THE UNIVERSITY OF RHODE ISLAND COOPERATIVE EXTENSION

VEGETABLE PRODUCTION

THE WEEK IN VEGETABLES

October 31, 2020

Photo: Heather Faubert

Winter High Tunnel Environment: Limiting factors to growth

Your tunnel plantings have all popped and they've been growing. The warm weather has been great. But it's getting darker. And the growth is slowing. Here comes cold. You're probably wishing you seeded just a week earlier. But you can't turn back the clock. Are you doomed?

Here are the environmental parameters that affect your winter crops, ways to modify the environment, and some trade-offs.

Light is the most limiting factor

If you want plant growth in the winter, you'll have to be understanding of the fact that **light is the most limiting factor**. Unless you supplement with artificial light, you can't change that unless you move to a much lower latitude. So it may help to adjust your expectations by knowing when your plants really won't grow much, and when they will.

Available light for photosynthesis is a combination of light duration and intensity. The measurement is called the Daily Light Integral (DLI) and is expressed as moles per meter^2 per day.* In general, plants grow very slowly or barely at all when DLI is 10 or less, which is generally the case in our latitude and climate from mid-November to mid-February. As we move into March, DLI can reach 20 or more. In June, average DLI in June is in the low 40s in the Northeast and upper Midwest. This link brings you to a really interesting map of DLI for the US. Note that climate also influences DLI (i.e. cloudy precipitation days.)

These measurements reflect conditions directly under the sky. But greenhouse plastic, especially a double layer (which is really important for winter insulation) only lets through 65% to 70% of daylight. So that should lower your expectations even more (for big growth in the middle of the winter.)

For winter growing, the choice of the orientation of your tunnel is no contest: East-West. The long side should be facing south to receive the most sun. And taller crops should be planted in the north beds so they don't shade anything else out.

In second place: Temperature is limiting

It's not a distant second place, either, because there will be no growth with temperatures consistently under freezing. Obviously, it's necessary to choose crops which are hardy enough to withstand subfreezing temperatures without damage. All of these crops can actually tolerate subfreezing temperatures through the following mechanisms:

- By concentrating sugars and other dissolved antifreeze-like compounds in cell sap, **the freezing point is lowered**.
- Water in cells also can move into the intercellular spaces where ice crystals can form without rupturing cell walls.
- Proteins are made in those cells that keep them from being harmed during this cell dehydration.
- The waxy cuticle layer also thickens, though the tunnel environment is often wind-less, so this plays a lesser role.

Mechanisms like these gradually kick in during the acclimation

***Intensity is measured in horticulture as # of photons hitting a unit area per time period. Photons are "light particles". One Mole is 6 X 10^{23} of particles. (You may recall this number from high school chemistry as "Avogadro's Number." A mole of oxygen molecules is 6 X 10^{23} oxygen molecules.)**

Pest Spotlight

Spinach Downy Mildew is increasingly common in fall and winter spinach, both inside and outside the tunnel. There's now **17** races of this water mold. This makes breeding for resistance difficult: while there are resistant cultivars, each is not resistant to all races. Still, there are some better choices, such as 'Carmel' and 'Escalade.' Moisture and humidity management are most important of all, as well as rotating away from locations where disease occurred previously. See this link from Cornell for more detail. (Photos: Heather Faubert)

Below**: Daikon Radish cover crop** at Little State Flower Company in Tiverton. This lush and flourishing cover was clearly planted in time (early August) to grow serious tops and deep roots, without irrigation. It loosens soil and reaches down to nutrients deep in the soil profile, particularly P, bringing them closer to following crops' rooting zone**.** (Photos: Anna Kocon)

period known as “hardening-off.” If you’ve planted into your tunnels in September, the gradual seasonal change will make this happen. But if plants grown in warm conditions are suddenly plunged into freezing conditions, they won’t survive.

We can modify temperature by implementing practices that take advantage of the all-important Greenhouse Effect. First, consider what you get when you have **a clear plastic tent over damp soil in the winter.** If it’s daytime and the sun is shining:

- You get warm air.
- If the heat can’t easily escape, you get *really* warm air.
- You get a lot of humidity: water stored in the ground as liquid turns into water vapor that fills the air. The warmer the air is, the more water vapor can be held by the air. Also, the warmer it is, the more water is transpired out into the air by the plants- unless the air is fully saturated with water (100% R.H.) In that case, plants won’t transpire. They also won’t transpire if the soil is frozen.
- You get condensation on the inside of the plastic cover in the daytime when the moist air comes into contact with the cold surface of the cover. This interferes with light transmission.
- You get *storage* of heat: the soil and its moisture are a perfect heat sink (mass which can absorb energy.) So you get warm soil, at least within the top few inches of the surface. Energy is not conducted to a great depth, though, because the Earth is a massive mass. Which is a good thing.

On cloudy days, the air doesn’t warm up much inside, and the relative humidity does not increase much, either. In fact, such a steady state is better for plant survival than big day/night fluctuations.

Heat loss

If it’s nighttime and the sky is clear, heat energy stored in warm masses on the Earth’s surface (such as a high tunnel) can freely radiate right through the plastic and out into space. (This is called radiational cooling.) This is usually the primary form of heat loss from a decently sealed-up high tunnel. Heat is also lost (in the form of “long wave radiation”) through the plastic and hoops (conductive heat loss) and through gaps that allow warm air to directly escape (convective heat loss.)

On cloudy nights, the cloud layer of water vapor acts like a blanket, holding heat in at the Earth’s surface. This keeps the night air from cooling down as much. And that, in turn, reduces the radiant heat loss from the high tunnel. The tunnel cover, itself, does *not* act like a blanket of clouds.

Inside the tunnel, the soil and other objects re-radiate heat during the night, and that heat passes through the tunnel cover (again, radiational cooling.) Also, the more above-ground mass stored inside the tunnel, the more absorption of heat during the

day and re-radiation at night. This is why some people put black barrels full of water inside their tunnels. Remember, though, that they should be along the north side so they don't cast shadows during the day.

Row covering adds another important layer of protection

This is essential for *survival* of most crops once the temperature gets down below 25°F, though some can survive down to the upper teens. There is no exact trigger temperature to apply row covers but to be safe, go with 35°F. Row covers work as miniature cloudy blankets over your crops: warm, moist air radiates from the soil and condenses on the inside of the cold fabric. It's essential that the covers are suspended over hoops so that the fabric is not in contact with the plants. Not only does this keep leaf surfaces from staying wet for long periods, it also prevents ice on the fabric from being in contact with foliage. If it is expected to get below 20 inside the high tunnel, a second cover may be necessary. It is very important to put on covers in such a way that makes it easy to remove them on sunny days. Also, cover edges should be fully on the ground to avoid convective heat loss. There are many innovative farmers who have developed assorted systems for this.

As long as you've chosen the right species, crops handle conditions pretty well, although extreme temperatures, low *or* high, could be injurious. Plants can freeze but they shouldn't be handled until they have thawed, or else they will suffer damage. Though harvest/washing/packing days are somewhat infrequent, monitoring of conditions and consequent chores to ensure plant health and safety are constant. Daily weather conditions will determine your management activities.

Humidity control

As mentioned before, hoops should be installed in preparation for the real cold. Make sure they are spaced closely enough to suspend fabric over the crops. The heavier-weight the cover you use, the more it will sag, especially when soaked with condensation, and the less light will penetrate. In months when the sun is higher (October, February, March), make sure that the temperature under the cover doesn't get above 75°F. Removal of covers would then be required by mid-morning, lest you accidentally cook your crop. Plants cool themselves by transpiring and if roots are sluggish from cold soil while the leaves are warm, it could be a disaster. Cover removal also allows the sun to heat the soil more, which, when covered back over late in the day, holds in heat for the cold night ahead.

Venting of the entire tunnel may also be required for reduction of both temperature and humidity. You don't want condensation on the high tunnel plastic during the day because it interferes with light. It can also keep the foliage wet, which leads to foliar disease. Avoid overwatering: it can lead to an excess buildup of humidity. Again, excess humidity results in wet leaf surfaces and more disease. Much of the soil moisture will hold pretty well through the darkest months when there's little growth, evaporation from the soil surface, or transpiration through the plants.

Your Input is Welcome

Please submit updates from your farm–

a paragraph or two in an email is all it takes. Also, please submit suggestions for articles, meeting topics, and research needs from us at URI.

Cinch down your rollup sides for the winter by mid-October by tucking the end-edges of the rollups into wiggle-wire tracks (to avoid nighttime convective heat loss.) Do your venting from the end walls, either by opening the doors, or having louvre vents near the peaks. High vents are better, both for convective flow and to keep cold winds from blowing on your crops.

Depending on the date (check DLI), full sun may not be strong enough to raise the temperature by very much. In that case, you may choose to vent the tunnel but leave the covers on, or vice-versa. It may depend on whether or not it's a harvest day or how humid the air is. Lots of condensation is a reason to vent the whole tunnel.

Any venting or uncovering that you do has to be put back in place by mid to late afternoon. Hold in any heat you gained during the day. If you can't always be there at the right times, play it safe, based on the weather forecast.

Make use of thermometers so you can accurately assess what's going on, both under the row covers and in the high tunnel space, night and day. (Monitoring tools may be the subject of a whole 'nother article.) Keeping records of temperatures and your management tactics will help you to learn what works best under various conditions through the winter months.

Sources:

Biernbaum, John, 2013. Hoophouse Environment Management: Light, Temperature, Ventilation. MSU Horticulture.

Maynard, Elizabeth and Michael O'Donnell, 2019. Managing the Environment in High Tunnels for Cool Season Vegetable Production. Purdue University. ag.purdue.edu/hla. HO-297-W.