HORTICULTURAL ENGINEERING

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Thank You Professor Bill Roberts!

As you know, Professor William (Bill) J. Roberts retired from Rutgers University in September 1999. He started his association with Rutgers University 40 years ago, first as a student and later as an extension faculty member. He served as Department Chair of Bioresource Engineering for 22 years and Director of the Center for Controlled Environment Agriculture for 11 years. Throughout his career, Bill was a shining example of what the extension service is all about. His service to our industry had a tremendous impact on greenhouse growers in New Jersey, the country, and far beyond. He was instrumental in several major developments in our industry, for example, double-poly greenhouse covers and floor heating systems. Bill realized that it was very important for the greenhouse industry in New Jersey and the Northeast to have access to a full-time extension agent. He began lobbying the University administration and greenhouse industry to ensure his position would be filled after his retirement. His efforts were successful and I was lucky enough to be hired to continue the work Bill has so successfully undertaken during his career. I think I speak for all of us when I want to thank Bill for all he has done for our industry and wish him and his family all the best for a long and joyful retirement! I hope Bill will continue to let me "lean" on him every now and then for advice and support. Bill, you are an inspiration and it will be a difficult job to fill your shoes!

A.J. Both ❖

In This Issue

Air Pollution: All Too Common In Greenhouses

By Ralph Freeman

Losses of greenhouse-grown plants due to air pollution are frequent and costly to many greenhouse and nursery growers. These often occur in metropolitan areas particularly during the late spring, summer and fall months. The purpose of this article is to discuss what air pollution is, identify self-induced air pollution problems, and provide some guidelines on how to control or prevent this frequently seen and unwanted problem.

What is air?

Air in its pure state is an invisible, odorless mixture of gases. It contains about 78% nitrogen and 21% oxygen, with the remainder made up mostly of argon, carbon dioxide, and traces of neon, helium, ozone, xenon, hydrogen, methane, krypton, and varying amounts of water vapor.

What is air pollution?

Air becomes contaminated whenever anything is added to it. The atmosphere can contain certain contaminants and remain unobjectionable. Generally, air pollution becomes objectionable only when large quantities of impurities are added which affect people, plants and animals. Air pollution covers the entire scale of contaminants, such as smoke, dust, fumes, mists, radioactive wastes, odors, gases, and combinations of these items. Air pollution is not a new problem. Patricians of ancient Rome complained because soot smudged their wool togas. In the Middle Ages, England's King Edward had an artificer put to death for burning coal instead of honest British oak, and early Spanish explorers noted the haze from Indian campfires which hung over the Los Angeles basin. These are just a few examples from early times. In more recent times, coal smoke, soot and fumes from smelting plants, burning trash, burning fuel for heating, transportation (exhaust fumes) and manufacturing have all contributed to air pollution.

How does air pollution affect plants?

Many plants serve as natural indicators for air pollutants since they are extremely sensitive to very low concentrations. Most plants are more sensitive to one kind of pollutant than to others. Plants are more sensitive than humans or animals. Some of the types of damage that result from air pollution are as follows: carnation flowers become 'sleepy'; chrysanthemums refuse to flower; petunia leaves collapse and have bleached white, brown or straw-colored dead spots in the leaf tissue; some plants lose their ability to orient properly with gravity; premature aging and dropping of leaves; chlorosis in older leaves; glazing (usually silver appearance) on lower leaf surfaces which subsequently may become bronzed and decayed; stunted growth; water-soaked spots on leaves; necrotic flecking of leaves; dry sepal of orchids. Many more symptoms have been observed.

Temperature inversion can be a problem

Normally, the air temperature nearest the earth's surface is the warmest and becomes cooler with increasing altitude. Temperature inversions occur when the normal decrease of temperature with elevation is reversed. For example, on a cloudless night the earth's surface cools by radiating heat into space. The air layer near the ground is cooled by contact with the earth, while the air aloft stays relatively warm. The stable atmospheric conditions caused by the heavier air below and the light air mass above prevents upward currents and favors accumulation of pollutants near the ground. This most often happens if a city or village is in a river valley. At night the cool air flows downward and is trapped in the valley. With warm air above which acts as a lid to convection currents, the cooler, stable layer soon becomes polluted. If, in addition, the temperature drops to the dew point, fog forms to combine with the haze of the polluted air. The stage is then set for a smog condition because fog may prevent the sun from warming the trapped, polluted air and lifting it upwards to be diluted in the vast ocean of air over the earth. These kinds of conditions frequently occur over large portions of the northeast, particularly during the spring and fall. They are usually associated with high-pressure or good weather systems when clear skies favor inversion development. On the good side, there are weather situations in which the atmosphere may remain unstable, and therefore, quite clean. For instance, when a cold front moves over a region, the mass behind the front is colder than the ground and is warmed from below. The developing updrafts keep the atmosphere clean at ground level. Rain, too, can be helpful in purifying the air. Meteorologists are doing research to learn more about the mechanics of such purification.

Avoid air pollution problems

Self-induced air pollution problems are those caused by burners or furnaces, which are not burning properly. Failures are often due to inadequate amounts of oxygen supplied to the combustion process. Other causes may be dirty nozzles, delayed ignition, off-center fires, oil or gas leaks, pulsating fuel pressure, etc. Perhaps the primary difficulty in greenhouses is due to a lack of oxygen for combustion; thus the fuel does not burn properly. This often results because in our energy conscious world we are making greenhouses tighter and tighter by sealing up all the leaks around the doors, etc. One method used to help avoid self-induced air pollution problems is to install an inexpensive air-duct such as a stovepipe from outside the greenhouse to the underside of the burner. To help size the duct or louver, here is a rule of thumb: one square inch of cross-sectional area per 2,000 BTU's. Therefore, a 100,000 BTU heating unit would require an air intake duct of at least fifty square inches. Newly developed, separated-combustion heaters isolate the air being used for combustion from greenhouse air. Greenhouse air often contains chemical pollutants (e.g., pesticide spraying) which can adversely affect the furnace heat exchanger and shorten its life. Their design provides a separate air handling system for combustion air. A fan draws air from outside, introduces it into the combustion chamber and then causes it to move out through the exhaust stack. Smoke stacks or chimneys, which are too short, don't allow sufficient draft to develop to carry away all the noxious gases from the combustion chamber of the burner/boiler to the atmosphere. Especially in gusty and windy periods, puff-backs and downdrafts through the fire tube can cause problems, too. All stacks (chimneys) should be at least two feet above the highest point of the greenhouse or nearest structure. If stacks are of sufficient height and the problem continues to occur, a draft inducer (a special fan in the chimney) can be installed to turn on when the burner is operating, creating adequate draft. When noxious gases are present in the proper concentration for sufficient time, damage such as glazing of the leaves; parallel veins; necrotic flecks, spots and areas between veins; twisted and distorted growth may occur. Crops such as tomatoes, marigolds, petunias, eggplants, lettuce, spinach, *Cotoneaster* and many others are very susceptible to air pollution injuries. The fact is, every year at least 15-20% of the growers with heaters in greenhouses experience self-induced air pollution problems because of lack of maintenance and attention to detail. Please make sure to provide plenty of air (oxygen) for combustion, construct chimneys of proper height, and properly adjust your burners ... and you'll be safe. Another way to control self-induced air pollution problems would be to place furnaces outside gable ends of greenhouses. There, plenty of oxygen would be available for the combustion process. To help protect the equipment, a shelter can be constructed for cover. Be sure, though, there is a louver built into the structure so there is an ample supply of oxygen.

Summary

Air pollution problems continue to plague the spring plant grower and many farmers even in field production (lettuce, tomato, eggplant and spinach are very sensitive). Some of the pollutants accumulate in the atmosphere to injurious levels and result in significant crop losses. Additionally, some growers create their own 'self-induced' problems by not supplying sufficient oxygen for complete combustion of fuels in greenhouses and enclosed structures. Some control methods to reduce induced pollution are as follows:

- Supply sufficient oxygen to all burners to allow for complete combustion.
- Clean and properly adjust burner nozzles. Also, have a professional check the draft carbon monoxide (CO) level and efficiency of your heating units. High stack temperatures (over 300°F) are a sign that the burner is operating inefficiently.
- Stacks and chimneys should be at least two feet above the greenhouse or nearest structure. Draft inducers (special fans inside chimneys) can also be used if necessary.
- Separated combustion heaters can provide the necessary draft for good combustion and isolate the air being used for combustion from greenhouse air. Often chemical pollutants in the greenhouse air can adversely affect the furnace heat exchanger.
- As hot air unit heaters age they should be carefully checked to ensure the combustion chamber is intact. Usually, most problems occur after approximately six years of service.

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Concrete Greenhouse Floors
By Bill Roberts

Several design choices are available to a grower whose operation includes growing on the floor. Each of these options should include the installation of a floor heating system to be able to maintain proper root zone temperatures. Porous and solid concrete have been popular choices for many growers.

Porous concrete is like traditional concrete in many aspects except that it has no sand in the mixture. This feature permits water to pass through the porous concrete by gravity but, because of the large pore spaces, it prevents water from moving up through the floor by capillary action. These unique characteristics make porous concrete a good choice for use as a greenhouse floor, especially for crops, which are or could be grown on the floor. Weed control is practically eliminated and the floor layout can be easily changed. Materials handling equipment can be effectively used throughout the greenhouse. Excess water applied to the crops through hand or automatic irrigation systems drains through the floor and is contained by a plastic liner placed under the floor. No water accumulates on the floor to cause disease and root damage to flats or potted plants growing on the floor.

The recipe for concrete mixes varies. An example of a recipe for one cubic yard of porous concrete is:

2700 pounds of 3/8" aggregate (gravel)
5 1/2 sacks of Portland cement
22-23 gallons of water

This formula produces a stiff mix, which is more difficult to manage than regular concrete. The concrete truck driver needs to be aware of this and refrain from adding more water. The addition of more water would make the material come down the chute more easily, but it would also result in a less porous concrete after hardening. Porous concrete also sets up quickly so provision should be made to keep it damp, particularly when pouring in high temperatures during the summer. The material is leveled only by screeding without using any hand troweling. Troweling tends to work the cement to the surface and creates an impervious surface. Even though the material is more difficult to screed and handle, the temptation to add water must be resisted at all cost.

The working load of the hardened porous floor (following the above mentioned porous mix recipe) has been determined to be about 600 psi by Penn State University. This is about half the strength of regular concrete. Light vehicle and personnel traffic is appropriate when the material is poured in 3" thick slabs. Main pathways in the greenhouse should be made of regular concrete because the surface of the porous floor is too rough for smooth movement of carts over long distances.

A porous concrete floor can become plugged with soil mix and debris if potting or soil handling operations are carried out on the floor. If these operations are required, a plastic liner should be placed on the floor and removed when the soil mixing and preparation are completed. Normal debris, which accumulates during the growing season, can be cleaned between crops by sweeping or with industrial vacuum equipment. Drying out the floor and vacuuming it between crops promotes good sanitation and keeps the floor from becoming plugged.

The cost for porous concrete is about the same as regular concrete. Current prices of $60 to $80 per cubic yard of concrete translate into a cost for a 3" thick floor of $0.55 to $0.75 per square foot. Labor and other incidental costs are not included.

Solid concrete is the choice when ebb and flood or floor-watering systems are chosen. This is a very popular system where zero runoff is allowed by environmental regulations. The floor is sloped approximately 1 inch in 10 feet to a center fill and drain trench. The finish on the floor needs to be nearly perfect to prevent puddling of irrigation water, which could cause disease and algae problems.

Sand, soil and gravel have also been used successfully with floor heating systems. A plastic, perforated weed barrier is used over the sand and gravel so that it is easier for the employees to work the floor system.

Floor heating systems have had significant impact on growing those crops on the floor which require minimum handling. Extension publication E047 describes the complete system and is available at a modest cost from your editor ❖

Three pictures of a heated concrete floor installation at John van Vugt near Pequannock, New Jersey.

Screening for Insect Control in Mechanically Ventilated Greenhouses
By Bill Roberts, Louis Vasvary, and Steve Kania

Screens covering ventilation inlets can be used to limit the access of insects into controlled environment growing areas such as greenhouses. However, screens can negatively impact the efficiency of the ventilation system by restricting the ventilation inlet opening. An adequate design provides a static pressure allowance for screens of approximately 30% of the available pressure capabilities of the ventilation fans. The design procedure developed resulted in no negative impact on the ventilation system performance and prevented all insects but thrips from entering the growing area. Static pressure difference on both sides of the screen was monitored to determine the effect of insect and dirt buildup. At no time throughout the season did the static pressure exceed design values, so it was not necessary to clean the screen throughout the growing season. The spraying schedule for insect control was significantly reduced compared to two prior years when the screen was not used.

A publication describing the design of screened ventilation systems is available from your editor ❖

Post Frame Building Handbook

The Post-Frame Building Handbook (NRAES Publication 1, the 1997 revised edition), is and excellent resource for those contemplating constructing a headhouse, service building, roadside market or other similar facility. Post-frame utility buildings, formerly called "pole barns," are versatile and economical structures. They can be appropriate for storing machinery or housing livestock. Other uses include residential and commercial buildings, boat sheds, fair exhibit buildings, corn cribs, horizontal silos, hay barns, shops, utility sheds, covered feed bunks, lumber sheds, warehouses, roadside stands, cabins, and airplane hangars. The National Frame Builder's Association defines a post-frame building as: "A building whose sidewalls have as its basic supporting member wood posts and/or laminated columns integrated into a structural system that acts as the bearing walls, partitions and support for the floor and roof systems." The characteristic and key element of this type of construction is the use of vertical posts or poles that act to carry building loads to the ground. Because these wooden columns are in contact with the ground, they must be preservative-treated (usually under high pressure) to resist decay. Post-frame buildings can be cost-effective for a variety of uses when compared with buildings constructed with continuous concrete footings, foundations, and stud walls. They can range in size from simple 10-foot-by-12-foot shelters to large, clear-span buildings several hundred feet long. The Post-Frame Building Handbook will help you understand design considerations involved in the construction of these buildings.

NRAES Publication 1 is available from your editor or from the Natural Resource, Agriculture, and Engineering Service (NRAES)
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Please let us know if you have any suggestions for topics you would like us to cover in one of the upcoming issues.