H o r t i c u l t u r a l E n g i n e e r i n g

Volume 13 No. 2 March 1998

GREENHOUSE AND NURSERY FILM RECYCLING

William J Roberts Director CCEA

During 1997 a greenhouse and nursery film recycling demonstration program was carried out. The New Jersey Nursery and Greenhouse Film Recycling Project was an effort to provide New Jersey growers with an alternative to disposing of used greenhouse and nursery films in the landfill. This project has been developed to recycle this material. Nursery overwintering films (both white and clear) and clear multi-season (2yr, 3yr, 4yr) greenhouse films were collected for recycling until June 30, 1997. Collection sites were conveniently located in Central and Southern New Jersey.

There was no charge for dropping greenhouse or nursery film off at any approved collection site. Growers from all counties in New Jersey participated. Since this demonstration program was a recycling project, the transporting vehicle did not have to be registered as a solid waste hauler with the NJDEP. The grower could handle the film or contract with a third party. The participating collection sites sponsored by MONMOUTH COUNTY, BURLINGTON COUNTY AND CUMBERLAND COUNTY waived tipping fees for all greenhouse and nursery plastic delivered to the approved collection sites. Growers from any area of New Jersey were eligible for the program not just the three counties listed.

This project was jointly sponsored by AT Plastics, Inc., New Jersey Department of Agriculture, New Jersey Nursery and Landscape Association, Inc., New Jersey Department of Environmental Protection, Rutgers Cooperative Extension, E.C. Geiger, Recycling con't

Inc., Monmouth County, Burlington County Office of Solid Waste, and the Cumberland County Improvement Authority. Ms. Karen Kritz of NJ Department of Agriculture, Howard Davis of NJ Nurseryman Association and Mr. Frank Fornari of AT Plastic Inc. were prime movers in the project.

Key points to the program

- Tipping fees were waived for all film delivered to approved sites for recycling.
- Film could be bundled or rolled - it **COULD NOT** be tied. For ease of handling it was recommended that the film be rolled up as it is removed from the structure which helped to keep dirt from attaching itself through static electricity and direct contact with the soil.
- Film had to be free of lathing, staples or saran tape.
- Film should be as clean as possible.
- No plastics other than greenhouse and nursery film could be accepted - no bags, mulch film, shrink film, stretch film, or ground cover film could be a part of the demonstration program.

The program was successful and it is hoped to be repeated in 1998 with some revisions and modifications to the program. Two hundred and twenty five (225) tons of nursery and greenhouse film were collected.

Burlington County 68 tons recycled
All county Recycling (Monmouth) 7.5 tons recycled
Cumberland County 150 tons recycled
225 tons total

Containment Growing Systems

William J. Roberts Director CCEA
The Center for Controlled Environment Agriculture

Most growers are determined to use an environmentally friendly greenhouse production system. The Dutch greenhouse operators have been leaders in this respect. Several years ago they agreed by handshake with the Dutch Government that there would be no runoff from greenhouses by the turn of the century. This gentleman's handshake actually became a law with the date moved forward to 1997. All greenhouses must meet this requirement and many attribute the current 20% greenhouse area vacancy rate in the Netherlands at this time to this law. Greenhouse operators were simply not able to conform to the requirements of the law.

System Designs

There are two systems being used to meet the terms of this environmental requirement which are necessary for a country with the water table constraints common to the Netherlands. These systems are the ebb and flood bench system and the ebb and flood floor system. Both systems require the same basic components. These include water and nutrient holding tanks, pumps, irrigation controls and a watertight table or floor to contain the water in shallow depths when irrigation occurs.

Bench Systems

Bench systems utilize water tight, welded aluminum tables for the growing surface. The tables usually have configured bottoms to allow the water to quickly spread to all

New Jersey Agricultural Experiment Station Publication Number P03130-3-98

areas of the bench. This insures that all the plants will receive the same quantity of water. The irrigation system is designed so that bench positioning is not critical for movable systems. Although fixed benching systems can be used, transportable or moveable systems are popular because of potential labor and space efficiency benefits. These systems are particularly suited for crops which require hand work and are most adaptable to small greenhouses.

Flooded Floor Systems

Flooded floor systems have been developed for larger greenhouse. In a sense the entire floor or floor sections become large benches, containing the water for irrigation. This system has become popular in the Netherlands and it is reported that over 1200 acres of flooded floors have been constructed in the last 10 years.

An ebb and flood or flow floor system actually combines three management systems into one, **watering**, **heating** and **materials handling or internal transport**. The development of floor heating systems has made the system possible. The driving force for the system is the requirement that there be no runoff from greenhouses. It turns out that each of the three components of the system are very efficient and many growers are happy with the results of the floor system. One of the lasting impressions of having visited ebb and flood floor systems in the Netherlands is the noticeable lack of people working in the greenhouse. Electric fork lift trucks are used to convey the product to the head house area and floor space utilization is nearly 90%.

Negative aspects of the floor system are the high initial costs, its permanent character and the absolute need for precision concrete work.

The requirements of a good ebb and flood floor production system include the following:

- allow transport in all directions.
- provide for easy cleaning and main tenance.
- be poured perfectly to provide uniform and rapid filling and drainage without pockets or puddles being created.
- support many different transport devices.
- floor heating is essential for crop growth.
- the greenhouse needs to be divided into manageable sections.

Special Equipment

Several holding tanks and mixing tanks are required depending upon the desired number of fertilizer solutions to be fed. Filtration is mandatory to limit large particles of peat moss and leaves from plugging up the system. Simple, self-cleaning gravity filters are often used.

The greenhouse will usually be divided into zones of 1000 to 3000 square feet corresponding to the greenhouse design. Each section can be flooded and drained through an underground system independently. A section of 3000 square feet, flooded to 1 ½" in 15 minutes would require 3500 gallons of water and a pump delivery and return capability of 233 gallons per minute. Following each zone watering another section will be automatically irrigated.

Containment Growing Systems con't

There are several important topics to consider beyond the scope of this handout. These include: Cultural Aspects, Heating Considerations, Disease Control and overall Transport Management. They are discussed in the publications listed on page 4

Cultural Aspects

Floor heating and excellent drainage provide a situation where the floors are dry most of the time. This prevents excessive evaporation of water and also prevents the spread of disease.

Consideration must be given to the type of media used for growing the plants. A mix of at least 10% air is required when soil is in the saturated condition. A good contact must be maintained between the floor and the plant container. Air locks can cause a disaster. Solution of nutrients should be maintained at low concentrations because of the frequency and type of watering which could cause a buildup of salts.

Managing fertility is a challenge with a sub-irrigation system. The duration of each irrigation event should be long enough to allow the potting medium to approach field capacity. This varies for the size of container. For flats and plugs this may be only 3-4 minutes. For 3 to 6 inch pots this may be 10 minutes. Larger containers or tubs may require 20 minutes.

Disease Control:

The danger or spread of diseases is still one of the major concerns for the closed watering system either on benches or on the floor. Fungi, bacteria and spores can be transported by the watering system so sanitation is imperative. Although expensive, there

Containment Growing Systems con't

are several sterilization methods used to overcome these potential problems. Pasteurization, ozone treatment, ultra violet light and hydrogen peroxide.

Sources of Ebb and Flood Benching Equipment

Agro Dynamics Inc East Brunswick, NJ
Conley's Mfg. and Sales, Pomona, California
Mid-West GROmaster Inc Saint Charles, Illinois
Rough Bros. Cincinnati, Ohio
Ludy Mfg. Co. New Madison, Ohio
Westbrook Greenhouse Systems, Grimsby, Ontario Canada
Van Wingerden Greenhouse Co. Horseshoe, North Carolina

Sources of Information and Installation of Ebb and Flood Floors.

Greenlink Ratus Fischer Asheville, North Carolina
John Hoogeboom, Agronomico Inc Hendersonville, North Carolina

* Publications and Articles

Ebb and Flood Benching Systems, Dr. Richard McAvoy, Floriculture Specialist at the University of Connecticut, Storrs Connecticut.
Greenlink Flood Floors, Mr Ratus Fischer, Contractor Asheville, North Carolina
Flooded Floor Systems, Ratus Fischer Asheville, North Carolina
Culture Floors Peter Van Weel, Research Station for Floriculture, Aalsmeer The Netherlands
Sub Irrigation Floors Peter Van Weel, Aalsmeer, The Netherlands
Modular Construction of Closed-Loop Production Systems J.C. M. Tas and Peter Van Weel
Bench Heating Systems and Their Influence on Microclimate. Vogelezang and Van Weel

* Individual photo copies of these publications are available from your editor free of charge.

Greenhouse Film Coninued from page one.

During the 1997 program the collection sites received a good price in a poor market. On average, they received $100 per ton. One of the end market users (Trade Pro-plastic recycling firm) is anxious to get more of the recycled material which was collected this year.

Participation was mixed. Burlington County had 12 growers. All County had 5 growers participate and Cumberland County had 96 growers participating. Although the participation of growers at the Monmouth County site was disappointing the company feels that through a joint promotional effort the participation levels will increase dramatically.

Quality control was the issue which caused the most concern. This can be addressed best by developing and distributing amended grower collection guidelines. The spring collection period works well with nursery overwintering systems but does not fit in well with greenhouse operations who traditionally reglaze their structures during the late summer months, usually having the reglazing

Secretary Brown Pleased with the Program

Speaking at the Vegetable Growers meeting in Atlantic City, **Secretary Brown** of the NJ Department of Agriculture, indicated his pleasure with the program and his desire to repeat the program this season for film glazings and expand the program to include polystyrene pots and containers used for growing and shipping.

Karen Kritz of the NJDA has coordinated this important program.
609 984 2506

Soil Heating for Transplant Production

William J. Roberts Director CCEA
Rutgers University,

The well-documented benefits of soil heating have developed a considerable interest in greenhouse floor heating. Traditional greenhouse production systems have used benches to elevate plants from the cold soil. In most systems heating pipes are installed under the benches or surface bench heating systems are used to increase soil temperatures.

Bedding plant operators have traditionally grown in polyethylene glazed plastic film greenhouses and have placed the plant material directly on the floor to eliminate the cost of benches. This growing system can create a serious problem with cold soil temperatures. Neither warm air nor hot water heating systems are able to maintain warm soil temperatures without operating the greenhouse at ambient temperatures much higher than necessary, dramatically increasing costs of energy for heating. Soil heating systems reduce operating costs when growing on the floor. The temperature of the microclimate at the floor canopy can be maintained at the proper level with lower ambient air thermostat settings. This feature significantly reduces heating costs with savings depending upon the crops being grown.

TYPES OF SOIL HEATING SYSTEMS IN THE FLOOR:

Growers have successfully used soil heating systems with various types of floor construction. These include, gravel, sand,

New Jersey Agricultural Experiment Station Paper #NJAES P03130 -34-97

soil, porous and solid concrete. Each of these systems work well from the heating standpoint and have varying favorable characteristics from the production standpoint. Soil, gravel and sand floors are the least expensive but offer the least benefits from a materials handling standpoint and ease of worker performance. The concrete options are the most expensive to install but provide excellent materials handling characteristics, easier maintenance, long life, and weed control.

A Word About Temperature

Table one illustrates temperatures at various locations in a ½ acre greenhouse. The greenhouse is 210 feet wide with two 100' floor-heated sections on either side of a center aisle which is 10 feet wide. The important temperature differences are noted in Table 1 between the temperature under the pot in the alley (the paved walk area), where there is no floor heat, as compared to the temperature under the pot in the floor-heated area. These plants are within a few feet of each other, yet the soil temperature in the pot on the unheated floor is 14^{o}F cooler. Crop performance suffers significantly with low soil temperatures. Greenhouse operators growing on unheated floors can expect the soil and floor canopy temperature to be at least 10^{o} F lower than at the temperature recorded at the 6 foot level. This is not a problem in itself because the temperature at the 6 foot level can be elevated 10^{o}F and maintained to give the desired floor temperature. However, the greenhouse would have to be operated at 75^{o} F to give the desired soil temp. of 65^{o} F. leading to very high energy costs.

TABLE 1

Temperatures Recorded in ^{o}F at **George Schaefer's** Greenhouses in Triangle, New York, January 1980

	Floor heated area			Alley	Foyer	Shop
	1800	2100	0800	0800	0800	0800
Outside	30	20	3	-	-	-
Soil Temp. in pot	62	61	64	-	-	-
Under pot	64	63	**67**	**53**	55	39
12 inch level	60	61	65	58	55	45
72 inch level	65	65	67	70	68	63

Many growers have saved energy by operating the greenhouse at least 5^{o}F lower at the 6' level than conventional settings. For instance, some growers with floor heating can operate the greenhouse at 55^{o}F rather than 60^{o}F with the same crop response because the crop on the floor is in fact, at the desired higher temperature.

Supplemental Heating Required

Each warm floor heating system should be viewed as a supplement to a greenhouse heating system. Since the floor operates at relatively low temperature, it cannot deliver all the heat required by the greenhouse during very cold periods. The actual percentage of the total which is supplied depends upon location and heating demand and time of season. Approximately 30 - 50% of the design heat load can be delivered from the floor system. Overhead unit heaters either combustion type or hot water to air heat exchanger units are popular to meet the heating design loads required for a greenhouse. The uniformity of the warm floor overcomes many of the heat distribution and uniformity problems associated with unit hot air heaters. Overhead pipe loops can also be used. Although more costly, these provide excellent temperature uniformity throughout the greenhouse.

Selection of Pipe

Present information indicates that virgin polyethylene pipe, cross-linked polyethylene PEX, polybutylene pipe, larger diameter EPDM flexible tubing, CPVC or polyvinylchloride pipe offer the best design for economy, corrosion resistance, and labor of installation. However, just recently Shell Chemical Co withdrew polybutylene pipe resins from the United States market as a result of a recent legal settlement over floor systems which failed in homes and commercial buildings. With the coming unavailability of the polybutylene pipe, which has been the industry standard for many years, it appears that cross-linked polyethylene pipe, PEX will be the logical replacement for headhouse applications as well as greenhouse applications where concrete ebb and flood irrigation systems will be used.

Proper water temperature is critical to the effective operation of floor heating systems. Normal operating temperatures are from 90°F to 110°F to maintain a low temperature drop in the loop, around 5°F, so that a uniform soil temperature can be achieved in the crop. When a higher heat release from the greenhouse floor is needed, such as in germination areas, it is advisable to space the pipe closer (6"-9") than to increase the temperature of the water in the system. This avoids the problem of uneven heat distribution. Observing strip growth in seedlings is a good indication that the temperature of the water in the pipe is too high. Temperatures higher than recommended also increase the amount of energy lost to the soil and increase the probability of deformation of the fittings with the potential for failure.

When the floor choice is either porous concrete or concrete, connections for the coiled pipe loops can be easily made at the ends of the greenhouse and the connections covered with gravel so that leaks can immediately be detected and repaired without having to remove either porous or solid concrete.

SYSTEM DESIGN:

Current design practice for the floor system is to estimate that approximately 20 btu/hr are given off to the greenhouse from each square foot of floor with a 90°F average water temperature in the plastic pipe loop and a 60°F ambient temperature for potted plant or flat production on the floor. Tightly spaced flats may limit the rate of heat transfer but usually normal irrigation practices ensure that the heat transfer is adequate. Lower ambient air temperatures and higher soil temperatures will increase the rate of heat transfer from the

Soil Heating con't

floor. If higher water temperatures are selected then closer pipe spacing may be required. A good conservative design practice is to provide 30 bty/hr per square foot from the hot water heating system. However, when calculating the total heating requirement from the greenhouse, consider that only 20 btu/hr per square foot is available from the floor and provides the remainder of the heating capacity needed for the greenhouse from an overhead heating system.

Water flow rates in the pipe loops are very important. A velocity of 1.5 to 2 feet per second gives adequate heat transfer and helps eliminate pockets of air which are prone to accumulate in a horizontal pipe system. This translates to a flow of 2 to 2.75 gpm per loop with 3/4 inch pipe. Pipe loops should be no longer than 400 feet to minimize friction and provide a balanced design for the system-pump. Shorter pipe loops are adequate but require a larger pump for the system since each loop requires the aformentioned flow.

Those interested in learning more about floor heating or desiring to install a system might benefit by purchasing the publication E207, **"Soil Heating Systems for Greenhouse Production."** Written by your editor, it is available from him for $4.00.

William J. Roberts
Bioresource Engineering Department
Rutgers, The State University
20 Ag Extension Way
New Brunswick, NJ 08901-8500

Make check payable to
Rutgers the State University.

NEW ENGLAND GREENHOUSE CONFERENCE
October 19 -21, 1998

This popular grower conference will be moving to a new location, the **<u>New Worcester Convention Centre</u>**

This event attracts over 2000 participants and 130 exhibitors from the US and Canada. Make plans to attend and in the meantime visit their website @:
www.uvm.edu/"pass/greenhouse/negc.html

GREENHOUSE IPM NOTES

This is a new publication being produced by Rutgers and Cornell University Cooperative Extension personell, James Willmott, County Agricultural Agent of Camden County and Ralph Freeman, area Floriculture Specialist at Riverhead, Long Island.

This new attempt at partnering is geared to promoting synergy, creative thinking and a cohesive union between the primary parties. It is a new way of conducting business designed to empower all to be more productive and efficient.

This new publication is designed for the grower in the Northeastern United States. It will provide up-to-date information on integrated pest management (IPM) for producers of greenhouse, perennial and field-grown horticultural crops.

If you are interested in receiving this publication contact Jim at Rutgers Coop Ext. 152 Ohio Avenue, Clementon, NJ 08021

HORTICULTURAL ENGINEERING

William J. Roberts Editor
Extension Specialist
Bioresource Engineering Department
Rutgers, The State University of NJ
George H. Cook College
20 Ag Extension Way
New Brunswick, NJ 08901 - 8500
Comments, questions and suggestions are welcomed.

Phone 732 932 9534
Fax 732 932 7931
e-mail

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

Distributed in cooperation with 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. Zane Helsel, Director of Extension. The Cooperative Extension Service provides information and educational services to all people without regard to sex, race, color, national origin, age or handicap. Cooperative Extension is an equal opportunity employer.