

Horticultural Engineering

Volume 18 No. 4, August 2003

Website: <http://aesop.rutgers.edu/~horteng>

In this Issue:

Page 1

Fall Pesticide Container and Pot Recycling Program

Page 2

Collection Schedule and Program Guide

Page 3

ASAE Blue Ribbon Award

Page 4

Greenhouse Management Workshop

Page 5

Carbon Dioxide Enrichment

Page 8

Upcoming Meetings, Shows, etc.



Example of plastic recycling at a nursery.

Recycle Your Pesticide Containers and Nursery Pots

The New Jersey Department of Agriculture will offer free recycling of empty plastic pesticide containers and nursery pots at five regional collection sites on Sept. 27 and Oct. 3, 8, 9 and 10 this year (2003).

Non-refillable, high-density polyethylene # 2 (HDPE #2) containers used by agricultural, professional and commercial pesticide applicators will be accepted at the collection sites, as will HDPE #2 nursery pots.

Containers must be no larger than 55 gallons and properly rinsed. Nursery pots must also be properly rinsed.

The program is open to anyone who holds a New Jersey Department of Environmental Protection pesticide license and to state, county and municipal government agencies. Participants must follow the processing guide or material will be rejected.

The NJ Department of Environmental Protection will issue one core credit to pesticide license holders for participating in the program.

To receive credit, participants must bring their pesticide license to the collection site and must follow the processing steps. Credits will not be issued for recycling nursery pots.

To register for the program, contact Program Manager Karen Kritz of the New Jersey Department of Agriculture at (609) 984-2506 or karen.kritz@ag.state.nj.us. Please provide the estimated size and quantity of the various pesticide containers and nursery pots that will be delivered and to what site.

The fall 2003 agricultural product container-recycling program is a collaborative effort involving the New Jersey Departments of Agriculture and Environmental Protection, Atlantic County Utility Authority, Burlington County Solid Waste, Cumberland County Improvement Authority, Monmouth County Board of Chosen Freeholders, Pollution Control Financing Authority of Warren County, Ag Container Recycling Council and USAg Recycling, Inc.

Please see the following collection schedule and processing guide for further information or visit www.state.nj.us/agriculture/recyclingpestcons.htm.

**Pesticide Container and Nursery Pot
Collection Program
2003 Fall Collection Schedule**

Southern Region

Collection Date: **Saturday, September 27**
Location: Hammonton Public Works Department
11th & Egg Harbor Road (Rt 561)
Hammonton, New Jersey
Time: 9 a.m. to 2 p.m.
Contact: Ron Berenato, Atlantic County Utility
Authority (609) 272-6920

Collection Date: **Friday, October 3**
Location: Cumberland Cnty Solid Waste Complex
169 Jesse Bridge Road
(located off Route 55 Exit 29)
Deerfield, New Jersey
Time: 8 a.m. to Noon
Contact: Dennis DeMatte, Jr. (856) 825-3700

Northern Region

Collection Date: **Wednesday, October 8**
Location: Warren County Fair Grounds
Route 519 & Strykers Road
Harmony Township, New Jersey
Time: 8 a.m. to Noon
Contact: William Carner (908) 453-2174
Pollution Control Financing Authority
of Warren County


Central Region

Collection Date: **Thursday, October 9**
Location: Upper Freehold Highway District Yard
Route 539
South of the Cream Ridge Golf Course
Time: 9 a.m. to 2 p.m.
Contact: Larry Zaayenga (732) 431-7460
Monmouth County

Collection Date: **Friday, October 10**
Location: Burlington County Resource Recovery
Complex
Burlington-Columbus Road (Route 543)
Mansfield, New Jersey
Located off I-295 Exit 52A (Columbus
Exit)
Time: 8 a.m. to Noon
Contact: Anne Moore (609) 499-1001

**New Jersey Pesticide Container and
Nursery Pot Collection Program Guide**

**Plastic Pesticide Container Processing
Steps**

1. All pesticide containers must be either triple rinsed or pressure rinsed and drained;
 2. All pesticide containers must be free of residue (other than stains);
 3. Lids must be removed;
 4. Plastic labels with MSDS sheet must be removed;
 5. Paper labels must be removed (to the best of your ability);
 6. Only non-refillable pesticide containers will be accepted – drill a ¼-inch hole in the bottom of the container or with a utility knife make a 6-inch slit in the bottom of the container so the container will not hold liquids;
 7. Only pesticide containers embossed with HDPE and the recycling #2 will be accepted;
- 
8. Pesticide containers up to 55 gallons in capacity will be accepted; and
 9. Pesticide containers must have originally held an EPA registered pesticide.

Agricultural, professional and commercial applicators who generate large quantities of pesticide containers may contact USAg Recycling at 1-800-654-3145 for direct service. USAg will come to your site and there is no charge for the service.

Plastic Nursery Pot Processing Steps

1. All soil must be knocked free from the nursery pots and then the pots must be rinsed;
2. All nursery pots must be free of soil and plant material; and
3. Only nursery pots embossed with recycling #2 or HDPE will be accepted.

Items That Will Not Be Accepted and Will be Returned to the Recipient

1. Pesticide containers with dried formulation on the container, pour spout or the spout threads;
2. Pesticide containers with any liquid residue;
3. Pesticide containers where the insides are caked with dried residue;
4. Mini-bulk, saddle tanks and nurse tanks, which can be made of fiberglass;
5. Pesticide containers with lids or lids by themselves;
6. Pesticide containers that originally held veterinary products, consumer products or home and garden pesticides;
7. Nursery pots not embossed with # 2 or HDPE;
8. Nursery pots with soil residue; and
9. Nursery pots with plant residue.



Plastic pots used for growing nursery plants.



Example of the use of polyethylene film to cover overwintering hoops at a nursery.



Horticultural Engineering Newsletter wins a Blue Ribbon Award!

At the annual ASAE (Society for Engineering in Agricultural, Food, and Biological Systems) in Las Vegas, Nevada, July 27-30, the Horticultural Engineering Newsletter received a Blue Ribbon Award in the Educational Aids Competitions in the category Newsletters. This annual competition evaluates a variety of extension materials and methods and rates them based on a set of criteria, including format, content, organization, use of tables, graphs and figures, etc. Obviously, we are very proud of this award and want to thank our readers for their continued interest in and support of our newsletter. We will continue to strive to produce high quality newsletters.

**GREENHOUSE MANAGEMENT:
COST ACCOUNTING AND
CROP PRODUCTION**
A One Day Workshop

Monday, October 20, 2003

TIME: 8:30 am - 4:00 pm

LOCATION: COOK Campus, NEW BRUNSWICK, NJ

SPONSORED BY: CSREES/USDA and the Northeast Center for Risk Management Education, Rutgers Cooperative Extension in Cooperation with The Cook College Office of Continuing Professional Education

Is your greenhouse business growing GREEN (\$\$) or RED (INK)? Do you really know for sure or do you wait for your accountant to tell you? The first part of this workshop is a software training session designed to help you better manage your greenhouse costs. During the morning session, Dr. Robin G. Brumfield, Farm Management Specialist, will introduce you to a new user-friendly cost accounting software program. Dr. Brumfield's windows based application software was specifically created for greenhouse owners and managers. It enables users to easily determine the profitability of their greenhouse crops and explore a full range of cost accounting capabilities. With the software, you can analyze incremental production costs and track financial categories, as well as program costs options typically found on income statements. You will be able to generate information showing total costs, and net returns per plant. This software also will assist you when making decisions on pricing, identifying and reducing unprofitable production costs and increasing sales of profitable crops. During the afternoon session, current trends in greenhouse crop production and environment control will be discussed. In addition, some preliminary data from our 2003 NJ Greenhouse Industry Survey will be presented.

PROGRAM DESCRIPTION

The three-and-a-half-hour morning program will demonstrate how to use the new cost ac-

counting software developed by Dr. Brumfield. You will meet in a computer lab and be introduced to the unique capabilities of the software. Case studies will be explored using greenhouse examples and by the end of this interactive program you will be able to take your software home and put it right to work. The three-and-a-half-hour afternoon program consists of a half hour overview of the preliminary results of the NJ Greenhouse Survey, conducted during the spring. This discussion will be followed by two one-and-a-half hour presentations on: 1) Developments in Greenhouse Crop Production, and 2) Developments in Greenhouse Environment Control.

SPEAKERS

Dr. Robin Brumfield, Farm Management Specialist

Dr. George Wulster, Floriculture Specialist

Dr. A.J. Both, Controlled Environment Agriculture Specialist

Fee

\$65 (includes software and lunch)

REGISTRATION

Through the following website:

www.cook.rutgers.edu/~ocpe

By Phone:

Office of Continuing Professional Education (732) 932-9271 ext. 630, Monday through Friday, 8:00 a.m. to 4:30 p.m. Please have your credit card information ready. OCPPE accepts Visa, MasterCard or the American Express cards.

For more information about the registration process, please contact Mr. Keith Wilson at (732) 932-9271 ext. 617 or via email at kwilson@aseop.rutgers.edu.

Mailing address:

Cook College, Office of Continuing Professional Education, attn. Mr. Keith Wilson
102 Ryders Lane
New Brunswick, NJ 08901-8519

Interested? Don't wait registering till the last minute: seating is limited!

Carbon Dioxide Enrichment

A.J. Both

Just like water, nutrients, and light (energy), plants need carbon dioxide (CO₂) for the process of photosynthesis. Without sufficient CO₂ available, the growth rate of plants will be reduced. At ambient temperatures, CO₂ is a gas and plants take up CO₂ through their stomates located along the surface of the leaves. Thus, as long as the CO₂ concentration around the leaves is sufficient, plant growth will not be limited due to a lack of available CO₂. However, for plants grown in the greenhouse, the CO₂ concentration can be below the concentration normally measured in the outside air. The reason is that, particularly during periods with low outdoor temperatures (at night and during the heating season), the ventilation rate is too low to bring in sufficient amounts of “fresh” CO₂. When this happens, the demand for CO₂ is greater than the supply and the below normal CO₂ concentration limits the plant’s growth rate. In addition, during these colder times of the year, some growers use supplemental lighting in an attempt to boost plant growth. But if the CO₂ concentration is too low, the added supplemental lighting will not increase plant growth much because the low CO₂ concentration limits photosynthesis. When such conditions happen regularly, growers often consider providing extra CO₂ to the plants. This article discusses some of the issues associated with CO₂ enrichment in greenhouses.

CO₂ gas is considered one of the so-called “greenhouse gases” because it can absorb heat. Thus, as the theory goes, heat that would otherwise be radiated from the Earth’s surface into space is now trapped in the atmosphere, causing the average air temperature to rise. One of the by-products of burning fossil fuels, such as natural gas and oil, is CO₂. Since the industrial revolution that started in the eighteenth century, the burning of fossil fuels has increased tremendously, resulting in a steady increase in the CO₂ concentration in the atmosphere. Since the World’s desire for energy is not likely to decline any time soon, the CO₂ concentration in

our atmosphere is expected to continue to rise, further contributing to the so-called “greenhouse effect”, but perhaps also boosting plant growth rates.

Today, on average, the outdoor CO₂ concentration is between 350 and 400 μmol mol⁻¹ (or ppm, which is perhaps a more commonly used unit). This concentration is often referred to as the ambient CO₂ concentration. The air we breathe consists of approximately 79% nitrogen, 21% oxygen, and some very small quantities of other gasses, among which 0.035-0.040% CO₂. In a well-lit closed greenhouse with a full canopy, the CO₂ concentration can drop below 200 ppm (or 0.020%) without CO₂ enrichment, significantly reducing the crop growth rate. A lot of research has been conducted investigating the positive effects of elevated CO₂ concentrations on crop growth. Many different plant species have been studied. These studies have shown that plant growth can be increased under elevated CO₂ concentrations, but that in general, a concentration above 1,000 ppm (or approximately three times the ambient concentration) no longer resulted in an increase in plant growth. This result is somewhat fortuitous because: 1) CO₂ concentrations above 5,000 ppm can be harmful to humans, and 2) increasing the CO₂ much above 1,000 ppm becomes more expensive because of the inevitable leakage of CO₂ through cracks and small openings in the greenhouse cover. Thus, it is often recommended to enrich the greenhouse environment to a concentration not higher than around 1,000 ppm. In addition, research has shown that an increase in the CO₂ concentration has a larger impact when the original concentration is closer to the ambient concentration (350-400 ppm) compared to being closer to the upper limit of CO₂ enrichment (around 1,000 ppm). In other words, adding CO₂ returns a bigger bang for the buck (in terms of increased crop growth) when the starting CO₂ concentration is lower rather than higher (over the 350-1,000 ppm of CO₂ range). It is also important to remember that some plant species get acclimated to ele-

vated CO₂ concentrations and, over time, do not show a continued increase in crop growth.

CO₂ can be supplied to the greenhouse environment using different methods. For example, CO₂ gas can be released from compressed CO₂ gas tanks. Since CO₂ is a by-product of many different chemical processes, compressed CO₂ is often readily available for a reasonable price. Note: compressed CO₂ gas is added to soft drinks to produce the fizze. But a lot of compressed CO₂ tanks are needed to provide a larger sized greenhouse with sufficient CO₂. Therefore, growers that use a lot of CO₂ can opt to install a liquid CO₂ tank that can be purchased or rented through local gas distributors. A refrigeration unit is connected to such a tank to cool the CO₂ to a temperature where it becomes a liquid. The advantage of storing CO₂ as a liquid is that you need less volume, but on the other hand you need a refrigerator (and electricity) to keep the CO₂ cold enough so it will stay in the liquid form. The liquid CO₂ is vaporized (i.e., converted from a liquid to a gas) before it is released into the greenhouse. CO₂ gas is often distributed throughout the greenhouse with small inflatable polyethylene tubes that run the length of the greenhouse and are mounted inside and towards the bottom of the plant canopy (CO₂ gas is heavier than air). Along the length of these inflatable polyethylene tubes are small holes through which the CO₂ can escape, ensuring even distribution throughout the greenhouse. Another method of CO₂ enrichment uses CO₂ burners (i.e., natural gas burners) to produce CO₂ from the combustion of natural gas. These burners are usually distributed throughout the greenhouse to increase the uniformity of the gas distribution. Drawbacks of CO₂ burners can be that they produce (some) heat at the same time they produce CO₂ and that improperly installed burners can be a fire hazard. During normal greenhouse operation, heat and CO₂ are not always needed at the same time. Finally, CO₂ can be captured from heating system exhaust gasses and used for greenhouse enrichment.

With any of the different CO₂ distribution meth-

ods, it is important that no harmful contaminant gasses are released at the same time. For example, ethylene gas is known to cause serious problems for some crop species even at extremely low concentrations. Therefore, a grower using CO₂ enrichment should make sure that the CO₂ gas released is of the highest purity (check with your gas supplier and/or inspect all CO₂ burners regularly).

When growers use supplemental lighting during the darker periods of the year, it is often recommended they enrich the greenhouse environment with CO₂ at the same time. This practice ensures that the CO₂ concentration does not limit plant growth during those hours of the day when (expensive) supplemental lighting is used to boost crop growth. However, when any amount of ventilation is needed to maintain the set point air temperature, CO₂ enrichment quickly becomes uneconomical because any released CO₂ will quickly be vented to the outside air, and, thus, wasted. Some growers continue with CO₂ enrichment during periods when only a little ventilation (e.g., the first ventilation stage) is required because they feel that even a little increase in CO₂ concentration still makes economic sense.

For control of the CO₂ concentration, a CO₂ sensor is needed. Accurate CO₂ sensors are relatively expensive and need periodic calibration. The sensor should be mounted at a representative location and close to the plant canopy. Manual or computer control can be used to open and close a solenoid valve that releases the CO₂ gas into the greenhouse, or to turn the CO₂ burners on and off. Some CO₂ sensors are temperature sensitive, and those sensors should be located inside an insulated and aspirated box. This box prevents solar radiation from influencing the measurements. There are no human health concerns as long as the CO₂ concentration is not elevated above 3-4 times the ambient concentration (dangerous and eventually fatal CO₂ concentrations start around 5,000 ppm). CO₂ enrichment is generally only supplied during the light period of the day (which includes any

hours of supplemental lighting), since adding CO₂ during the dark period has little positive effect on plant growth.

For some crops (e.g., leafy vegetables), research has shown that, within limits, supplemental lighting can be “traded” for CO₂ enrichment. This means that instead of adding a certain amount of supplemental lighting, the CO₂ concentration can be increased resulting in the same increase in crop growth. The obvious advantage is that adding CO₂ is likely to be cheaper than running the supplemental lighting system. A computer control system can be used to determine when it is more advantageous to add CO₂ or when it is necessary to run the supplemental lighting system (e.g., when the solar radiation causes the greenhouse to heat up above the set point temperature, necessitating the operation of the ventilation system and making CO₂ enrichment uneconomical). The benefits of CO₂ enrichment can be further exploited when the set point temperatures are allowed to drift upward at the beginning and towards the end of the light period. These higher set point temperatures would delay the onset of ventilation, making CO₂ enrichment economical during those periods of the day. However, such a strategy should always be tested first for the particular crop(s) grown. During periods of the day with a high light intensity, it is likely that the ventilation system is needed to maintain the set point temperature, and under those conditions, CO₂ enrichment is probably not economical.



A deflated polyethylene tube (visible between the two metal heating pipes on the floor of the greenhouse) used to distribute CO₂ gas. The tomato crop is grown hydroponically in gutters that are elevated for ease of harvesting.



A liquid CO₂ storage tank secured with a gate.



A CO₂ sensor located inside a greenhouse and used for monitoring and control of the CO₂ concentration. The readout from this sensor can be used to operate a solenoid valve either manually or with a computer control system. Opening the valve will allow pure CO₂ gas to be distributed throughout the greenhouse.

**RUTGERS COOPERATIVE EXTENSION
COOK COLLEGE
RUTGERS, THE STATE UNIVERSITY
NEW BRUNSWICK, NJ 08901**

Distributed in cooperation with the US Department of Agriculture in furtherance of the Acts of Congress of May 8 and June 30, 1914: Cooperative Extension Service work in agriculture, home economics and 4-H. Karyn Malinowski, Dean of Outreach and Extension Programs. Rutgers Cooperative Extension provides information and educational services to all people without regard to sex, race, color, national origin, age or handicap. Rutgers Cooperative Extension is an equal opportunity employer.



High tunnel tomato production.

HORTICULTURAL ENGINEERING

Dr. A.J. Both
Assistant Extension Specialist
Director of CCEA
Bioresource Engineering
Rutgers, The State University of NJ
George H. Cook College
20 Ag Extension Way
New Brunswick, NJ 08901-8500
Your comments, questions, and
suggestions are always welcomed.
Phone (732) 932-9534
email: both@aesop.rutgers.edu
Web: <http://aesop.rutgers.edu/~horteng>

Horticultural Engineering Web Site

This issue of Horticultural Engineering, like previous ones, is available on the internet at:

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

If you provide us with your 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, etc.

HortiFair (NTV)
Amsterdam, the Netherlands
November 5-8, 2003
<http://www.hortifair.nl>

**!! Important Dates !!
January 8 – 9, 2004
Greenhouse Engineering Short
Course
at Rutgers University**

This 2-day course, coordinated by your editor, features timely topics for greenhouse operators and those interested in learning more about greenhouse engineering or perhaps thinking about getting started in the greenhouse business. Registration information is available for the Office of Continuing Professional Education at Cook College, Phone: (732) 932-9271, or on the web: <http://cook.rutgers.edu/~ocpe>
It is not too early to plan to attend this program! Topics include heating, ventilation, supplemental lighting, environment control, insect screening, open-roof greenhouses, simple greenhouses (high-tunnels), planning, crop production, and more.