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XVI - Managing the Indoor Climate of Your SunCatcher

Operating a greenhouse involves taking care of the plants (food crops, ornamentals, ...) you intend to grow, but also managing its internal climate conditions that allow those crops to thrive. Unlike commercial, conventional greenhouses using fossil fuels for heating, lighting and ventilation, passive solar greenhouses use the Sun and natural processes to regulate internal temperature, humidity and O_2/CO_2 levels. Successful operation of a PSG requires an understanding of the biophysical conditions (weather/climate, terrain, ..) at your location. This chapter will guide you in operating your SunCatcher by describing weather scenarios throughout the year and strategies we have used to successfully manage the SunCatcher.

Management of your SunCatcher begins with understanding the sun and its position in the sky throughout the year. It is easier if you think about the day in terms of sunrise, sunset, and solar noon (mid-way between sunrise and sunset) instead of using standard or daylight-saving time. The strongest sun occurs in the 3 hours before and after solar noon, when the sun is at the highest point in the sky, *not* when the clock reads 12:00pm. Locations will experience slight variations in solar noon, sunrise and sunset times depending upon longitude.

Solar time has to do with the time taken by earth to rotate on its axis. One rotation defines a **solar day**. But the speed of the earth along its orbit around the sun is not constant. The length of day is irregular because the earth must complete more than one rotation before the sun returns to the same meridian. The constant **sidereal day** is defined as the interval between two successive apparent transits of a star (the first point of Aries), across the same meridian. If the sun is at the equinox and overhead at a meridian one day, then the next day the sun will be to the east of the first point of Aries by approximately one degree. Thus, the sun will not cross the meridian until about 4 minutes after the sidereal noon (in other words, a day is 24 hours and 4 minutes in length., based on when the sun passes the same meridian (degrees longitude). Source: B.M. Willett, ed. 1987. The Great International Atlas. New York: Portland House.

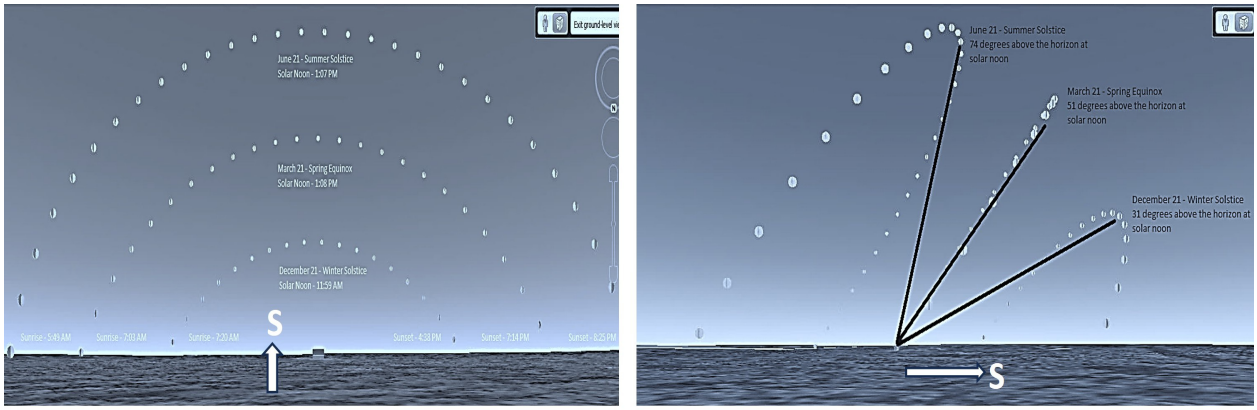


Figure XVI.1. Solar noon marks the middle of the day when the sun is at its highest point and is due south in the sky. The dots mark the Sun's path on the Summer Solstice (June 21), Spring and Fall Equinoxes (March 20 and September 20), and on the Winter Soltice (December 21). Left is looking South from the SunCatcher, at right is looking East.

Between the mid-Fall to mid-Spring period (roughly, Nov 6 through May 5), a general operating principle for your SunCatcher is to start opening vents at approximately 10am as the sun warms the interior, and then close these vents at around 3 pm as photosynthesis declines. Your SunCatcher can then capture heat in the late afternoon to carry over through the night and into the next morning. The number of vents to open/close and how much to open them depends on outdoor (ambient) temperature, cloudiness, and the optimal growing temperature to maintain inside the greenhouse. Other factors such as wind speed and direction, insulation amounts, location, and number of plants will factor in the performance of your SunCatcher.

As you become more familiar with your SunCatcher's responses to variable weather situations, you will become more proficient at its management and be able to predict daily strategies based on the weather forecast. For a more detailed understanding, we describe four hypothetical days and management scenarios below with information regarding the management of your SunCatcher; the times are based on our observation in Boone, NC, which you need to adjust to your time zone and location.

DAY 1 - December 21

Sunrise: 7:34am	Temperature High: 20°F
Solar Noon: 12:24pm	Temperature Low: 9°F
Sunset: 5:15pm	100% Sun (clear skies)
Day length: 9h 41m	

December 21 is the shortest day of the year. For this scenario, the day will only be 9 hours 41 minutes long. The sun will travel the shortest and lowest path across the southern sky from east to west. By around 9:00am, sunlight will strike the south glazing of the SunCatcher, the interior will start heating up and plants will begin photosynthesis. The thermal mass absorbs some of this heat to replenish heat lost the night before to maintain the interior temperature. As photosynthesis kicks in, the plants will be absorbing carbon dioxide while releasing water vapor and oxygen, increasing humidity but decreasing carbon dioxide levels. Some ventilation may then be required to vent excess heat and humidity while bringing in fresh air with replenished carbon dioxide levels. Because it may be cold outside, some lower south-facing vents in the center may be opened one-two inches and the upper vents are opened only slightly. Watch interior and ambient temperatures to see what works best (that is, the number of vents to open and by how much) for various weather scenarios.

Because the day length is the shortest of the year, so is the photosynthetic period. All vents should be closed around 3:00PM to allow the SunCatcher to capture and store more heat with the remaining sunlight in preparation for the cold night ahead.

DAY 2 - February 3

Sunrise: 7:27am	Temperature High: 35°F
Solar Noon: 12:40pm	Temperature Low: 25°F
Sunset: 5:54pm	0% Sun
Day length: 10h 27m	

For this scenario, the day will be overcast, so plants will conduct minimal if any photosynthesis, and the interior will not gain heat. The thermal mass will be releasing heat throughout the day in order to maintain the interior temperature and will recharge on the next sunny day. The plants will be absorbing minimal carbon dioxide and releasing little if any water vapor, so no ventilation is required. The vents will remain closed to conserve heat in the SunCatcher.

DAY 3 - March 21

Sunrise: 7:30am (DST)	Temperature High: 60°F
Solar Noon: 1:34pm	Temperature Low: 35°F
Sunset: 7:38pm	100% Sun (clear skies)
Day length: 12h 8m	

March 21 marks the first day of spring and marks the sun's halfway point in its climb to its highest position in the sky on June 21 (summer). For this scenario, the day will be 12 hours 8 minutes long and solar noon will be at 1:34pm (DST). The sun will have a longer and higher path across the southern sky from east to west than on December 21. This allows the photosynthetic and heating periods of the SunCatcher to be longer. Daytime temperatures inside the SunCatcher can get very warm on sunny spring days.

Around 9:00 am, as sunlight starts to enter the south glazing of the SunCatcher, plants will begin photosynthesis, and the interior will collect heat energy and warm. The thermal mass will be absorbing some of this heat to replenish heat it lost the night before. The plants will be absorbing carbon dioxide while releasing water vapor. The SunCatcher is heating up, humidity is increasing, and carbon dioxide levels are decreasing.

Mid-morning, when sufficient heat has been gained, initiate more ventilation than on December 21. This will vent excess heat and humidity while bringing in fresh air with replenished carbon dioxide levels. Because it is mild on the outside, the lower south-facing vents are opened two-six inches and the upper vents are opened as needed to regulate the interior temperature without allowing it to overheat. All vents are closed by 3:00PM to allow the SunCatcher to capture and store more heat with the remaining sunlight in preparation for the colder night as needed. (Watch your temperatures to see what works best for your various weather scenarios.)

As nights stay consistently warmer (10^0C / 50^oF or better), all vents (including back north wall vents) can be left open.

DAY 4 - March 21

Sunrise: 7:30am (DST)	Temperature High: 52°F
Solar Noon: 1:34pm	Temperature Low: 45°F
Sunset: 7:38pm	50% Sun (partly cloudy)
Day length: 12h 8m	

Here is March 21 again, but with cloudy skies allowing only about 50% sun and a lower daytime temperature. Plants will be limited in the amount of photosynthesis because of the cloud cover, and the interior will be gaining heat only when the sun peeps through the clouds. The thermal

mass will be absorbing some of the heat lost the night before. The plants will be absorbing carbon dioxide while releasing water vapor, but at lower levels compared to a clear day.

When sufficient heat has been gained, some ventilation can be used based on weather conditions. The humidity levels will not be as high and the carbon dioxide levels will not be as low as during a sunny, clear day with full photosynthesis occurring. All vents are closed by 3:30-4:00PM if not before to allow the SunCatcher to capture and store more heat with the remaining sunlight in preparation for the cooler night.

Spring and Fall are times when the sun can be very direct into the SunCatcher, with periods of too much direct sunlight that can overheat the greenhouse. To reduce overheating, we recommend using shade cloth (over or under the glazing) or a retractable awning.

SunCatcher management during the Summer

As the days get longer and through the summer months, the SunCatcher is designed to have the opposite performance than it does during winter. It deflects the direct radiant energy of the sun that is high overhead and provides a shaded, diffuse light-filled growing area that provides protection from storms (see Figure VI.1). During the hottest days, all vents (front and back) and doors should be opened to provide proper ventilation to the plants. You may want to install a shade cloth if the summer temperatures remain too hot even with full ventilation for the plants you choose to grow.

The hot summer months also provide an excellent time to clean out and sterilize your SunCatcher for the next growing season. You will want to wipe down surfaces, pots, floors, etc. with a dilute solution of vinegar. After completing the disinfecting, you can seal your greenhouse completely for a week or two in order to try to build up excess heat to sterilize it with high temperatures.

Cold Weather and your SunCatcher

In cold climates, extreme low temperatures can occur during the months from November through April. December 21, winter solstice, marks the shortest day of the year in terms of available sunlight in the Northern Hemisphere. However, your SunCatcher has been designed to capture the maximum amount of sunlight on sunny, cold winter days when it performs at its best. This period is actually SunCatcher 's summer when it is filled with sunlight (even more when there is snow on the ground!). On a clear winter day, you can expect full photosynthetic potential for your plants. The SunCatcher 's heat gain will be much higher on a clear, 20°F day than a cloudy, 35°F day.

The sunlight is doing three things: (1) providing light for photosynthesis, (2) providing heat for storage in the thermal mass, and (3) providing more than enough heat for the optimal interior temperature. The "more than enough heat" is important because this allows you to ventilate the space during the photosynthetic period of the day, which releases the excess heat and humidity and brings in fresh air with replenished carbon dioxide levels.

Temperatures should be monitored to help you understand the performance at your specific location. A thermometer is the most important tool for managing your SunCatcher. Keeping records and reviewing the performance of your SunCatcher during variable weather will help you quickly understand its management. Understanding the temperature range needed for the types of plants you are growing and maintaining that temperature range with successful ventilation strategies will increase production. Note that plants require several degrees cooler conditions at night than during the day.

While SunCatchers will start heating in the morning shortly after the winter sun rises, the further north (south in the southern hemisphere) a SunCatcher is built the longer it will provide heat into the spring and the earlier in the fall when heat may be needed.

NOTE:

- Be careful not to place cold-sensitive plants close to the vents during the cold weather months. During ventilation, these plants may be harmed by the influx of cold air from the outside.
- Plants may also be harmed by stratification of the air on cold days/nights (=cold air settling in a 1ft or so layer along the floor). The use of ceiling fans that blow (warm) air down can prevent stratification by mixing the interior air.

Managing humidity levels

Humidity levels are a reflection of the amount of moisture in the air and its temperature. In modern crop management, Vapor Pressure Deficit (VPD) expresses the relationship between air temperature and relative humidity (RH) - the difference between the amount of moisture in the air and how much moisture the air can hold when it is saturated at a particular temperature. Both low and high humidity levels stress plants and depress their yields. The VPD is low when the RH is high and moisture from the air starts to condensate on the glazing, leaves, and other cold surfaces; leaf wetness may lead to fungal diseases. As explained in Chapter X, plants transpire 50-300 water molecules for each molecule of carbon dioxide absorbed. But, if the air approaches 100% RH, they cannot release these extra water molecules, thus slowing down or halting photosynthesis. On the other hand, a high VPD means the RH is low and plants need to draw more water through their roots translating into high transpiration rates. When the plants can't keep with sucking up more water, they close the stomata in their leaves and stop photosynthesizing. You can see that, for example, in leafy greens dropping their leaves mid-day to protect themselves from too much sun and water demand - no, they are not dead, they will perk up once the sun goes down and temperatures drop in the evening.

The ideal VPD range in a greenhouse is from 0.45 kPa to 1.25 kPa, ideally sitting at around 0.85 kPa. As a general rule, most plants grow well at VPDs of between 0.8 and 0.95 kPa (source: Wikipedia , accessed Aug 18, 2025). A home grower most likely will have a mixture of different crops and plants at different life stages growing year-round, so you would need to figure out a VPD range that works best for the things you grow. Table XV-2 below indicates recommended VPD at different life stages of crops.

Table XV-2. Recommended VPD levels at different life stages of plants.

Recommended Leaf VPD

Leaf cooler than room temp by: 4 °F ≈ 2.25 °C

Propagation / Early Veg Stage 0.4 - 0.8 kPa
Late Veg / Early Flower Stage 0.8 - 1.2 kPa
Mid / Late Flower Stage 1.2 - 1.6 kPa
Danger Zone Below 0.4 / Over 1.6

Room Temp		Relative Humidity																		
C	F	90%	85%	80%	75%	70%	65%	60%	55%	50%	45%	40%	35%	30%	25%	20%	15%	10%	5%	0%
15	59	-0.06	0.02	0.11	0.19	0.28	0.36	0.45	0.54	0.62	0.71	0.79	0.88	0.96	1.05	1.13	1.22	1.30	1.39	1.47
16	61	-0.06	0.03	0.12	0.21	0.30	0.39	0.48	0.57	0.66	0.75	0.85	0.94	1.03	1.12	1.21	1.30	1.39	1.48	1.57
17	63	-0.07	0.03	0.13	0.22	0.32	0.42	0.52	0.61	0.71	0.81	0.90	1.00	1.10	1.19	1.29	1.39	1.48	1.58	1.68
18	64	-0.07	0.04	0.14	0.24	0.34	0.45	0.55	0.65	0.76	0.86	0.96	1.07	1.17	1.27	1.38	1.48	1.58	1.69	1.79
19	66	-0.07	0.04	0.15	0.26	0.37	0.48	0.59	0.70	0.81	0.92	1.03	1.14	1.25	1.36	1.47	1.58	1.69	1.80	1.91
20	68	-0.07	0.04	0.16	0.28	0.39	0.51	0.63	0.75	0.86	0.98	1.10	1.21	1.33	1.45	1.56	1.68	1.80	1.91	2.03
21	70	-0.07	0.05	0.17	0.30	0.42	0.55	0.67	0.80	0.92	1.04	1.17	1.29	1.42	1.54	1.67	1.79	1.91	2.04	2.16
22	72	-0.08	0.06	0.19	0.32	0.45	0.58	0.72	0.85	0.98	1.11	1.24	1.38	1.51	1.64	1.77	1.91	2.04	2.17	2.30
23	73	-0.08	0.06	0.20	0.34	0.48	0.62	0.76	0.90	1.04	1.18	1.33	1.47	1.61	1.75	1.89	2.03	2.17	2.31	2.45
24	75	-0.08	0.07	0.22	0.37	0.52	0.66	0.81	0.96	1.11	1.26	1.41	1.56	1.71	1.86	2.01	2.16	2.31	2.45	2.60
25	77	-0.08	0.07	0.23	0.39	0.55	0.71	0.87	1.02	1.18	1.34	1.50	1.66	1.82	1.98	2.13	2.29	2.45	2.61	2.77
26	79	-0.09	0.08	0.25	0.42	0.59	0.75	0.92	1.09	1.26	1.43	1.59	1.76	1.93	2.10	2.27	2.44	2.60	2.77	2.94
27	81	-0.09	0.09	0.27	0.45	0.63	0.80	0.98	1.16	1.34	1.52	1.69	1.87	2.05	2.23	2.41	2.59	2.76	2.94	3.12
28	82	-0.09	0.10	0.29	0.48	0.67	0.86	1.04	1.23	1.42	1.61	1.80	1.99	2.18	2.37	2.56	2.74	2.93	3.12	3.31
29	84	-0.09	0.11	0.31	0.51	0.71	0.91	1.11	1.31	1.51	1.71	1.91	2.11	2.31	2.51	2.71	2.91	3.11	3.31	3.51
30	86	-0.09	0.12	0.33	0.54	0.76	0.97	1.18	1.39	1.60	1.82	2.03	2.24	2.45	2.66	2.88	3.09	3.30	3.51	3.72
31	88	-0.10	0.13	0.35	0.58	0.80	1.03	1.25	1.48	1.70	1.93	2.15	2.38	2.60	2.82	3.05	3.27	3.50	3.72	3.95
32	90	-0.10	0.14	0.38	0.62	0.85	1.09	1.33	1.57	1.81	2.04	2.28	2.52	2.76	2.99	3.23	3.47	3.71	3.94	4.18
33	91	-0.10	0.15	0.40	0.66	0.91	1.16	1.41	1.66	1.91	2.17	2.42	2.67	2.92	3.17	3.42	3.67	3.93	4.18	4.43
34	93	-0.10	0.17	0.43	0.70	0.96	1.23	1.50	1.76	2.03	2.29	2.56	2.83	3.09	3.36	3.62	3.89	4.16	4.42	4.69
35	95	-0.10	0.18	0.46	0.74	1.02	1.31	1.59	1.87	2.15	2.43	2.71	2.99	3.27	3.55	3.84	4.12	4.40	4.68	4.96

*Pressure has many different measurements!
1 hPa = 1 mb = 0.1 kPa = 2.09 lb/ft2 = 0.03 inHg = 0.001 bar

Location specific management

Where your SunCatcher is located (rural/urban area, flat or hilly terrain, tree or treeless landscape, ...) also influences the management of your greenhouse. Urban areas are heat-islands with less wind compared to rural areas. On flat open terrain or hilltops, there will be more and stronger winds affecting the greenhouse – in summer, wind will help cool the structure, but wind chill in winter may make it harder to maintain optimum growing temperatures. A windbreak to protect the structure against prevailing winds may mitigate wind chill (more on this in Chapter XVII). On hilly, sloping land with good solar access, it depends on where your PSG is located: cool/cold air settles in valleys which may reduce overheating in summer, but may make it difficult to keep the structure warm in winter. Mid-slope is the best location as farmers have known for centuries to grow frost-sensitive crops - as cold/cool air rolls down the slope in the valley, it pushes up the warmer air in a band mid-slope (Figure XVI.2).

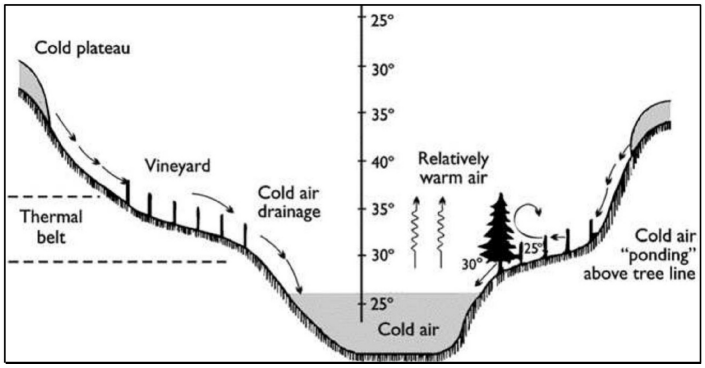


Figure XVI.2. Diagram of temperature inversion due to cold air drainage (Poling, 2008). Source: NC State Extension, 2021.

Trees or a structure build on the slope prevents cooler air from rolling down into the valley; instead, it will pond behind it where it provides a useful resource to help cool the greenhouse in summer through the back (north-wall) vents (Figures XVI.3 and 4). In addition, the shade cast by the PSG keeps the air and soil cool for most of the day even in summer. As the sun starts warming the greenhouse in the morning and with the north wall vents

open, cool air will be drawn through the vents and exits through the upper vents. We observed that this extra cooling lasts until about 11am in the Hawk's Nest SunCatcher. Yes, cool air will also pool behind the greenhouse in the winter, but the back vents will remain closed during this time period and the well-insulated north wall and vents minimize heat loss.

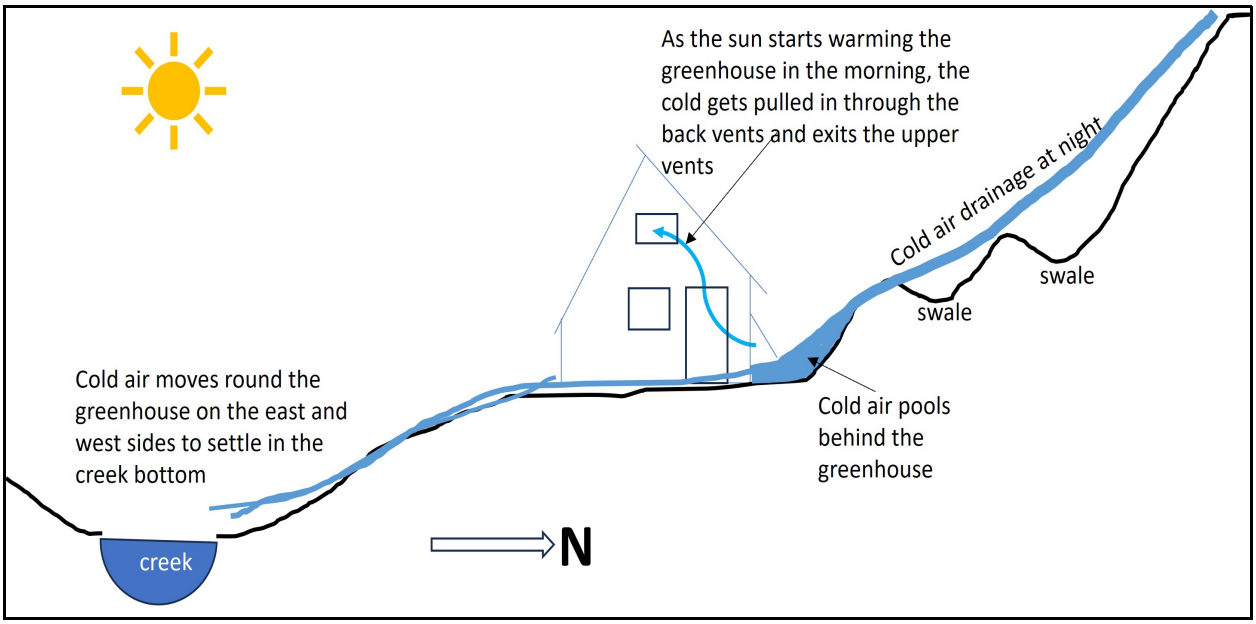


Figure XVI.3. Cooler air rolls down the slope towards the creek, but pools behind the SunCatcher where it helps cool the structure until about 11am in summer.



Figure XVI.4. The shade from the greenhouse plus the pooling of cool air during the night behind the greenhouse provide a resource for extra-ventilation to cool the SunCatcher in the morning hours.

Initial troubleshooting as you set up your SunCatcher

When you have excess heat during the day, but not enough to maintain desired temperatures at night or on cloudy days, you need to add thermal mass. This will absorb more of that excess heat during the day and make it available to release at night. Remember, smaller water-filled containers absorb and release the heat at a quicker rate than larger ones, but larger ones hold more heat and for longer periods.

If you live in a very cold climate and your SunCatcher has adequate heat during the day, but not enough at night or on cloudy days, you have to following options:

1. Add supplemental heat for the night and on cloudy days. As the SunCatcher is very well insulated, a small heater running intermittently will do the job.
2. Install a thermal blanket to prevent heat loss through the glazing surface at night. Remember, though, that the colder the air temperature, the fewer clouds and the more sun to heat your greenhouse during the day. However, it will also cool off more through radiative heat loss at night, so a nighttime curtain may help reduce heat loss.

If you have excess heat levels during the day and adequate ones during nights and on cloudy days, you probably live in a warm climate requiring more ventilation during the day. This is good because it will provide fresh air for your plants.

During prolonged cloudy periods, the temperature of your SunCatcher needs to be monitored closely as the thermal mass will be losing heat without recharging. If this lasts for an extended period, a supplemental heat source may need to be added to maintain an adequate temperature for your plants.

Plants that exhibit slow or no growth, are spindly, have yellow leaves, or are late flowering may need supplemental lighting during the shortened days of winter. Yellow and/or falling leaves may be due to over-watering, pests or diseases. Another cause can be stratification of the air in the greenhouse (i.e., cold air settling along the floor, pushing up warmer air). Ceiling fans to push warm air down will mix the air to eliminate this stratification.

Plants with scorched patches on leaves, faded leaves, or leaves drying out and falling off may be getting too much light and need to be placed behind other plants or shade cloth needs to be installed against the glazing. However, shade cloth will reduce the thermal performance of your SunCatcher.

Reference

NC State Extension. 2021. Diagram of temperature inversion due to cold air drainage by B. Poling (2008). In: Prevention and Management of Frost Injury in Wine Grapes. https://content.ces.ncsu.edu/prevention-and-management-of-frost-injury-in-wine-grapes , accessed July 12, 2026.