

Innovations in and Techniques for Managing High Tunnel Environments

Tri-State High Tunnel School
March 14, 2025

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Extension Specialist

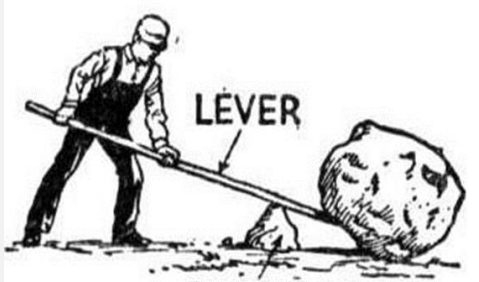


1

Roots of Success

As a grower, knowing and applying your leverage from seed to sale, especially during production.

2



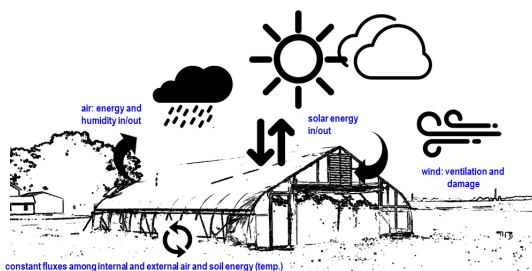
Knowledge is leverage, power. Leverage is a 'force multiplier,' something that allows us to do the most with what's available.

3



Farming in a clear box without the aid of active climate control systems.

4



High Tunnel Systems: powered by solar and natural energy fluxes. The HT grower's challenge - how to manage these inputs and losses using only natural laws governing energy flow?

5

Successful HT Environmental Management

external weather conditions
+
ventilation status (VS) + other practices
= internal, near-crop conditions
+
crop genetics → cropping outcomes

6

The Laws of Physics, Chemistry, and Biology

- work nonstop
- unalterable
- must work with them

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AIR

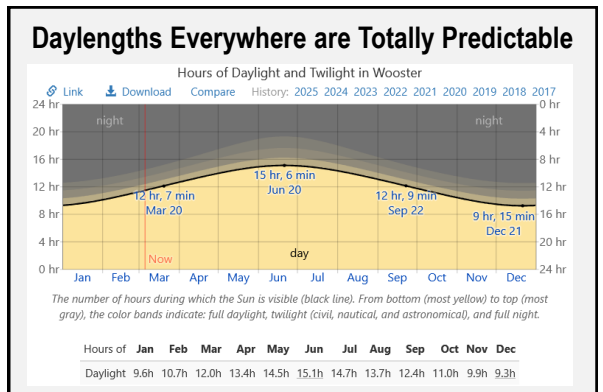
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+

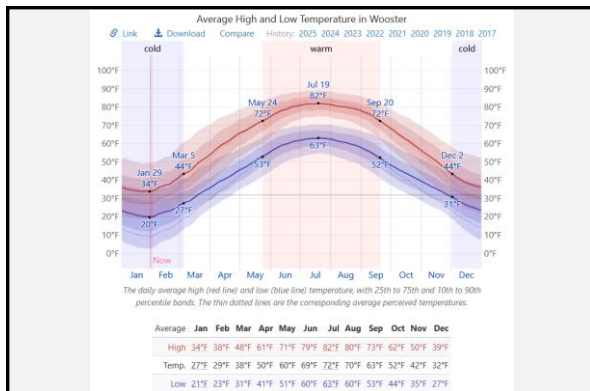
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Roots of Success

Growers and their crops have fixed levels of time, sun, water, nutrients, and other resources each season.

... anything that interferes with best possible use of basic resources (rate, efficiency) hampers success.

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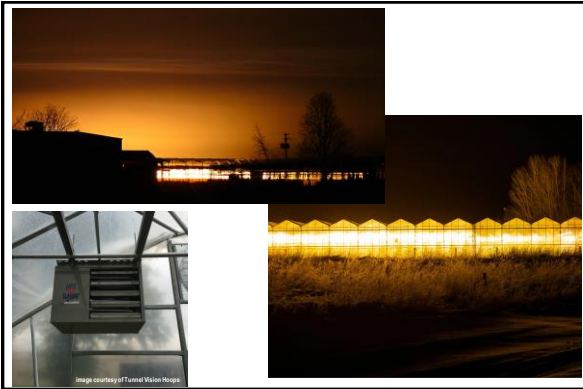
Two kinds of races:

- a) fixed distance, how much time?
- b) fixed time, how much distance?

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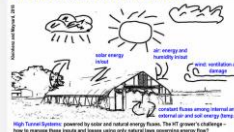
Light-temperature relationships are a major driver of productivity.

14

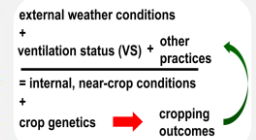


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Environments in high tunnels are strongly influenced by external conditions and grower decisions that, in turn, also affect crops and sustainability metrics.



Successful HT Environmental Management



HT environments have many acute, chronic, and cumulative effects on crops and growers. Huge amounts of time, effort, money, and 'on the job learning' are put into HT environmental management as if they are just the costs of doing business. Yet, the process is rarely discussed or studied and less tends to be done to enhance it directly than for other practices.

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High Tunnel Environmental Mngmnt (Emphasizing Temperature, RH, light)

- **No recipe, formula, or DIY how-to guide**

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High Tunnel Environmental Mngmnt (Emphasizing Temperature, RH, light)

- No recipe, formula, or simple how-to guide ... learn by trial and error
-
- principles, tools, resources, weighted observations/trends

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High Tunnel Environmental Mngmnt (Emphasizing Temperature, RH, light)

1. films
2. covers
3. fans (+/- misting)
4. heating (root zone)
5. ventilation status

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TECHNICAL PRODUCT INFORMATION

Product: Diffused non-aerated thermic film

Product Number: E1846

Product description: Diffused thermic film. The film is by extra high mechanical properties. The light distribution in the greenhouse is "warmer" during the cold nights.

Durability: 3-8 years

Thickness: 150-200 µ

Width: 1.0-14.5 m

Length: According to customer order

Sun View Cool 4 Year Plastic Film

15% OFF Orders \$150 or more!

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High Tunnel Environmental Mngmnt (Emphasizing Temperature, RH, light)

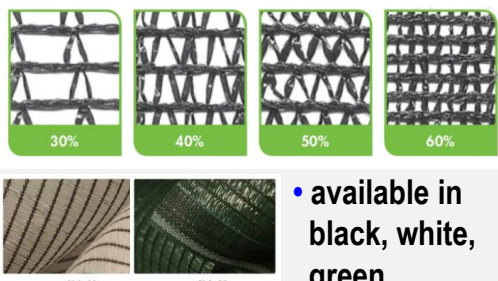
1. films
2. covers
3. fans (+/- misting)
4. heating (root zone)
5. ventilation status

23

image courtesy of Hummert Intl

image courtesy of AM Leonard

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- available in black, white, green
- variable effects on temperature, aging of HT plastic

25



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Factors to Consider with Shading

1. Your crops (cool? warm? both?)
2. Plant responses, sensitivities to light (L), temperature (T) and L-x-T levels and interactions ... crop and stage specific.
3. What level? When on? When off?
4. Impact on HT plastic.

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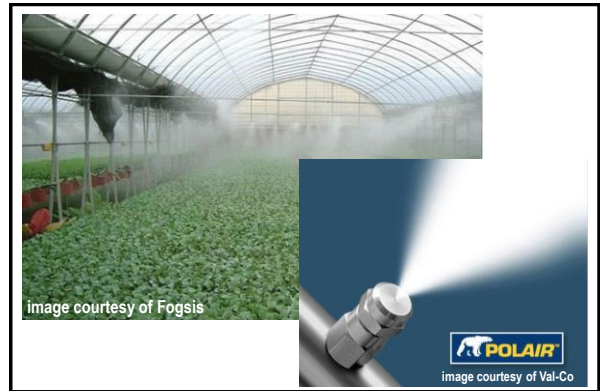
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33

**High Tunnel Environmental Mngmnt
(Emphasizing Temperature, RH, light)**

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Heat
instead of
Cool

(summertime crops often established when temperatures are much lower)

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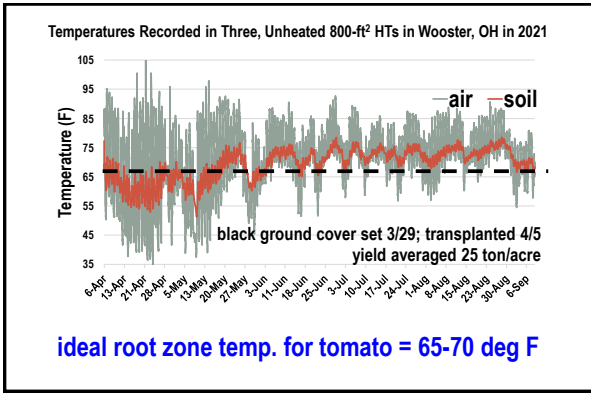
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- emergency
- short-term
- must limit risk

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Soil Temperature Effects on High Tunnel Crop Yields

A relatively small number of scientific reports

- pepper, tomato, lettuce, other
- various regions, approaches to manipulating soil temperature

Temperatures more consistently in optimal range associated with highest and, sometimes, earliest yields. Clear trend but warmer soil temperatures not a 'guarantee' of significantly (statistical) greater yields.

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Root Zone Heating as a Topic in Recent Major Grower Conferences

State/Province	Years*	# titles referencing root zone heating
DE	2022	0
IL	2019-2021	2
MI	2017-2023	0
MN	2019	0
NH	2019, 2021	2
NJ	2017-2022	0
NY	2017-2023	0
OH	2017-2023	0
PA	2021-2023	0
TN	2022-2023	0
VT	2021-2022	0
WI	2020-2023	0
Ontario	2017-2020, 2022-2023	0
Quebec	2022	0

*total of 53 agendas checked in Jan-2022, Dec-2023

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related studies completed on 4 farms

images courtesy Green Edge Gardens

with, without ...

- subsurface heating
- aerial cover

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9.1-m x 24.4-m single-layer high tunnel containing 20, 1.2-m x 3.7-m wood-framed raised beds (10 @ 46.0 cm and 10 @ 25.4 cm high)



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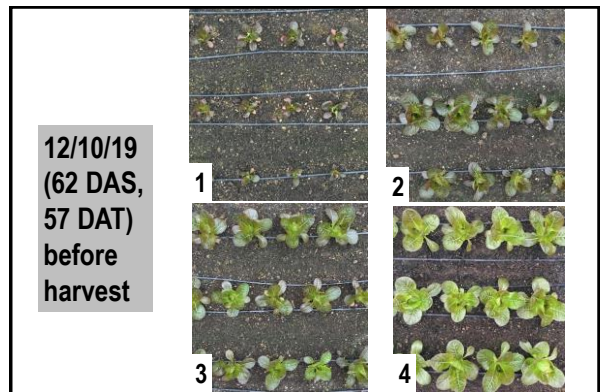
Root zone heating by electric cable (136.4 Watts per m²). Remove top 15 cm of soil, place 36.6 m of cable/bed, replace medium.



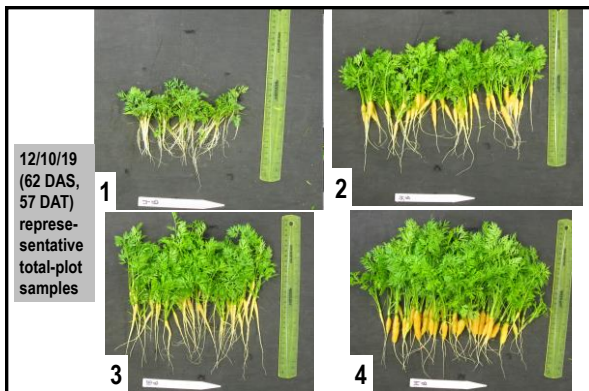
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Period	Material / Tech Used	Treatment			
		1	2	3	4
day 9am-6pm	Perforated Film (PF)	-	-	+	+
	Cable (C)	-	+	-	+
	Fabric (F)	-	-	-	-
Night 6pm-9am	Perforated Film (PF)	-	-	+	+
	Cable (C)	-	-	-	-
	Fabric (F)	-	+	+	+

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Overall treatment ranks based on summing rank scores for a total of 8 shoot and root variables measured 9 WAS.

Treatment	carrot		lettuce	
	root	shoot	root	shoot
1	4 (16)	4 (16)	4 (16)	4 (16)
2	2 (8)	2 (9)	2 (8)	2 (9)
3	3 (12)	3 (10)	3 (12)	3 (10)
4	1 (4)	1 (5)	1 (4)	1 (5)

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Soil can be more effective than air but more complicated and costly.

System (approach) must match crops.

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High Tunnel Environmental Mngmnt (Emphasizing Temperature, RH, light)

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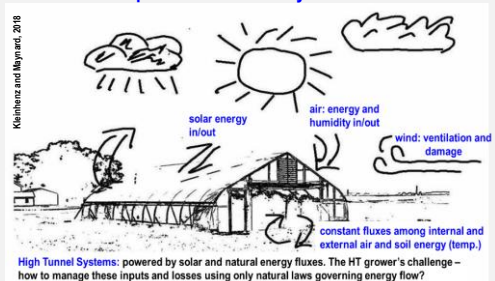
HT Envtl Management Ventilation Status (VS)

Positions of doors, sidewalls, vents (if present)

- Level of “open-ness,” including the amount and distribution of exposed surface area relative to the HT’s volume when fully closed.

51

Environments in high tunnels are strongly influenced by external conditions and grower decisions that, in turn, also affect crops and sustainability metrics.

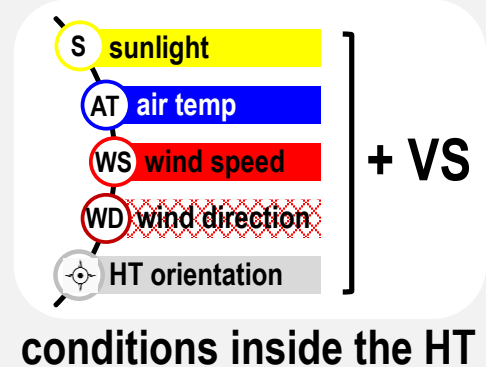


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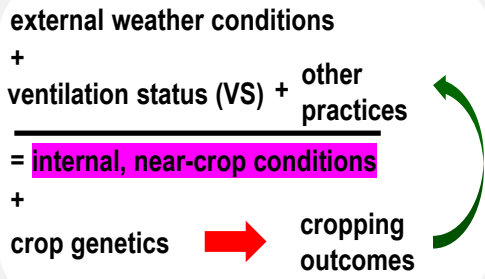
HTs and crops can be damaged if ventilation status (e.g., sidewall position) is improperly matched with weather conditions.

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Successful HT Environmental Management



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Most ventilation (temp. mngmnt.) accomplished via vents, end wall doors, and sidewalls.

Ventilation capacity, level, timing, duration impacts outcomes significantly.

56

U TN Organic Research Unit (2018)

57

<https://farm-energy.extension.org/natural-ventilation-in-high-tunnels/>
 photo by Vern Grubinger

58

“kneewalls” allow ventilation when cold outside but above the soil and young plants

59

“kneewall” installation

- simple • fast
- cheap • effective

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HT Env'tl Management Ventilation Status (VS)

Positions of doors, sidewalls, vents (if present)


- Level of “open-ness,” including the amount and distribution of exposed surface area relative to the HT’s volume when fully closed.

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Selecting/Setting HT VSs

- crop temperature, RH optima
- solar radiation/sky cover
- air temperature
- wind speed • wind direction
- HT orientation

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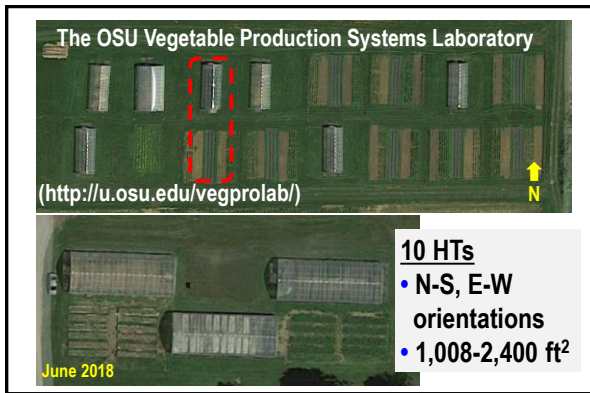
Likely effects of VS Management



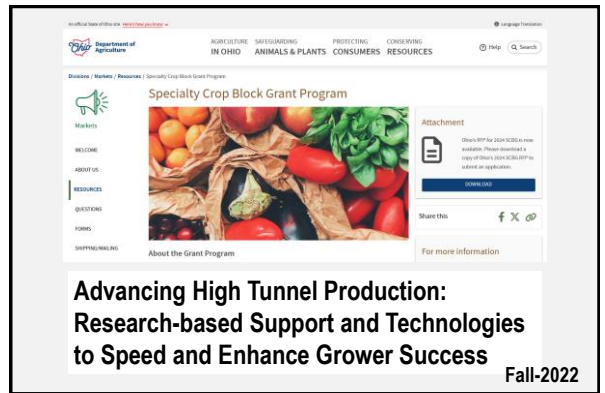
What’s known about grower attitudes, practices, experiences

VS management may be the least well-studied, explained, or supported factor relative to its likely its persistent, diverse impacts.

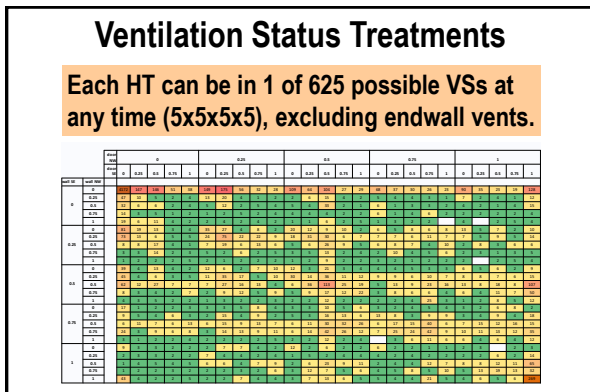
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COLLEGE OF FOOD, AGRICULTURAL, AND ENVIRONMENTAL SCIENCES

VEGETABLE PRODUCTION SYSTEMS LABORATORY
Department of Horticulture and Crop Science

HOME ABOUT US RESEARCH FOCUS AREAS PUBLICATIONS

High/Mid Tunnel Systems
<https://u.osu.edu/vegprolab/research-areas/high-mid-tunnel-systems/>

A. Managing the Temperature and Other Conditions Inside Your High Tunnel(s)

Resource 1. Real-time Report of Current Conditions In- and Outside Eight High Tunnels in Wooster, OH and the Ventilation Status of the High Tunnels
Compare the current conditions in and near your high tunnels with conditions in and near eight high tunnels at the OSU Wooster Campus in Wooster, OH. Use the comparison to help explain and optimize conditions in your high tunnel(s). In the process, pay close attention to the ventilation status of your and our high tunnels.

Click [here](#) to access Resource 1.

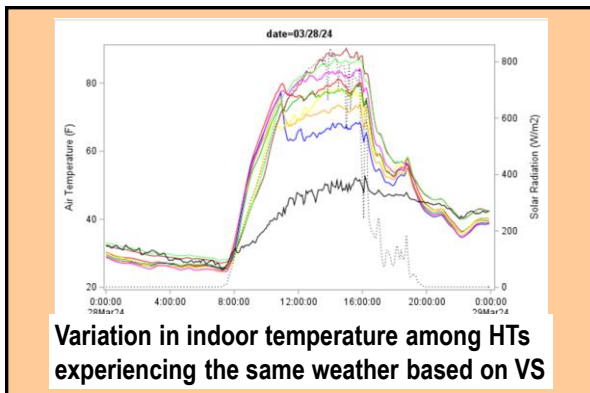
Resource 2. Searchable Database of Weather and Ventilation Status Effects on Conditions Inside Nine High Tunnels in Wooster, OH May 10, 2022 – April 16, 2024
Use our large historical record to help select a ventilation status for your high tunnel(s) based on your target temperature and current or forecasted weather (air/particle cover, air temperature, and wind speed and direction), select a ventilation status for your high tunnel(s) – e.g., to help maintain a target temperature – more confidently.

Click [here](#) to access Resource 2.

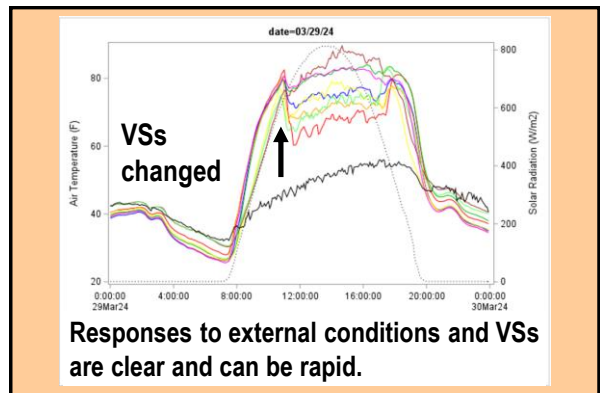
decision-support dashboard

kleinhenz.1@osu.edu; 330.263.3810

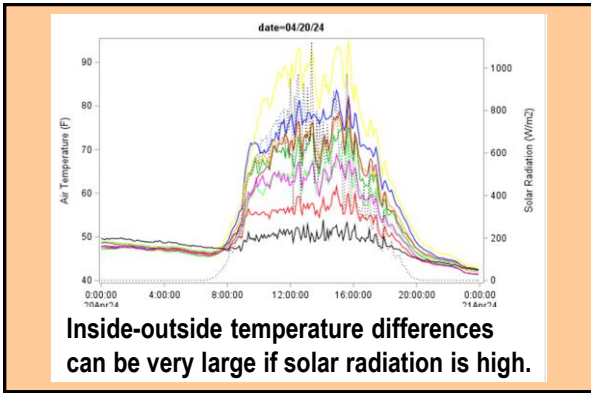
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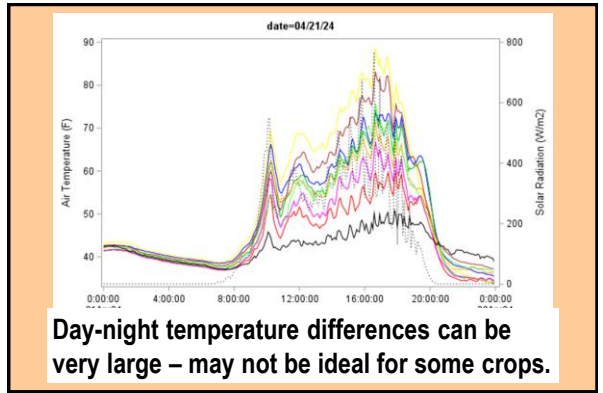
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decision-support dashboard

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East West High Tunnels North South High Tunnels

For High Tunnels with an East West Spine (Orientation)

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Current	Forecasted	Conditions	Outside	HT	percent door or wall is open							
2	Air Temp. (deg F)	Sky Cover	Wind Speed (MPH)	Wind Dir. (Deg)	East Door	South Wall	North Wall	# of					
41	15	dark	W	0	0	0	0	0	18				
41	15	dark	W	5	0	0	0	0	49				
41	15	dark	W	10	0	0	0	0	15				
41	15	cloudy	SW	15	0	0	0	0	22				
41	15	cloudy	SE	0	0	0	0	0	12				
41	15	dark	Calm	0	0	0	0	0	20				
41	15	dark	SW	0	0	0	0	0	48				
41	15	dark	SW	5	0	0	0	0	59				
41	15	dark	SW	10	0	0	0	0	48				
41	15	dark	SW	20	0	0	0	0	16				
41	15	dark	S	0	0	0	0	0	41				
41	15	dark	S	5	0	0	0	0	83				
41	15	dark	S	10	0	0	0	0	17				
41	15	dark	SE	5	0	0	0	0	19				
41	15	dark	SW	0	0	0	0	0	64				
41	15	dark	SW	5	0	0	0	0	18				
41	15	dark	SW	10	0	0	0	0	46				
41	15	dark	SW	15	0	0	0	0	100				
41	15	dark	SW	20	0	0	0	0	19				
41	15	dark	W	0	0	0	0	0	78				

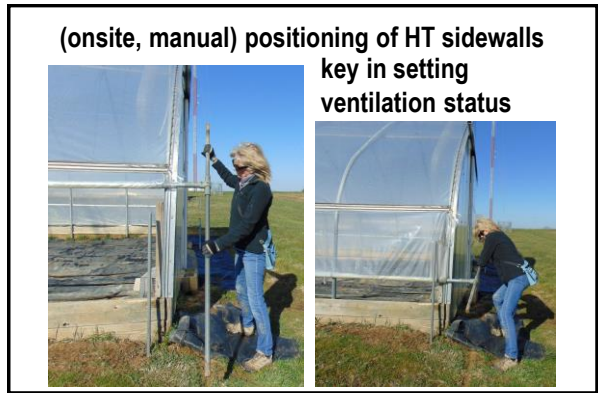
For High Tunnels with a North South Spine (Orientation)

Filter the worksheet (data) to meet your interests

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- under many conditions
- physical harm possible

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Greenhouse Controllers

- Controller Interface Box – 2 Motor with Manual Override: \$460.00
- AugiTEC- Wireless Interface: \$975.00
- Temperature Sensor for Greenhouse Controller: \$60.00 - \$75.00
- Control Slave Boards – Humidity, Rain, etc: \$90.00

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19 December 2021

A Simple, Inexpensive, DIY System for Controlling the Height of High Tunnel Sidewall Rollbars Remotely

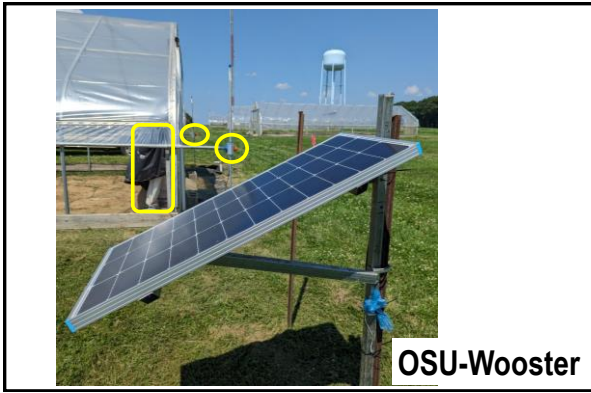
1. Standard sidewall motors powered by a battery-solar panel combination, as described above;
2. A standard voltage-regulating unit converting 12 volts from the battery to 24 volts needed by the motors (approx. \$80.00);
2. A motor controller (available at electronics stores or online for approx. \$15.00);
3. An off-the-shelf, WiFi-enabled microcontroller to act as the brains of the system (approx. \$5);
4. WiFi already present on the farm property or wireless access with a hotspot or similar (\$0 to monthly charge typical of a mobile phone plan); and
5. Code for the motor controller (no charge)

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Current High Tunnel Environmental Control Options (primarily position of sidewalls)

	On-site, Manual (hand crank)	Automated, Thermostatically Controlled	Remote, Manual, Motorized (VPSSL System 1)	On-site, Motorized (VPSSL System 2)
current usage	greatest	high, increasing	low, increasing	-
relative cost	low	high	medium	low
individual sidewall control	yes	no	yes	yes
scalability to > 1 HT	yes	moderate	yes	yes
why sidewall position changes	user wants it to and turns crank	temp. only*	user wants it to and opens app	user wants it to and pushes button

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Xenia

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Mansfield

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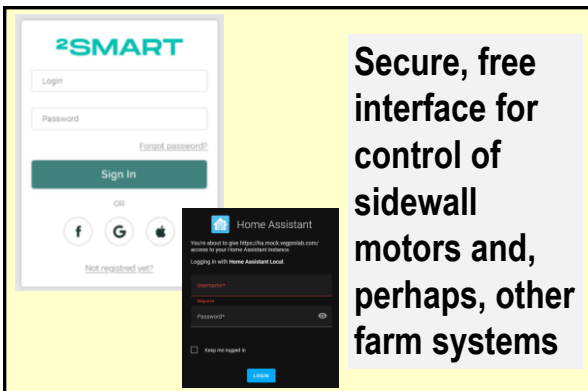


Columbus

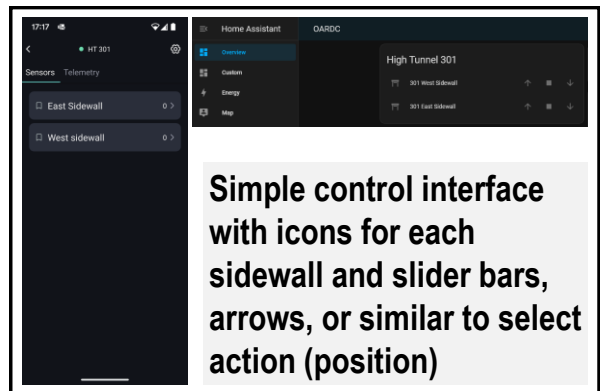
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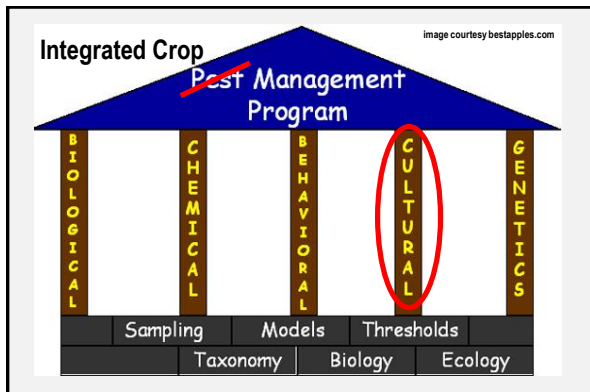
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Feedback has been **positive**.
 Enthusiasm is **high**.
 >10 additional installations have
 been requested. Additional
 applications are being tested.
 Stay tuned for DIY guide,
 videos, programs.

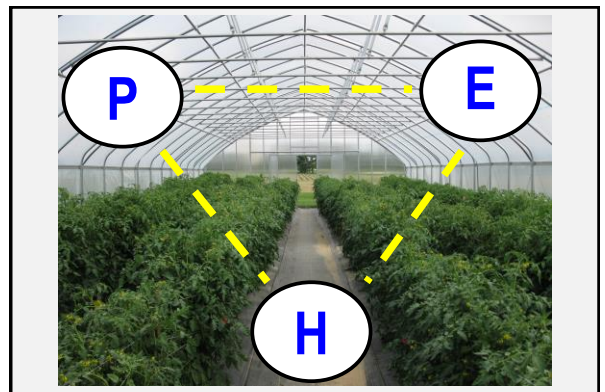
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SUMMARY

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THANK-YOU
 and
 GOOD LUCK!



QUESTIONS?

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 YouTube: <https://www.youtube.com/@theosuvpsl>

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