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Ethylene in the greenhouse

Heater maintenance and proper ventilation will help you avoid this common spring problem.

What do the following grower observations have in common?

1. Geraniums in hanging baskets near a natural gas furnace had yellow lower leaves and flowers that did not fully open.
2. New Guinea impatiens in a double poly house did not come into flower until June.
3. Fibrous begonias did not flower until several weeks after their counterparts in a neighboring greenhouse.
4. On a cold night, tomatoes in a high tunnel were kept from freezing with a portable ventless propane heater. By morning, leaves on plants near

Figure 1. Tomato 'Beefsteak' exposed to (Left to Right), 0.0, 0.01, and 0.05 ppm ethylene for several days. Notice the stems of and leaves of the 0.05 ppm plant are bending down (exhibiting epinasty).

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Figure 2. Mexican heather (Cuphea hyssopifolia) exhibited flower drop with 1 day of exposure to either 0.01 or 0.05 ppm ethylene.

the heater were bending down and had yellow leaf edges.

The cause of all four problems was exposure to ethylene. Ethylene is a small colorless, odorless gas composed of two carbon and four hydrogen atoms (C_2H_4). Ethylene is a naturally occurring plant hormone involved in flower senescence and fruit ripening. The most common source of unwanted ethylene in the greenhouse is from heaters that are not functioning properly. Ethylene (as well as carbon monoxide dangerous to humans) can result from incomplete combustion of the heater. If the heater is vented properly the combustion products will not enter the growing environment. But if there is improper venting or a cracked heat exchanger, ethylene can affect the growing plants. Therefore it is important to ensure that the heater is firing and venting properly. Examples 1-3 came from greenhouses where the heater had a cracked heat exchanger. Example 4 arose because the ventless heater was not firing correctly.

Ethylene problems are more common when outdoor temperatures are cold (furnace running frequently) and the green-

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house is very tight such as a double poly greenhouse. While it is important to insulate greenhouses and reduces air leaks to save on fuel costs, adequate ventilation is needed to supply fresh air for plant growth and to help avoid accumulation of ethylene. In examples 2 and 3, plants came into flower later in the spring, while ethylene was still getting into the greenhouse, the heater was used less frequently and the greenhouse was vented more as the spring progressed.

A plant's response to ethylene depends on the ethylene concentration and length of exposure. Temperature also plays a role; less impact of ethylene is noted at lower temperatures. Different plant species vary in how sensitive they are to ethylene. Symptoms of acute, or short-term but high concentration (> 0.1 ppm ethylene), exposure are well described. Depending on species, symptoms include: shedding of flowers or leaves, flower bud abortion, yellowing (chlorosis) of leaves, premature aging of flowers, and downward bent leaves that look wilted but are turgid (epinasty). Symptoms of chronic ethylene (i.e. low concentration but exposure over many days) are less well known. We conducted an experiment at Cornell University whereby several species of bedding plants were exposed to 0.01 and 0.05 ppm ethylene for 16 hours each night

Figure 3. Leaf epinasty of baby's breath euphorbia (Euphorbia hybrid) was evident with 1 day of 0.05 ppm ethylene exposure (plant on Right), control plant on Left.

for several weeks. Among the more sensitive plants in our trial were tomato, baby's breath euphorbia (Euphorbia hybrid), and Mexican heather (Cuphea hyssopifolia). Within 1 day of exposure tomato and baby's breath euphorbia exhibited leaf epinasty especially at the 0.05 ppm ethylene treatment (Figures 1 and 3, respectively). Mexican heather exhibited flower drop with 1 day of exposure to either 0.01 or 0.05 ppm ethylene (Figure 2). Petunia flowers began to wilt prematurely with 1 day of ethylene exposure. Many other species we studied were less sensitive to ethylene, but demonstrated noticeable symptoms after many days of chronic ethylene exposure. For example, begonia, impatiens, lobelia, and petunia showed reduced growth and less flowers than plants not exposed to ethylene (Figure 4), but appeared otherwise healthy. Once we stopped exposing the plants to chronic ethylene they mostly recovered though many species exhibited delayed or reduced flowering. The complete list of crops we looked at is available at the Cornell Commercial Greenhouse website http://www.hort.cornell.edu/mattson/leatherwood/

If you suspect ethylene is present in the greenhouse, the first thing to do is verify that there is indeed a problem. One of the easiest ways of detecting ethylene is by the use of indicator plants. Tomato is the most commonly used indicator plant, but as noted above baby's breath euphorbia and Mexican heather are also very sensitive to ethylene. Use indicator plants which have not previously been exposed to ethylene and place them at different points throughout the greenhouse including near the furnace and farther away. Some growers will place tomato transplants in each greenhouse when they begin heating it in the winter. Responses typically

Figure 4. Petunia multiflora 'Saguna Pastel Yellow' exposed to (Left to Right), 0.0, 0.01, and 0.05 ppm ethylene for several weeks. Ethylene treated plants were smaller and had few flowers.

show up within 24 hours of exposure, though lower greenhouse temperatures can slow the response. A second and more reliable method to detect ethylene is by sending an air sample to a commercial or university lab that has the capability of making accurate ethylene measurements. One such lab is the North Carolina State University Plant Disease and Insect Clinic. Contact the lab for submission instructions and fees http://www.cals.ncsu.edu/plantpath/extension/clinic/

If an ethylene problem is detected the most immediate intervention is periodic ventilation of the greenhouse with clean outside air. Of course this is only a short term fix, and shouldn't be considered a long term solution. Fixing and maintaining your heating system will not only prevent ethylene problems but also improves your system's efficiency. Of all the heating systems available, typically propane and natural gas fired unit heaters require the most attention in terms of ethylene. An annual maintenance program should start with the heat exchanger. Check the exchanger for cracks by operating the unit while looking for light through seams and connections. Gas lines should be checked for leaks by painting them with soapy water and looking for bubbles. Vent stacks should be examined for blockages or leaks between the seams. The stacks should be high enough so that there is no risk of exhaust making its way back into the greenhouse. The pilot light and orifice should also be inspected and cleaned. The furnace flame normally burns light blue, if it is orange or yellow combustion is incomplete and service is needed. When unvented heaters are used it is critical to proactively check that they are firing correctly and that adequate ventilation of outside air is available.

Outside of maintenance, the installation of gas fired unit heaters must be done carefully to avoid ethylene problems from a heater that is otherwise capable of correctly. Air intake required for combustion (make-up air) is also important for unit heaters. If the heater has insufficient make-up air, oxygen levels within the greenhouse can drop and pollutants can build up quickly. Such a condition is not only dangerous to the crop but to personnel as well. Generally, 1 square inch of vent cross-sectional area per 2,000 BTU capacity is sufficient. You will find specific information in the installation and operation manual for your furnace. Don't be afraid to call in the professionals for installation and maintenance. A few hours of labor can save thousands in losses.

The key to preventing ethylene damage is being proactive. Ensure that heaters and equipment are well maintained, and reduce plant exposure to potential ethylene sources. Keep an eye on your plants for irregular growth and if potential ethylene damage is suspected be ready to take steps to identify the source of the problem and eliminate the cause.