Save energy, but watch for hidden risks

By Peter Ling, Claudio Pasian and Michelle Jones

Tightening a greenhouse saves money but may create other problems.

Tightening a greenhouse can save energy Reducing infiltration heat loss by sealing cracks and other openings in a greenhouse is a good idea for energy conservation. A tight greenhouse may also result in high humidity, low carbon dioxide and high ethylene levels that are undesirable for plant production. You may need to adjust management practices to ensure quality production and maintain profitability.

Humidity management

The most obvious result of tightening a greenhouse is high humidity. A poly house is more airtight than a glass house, and thus more likely to have higher humidity.

Tightening a poly house to increase energy efficiency can lead to the accumulation of additional moisture. This moisture can increase the incidence of botrytis and other fungal diseases. To reduce disease pressure, keep relative humidity in the greenhouse below 85 percent to prevent condensation on the plant surface.

Using a heat-and-vent dehumidification strategy is an effective way to reduce relative humidity. Typically, you can temporarily raise the greenhouse temperature a few degrees higher than the normal set point before venting. Warmer air absorbs more water and subsequent venting of this air more effectively reduces moisture levels in the greenhouse. However,

A tight greenhouse, while saving on energy, may result in high humidity, low carbon dioxide and high ethylene levels.

the associated energy cost is the highest among the possible alternatives for reducing moisture levels.

Keep the plant canopy dry to reduce disease. Irrigation, condensate dripping from the greenhouse structure and condensate on the plants themselves result in wet conditions that favor disease. Condensate forms when warm, moist air contacts cold surfaces. Keeping the air dry and/or increasing surface temperatures minimize condensation.

Growers should keep plants warm and keep the relative humidity low around the plants. To lower the relative humidity around plants, reduce sources of moisture and provide sufficient air movement. An air velocity of 2 feet per second is desirable. In case you can't measure air velocity, slight leaf movement is a good indicator of sufficient air movement.

Evening out the moisture

Evening out moisture distribution in the greenhouse can prevent condensate from forming on the plant canopy. Plants transpire both day and night, and the moisture trapped in the plant canopy should be removed to reduce high local relative humidity and to prevent condensation.

Horizontal-airflow circulation is an effective way to balance moisture in the canopy and in all parts of a greenhouse. Horizontal-airflow fans can provide this air movement.

Vertical air movement is also heneficial. Holes in growing trays, bench tops with openings, lifting plants off the ground and bottom heating allow gentle vertical air exchange throughout the plant canopy without the need for extra fans.

Provide adequate carbon dioxide

If ventilation is minimized and greenhouses are sealed tightly to prevent heat loss and to conserve energy, carbon dioxide levels may be depleted. Plants need carbon dioxide for photosynthesis.

Because of the high costs of heating greenhouses, some energy-conscious growers have sealed greenhouses to reduce air leaks.

Plants that are well-watered and -fertilized can take advantage of the light and photosynthesize in tightly closed greenhouses. By doing so, plants remove carbon dioxide from the air. Since the greenhouses are closed, carbon dioxide removed by the plants cannot be replaced by outside carbon dioxide. This results in carbon dioxide depletion and a lower photosynthetic rate. When the carbon dioxide level drops below 200 parts per million, photosynthesis stops and plants stop growing. In this situation, energy is wasted keeping plants warm while they are not growing.

Maid proper carbon dioxide level

Research has shown beneficial effects of providing supplemental carbon dioxide greenhouse vegetable and floriculture crops. This research has shown that increasing carbon dioxide levels three to five times the ambient level will increase yield and quality and often shorten production times. Some crops,, such as tulips and Easter lilies, do not respond to supplemental carbon dioxide, and for other crops the level of response **is culticar-dependent**. Measure greenhouse carbon dioxide levels using a small portable meter.

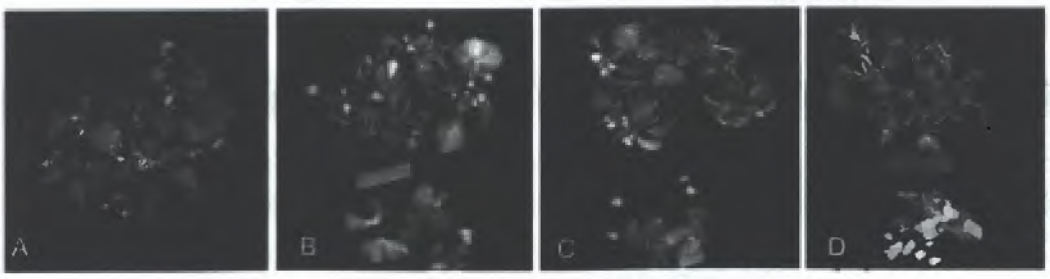
Fuel combustion. This is the most common carbon dioxide generation method. Clean burning of a fuel like propane produces carbon dioxide and water. Unvented heaters increase the carbon dioxide level by releasing combustion gases inside the greenhouse. There are two concerns with this enrichment method: possible contamination from ethylene or other gases and that these heaters are operated more often at night when plants are not photosynthesizing as much and the additional carbon dioxide is not needed.

Pumping gases. Another method to increase carbon dioxide levels is to pump some of the flue gases from large boilers into the greenhouses. Regardless of the combustion method used, the absence of contaminants is essential.

Adding pure carbon dioxide. The use of pure carbon dioxide is ideal if it's price competitive. Liquid carbon dioxide is stored in special tanks and then released inside the greenhouses using perforated plastic tubes. Carbon dioxide can be diffused evenly through a greenhouse using a horizontal-airflow system.

Plant sensitivity to ethylene

Ethylene is a hormone produced by plants. It has biological activity at very low concentrations. Plants produce ethylene when they are wounded, under stress or when flowers or leaves senesce. The end result is often leaf yellowing, flower wilting or abscission of buds, flowers or leaves. When plants are exposed to ethylene in the greenhouse, leaf, flower or whole plant senescence accelerates.



Ethylene damage symptoms on impatiens include bud, leaf and flower abscission.

The extent of ethylene damage depends on the level of sensitivity of the plant, the concentration of ethylene, exposure time and the developmental stage of the plant.

Mature flowers and buds are more susceptible to damage than young buds or leaves so symptoms appear on these tissues first. At higher temperatures or under drought stress, ethylene damage is more severe.

Symptoms of ethylene damage include:

- Shedding or shattering of flower petals.
- Bud, flower or leaf drop.
- Rapid flower aging and wilting (i.e., senescence).
- Epinasty or drooping of the leaves and bracts.
- Flower bud abortion.
- Leaf chlorosis.

Crops very sensitive to ethylene

Plant	Visual symptoms
Begonia (fibrous)	Flower and flower bud abscission.
Fern (Bostan)	Defoliation.
Geranium	Flowers do not open, petal shattering, leaf chlorosis.
Impatiens	Bud, leaf and flower abscission.
New Guinea impatiens	Bud and flower abscission.
Kalanchae	Buds da nat apen, petal fading and drying, open florets close.
Lily (Easter and hybrid)	Floral bud abscission, flower numbers reduced.
Orchid (Cattleya)	Accelerated flower wilting and senescence.
Petunia	Accelerated flower wilting and senescence.
Snapdragon	Flower abscission.
Tomato	Epinasty, no fruit set.

- Malformed leaves or flowers.
- Stunted growth.

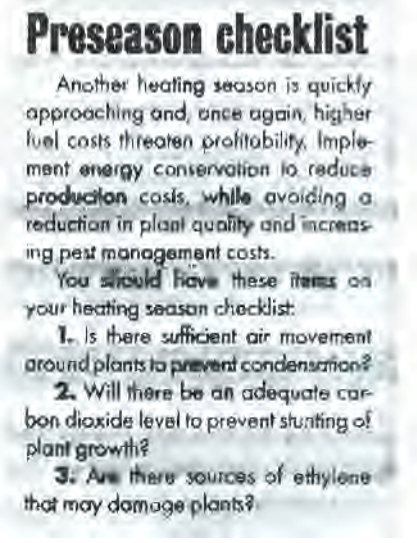
Spotting sensitivity early

For some species, like petunia, ethylene sensitivity can be very cultivar specific so it is difficult to generalize an entire species. Plants classified as very sensitive to ethylene

Tomato plants placed directly below this unit heater will indicate any ethylene given off by the heater.

are good indicators of ethylene damage. They will show the first visual symptoms of ethylene contamination in the greenhouse.

The best way to determine if ethylene is present is to carefully monitor plants sensitive to the gas. Ethylene damage can easily be confused with other types of stress that cause similar



Preseason checklist

Another heating season is quickly approaching and, once again, higher fuel costs threaten profitability. Implement energy conservation to reduce production costs, while avoiding a reduction in plant quality and increasing pest management costs.

You should have these items on your heating season checklist:

1. Is there sufficient air movement around plants to prevent condensation?
2. Will there be an adequate carbon dioxide level to prevent stunting of plant growth?
3. Are there sources of ethylene that may damage plants?

Ethylene sources

Ethylene gas can be a byproduct of incomplete fuel combustion. While it is not harmful to people (like carbon monoxide), it can be detrimental to plants.

If a greenhouse is tightened up and there is little ventilation, ethylene concentrations can accumulate and cause plant damage and death. Growers need to be aware of potential sources of ethylene and recognize ethylene toxicity symptoms. An improperly functioning greenhouse heating unit is the most source of ethylene contamination.

Others sources include:

- Exhaust from combustion engines.
- Cigarette smoke.
- Leaky gas lines or contaminated fuel.
- Ripening fruit.
- Senescing flowers.
- Dying and decaying plant material.
- Wounded plant tissue.

damage so you may want to locate indicator plants near potential ethylene sources such as heating units.

Preventing ethylene damage

Here are some management practices that can be used to prevent damage caused by ethylene gas.

- Proper use and Maintenance of greenhouse heating units is the best way to prevent ethylene damage. Regular maintenance can identify leaks or cracked heat exchangers that may result in harmful levels of ethylene.
- Adequate greenhouse ventilation can prevent toxic gases from reaching harmful levels.
- Use of electric carts, forklifts or bicycles rather than modes of transportation that burn gasoline or propane.
- Pick up and properly discard dying and damaged plant material.

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