



Erin C. Hill
hill12@msu.edu



Roberto G. Lopez
rglopez@msu.edu

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Epinasty, malformation & bud abortion, what are the possible causes?

The distortion and stunting of plants, along with reduced/delayed flowering and bud abortion are not uncommon observations during cold winter months due to ethylene exposure from faulty or improperly vented heaters. Other causes to consider year-round include injury from plant growth regulators (PGRs) or herbicides.

The recent arctic air sitting over much of the United States is causing greenhouse heaters to run much more frequently or be turned on for the first time in southern locations. Over the past two decades, growers in temperate regions have reduced their heating bills by insulating and sealing up their greenhouses or they have taken advantage of new greenhouse designs and technologies. Regardless of these changes, most rely on either unit heaters or boilers to heat their greenhouses during the winter months. Some smaller growers may also burn wood within the greenhouse. Growers in southern regions who do not typically have permanent heaters in their greenhouse are utilizing unvented portable heaters to save their crops (Figs. 5 and 6). Unfortunately, we are seeing some crop injury due to faulty, damaged, improperly vented unit or portable heaters. The symptoms



Figure 1. Unit heater in a high wire tomato production greenhouse.

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often mimic those of herbicide injury and the underlying issue is often ignored.

Unit heaters can burn no. 2 fuel oil, kerosene, propane, or natural gas. The products of burning most fuels are carbon dioxide (CO₂) and water (H₂O). However, combustion is most often incomplete resulting in the release of deadly carbon monoxide (CO), sulfur dioxide (SO₂), and ethylene (C₂H₄). These impurities can be toxic to either plants or humans if not properly vented.

Ethylene

Ethylene (C₂H₄) is an odorless and colorless gas that is produced by both biological (ie. plants as a hormone) and non-biological sources (ie. by-product of combustion). As a plant hormone it plays a role in seed germination, adventitious rooting, fruit ripening and flower and leaf senescence. It is a simple organic substance that is highly active at very low concentrations. You maybe familiar with the effects of C₂H₄ if you use ethephon (ie. Florel or Collate) on your crops to abort unwanted flowers, induce branching or reduce stem elongation. Some crops such as tomatoes are highly sensitive to C₂H₄ and major losses are reported each year from non-biological sources (Table 1). The major source of ethylene in greenhouses is from the combustion of fuels and wood due to improper venting, cracked heat exchangers (Figures 2, 3, and 4), exhaust from fork lifts, blowers, trimmers, vehicles, and carts that use combustion engines, gas fired water heaters, smoke from fires, cigarettes, decaying leaves, vegetables, or fruit (Figures 5 and 6).

The symptoms of ethylene exposure include epinasty (ie. leaves, petioles, or stems appear wilted, twisted, and/or curled), chlorosis, misshapen or malformed leaves, stunted plant growth, stem swelling, delayed/reduced flowering, and flower bud abortion or flower senescence or abscission (Figures 7 and 8).



Figure 2. Crop loss due to an unvented unit heater. [Photo: Roberto Lopez, Michigan State University (MSU)]



Figure 3. A cracked heat exchanger on a greenhouse unit heater. (Photo: Roberto Lopez, MSU)



Figure 4. Route heater inspection and maintenance can prevent crop damage and losses and potential carbon monoxide exposure (Photo: Roberto Lopez, MSU)



Figure 5. Unvented portable propane heaters should never be used in a greenhouse. (Photo: Roberto Lopez, MSU)



Figure 6. Unvented gas powered heaters should never be used in a greenhouse. (Photo: Roberto Lopez, MSU)



Figure 7. Epinasty of tomato leaves after exposure to ethylene. (Photo: Rebekah Faivor)



Figure 8. Close up of a tomato leaf exhibiting ethylene injury. This can be confused with herbicide injury. (Photo: Erin Hill, MSU)

Table 1. Ethylene Sensitive Crops

Crop	Symptom	Crop	Symptom
Alyssum	leaf yellowing, leaf & flower senescence	Impatiens, NG	bud and flower abscission
Begonia, wax	flower bud abscission	Kalanchoe	buds do not open, petal fading & drying, open florets close
Boston fern	defoliation	Lily, Easter & hybrid	floral bud abscission, flower # reduced
Carnation	accelerated flower wilting	Orchid, Cattleya & Phalaenopsis	accelerated flower wilting & senescence
Cuphea	accelerated flower wilting & senescence	Petunia	accelerated flower wilting & senescence
Fuchsia	epinasty, flower bud abscission	Portulaca	leaf abscission
Geranium	flowers do not open, petal shattering, leaf yellow	Primula	flower wilting
Herbs (marjoram, mint, parsley, & oregano)	yellowing, epinasty	Snapdragon	flower abscission
Impatiens	bud, leaf & flower abscission	Tomato	epinasty & no fruit set

However, symptoms often vary by species, with some being more sensitive than others (Table 1). Research has determined that the severity of symptoms and damage depends on species sensitivity, plant developmental stage, ethylene concentration and exposure time. Young flower buds and leaves in general are less sensitive than open flowers. In many instances, plants can recover if the source of exposure is removed; however, recovery is dependent on the dose and duration of exposure.

The best prevention is to routinely have a qualified technician perform the maintenance items in Table 2. While it is possible to take air samples to test for the presence of ethylene, this can be tricky as by the time injury is noticeable the ethylene may have dissipated.

PGRs, Herbicides and Heat Stress

Symptoms similar to ethylene exposure can also result from direct exposure to other natural and synthetic auxins and ethephon (ie. ethylene), herbicide drift, and heat stress (Figure 9). This can be the result of accidental or over application of certain plant growth regulators (PGRs), including rooting hormones containing alcohol. Consider the use of such products in proximity to the affected crops and also the possibility of tank contamination.

Synthetic auxin herbicides (ie. 2,4-D, dicamba, clopyralid, etc.) are another source to consider. If injury is observed during the outdoor growing season, consider the possibility of drift from areas adjacent to the facility, particularly if the severity of symptoms concurs with areas of air intake (Figures 10 and 11). These types of herbicides are prone to movement and in some cases have been seen to cause injury to highly sensitive plants miles away. If irrigation is being pumped from areas with surface exposure, also consider herbicide use around that body of water as these herbicides are highly soluble.



Figure 9. Curling and distorted tomato leaves from heat stress caused by close proximity to high-pressure sodium lamp. (Photo: Roberto Lopez, MSU)

Table 2. Unit Heater Checklist

Component	Maintenance
Heat exchanger	Check for cracks (Figure 3) by inspecting for light penetration while the furnace is running.
Furnace	Check for leaks by placing a smoke bomb or furnace candle within the firebox.
Gas lines	Check for leaks by painting soapy water on the joints and seams.
Exhaust chimney	The chimney/ stack should be high enough so there is no risk of exhaust making its way back into the greenhouse. Check for leaks between the seams and obstructions.
Pilot light	Clean pilot and orifice.
Flame	Make sure the burner flame is clear blue. Yellow or orange flames represent impurities or a wrong setting.

Other considerations, including, but not limited to the cooler months of the year include spray tank contamination, substrate or amendment contamination, and herbicides stored within the facility.

If herbicides are used in or outside the facility it is critical that a separate sprayer be used for such applications to prevent accidental exposure due to tank contamination.

Soil amendments can sometimes contain herbicides or other contaminants. Examples of this form of contamination include: field soil that was treated in previous seasons, manure from animals fed treated plants, wood fiber from materials such as pallets that have been exposed to an injurious substance, and herbicide-treated grass clippings from a municipal source. In addition to these examples, plastic mulches, concrete pads, and weed mats can also be a source of exposure if any herbicides applied over top of these surfaces do not photodegrade or get rinsed off prior placing plants in the area.

Finally, herbicides and PGRs should be stored in a well ventilated area isolated from the growing area. Vapors produced in storage areas can move within the facility and cause crop injury.

Figure 11. Poinsettia showing twisted petioles and malformed leaves as a result of movement of a turf herbicide application outside the greenhouse aimed at broadleaf weed control. (Photo: Erin Hill, MSU)

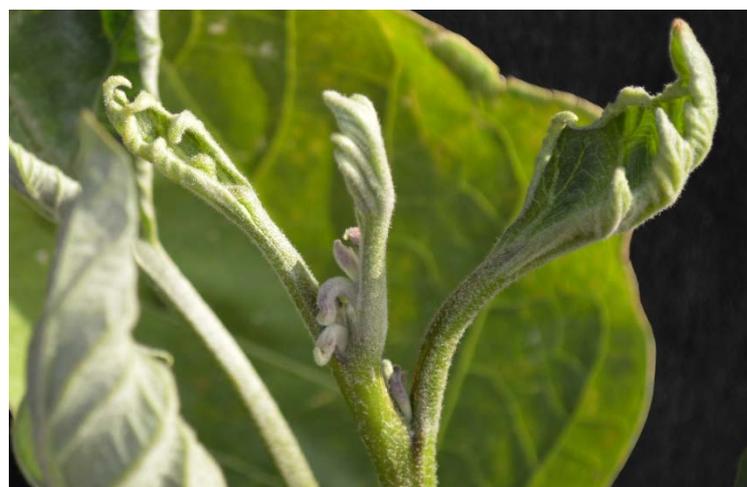
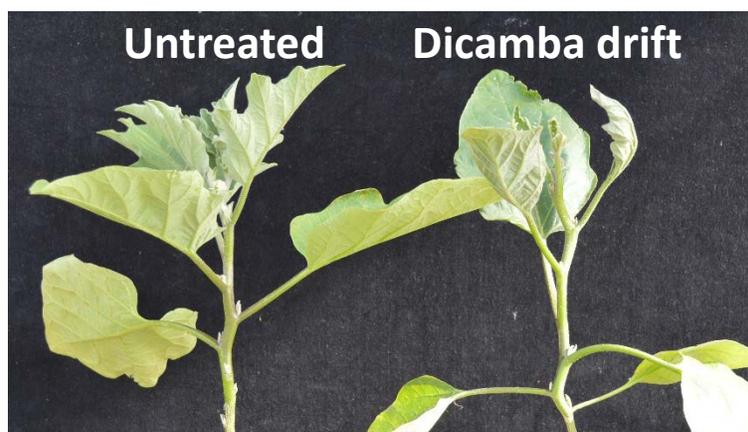


Figure 10. Eggplant with (top right and bottom) and without (top left) drift injury from the herbicide dicamba. Note the distortion occurs on the newest growth, as with all auxin injury. (Photo: Erin Hill, MSU)



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CONTRIBUTORS

Dr. Nora Catlin
Floriculture Specialist
Cornell Cooperative Extension
Suffolk County
nora.catlin@cornell.edu

Dr. Chris Currey
Assistant Professor of Floriculture
Iowa State University
ccurrey@iastate.edu

Dr. Ryan Dickson
Greenhouse Horticulture and
Controlled-Environment Agriculture
University of Arkansas
ryand@uark.edu

Thomas Ford
Commercial Horticulture Educator
Penn State Extension
tf2@psu.edu

Dan Gilrein
Entomology Specialist
Cornell Cooperative Extension
Suffolk County
dog1@cornell.edu

Dr. Joyce Latimer
Floriculture Extension & Research
Virginia Tech
jlatime@vt.edu

Heidi Lindberg
Floriculture Extension Educator
Michigan State University
wolleage@anr.msu.edu

Dr. Roberto Lopez
Floriculture Extension & Research
Michigan State University
rglopez@msu.edu

Dr. Neil Mattson
Greenhouse Research & Extension
Cornell University
neil.mattson@cornell.edu

Dr. W. Garrett Owen
Greenhouse Extension & Research
University of Kentucky
wgowen@uky.edu

Dr. Rosa E. Raudales
Greenhouse Extension Specialist
University of Connecticut
rosa.raudales@uconn.edu

Dr. Beth Scheckelhoff
Extension Educator - Greenhouse Systems
The Ohio State University
scheckelhoff.11@osu.edu

Dr. Ariana Torres-Bravo
Horticulture/ Ag. Economics
Purdue University
torres2@purdue.edu

Dr. Brian Whipker
Floriculture Extension & Research
NC State University
bwhipker@ncsu.edu

Dr. Jean Williams-Woodward
Ornamental Extension Plant Pathologist
University of Georgia
jwoodwar@uga.edu

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