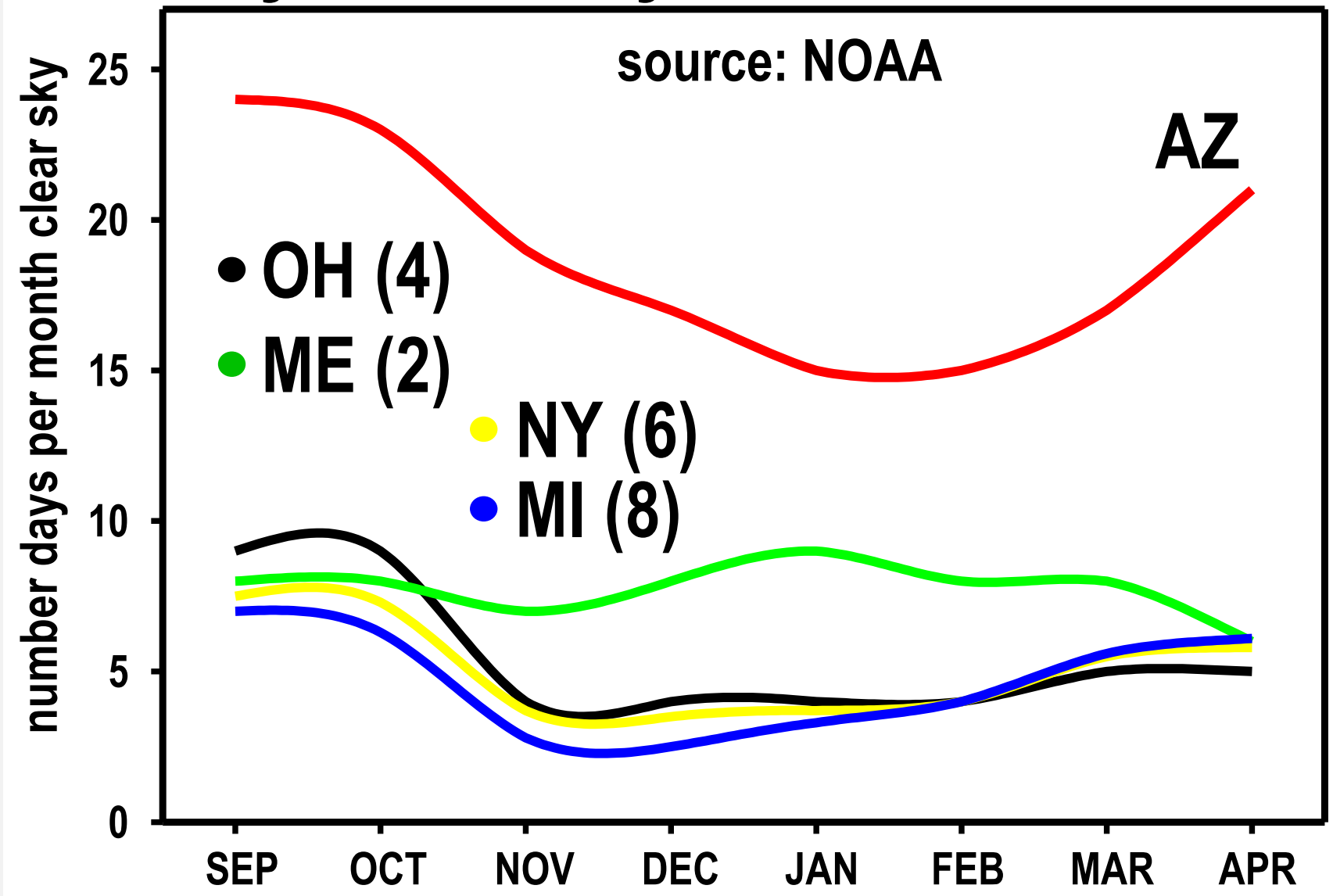


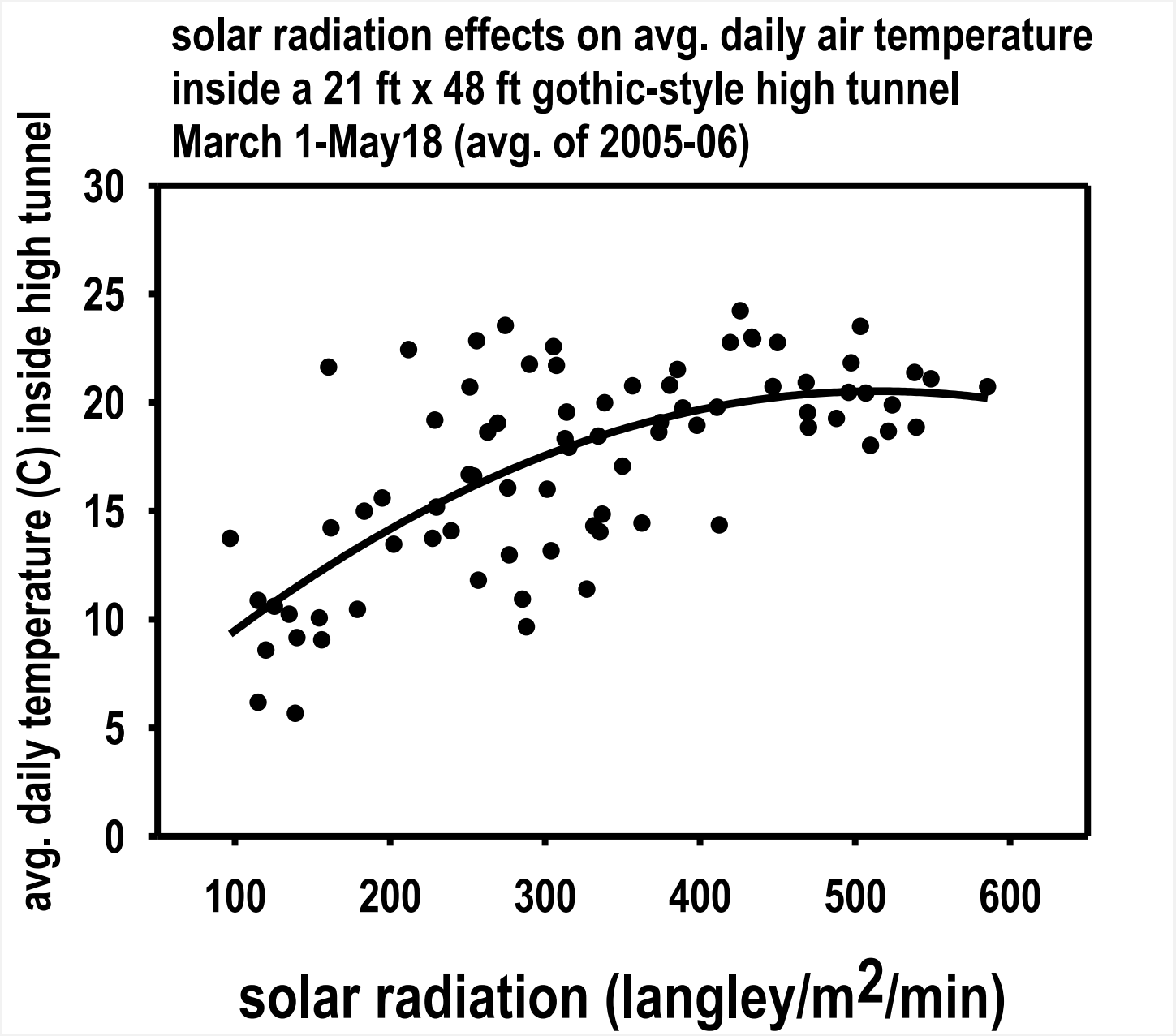
https://rredc.nrel.gov/solar/old_data/nsrdb/1961-1990/redbook/atlas/

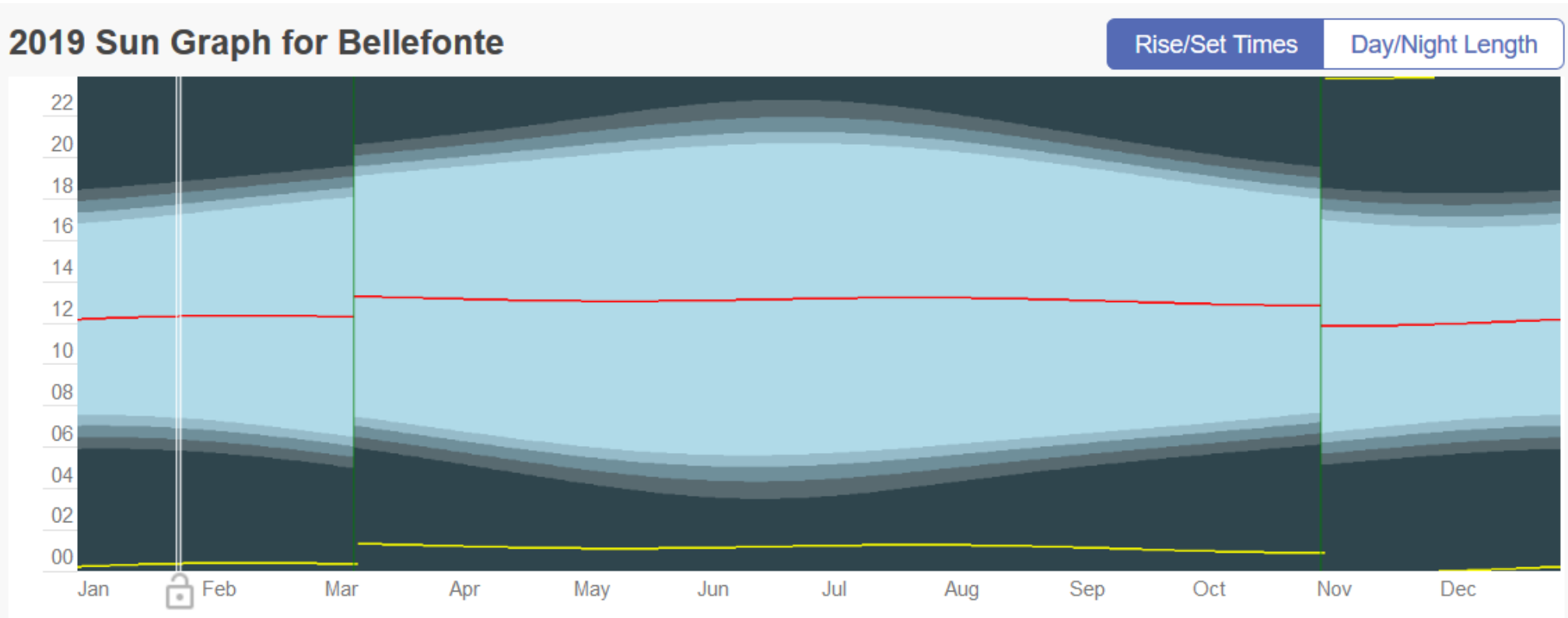


https://rredc.nrel.gov/solar/old_data/nsrdb/1961-1990/redbook/atlas/

Sky Status by Month and State




solar radiation effects on avg. daily air temperature
inside a 21 ft x 48 ft gothic-style high tunnel
March 1-May18 (avg. of 2005-06)
avg. daily temperature (C) inside high tunnel
0
5
10
15
20
25
30
100
200
300
400
500
600
solar radiation (langley/m2/min)

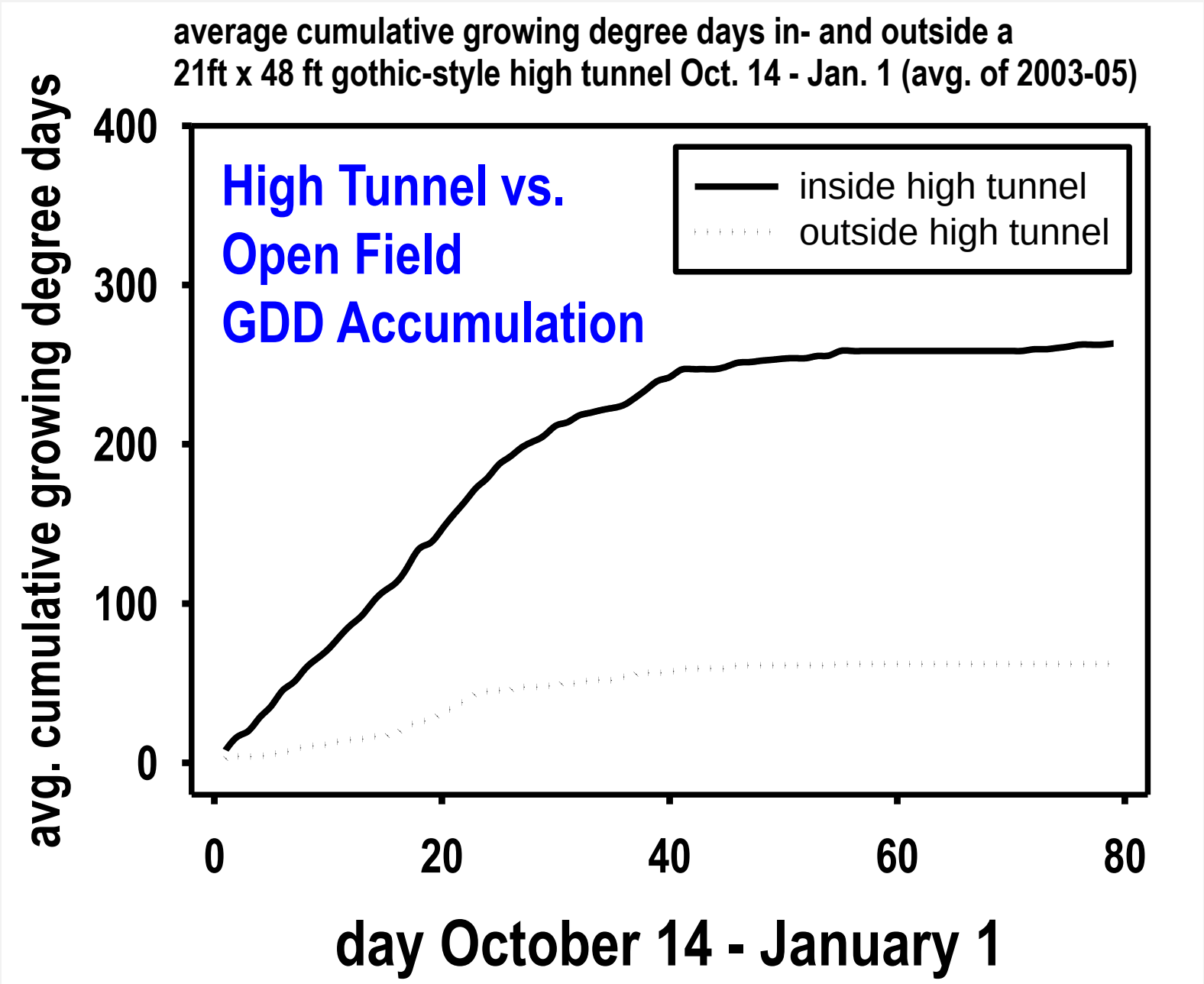


approx. elevation (°) of sun at noon on 15th of each month

Sept	Oct	Nov	Dec	Jan	Feb	Mar
49.2	38.8	29.2	24.0	25.2	33.0	43.3

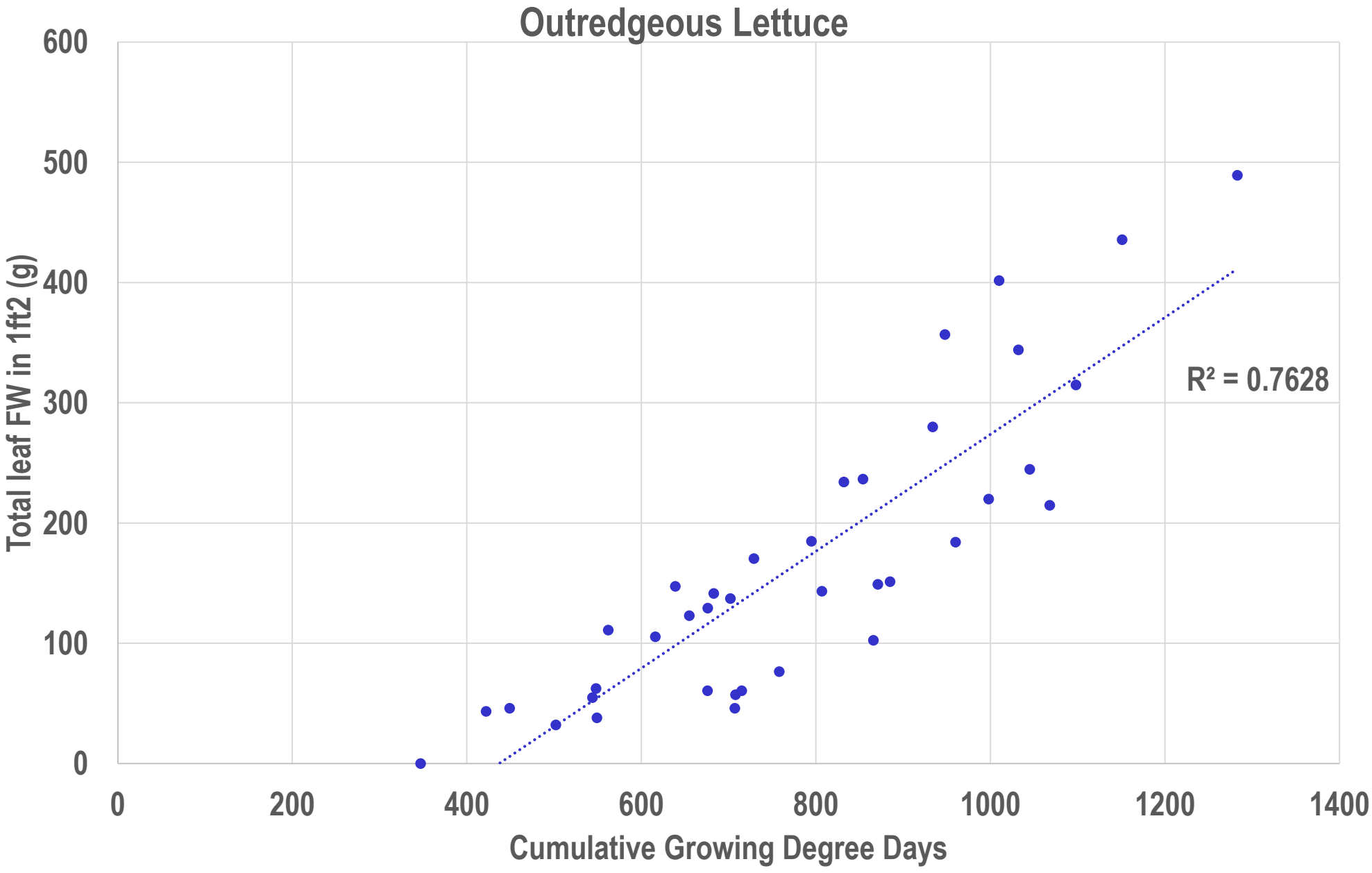
Thermal Time
Growing Degree Days (GDD)
Heat Units

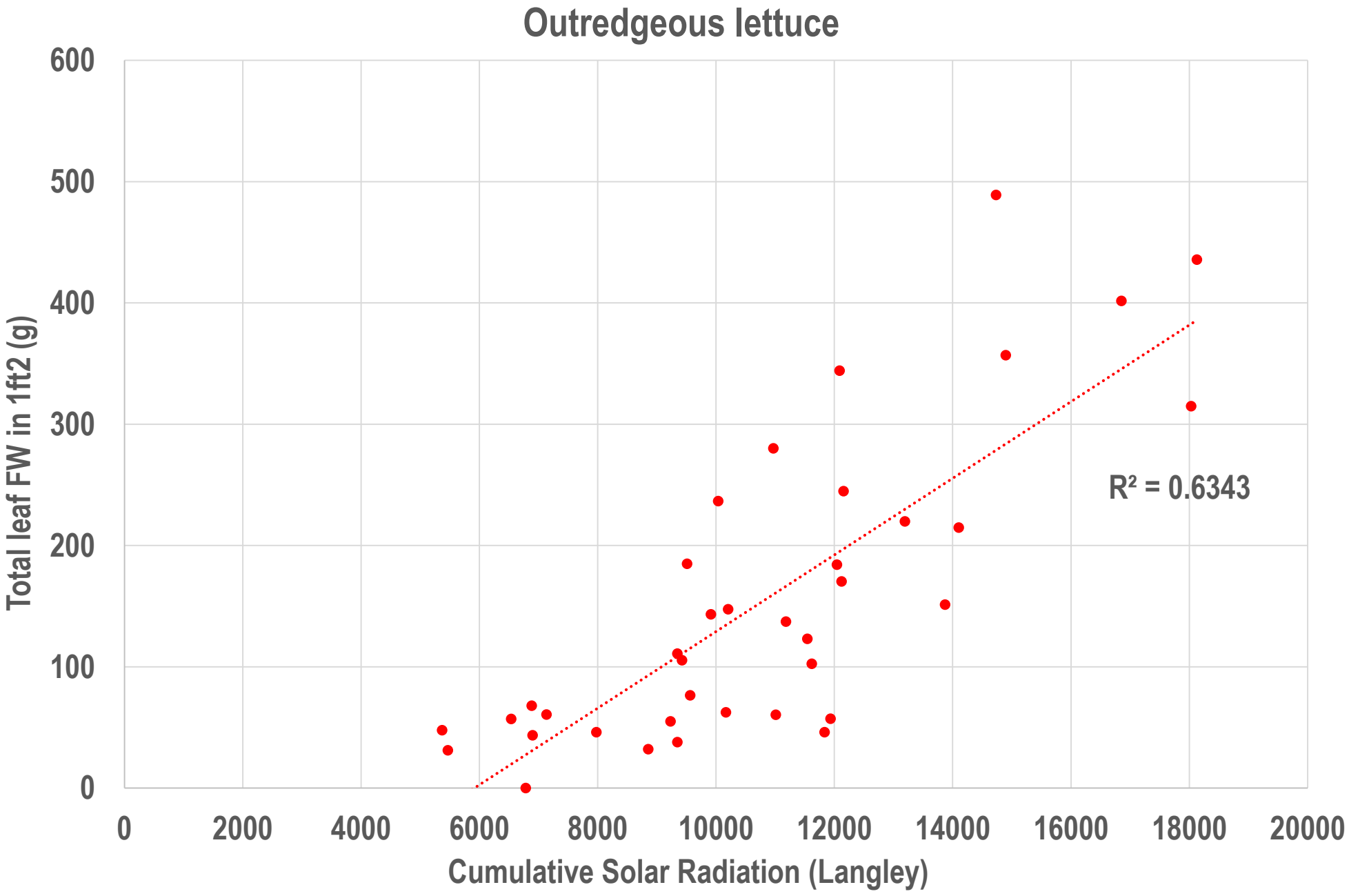
$$GDD = \frac{Tmax + Tmin}{2} - Tbase$$


average cumulative growing degree days in- and outside a
21ft x 48 ft gothic-style high tunnel Oct. 14 - Jan. 1 (avg. of 2003-05)
High Tunnel vs.
Open Field
GDD Accumulation
inside high tunnel
outside high tunnel
avg. cumulative growing degree days
400
300
200
100
0
0
20
40
60
80
day October 14 - January 1

Correlation: Yield by Average Temperature and GDD

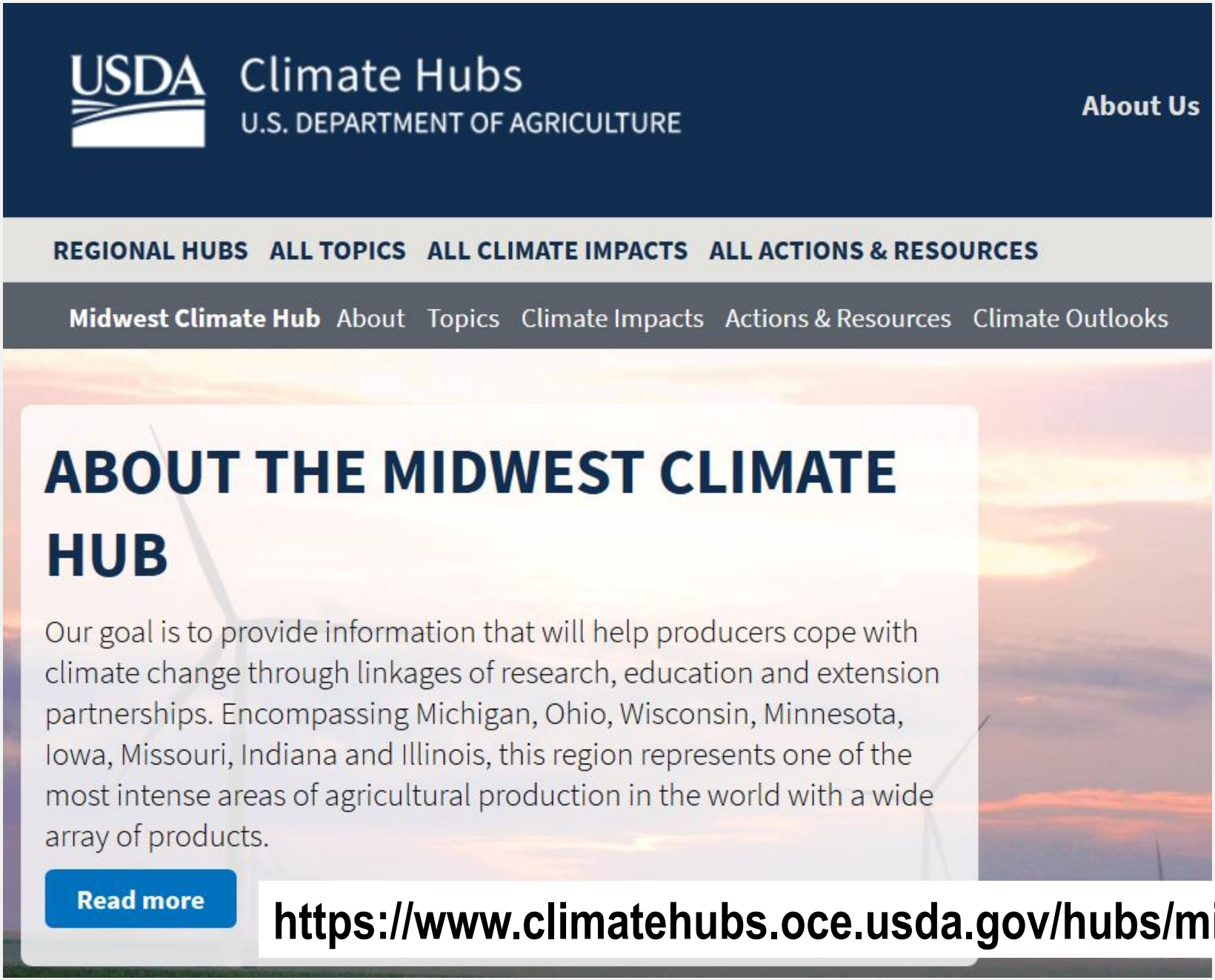
High Tunnel	r (probability value)
T above	0.60 (0.015)
T below	0.47 (0.068)
GDD above	0.68 (0.034)
GDD below	0.53 (0.033)
GDD total	0.64 (0.008)


Outredgeous Lettuce
Total leaf FW in 1ft2 (g)
600
500
400
300
200
100
0
0
200
400
600
800
1000
1200
1400
Cumulative Growing Degree Days
R² = 0.7628


Outredgeous lettuce
Total leaf FW in 1ft2 (g)
600
500
400
300
200
100
0
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
20000
Cumulative Solar Radiation (Langley)
R² = 0.6343

https://www.nrel.gov/

https://www.noaa.gov/


USDA Climate Hubs
U.S. DEPARTMENT OF AGRICULTURE
About Us
REGIONAL HUBS ALL TOPICS ALL CLIMATE IMPACTS ALL ACTIONS & RESOURCES
Midwest Climate Hub About Topics Climate Impacts Actions & Resources Climate Outlooks
ABOUT THE MIDWEST CLIMATE HUB
Our goal is to provide information that will help producers cope with climate change through linkages of research, education and extension partnerships. Encompassing Michigan, Ohio, Wisconsin, Minnesota, Iowa, Missouri, Indiana and Illinois, this region represents one of the most intense areas of agricultural production in the world with a wide array of products.
Read more
https://www.climatehubs.oce.usda.gov/hubs/midwest

https://mrcc.illinois.edu/

http://agebb.missouri.edu/weather/realTime/maps/index.php

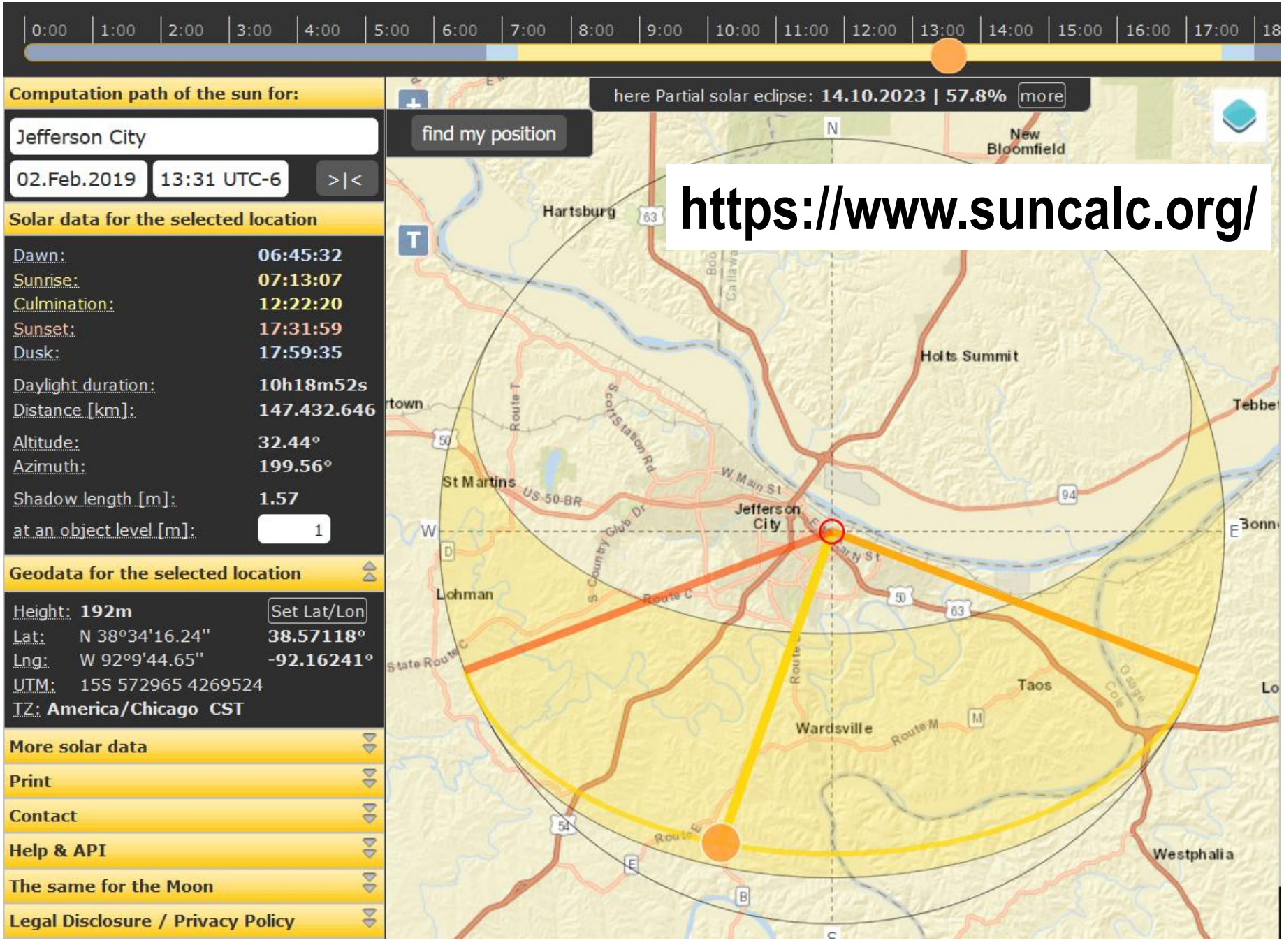
Location: W092 11, N38 34

JEFFERSON CITY, MISSOURI
Central Standard Time

Astronomical Applications Dept.
U. S. Naval Observatory
Washington, DC 20392-5420

Duration of Daylight for 2019

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m
01	09:32	10:16	11:20	12:38	13:49	14:41	14:49	14:09	13:01	11:47	10:34	09:41
02	09:33	10:18	11:23	12:41	13:51	14:42	14:48	14:07	12:59	11:45	10:32	09:40
03	09:33	10:20	11:25	12:43	13:53	14:43	14:48	14:05	12:56	11:43	10:29	09:39
04	09:34	10:22	11:28	12:46	13:55	14:44	14:47	14:03	12:54	11:40	10:27	09:38
05	09:35	10:25	11:30	12:48	13:57	14:45	14:46	14:01	12:52	11:38	10:25	09:37
06	09:36	10:27	11:33	12:50	13:59	14:46	14:45	13:59	12:49	11:35	10:23	09:36
07	09:37	10:29	11:35	12:53	14:01	14:46	14:45	13:57	12:47	11:33	10:21	09:35
08	09:38	10:31	11:38	12:55	14:03	14:47	14:44	13:55	12:44	11:30	10:19	09:34
09	09:39	10:33	11:40	12:58	14:05	14:48	14:43	13:53	12:42	11:28	10:17	09:33
10	09:40	10:35	11:43	13:00	14:07	14:48	14:42	13:51	12:39	11:25	10:15	09:32
11	09:41	10:38	11:45	13:03	14:09	14:49	14:41	13:49	12:37	11:23	10:13	09:32
12	09:43	10:40	11:48	13:05	14:11	14:50	14:40	13:47	12:34	11:20	10:11	09:31
13	09:44	10:42	11:50	13:07	14:13	14:50	14:38	13:45	12:32	11:18	10:09	09:31
14	09:45	10:45	11:53	13:10	14:14	14:50	14:37	13:43	12:29	11:16	10:07	09:30
15	09:47	10:47	11:55	13:12	14:16	14:51	14:36	13:40	12:27	11:13	10:05	09:30
16	09:48	10:49	11:58	13:15	14:18	14:51	14:35	13:38	12:25	11:11	10:03	09:29
17	09:49	10:51	12:00	13:17	14:20	14:51	14:33	13:36	12:22	11:08	10:02	09:29
18	09:51	10:54	12:03	13:19	14:21	14:52	14:32	13:34	12:20	11:06	10:00	09:29
19	09:53	10:56	12:05	13:22	14:23	14:52	14:31	13:31	12:17	11:04	09:58	09:29
20	09:54	10:59	12:08	13:24	14:25	14:52	14:29	13:29	12:15	11:01	09:57	09:28
21	09:56	11:01	12:10	13:26	14:26	14:52	14:28	13:27	12:12	10:59	09:55	09:28
22	09:57	11:03	12:13	13:29	14:28	14:52	14:26	13:25	12:10	10:57	09:53	09:28
23	09:59	11:06	12:16	13:31	14:29	14:52	14:25	13:22	12:07	10:54	09:52	09:28
24	10:01	11:08	12:18	13:33	14:31	14:51	14:23	13:20	12:05	10:52	09:50	09:29
25	10:03	11:11	12:21	13:36	14:32	14:51	14:21	13:18	12:02	10:50	09:49	09:29
26	10:05	11:13	12:23	13:38	14:33	14:51	14:20	13:15	12:00	10:47	09:47	09:29
27	10:06	11:15	12:26	13:40	14:35	14:51	14:18	13:13	11:57	10:45	09:46	09:29
28	10:08	11:18	12:28	13:42	14:36	14:50	14:16	13:11	11:55	10:43	09:45	09:30
29	10:10		12:31	13:44	14:37	14:50	14:14	13:08	11:52	10:40	09:43	09:30
30	10:12		12:33	13:47	14:39	14:49	14:11	13:06	11:50	10:38	09:42	09:31
31	10:14		12:36		14:40		14:09	13:03		10:36		09:31


0:00 1:00 2:00 3:00 4:00 5:00 6:00 7:00 8:00 9:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00
Computation path of the sun for:
Jefferson City
02.Feb.2019
13:31 UTC-6
>|<
Solar data for the selected location
Dawn: 06:45:32
Sunrise: 07:13:07
Culmination: 12:22:20
Sunset: 17:31:59
Dusk: 17:59:35
Daylight duration: 10h18m52s
Distance [km]: 147.432.646
Altitude: 32.44°
Azimuth: 199.56°
Shadow length [m]: 1.57
at an object level [m]: 1
Geodata for the selected location
Height: 192m
Set Lat/Lon
Lat: N 38°34'16.24" 38.57118°
Lng: W 92°9'44.65" -92.16241°
UTM: 15S 572965 4269524
TZ: America/Chicago CST
More solar data
Print
Contact
Help & API
The same for the Moon
Legal Disclosure / Privacy Policy
here Partial solar eclipse: 14.10.2023 | 57.8% more
find my position
https://www.suncalc.org/
New Bloomfield
Hartsburg
Holts Summit
St Martins
Jefferson City
Lohman
Taos
Wardsville
Westphalia
Route T
Route C
Route M
Route E
W Main St
US-50-BR
94
50
63
54

‘Next’ Level Tunnel Production

Devices to Monitor:

- **temperature**
- **relative humidity**
- **light levels**
- **crop condition**

… in the tunnel.

Some have useful features (e.g., record automatically, send notices).

shielded sensor and datalogger in each plot

temperature readings:

- 15- or 30-min intervals seeding-harvest
- 20 cm above, 4 cm below surface


New! HOBOnet™
Field Monitoring
System
HOBO

real-time, historical, georeferenced weather data

+

conditions in nearby tunnels

+

crop microclimates

better management and outcomes

crop status, outcomes

+

+

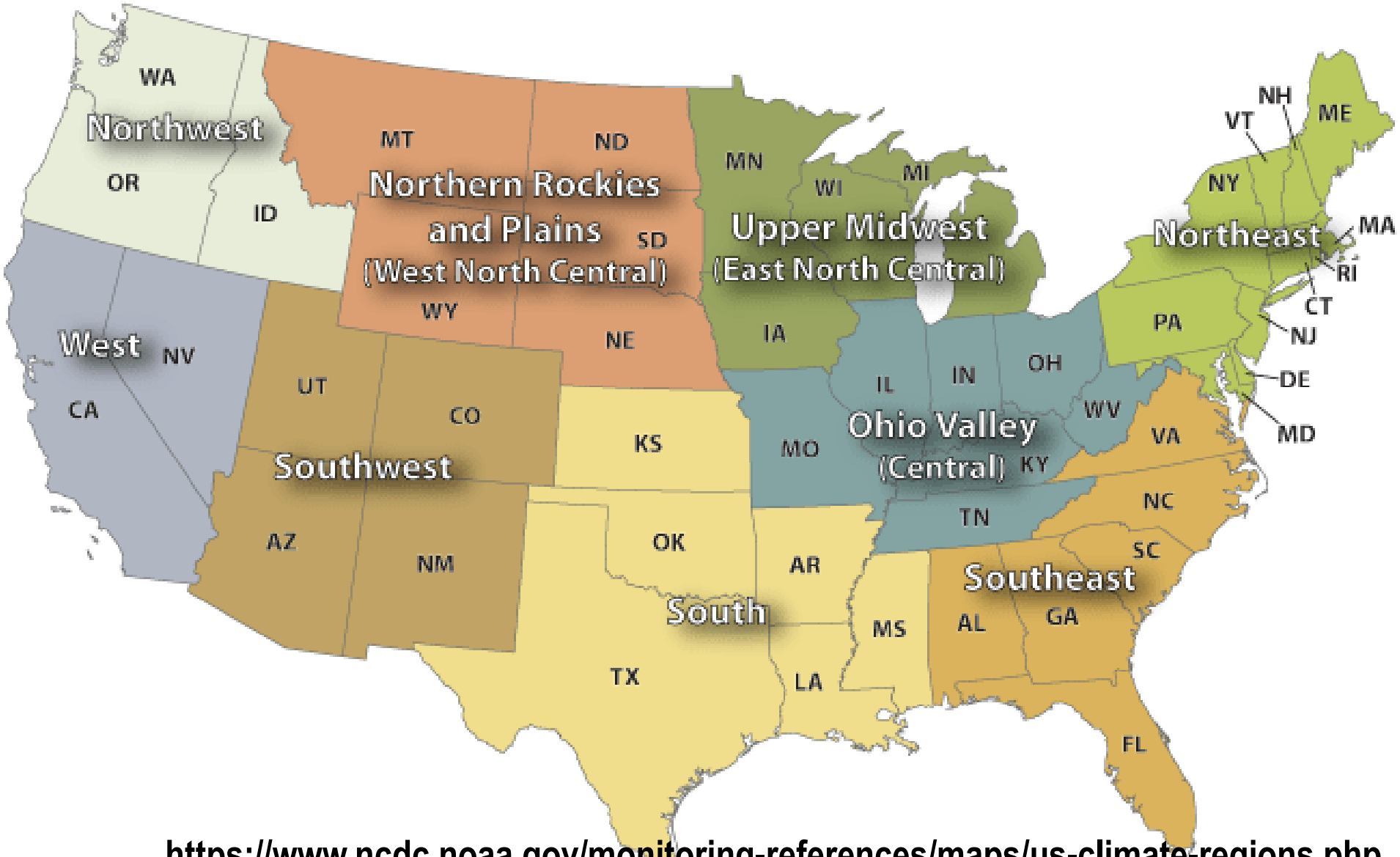
analysis, synthesis, resource development

- farmers
- crop physiologists
- pathologists
- sociologists
- forecasters
- engineers
- economists

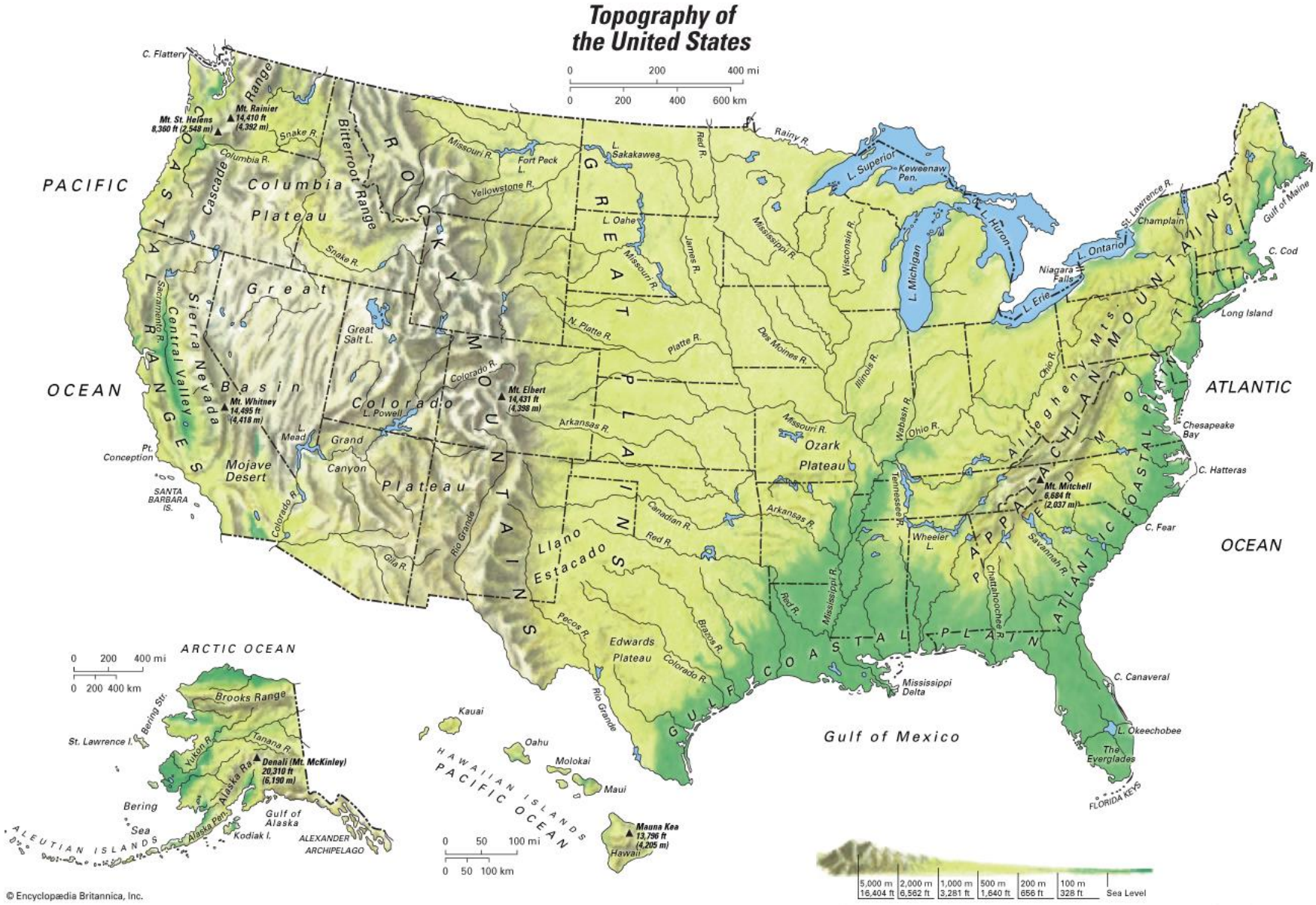
From Idea to Practice

- entomologists
- entomologists
- climatologists
- statisticians
- educators

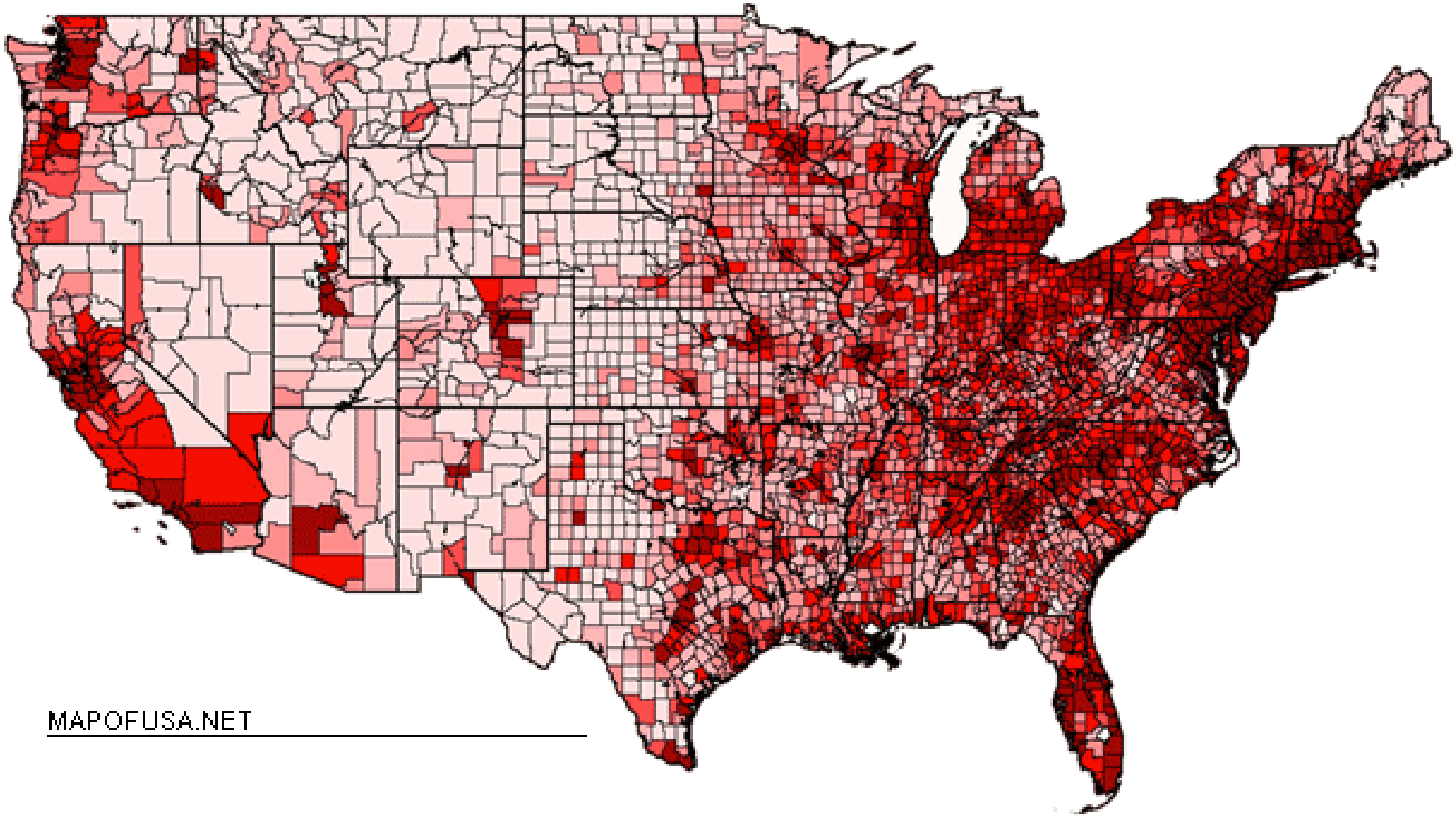
U.S. Climate Regions



https://www.ncdc.noaa.gov/monitoring-references/maps/us-climate-regions.php



https://kids.britannica.com/students/assembly/view/166203



https://mapofusa.net/us-population-density-map.htm

- increase real-time control
- increase predictability
- increase productivity and efficiency
- decrease risk
- increase success

There is no routine cancer.

https://cancer.osu.edu/blog/there-is-no-routine-cancer

Just as no two people are exactly the same, neither are their cancers.

No two farms are alike.

What's different? The medical community has systems for developing, communicating, and implementing standards of care. Winter production needs a system for establishing and meeting minimum cropping expectations.

SUMMARY

THANK-YOU and GOOD LUCK!

QUESTIONS?

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The OSU-OARDC

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Web: u.osu.edu/vegprolab
Facebook: www.facebook.com/osuvpslab

THE OHIO STATE UNIVERSITY
COLLEGE OF FOOD, AGRICULTURAL, AND ENVIRONMENTAL SCIENCES

Growth Rates and Quality of Baby-sized Greens Grown in High Tunnels during Fall and Spring

30’ x 80’ high tunnels covered with single layer of 6-mil poly film

Each high tunnel contains twenty 4’ x 12’ raised beds

Each covered with low tunnel of Agribon as needed

‘Parris Island’ lettuce

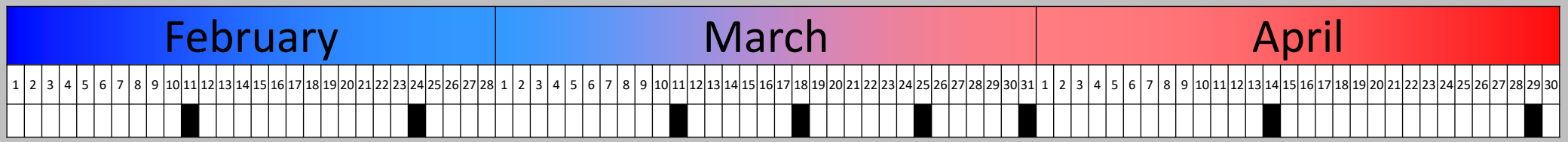
‘Ovation’ mesclun mix

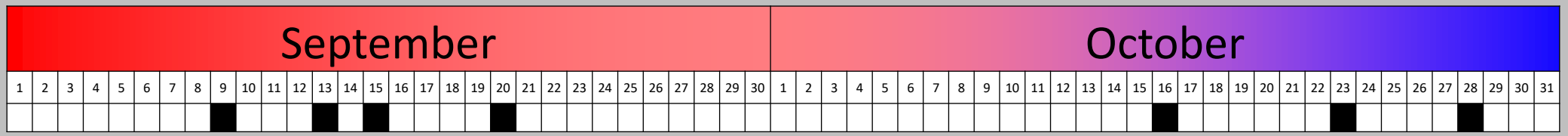
‘Outredgeous’ lettuce

‘Fordhook’ Swiss chard

‘Oriole’ Swiss chard

Seeding dates





Targeted Seeding Rates

Lettuce & mesclun mix-360 seed/ft2

Swiss chard-240 seed/ft2

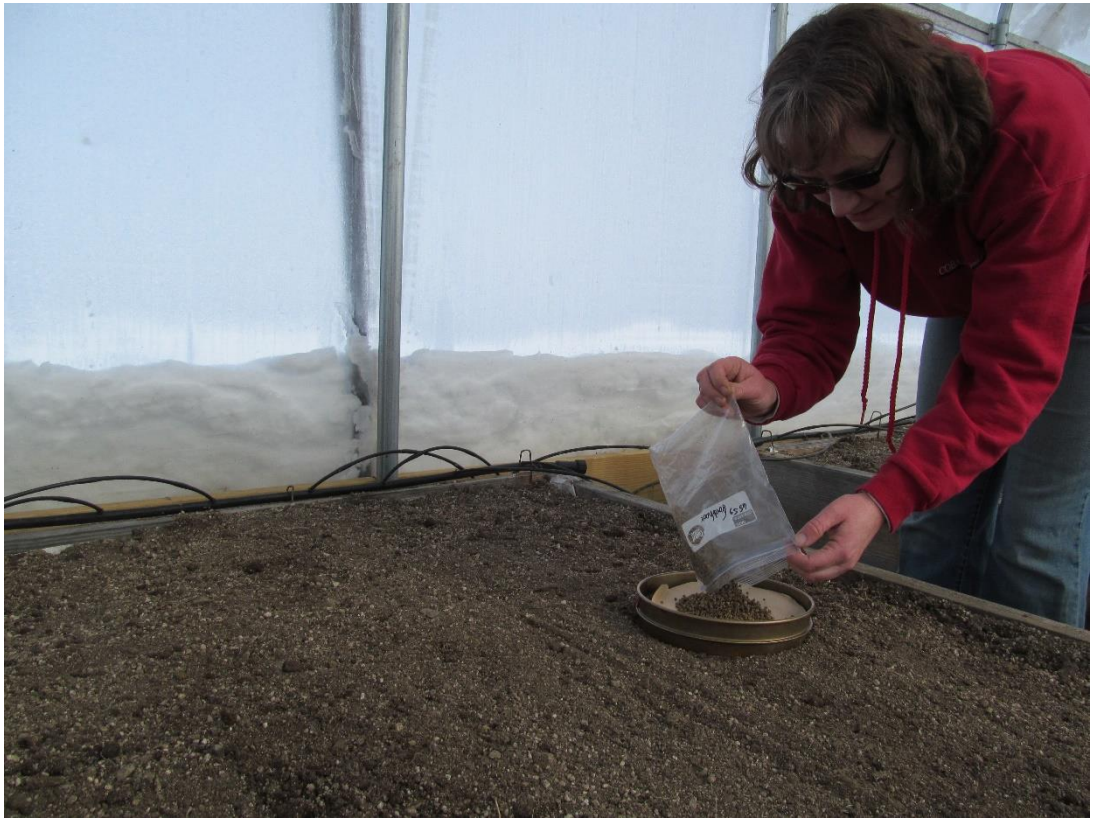
Pictures taken on 8.5”x11” paper

Heated soil vs unheated soil

October 16, 2014
October 23, 2014
March 11, 2015
March 18, 2015

} Seeding dates

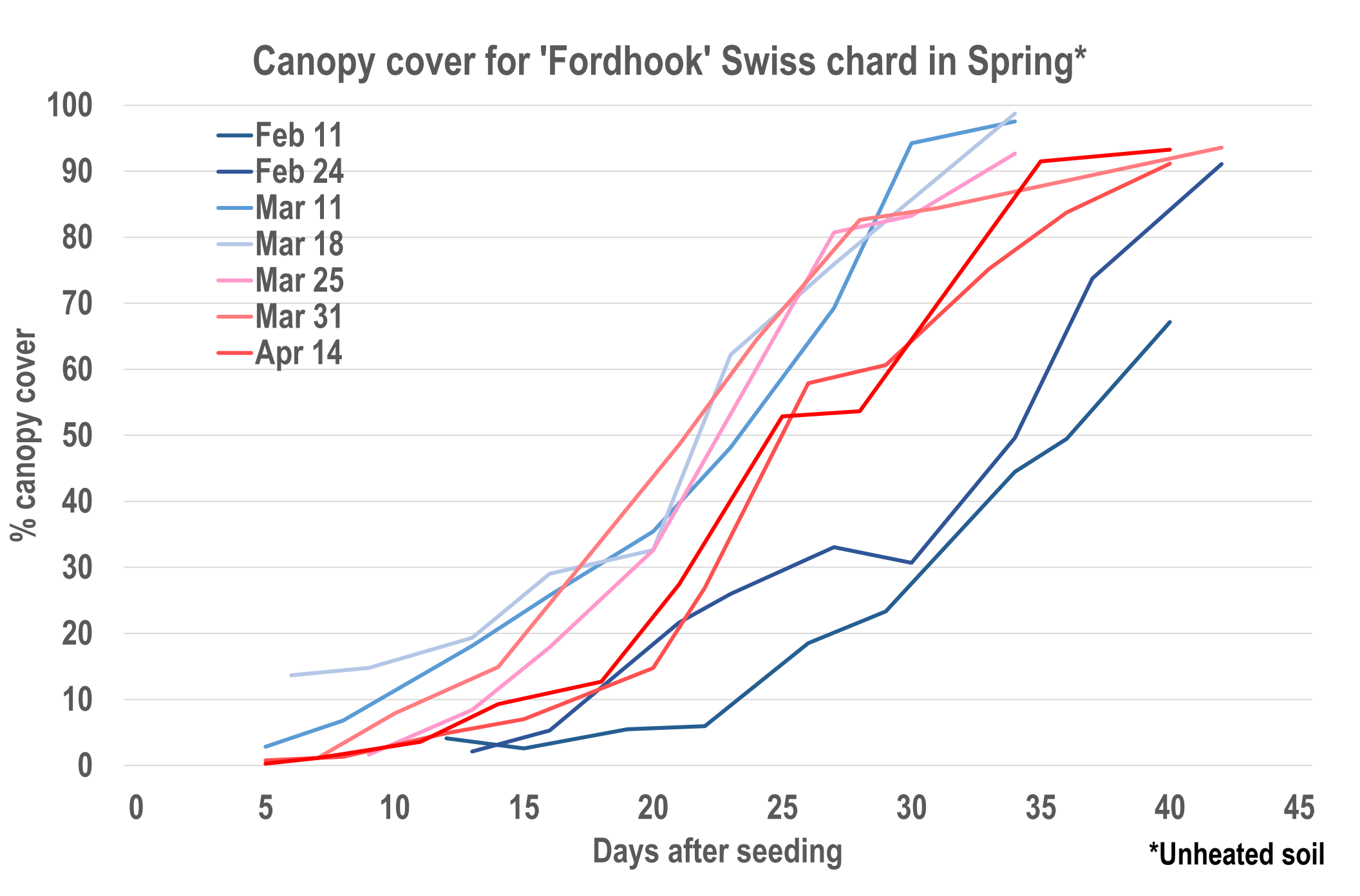
Soil heating cables used to raise soil temperature. Cables ran at 74F.

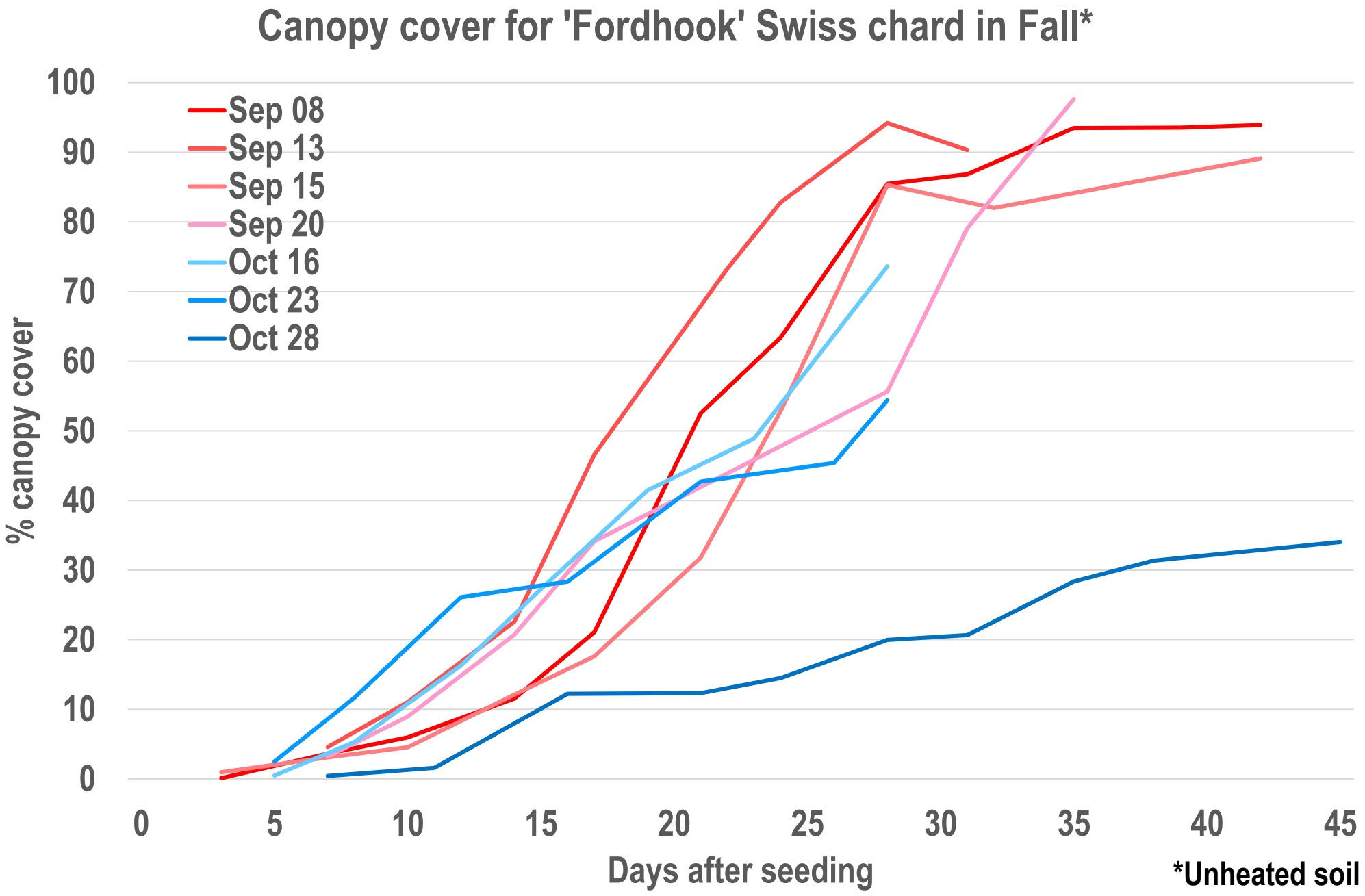


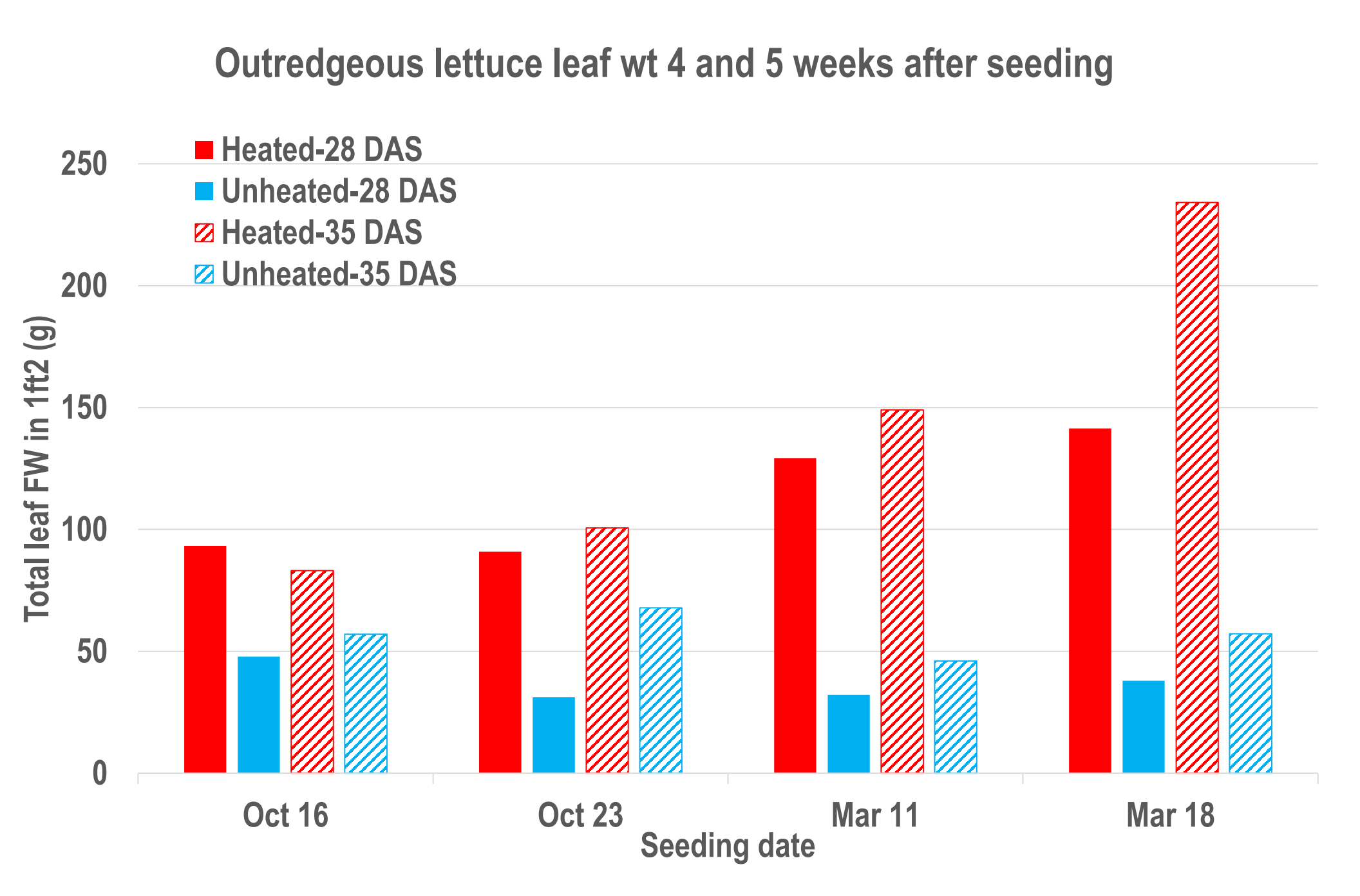
Feb. 11, 2016

Harvested 1ft^2 areas

Each seeding date harvested 2-3 times


Canopy cover for 'Fordhook' Swiss chard in Spring*
100
90
80
70
60
50
40
30
20
10
0
% canopy cover
Feb 11
Feb 24
Mar 11
Mar 18
Mar 25
Mar 31
Apr 14
0
5
10
15
20
25
30
35
40
45
Days after seeding
*Unheated soil


Canopy cover for 'Fordhook' Swiss chard in Fall*
100
90
80
70
60
50
40
30
20
10
0
% canopy cover
Sep 08
Sep 13
Sep 15
Sep 20
Oct 16
Oct 23
Oct 28
0
5
10
15
20
25
30
35
40
45
Days after seeding
*Unheated soil


Outredgeous lettuce leaf wt 4 and 5 weeks after seeding
Heated-28 DAS
Unheated-28 DAS
Heated-35 DAS
Unheated-35 DAS
250
200
150
100
50
0
Total leaf FW in 1ft2 (g)
Oct 16
Oct 23
Mar 11
Mar 18
Seeding date