Tight Houses + Unvented or Faulty Heaters = High Risk For Disaster

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Several changes have occurred in greenhouse heating practices. One can see merit in each change, perhaps, but potential disaster can result when some changes are combined. For example, the reduction in fuel consumption when double-layers of film plastic are used, rather than a single layer, surely justifies using double layers, even now when energy conservation is tempered by abundant supplies of oil. The situation could change very quickly, and it is unwise to waste heat, whatever the economic status might be. Some growers also have believed that they were being cost and energy conscious by replacing their vented unit heaters with direct-fired unvented heaters, as an energy reduction of 20 to 30% was predicted. Tight houses and unvented heaters too often resulted in trouble in 1986, rather than in cost reduction.

Last Fall we had inquiries of concern from 4 greenhouse firms whose poinsettia plants did not seem to be initiating and developing flower buds properly, if at all. The 4 firms had 2 other common traits . . . double layers of polyethylene, and unit heaters. Several reasons for the delayed flower initiation and/or development were considered, but air samples from one of the greenhouses revealed ethylene pollution.

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The problem was common to all 4 firms, but the reasons for the problem did vary. In one instance the heater electrodes were cracked and the units were not operating properly. In another case new heaters had been installed, and the design of the heater and location of a fan with the heater caused the exhaust to blow out over the poinsettia crop, rather than be discharged from the greenhouse (Figure 1).

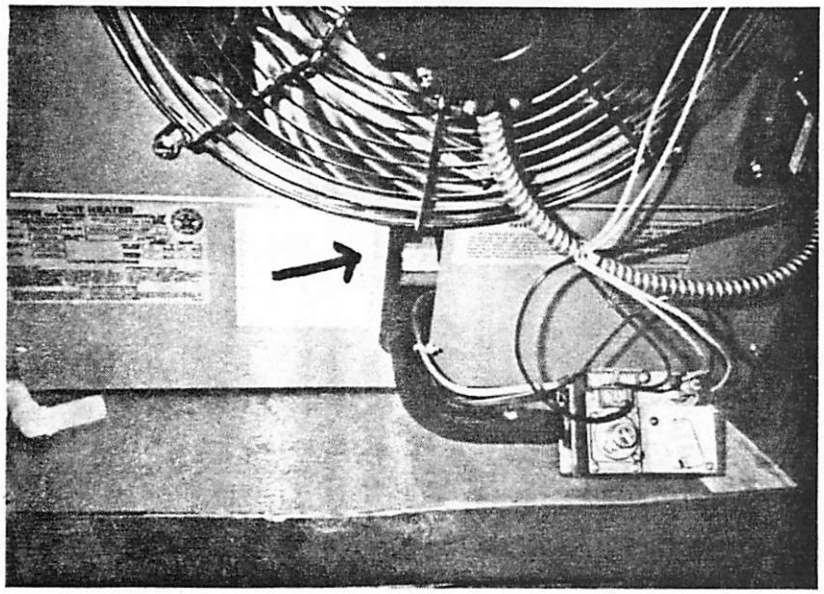

Figure 1. The opening in the heater (see arrow), and the location of the fan, combined to transfer some of the exhaust fumes into the greenhouse, rather than outside through the stacks. Ethylene then delayed flower development.

In the 2 other instances growers had installed new, unvented heaters, to conserve fuel and reduce heating costs.

Ethylene is by no means a new pollutant in floriculture, nor are its consequences unknown. Researchers 80 years ago showed what ethylene could do to carnations, and other plant species have been studied, to determine plant response at different levels of ethylene. One of the most complete lists was that compiled by Heck and Pires (2), in which the poinsettia was listed. Only 2 plants were included in the evaluation, however, and there was no rating of floral injury. Hasek, James and Sciaroni (1) reviewed the information on ethylene which was available and of interest to the flower industry up to 1969. Sources of ethylene and damage caused by it were thoroughly reviewed, but plant lists were not included. They did list 10 things growers should and should not do to lessen ethylene damage possibilities. Also in 1969 researchers at the University of Missouri (6, 8) reported that normal chrysanthemum flower bud development did not occur if ethylene at concentrations as low as 0.018 to 0.072 ppm was present in the greenhouse. Crown buds did form, but these were by-passed by vegetative shoots. No provisions to supply fresh air had been made in all cases where flowering was either prevented or delayed, but the daylength and temperature were suitable for flower initiation and development. A preliminary experiment by the same authors showed that ethylene could delay flowering of poinsettias. They hypothesized that the short day responses of both chrysanthemums and poinsettias could have some bearing on the sensitivity of the plants to low ethylene levels. They also gave some very practical advice for reducing the possibility of ethylene pollution. The need for fresh air, rather than fans just recirculating the air in the greenhouse, was emphasized. The use of indicator plants, such as tomatoes, to monitor the environment for ethylene, also was suggested. A greenhouse firm in eastern North Carolina was troubled by the inhibition of flowering of chrysanthemums, and the production of vegetative by-pass shoots, shortly after the Missouri work was published. Improper combustion of CO_2 generators and unit heaters was shown to be the sources of ethylene. Admission of fresh air prevented repetition of the trouble.

The impact of ethylene on cut flowers has gained more attention in the past 20 years than has the possibiity of pollution in the greenhouse environment, but the topic received consideration in 1983 when Swindleman, Krauskopf, and Dilley (7) reported the results of a survey they conducted in southern Michigan and northwestern Ohio, pertaining to pollution in the greenhouse. There were 58 greenhouse firms included in the report, and 31% had sufficiently high levels of ethylene, carbon monoxide, propane and natural gas to be considered as harmful. The authors believed that heaters now were no more faulty in operation than previously, but that very tight plastic houses caused an accumulation of ethylene to toxic levels. Previous ethylene studies had been concerned with high levels for possibly short periods of time, while the ethylene concentration in tight plastic houses could be low for long periods of time.

They gave 7 suggestions to reduce the possibilities of ethylene pollution in the greenhouse. These guidelines, briefly summarized, are:

1) Locate heaters for minimum exposure to dust and high humidity.
2) Provide adequate oxygen for combustion. Run a pipe or flexible hose from outside to the burner. One square inch of opening/2500 BTU output is necessary. (An 8" pipe has 50 sq. in., needed for a heater producing 125,000 BTUs). Screen off outside end of pipe or hose to prevent closure from debris, birds, and insects.
3) Never vent the exhaust into the greenhouse. Vents also should be tall enough to avoid emission of exhaust fumes into the greenhouse.
4) Clean heating equipment (heater and fuel orifice) at least twice each year.
5) Check color of flame. Small yellow tips on flames from propane gas, soft blue flames from natural gas, will indicate proper adjustment.
6) Check regularly for gas leaks. Items 5 and 6 might require visits and advice from the fuel supplier or heater company.
7) Maintain proper ventilation.

Table 1. Effects of ethylene pollution on selected floricultural crops. (Data taken from Hickman et al. (3).

Crop	Sensitivity Rating	Symptoms
Begonia spp.	Moderate	Flower drop
Chlorophytum comosum	Low	Leaf spot, burnt margins
Dieffenbachia amoena	Severe	Leaf scorch
Euphorbia pulcherrima (poinsettia)	Moderate	Bract drop, epinasty
Gerbera jamesonii	Slight	
Impatiens sultanii	Severe	Leaf damage, flower drop
Pelargonium species (geranium)	Very severe	Flower drop
Petunia hybrida	Moderate	Leaf drop, flower death
Philodendron scandens oxycardium	Severe	Leaf death
Rhododendron "Hexe" azalea	Moderate	Loss of old leaves
Schlumbergera bridgesii	Severe	Flower drop
Tagetes patula (French marigold)	Slight	

The "slight" response of marigolds listed in Table 1 is surprising, as marigolds often have been suggested as indicator plants for ethylene.

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In 1986 Hickman et al. (3) reported that 5 foliar plant operators in California had suffered crop losses because of ethylene pollution. The crops and symptoms were:

Schefflera, Cissus	Premature leaf drop
Tradescantia	Leaf yellowing
Chlorophytum	Leaf spotting
Poinsettia, Syngonium	Epinasty
Dracaena, Dieffenbachia	Leaf browning, death

All 5 growers had replaced vented heaters with direct-fired unvented heaters to realize a 20 to 30% reduction in energy consumption. A list of plants, showing sensitivity to ethylene and the injury symptoms, was published by Hickman et al., and selected plants are shown in Table 1.

Data presented by Heck and Pires (2) and encapsulated by Poole (5) reveal the damage done by ethylene to several horticultural crops. Damage done to some of these crops at various ethylene levels is shown in Table 2, and listed in descending order of damage.

Table 3. Rating of damage caused by ethylene to selected horticultural crops.

Crop	Ethylene (ppm)	Damage 0 = none, 100 = maximum
Black-eyed peas	2	100
Impatiens	2	71
Philodendron scandens oxycardium	5	69
Tomato	10	67
Begonia	5	54
Coleus	2	46
Marigold	10	42
Poinsettia	2	38
Petunia	2	38
Azalea	5	38
Pansy	5	36
Sansevieria	5	19

Data taken from tables by Hickman et al. (3) and Poole (5).

SUMMARY AND CONCLUSIONS

Ethylene is an odorless, colorless gas. It is produced by plants and does regulate several growth and reproductive processes. It is also produced by internal combustion engines and burners, by the breakdown of rubber and some insulating materials, by ripening fruits and vegetables, and by many disease organisms. It was believed for many years that the minimum level of ethylene necessary to create adverse plant responses was 1 ppm, but it is now suspected that much lower rates for long durations of time could be just as damaging, as high concentrations for brief periods. Sensitivity to ethylene is affected by several factors.

Plants are more likely to respond to ethylene at warm rather than at cool temperatures, and a poinsettia house maintained at 65°F at night in late October and early November would qualify as a warm condition. Sensitivity to ethylene also has been shown to be influenced by plant age (Leshem et al. 4). Young plants usually are not as sensitive as older plants. Plants which are under some form of stress, such as those caused by improper levels of moisture, nutrients, light or temperature, are more likely to be affected.

It is difficult to keep all cultural conditions at optimum levels at all times, but it is not difficult to make certain that all combustion units are properly vented, that burners are inspected by experts to make certain they are functioning properly, and that appropriate heating units are purchased and installed in the greenhouse. Often ethylene damage will not be detected until the crop is severely affected. The placement of young tomato plants in several locations in the greenhouse could be as effective as the installation of costly gas analysis equipment. Growers should remember that tomato plants do attract whiteflies, and they would not want to exchange ethylene pollution with a pest problem.

Ethylene pollution was a serious problem for some poinsettia growers in 1986, when they had faulty or unvented heaters in greenhouses covered with double layers of polyethylene film. One must applaud the energy conservation in current greenhouse design and construction, but avoid the dangers caused by faulty equipment.

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Editor's note: Sylvia M. Blankenship is a post-harvest physiologist in the Department of Horticultural Science and was of great assistance in solving the ethylene problems in 1986.