

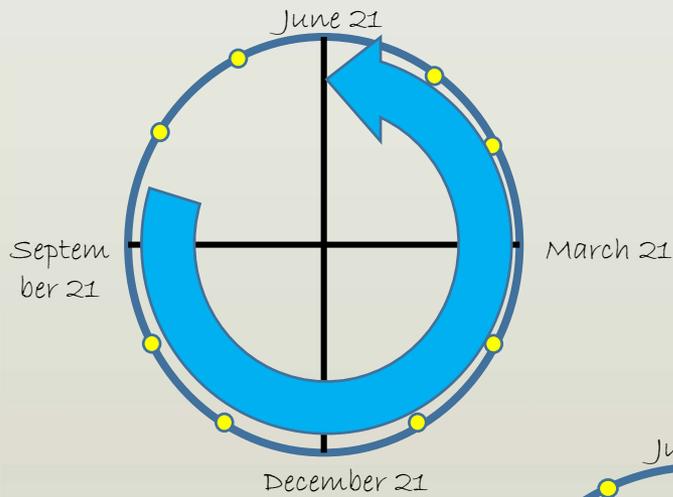


# Growing Vegetables During the School Year

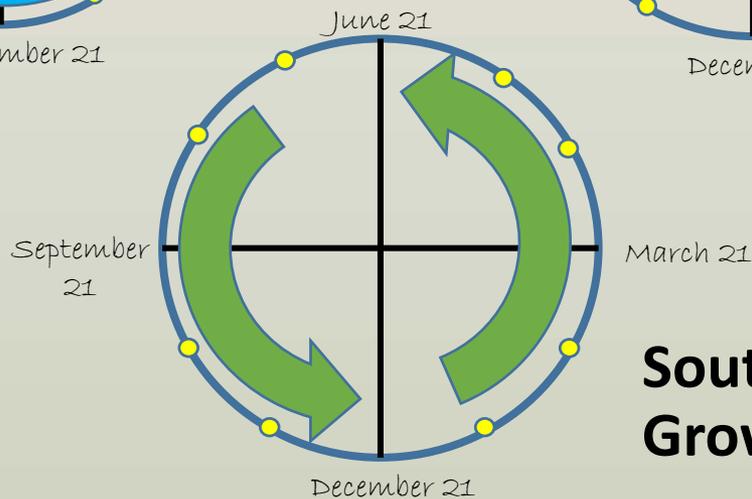
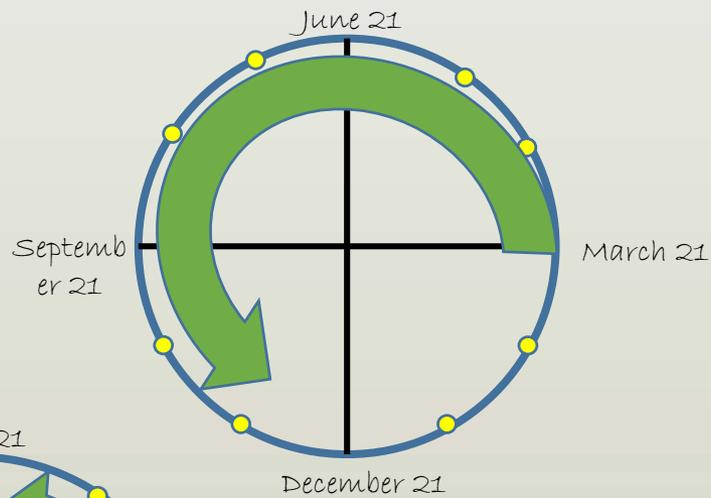
Dr. Rebecca Brown, URI Dept. of Plant Sciences

# A Fundamental Disconnect

## School Year



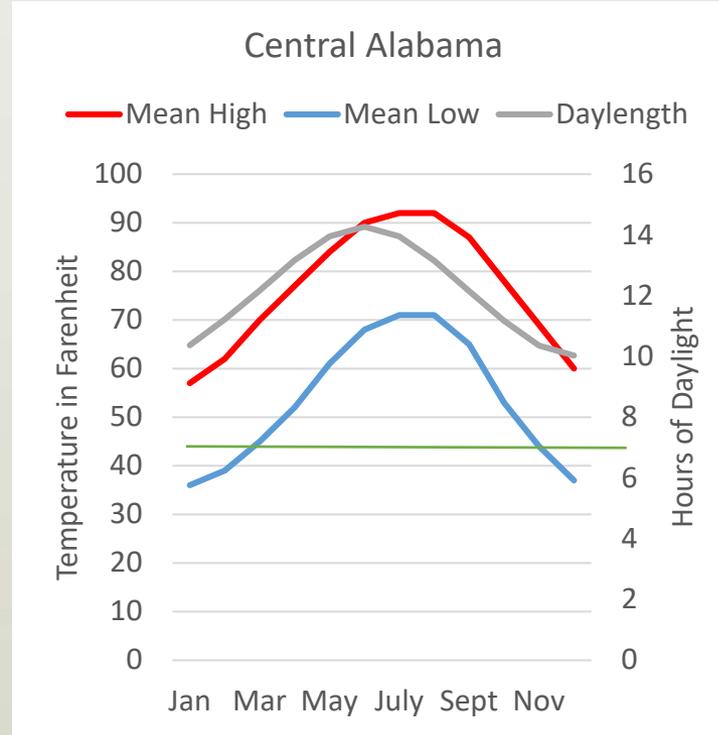
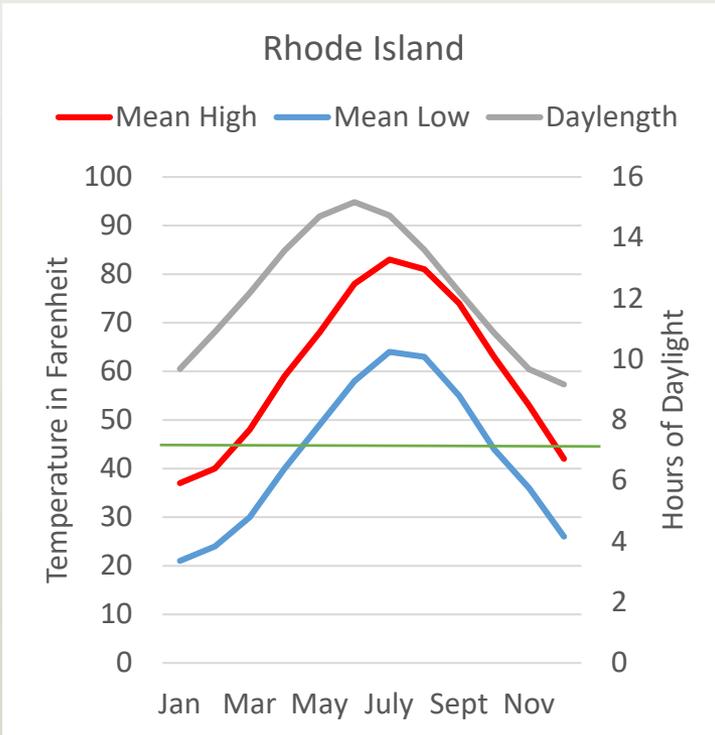
## RI Plant Growth Year



## Southern Plant Growth Year



# How is the south different?



Daylength is slightly longer in winter, but primary difference is temperature!

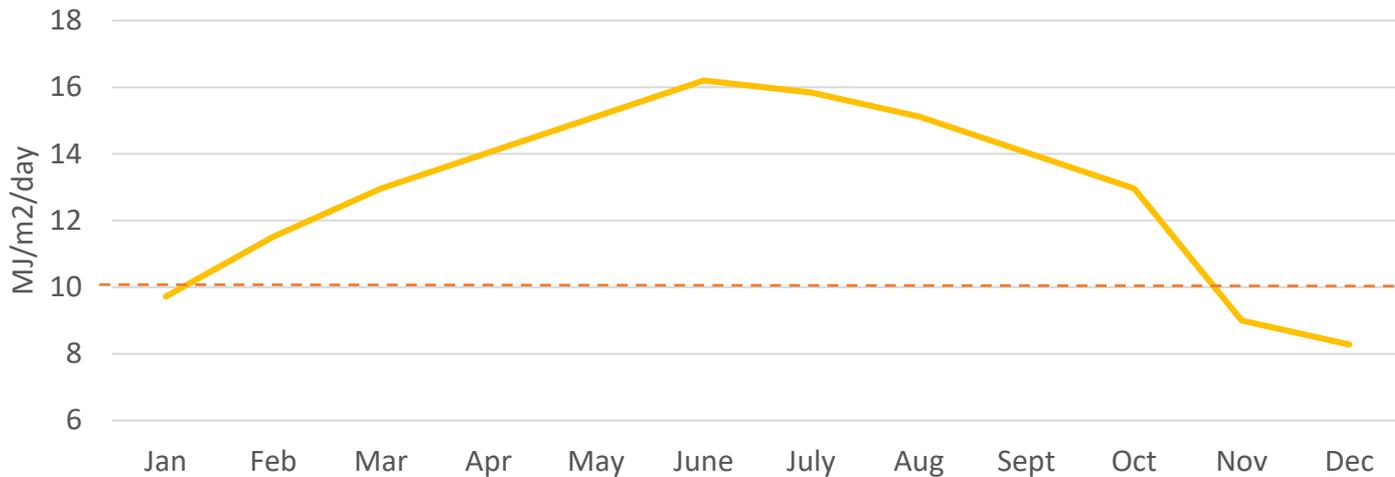


# What determines the plant growth year?

- Temperature
  - Essentially no growth below 45°F
  - Higher temperatures = faster growth
- Light intensity
  - Minimum of 10 MJ/m<sup>2</sup>/day
  - On a clear day intensity  $\approx$  1 MJ/m<sup>2</sup>/hr
- Daylength
  - Plants only grow during the day
  - More daylight = more growth



## Average Solar Radiation Providence 1961-1990



- We generally have sufficient light intensity except for mid November – mid January
- Temperature is much easier to manipulate than light!
- Solution is to create pockets of South in RI



# Temperature Manipulation on a Budget

- We need to increase the temperature of the air around the plants
- Heat can come from burning fuel (oil, gas, wood), from electricity, or from the sun
- How to use sunlight to increase temperature above ambient?

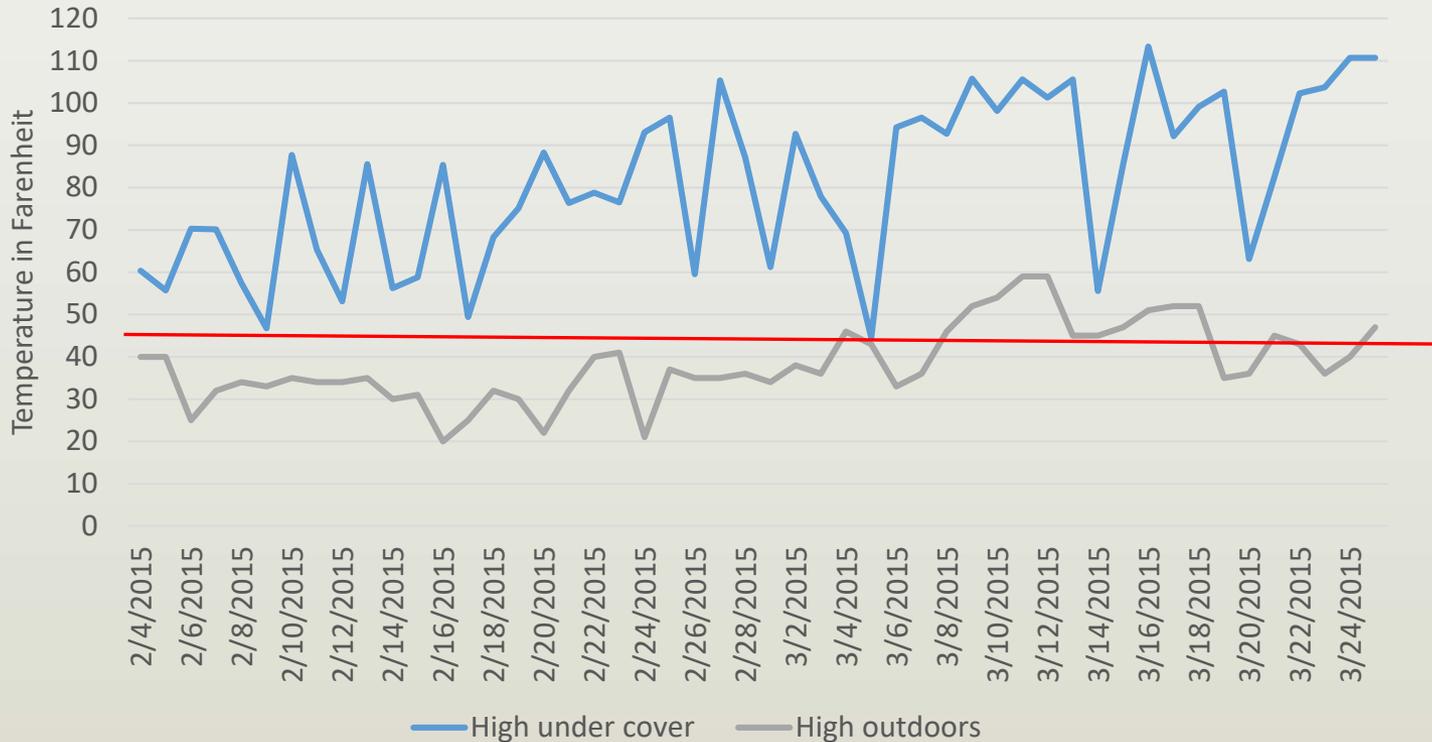


# Turning Light into Heat

- Transparent/translucent materials let light energy through
- Opaque materials reflect light energy
- Reflected light waves lose energy (slow down)
- Become heat waves
- Heat waves are reflected by transparent/translucent materials



## Effects of Poly Film on Daytime Air Temperature



Glass and clear poly film transmit light but retain heat, so inside greenhouse or tunnel is much warmer than outside

*Consistently above 45°F threshold for plant growth*



But what about when  
the sun isn't shining?

Plants don't grow at night, but they can still freeze!



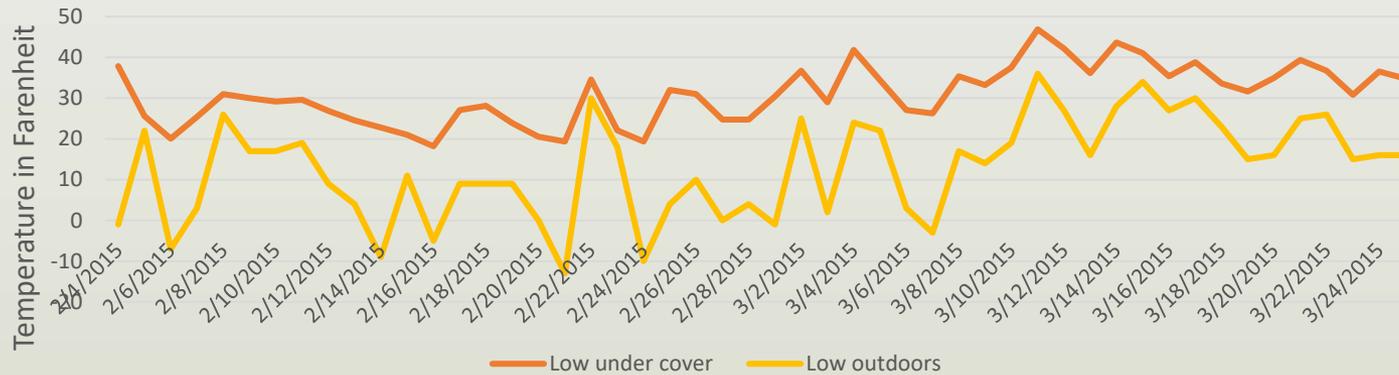
- Radiant heat energy (waves) is reflected by most solid materials
- But heat can also move molecule to molecule (conduction), so system is not tight
- Heat input must constantly exceed heat loss, or temperature falls
- Air has relatively few molecules per unit volume so can't store much heat

1. Minimize loss of heat via conduction – still air conducts less than solids, opaque materials conduct less than translucent
2. Minimize volume of air to be heated – just heat the air in the plant canopy
3. Maximize heat storage during the day – soil and water are much more effective than air

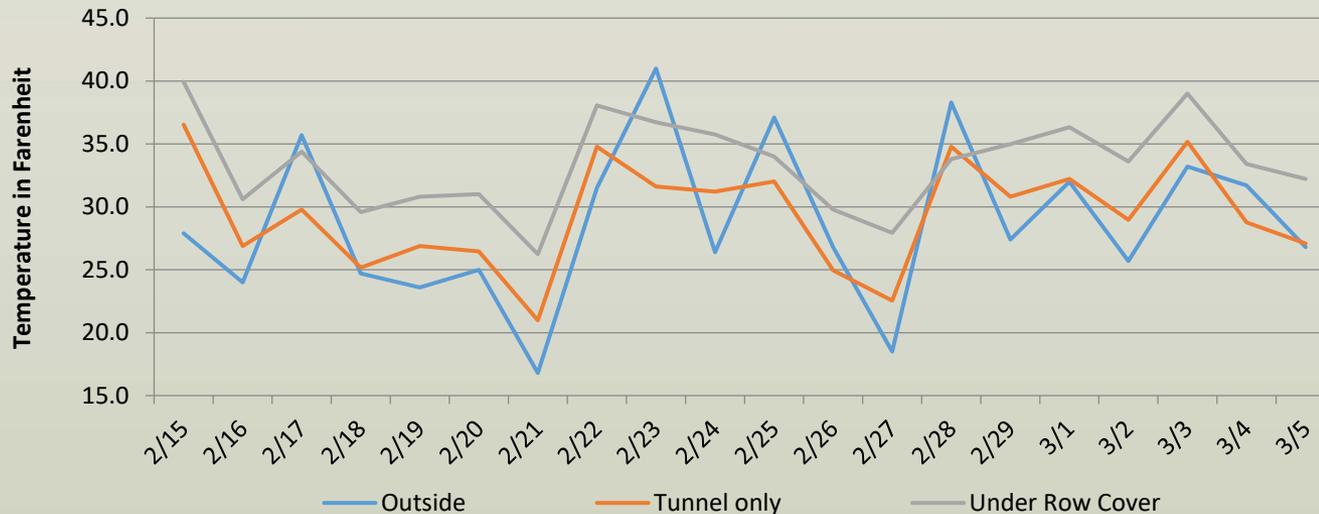


# Managing Heat at Night

## Effects of 2 Layers of Poly Film + Still Air on Nightly Low Temperatures



## Effects of Poly Film + Opaque Fabric on Nightly Low Temperatures



- Opaque rowcovers are particularly effective as they minimize radiant heat loss and the air volume to be heated
- Larger soil volume → greater heat storage
- Only need to keep the air in the canopy >25°F to keep plants alive
- Covers also protect plants from wind, rain, and low humidity
  - Less need to repair damage → more energy for growth



# How to Create the South in RI

Moving Beyond Greenhouses



# Structures to Trap Heat

High Tunnels



Greenhouses



Row covers

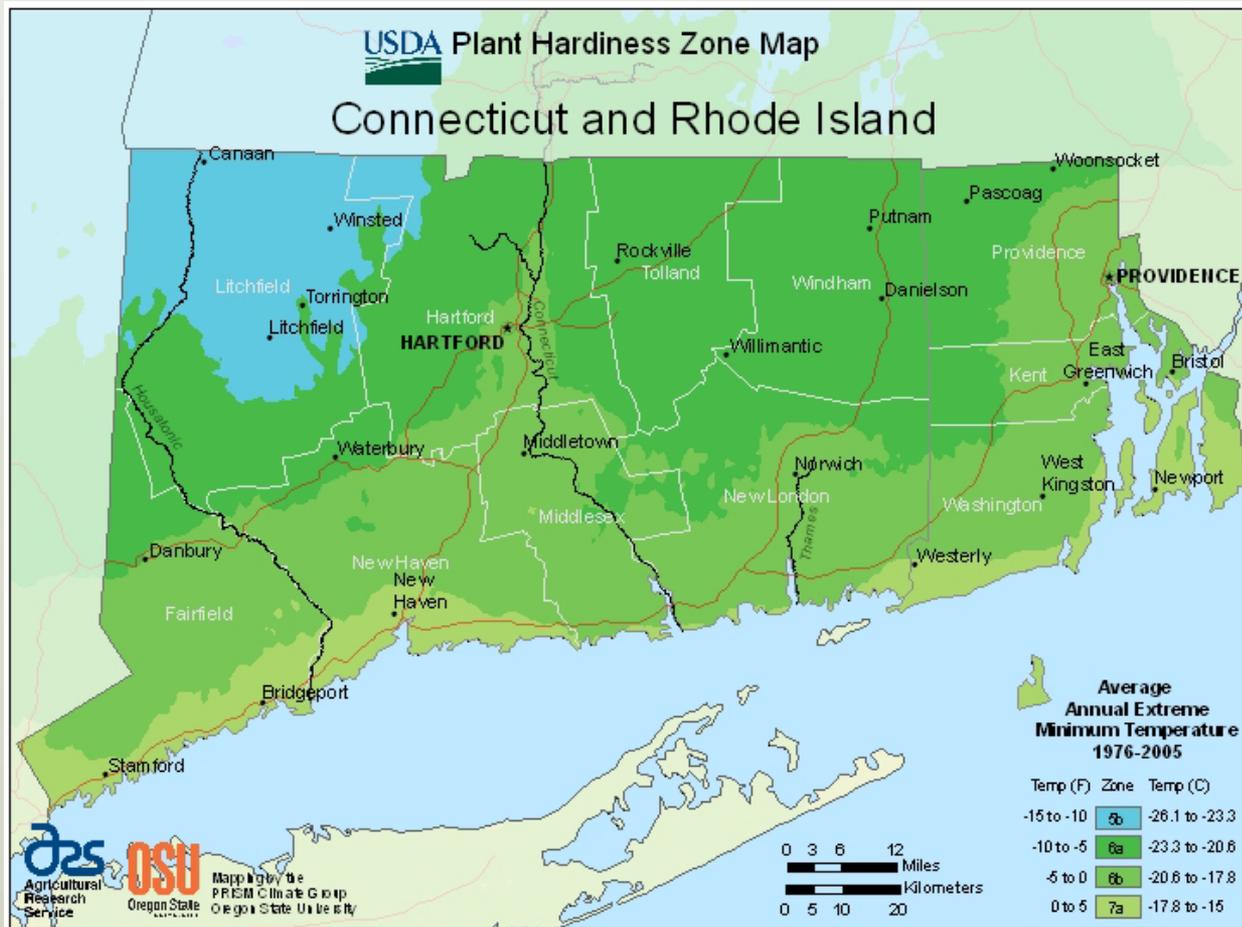


Low Tunnels



Walled Gardens

Each layer of protection moves your garden one hardiness zone south



Central Alabama is USDA zone 8a



# A Taxonomy of Tunnels

- High tunnel – 4-season structure with steel frame, up to 35 ft wide and 18 ft high
- Caterpillar tunnel - 3-season structure with frame of PVC pipe or lightweight steel, no more than 12 ft wide and 6 ft tall
- Low tunnel – up to 6 ft wide and 3 ft tall, frame of PVC or metal conduit. Used for winter protection
- Rowcovers – ventilated covers used for temporary protection. Free floating or supported by wire frames 1.5 ft high



For walled gardens low tunnels  
and caterpillar tunnels are  
probably sufficient protection

Otherwise, a high tunnel is the best choice



# Greenhouses vs. High Tunnels

## Greenhouse

- Steel frame covered with poly film, polycarbonate panels, or glass
- End walls of wood, polycarbonate, or glass
- Grow in containers on benches
- Has ventilation fans, heaters, and supplemental lighting
- Permanent structure with foundation; requires building permit

## Tunnel

- Steel frame covered with poly film
- End walls of poly film or polycarbonate panels
- Grow in the ground or raised beds
- Ventilated by wind, heat and light only from sun
- No foundation, regulated as a temporary structure



# Advantages of High Tunnels for School Gardens

- Large enough to hold class inside the tunnel
  - Students can work in the garden even if weather is cold, wet, or windy
- Structure will withstand snow load
  - No need to take cover off for winter
- Easy to construct – sold as kits, assembly can be done by volunteers
- Less expensive to build than greenhouse
  - Cost depends on size and features, but a “fully loaded” 30’x96’ tunnel is less than \$15,000 and a basic 30’x48’ tunnel is ≈\$5,000
  - Steel frame is most expensive component, and most variable – gauge of steel, shape and thickness of tubing, spacing between ribs
    - Strength needed is mostly determined by expected snow load



# Selecting a Site

- Need full sun, open ground to south, east, and west
  - Remember that sunlight comes from the south in the winter and shadows are longer than in summer
- Need to drive ground posts ~3 ft deep; rocky soil or pavement will increase costs
- Level ground inside tunnel, and graded to slope away from tunnel on outside
- Will need access to water for irrigation
  - Buried water line and frost-free hydrant inside tunnel is preferable
  - Can run a hose from an outdoor faucet, but will need to drain after each use in winter
- Access to electricity for inflation blower, automated vents, and supplemental heat is nice but not essential
- Test soil for nutrients, pollutants, pH and organic matter. Amend as necessary or install raised beds with plantable soil



# Components of a High Tunnel

- Steel frame – sold as a kit with hardware included. Gothic style recommended. Extra sidewall height probably not necessary
- Cover is 6 mil 4-year UV-treated poly film.
  - 2 layers will last longer, but requires electric inflation blower or spacer blocks
- Treated lumber or plastic wood for hipboards and baseboards
- Wood or metal to frame endwalls and doors
- Poly film or polycarbonate sheeting to cover end walls
- Roll-up or drop-down sides for ventilation
  - Drop-down is preferred for winter growing
- Automated roof or ridge vents
  - Will keep tunnel from overheating if no one is around to open sides
- Drip tape or micro sprinklers for irrigation
- Spun-bonded rowcover and wire hoops or frame for supporting rowcover



What can you grow in  
your tunnel in Fall and  
Spring?



# Cool Season Vegetables

- Able to tolerate light frost (26° F)
- Grow best with average daytime temperature of 60° to 80°
- Can be seeded August to November and February to April



- Lettuce
- Spinach
- Beets
- Carrots
- Radishes
- Turnips
- Broccoli
- Cabbage
- Bok choy
- Cilantro
- Peas
- Kohlrabi
- Potatoes
- Onions
- And others



# Fast-Growing Warm Season Vegetables

- Will not tolerate temperatures below 32°F
- Generally need soil temperatures above 60°F to germinate seed
- Can be seeded or transplanted in early April for harvest in June
- Pickling cucumbers
- Snap beans
- Summer squash/zucchini
- Basil
- Early tomato varieties

If your garden can be maintained over the summer, you can grow tomatoes, peppers, eggplant, pole beans, and okra in the tunnel and harvest them through October



# Other Crops for the School Year Tunnel

- Flowers
  - Pansies, snap dragons, stock, and sweet peas do well
  - Other frost-tolerant flowers could also work as long as they do not require long days to bloom
- Day neutral strawberries
  - Need to be maintained over the summer, but will fruit September – November and April - June

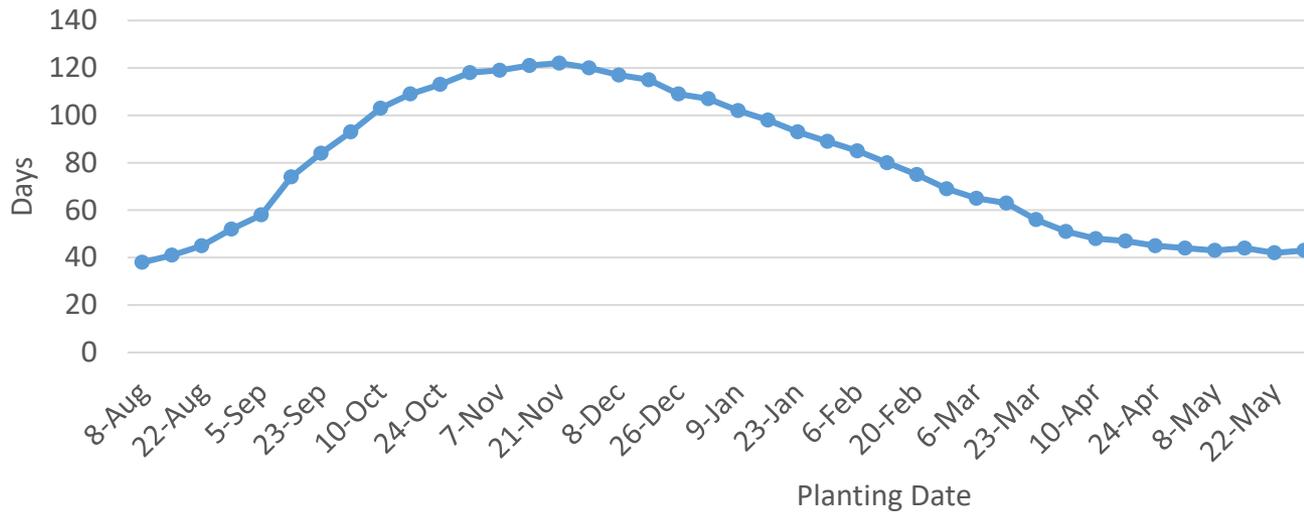


# Timing the Harvest

- Plants do not measure time in calendar days
- Instead, growing time is measured using a combination of temperature and daylength:
  - (Average temperature for calendar day – threshold for species) \* hours of daylight = growth units
  - Most cool-season crops have a threshold of 40°F
  - On a day in June with an average temperature of 67°F and 15 hours of light a crop would accumulate  $(67-40)*15 = 405$  growth units
  - In the tunnel in February with an average temperature of 55° and 10.5 hours of light the crop accumulates only 157.5 growth units
- Crops take much longer to mature in the Fall, Winter and Spring than in Summer



Effect of Planting Date on Days to Harvest for a 40-day Crop



Data from Eliot Coleman 'The Winter Harvest Handbook'

- The days to maturity in the seed catalog is based on summer growing
- For fall seeding multiply days by 3
- For late winter seeding multiply days by 2
- Crops seeded in November will be harvested in March or April



# Planning for Winter Harvest

- To have harvestable crops in December – February seed in August and September
- Goal is for plants to reach harvestable size by November 11
- Essentially no growth November 11 – February 14 due to insufficient light

Crop	Seed By
Baby Kale	1-Oct
Spinach	21-Sep
Cilantro	11-Sep
Carrots	11-Aug
Green onions	11-Aug
Leaf Lettuce	1-Sep
Baby Lettuce	1-Oct
Radishes	7-Oct
Turnips	1-Sep
Bak Choi	11-Sep



# Resources for High Tunnels and Winter Growing

- ‘The Winter Harvest Handbook’ by Eliot Coleman
- Johnny’s Winter Growing Guide  
<http://www.johnnyseeds.com/t-winter-growing-guide-high-tunnel-scheduling.aspx>
- Cornell’s High Tunnels in Schools Project  
<http://www.agclassroom.org/ny/programs/hightunnels.htm>
- Hightunnels.org
- Northeast SARE Learning Center  
[www.sare.org/Learning-Center](http://www.sare.org/Learning-Center)
- URI Cooperative Extension
  - Rebecca Brown [brownreb@uri.edu](mailto:brownreb@uri.edu)
  - Andy Radin [andy\\_radin@uri.edu](mailto:andy_radin@uri.edu)



A long, narrow greenhouse under construction. The structure is made of silver metal poles and clear plastic covering. Several workers are visible, some standing on red ladders, working on the interior structure. The ground is dirt, and there are wooden benches or structures on the right side. The sky is clear and blue.

Questions?