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New Jersey Nursery and Greenhouse Film Recycling Program

The 2002 New Jersey nursery and greenhouse film collection and recycling program will be held for the sixth year in a row and has been expanded to include collection from out-of-state growers operating in close proximity to the state's border. It is expected that the volume of film collected will increase by 10-15% by opening the recycling program to out-of-state growers. To date almost 1.8 million pounds of film has been kept out of our landfills and has been recycled for other uses. New Jersey is the first state in the nation to open its film recycling program to out-of-state growers.

There are two collection sites in Cumberland County and one in Burlington County. Each film collection site has specific procedures that must be followed, as well as specific collection dates and tipping fees. Please call before you plan to deliver your old film material.

Both white and clear nursery film and clear multi-season greenhouse film can be recycled. The film **must** be free of any foreign material (lathing, staples, nails, wood, dirt, stone, etc.). Loads containing other agricultural plastics (bags, mulch film, shrink film, ground cover, etc.) will be rejected.
All film must be rolled in manageable bundles and tied. The ties **must** be made of the nursery or greenhouse film material

For additional information, please contact the NJ Nursery & Landscape Association at (609) 291-7070 or Karen Kritz (NJ Dept. of Agr.) at (609) 984-2506.

Collection sites:

Cumberland County Solid Waste Complex (Feb 18-Sept 30, 2002)
169 Jesse Bridge Road
Deerfield, NJ
(856) 825-3700
Located off Route 55, Exit 29 (Sherman Avenue-Route 552)
Contact: Dennis DeMatte, Jr.
Hours: Monday-Friday 7:30 am-3:30 pm, Saturday by appointment only.

East Coast Recycling Associates
(April 1-Nov 27, 2002)
Millville Industrial Park
1801 Eden Road
Millville, NJ
(856) 327-8888
Located off Route 55, Exit 24 (Route 49)
Contact: George Glenn III
Hours: Monday-Friday 7:30 am-3:30 pm.

Burlington County Occupational Training Center (Feb 18-Sept 30, 2002)
Occupational Training Center of Burlington County
130 Hancock Lane
Mt. Holly, NJ
(609) 267-6889, ext. 160
Located off NJ Turnpike Exit 5 or Route 295 Exit 47A (Route 541-Burlington/Mt. Holly)
Contact: Kevin Carducci or Stephen Paulo
Hours: Monday-Friday 8:00 am-4:00 pm.

Controlled Environment Agriculture Program at the University of Arizona

I recently had an opportunity to visit with our former Rutgers colleagues Dr. Gene Giacomelli and Mr. Steve Kania in Tucson, AZ. Gene is the Director of the Controlled Environment Agriculture Center (CEAC) at the University of Arizona, and in February, a new office building (with staff and student offices and a high-tech classroom) was dedicated.

In addition to the new building, several research greenhouses and soon to be completed growth chambers are used by various plant science and engineering faculty members participating in CEAC.

Most of the research and teaching focuses on hydroponic vegetable production (tomatoes and peppers). Students in the program have an opportunity to grow these crops using the latest commercial production techniques and tremendously benefit from the interdisciplinary approach of the program. The dry and high sunlight conditions pose unique challenges to greenhouse production in Arizona. For more information about CEAC, visit the following web site: http://ag.arizona.edu/ceac/

Greenhouse Ventilation
A.J. Both

Greenhouse ventilation has three main purposes: to maintain the optimum temperature for plant growth, to bring in fresh air so that the plants have enough carbon dioxide for the process of photosynthesis, and to reduce the relative humidity inside the greenhouse. As soon as the sun is out, the temperature inside the greenhouse can quickly rise above the set point temperature and we need to bring in colder outside air to drop the temperature down to the set point. Or, and this is typically the case during the colder months of the year, when little ventilation is required to maintain the set point, the plants can rapidly consume the available carbon dioxide, reducing its concentration to below acceptable levels. Finally, plants transpire a significant amount of water when water is taken up by the roots and released into the air by the leaves. Because humid conditions can reduce plant transpiration and, thus, growth, and because wet surfaces can be breeding grounds for diseases, we need to maintain appropriate humidity levels inside the greenhouse and this can be accomplished through (heating and) ventilation.

Greenhouses are either equipped with a mechanical or natural ventilation system. Mechanical systems use fans and specifically designed inlet openings to move air through the greenhouse. Most mechanical systems pull air out of the greenhouse (creating a slightly lower air pressure inside), while only a few push outside air into the greenhouse (creating a slightly higher pressure inside). Natural ventilation systems don’t use any fans, but rely on strategically placed inlet and outlet windows. The rate of ventilation in a natural ventilation system is determined by thermal buoyancy (warm air is lighter and rises) and the so-called wind effect (wind outside the greenhouse creates small pressure differences –higher on the windward side, lower on the leeward side--, which results in air movement). When the outside wind speed is higher than 200 fpm, the wind effect is the dominant force in a natural ventilation system. Although natural ventilation systems require less electric energy to operate (all you need to do is open and close the windows), mechanical ventilation systems are generally preferred in the US because they allow for the installation of evaporative cooling pads in the ventilation openings. Combining evaporative cooling with mechanical ventilation is a relative cheap and easy method to further reduce the greenhouse temperature when the outside temperature remains above the set point. I will focus here on the design and operation of mechanical ventilation systems that pull outside air through the greenhouse.

Designing a mechanical ventilation system starts with determining the maximum (summer) and minimum (winter) ventilation requirements. For the maximum requirement, we use a value of 8 cfm per square foot of floor area for greenhouses equipped with a shade curtain, or 10 cfm/ft^2 for greenhouses without a shade curtain. The value of 8 cfm per square foot is based on the assumption that approximately one third of the incoming solar radiation is reflected by the greenhouse glazing or is used for photosynthesis, another third is converted to latent heat through evapotranspiration, and the final third is converted to sensible heat associated with a maximum allowable temperature rise (from inlet to outlet) of 7°F. Shade curtains help reduce the heat load from solar radiation, and, thus, the maximum ventilation requirement is lower when such a curtain is used. Therefore, once we know the dimensions of the greenhouse, it is easy to determine the maximum ventilation requirement. Note that the volume of the greenhouse is not a factor in this calculation. The minimum ventilation requirement (to bring in fresh air or remove excess humidity) is in the order of 10-15% of the maximum requirement, resulting in a ventilation requirement of approximately 1 cfm/ft^2. In addition to the maximum and minimum ventilation requirement, other ventilation stages are usually added. For example, in a three-stage ventilation system, the stages can be designed to provide 10-15%, 40-50%, and 100% of the maximum ventilation requirement. The stages are frequently selected asymmetrically (the step between stage 1 and 2 is smaller than the step between stage 2 and 3) in order to reduce equipment cycling (heating followed by cooling followed by heating) and to minimize electric energy use. Large greenhouses are usually designed with four ventilation stages. Once the stages are identified (i.e., once the required fan capacity is calculated), we can consult fan data provided by fan manufacturers in order to identify fans that would provide the required ventilation capacity at each stage.

When selecting fans (Photo 1), it is important to check if the particular model has been tested and rated in accordance with the Air Movement and Conditioning Association (AMCA) procedures.
If so, an AMCA seal (usually a yellow and blue sticker) will be visible on the fan housing. This ensures that the fan will deliver the stated airflow capacity (cfm) at a certain range of tested static pressures. These static pressures can be viewed as the total resistance the fan has to overcome to deliver a certain air flow rate, and include the resistance caused by outside wind patterns. The total resistance is a combination of resistances (obstructions) the airflow encounters as it moves through the greenhouse. Examples of airflow resistance in greenhouses are the design and opening width of the ventilation window, the design of the fan housing and the placement of the fan louvers, and the use of evaporative cooling pads (usually placed outside or immediately inside the ventilation window). In general, the selected fan should be able to provide the calculated ventilation requirement using a static pressure of 0.1 inches of water gauge.

Photo 1. Ventilation fan with louvers.

Under certain conditions we need to make an adjustment to the calculation of the maximum ventilation requirement. First, when the greenhouse is located at an elevation above 1,000 feet, the barometric air pressure is less than at sea level (and drops further as the elevation increases). Less pressure means less air, and, thus, we need to move more air through the greenhouse in order to maintain the temperature set point. Second, when the solar radiation is consistently high (above 5,000 ft-c inside the greenhouse; equals 960 µmol/m^{2}s), the heat load on the greenhouse is high. Thus, under such conditions, the maximum ventilation requirement needs to be increased. Third, when the standard design temperature increase (7°F) of the air as it moves through the greenhouse needs to be less that 7°F (e.g., because the plants located near the fans need to be kept at a temperature closer to the air temperature observed by the plants close to the inlet), the maximum ventilation requirement needs to be increased. Finally, when the distance the air travels through the greenhouse between the ventilation inlet and the fan is less than 100 feet (e.g., when the fans and inlets are located in the sidewalls of a single or dual-span greenhouse), the ventilation air is unable to absorb sufficient amounts of heat, and the maximum ventilation requirement needs to be increased. The equations for the appropriate adjustment factors for the above-described conditions are listed in Table 1.

Photo 2. Ventilation inlet opening.

The ventilation inlet openings (Photo 2) are designed in such a way that the inlet air velocity is sufficiently high (700 fpm) so that the momentum of the inlet air will ensure proper mixing with the air already in the greenhouse. During periods with cold outside conditions, this mixing is necessary to prevent cold injury on the plants closest to the inlet opening. Thus, for every 1,000 cfm of fan capacity, an inlet opening of 1.4 ft^2 is needed. It should be clear that all the ventilation air should enter the greenhouse through the ventilation opening and not through incidental openings (e.g., doors, and cracks in walls or glazing). Only by allowing the air to enter through the ventilation opening can we control its movement and speed. Any unwanted openings should be closed or sealed.

In order to automatically select the correct position of the ventilation inlet opening, a differential pressure sensor and switch (Photo 3) can be installed.

Photo 3. Differential pressure sensor and switch.

This device measures the (small) pressure difference between inside and outside the greenhouse caused by the ventilation fans, and adjusts the position of the ventilation window (by activating the window motor) to maintain a predetermined pressure difference. Thus, when more ventilation is required to maintain the set point temperature, the ventilation window is opened further, and when little ventilation is required, the window opens only a little. The differential pressure sensor and switch can be adjusted to maintain a pressure difference in the range of 0.05 – 0.1 inches of water gauge. The advantage of using a differential pressure sensor and switch, compared to for example a timed motorized opening mechanism, is that maintaining a constant pressure difference ensures a constant inlet air velocity, resulting in proper mixing with the air already in the greenhouse. In addition, the ventilation window position can be controlled in infinite small steps compared to the (large) incremental steps associated with a timed opening system.

Obviously, mechanical ventilation systems require electric energy to operate the fans and adjust the ventilation windows. Proper care should be taken to ensure that all wiring is installed according to the appropriate electrical codes. And all fan blades should be kept out of reach by installing guards (usually wire mesh screens) to prevent any injuries to greenhouse workers and/or visitors.

References

ACME. 1998. The Greenhouse Climate Control Handbook. ACME Engineering and Manufacturing Corporation, Muskogee, OK 74402. 23 pp. (http://www.acmehort.com)

Albright, L.D. 1995. Controlling greenhouse ventilation inlets by pressure difference. HortTechnology 5(3):260-264. (http://www.cornellcea.com)

Table 1. Equations for adjustments factors needed to calculate the maximum ventilation requirement under four specific conditions.

Specific condition	**Adjustment factor** (each larger than 1)	**Final adjustment factor for the calculation of the maximum ventilation requirement**
Elevation is more than 1,000 feet	F_1 = 29.92/actual barometric pressure	$F_{total} = F_1 \times F_2 \times F_3$; or $F_{total} = F_4$ when F_4 is larger than the product of F_1, F_2, and F_3
Inside light intensity is more than 5,000 ft-c (960 µmol/m²s)	F_2 = Light intensity/5,000	
Temperature increase from inlet to fan needs to be less than 7°F	F_3 = 7/desired temperature increase	
Inlet to fan distance is less than 100 feet	F_4 = 10/square root of the inlet to fan distance	

New fact sheets available:

In collaboration with Dr. Eileen Wheeler (Penn State University), two new fact sheets were developed (and a third is in the making):

1. Evaluating mechanical ventilation systems for commercial plant production facilities. Penn State fact sheet No. I-40, Rutgers University Fact sheet No. E275.
2. Instruments for measuring the aerial environment in commercial plant production facilities. Penn State fact sheet No. I-41, Rutgers University Fact sheet No. E276.

The Rutgers fact sheets should soon be available on http://www.rce.rutgers.edu

On-Farm Chemical Handling Facilities

On-farm handling and storage of agricultural chemicals is serious business and is regulated by state and federal laws. Improper handling and storage of pesticides and herbicides can cause severe illness to anyone coming in direct contact with the chemical(s) and may result in environmental contamination. In addition, improper handling and storage can lead to substantial fines. Thus, it is important to have a well-designed storage and handling system to prevent or properly deal with emergencies such as exposure, spills, and fires.

NRAES Publication 78 titled “On-Farm Agrichemical Handling Facilities” discusses in detail all the components and considerations for the design and construction of safe and acceptable storage and handling facilities. This publication was written by Dr. David Ross, Extension Agricultural Engineer of the University of Maryland, and John Bartok, Extension Specialist Emeritus of the University of Connecticut. Copies of this publication ($7 plus $3.75 shipping and handling) can be ordered directly from NRAES:

Natural Resource, Agriculture, and Engineering Service, Cooperative Extension
152 Riley-Robb Hall
Ithaca, NY 14853
(607) 255-7654
http://www.nraes.org

Get Professional Help When You Are Planning to Build New or Upgrade!

Whether you are considering a new greenhouse construction project, or you plan to upgrade your greenhouse heating system, it may be worth your while to enlist some help from one or more experts. An experienced consulting engineer or other design professional will usually be able to (1) help you secure the required building permits, (2) help you make sure all aspects of the project are considered before construction starts, (3) help you make sure all new construction will comply with the local building codes, (4) recommend reputable local contractors, (5) oversee the construction process, and (6) frequently help you reduce the overall construction costs. The better you are informed, the better greenhouse or greenhouse system you end up with.

It is not uncommon for extension people to be asked for help or advise after a construction or upgrade project is already underway or even completed. It is usually too late at that point to make significant changes in the design of the project. In most cases, the help of a specialist during the design phase, would have prevented the sometimes very costly mistakes, and their services would have paid for themselves very easily!

And remember: call before you dig!
In NJ: 1-800-272-1000
Or check the phone directory for the phone number in your area.

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HORTICULTURAL ENGINEERING

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Horticultural Engineering Web Site

This issue of Horticultural Engineering, like previous ones, will soon be available on the internet at:

http://aesop.rutgers.edu/~horteng

If you provide us with you e-mail address, we will send an e-mail announcing each Horticultural Engineering Newsletter as it is posted on our web site. Thanks to those of you who have elected to receive this newsletter via the Web. We appreciate your help in reducing the duplicating, postage, and handling costs.

Upcoming meetings/shows in 2002

Ohio Short Course
Columbus, OH
July 13-17, 2002
http://www.ofa.org

26th International Horticultural Congress
Toronto, Canada
August 11-17, 2002
http://www.ihc2002.org/ihc2002/cgi.html

New England Greenhouse Conference
Worcester, MA
October 21-23, 2002
http://www.uvm.edu/~pass/greenhouse/negc.html

HortiFair (NTV)
Amsterdam, the Netherlands
November 6-9, 2002
http://www.hortifair.nl

Floriade (once every 10 years)
Near Amsterdam, the Netherlands
April 6-October 20, 2002
http://www.floriade.nl