A BRIEF OVERVIEW OF VARIOUS CLOSED IRRIGATION SYSTEMS AND OTHER METHODS OF REDUCING CONTAMINATED RUN-OFF FROM GREENHOUSES

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There is a growing public concern about groundwater contamination from agricultural production practices, in particular the application of chemicals and fertilizers via irrigation systems. The move to reduce or eliminate groundwater contamination is best exemplified by the recent "chemigation" regulations enacted in Minnesota and the pending legislation on the application of fertilizers through irrigation systems ("fertigation"). These recent regulations require meticulous record keeping on the use of pesticides and required the installation of backflow preventive valves on water sources used for irrigation systems through which chemicals are applied. Greenhouses not complying to the regulations and those that do not have chemigation permits can be shutdown by the Minnesota Department of Ag. The future seems to hold even tighter restrictions on controlling run-off from greenhouse operations. Already, Dutch law requires that growers eliminate contaminated effluent by the year 2000 and it is safe to assume that the U.S. will follow suit with laws that will greatly restrict or prohibit the release of contaminated effluent from greenhouse operations. As with everything else in our industry, planning for future changes is essential for continued success in the business. So, what can you do now to ease the transition into new production systems that eliminate or greatly restrict run-off from your operation?

Currently, there are several options available to growers. The question is, "Which system is best suited to your operation and pocketbook?" The following will cover the various systems that eliminate or reduce run-off and a summary of their advantages and disadvantages. Some of the systems are fairly new and have little testing history behind them. Much research on these systems is currently under way and early results are promising.

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Ebb and Flow Systems

Ebb and flow systems are far and above the most well known of the closed systems with extensive research already concluded on the use of these systems in potted plant production. Ebb and flow is already widely used in Europe and parts of the U.S. by growers of potted plants, bedding plants and plugs.

Special water tight benches or greenhouse floors with built in drainage systems are used (Figure 1). The bench or floor is flooded with a nutrient solution, that contains the essential fertilizer elements, to a depth of about one inch for about 10 - 15 minutes. The solution is taken up by capillary action and the solution not used during flooding is returned to a holding tank for use in the next watering cycle. The nutrient solution is tested regularly and minor adjustments are occasionally necessary to keep nutrient and pH levels balanced.

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Advantages

1. Low labor requirements to operate this system.
2. Adaptable to mechanization and rolling bench systems.
3. Reduce the use of fertilizer by 30-40%.

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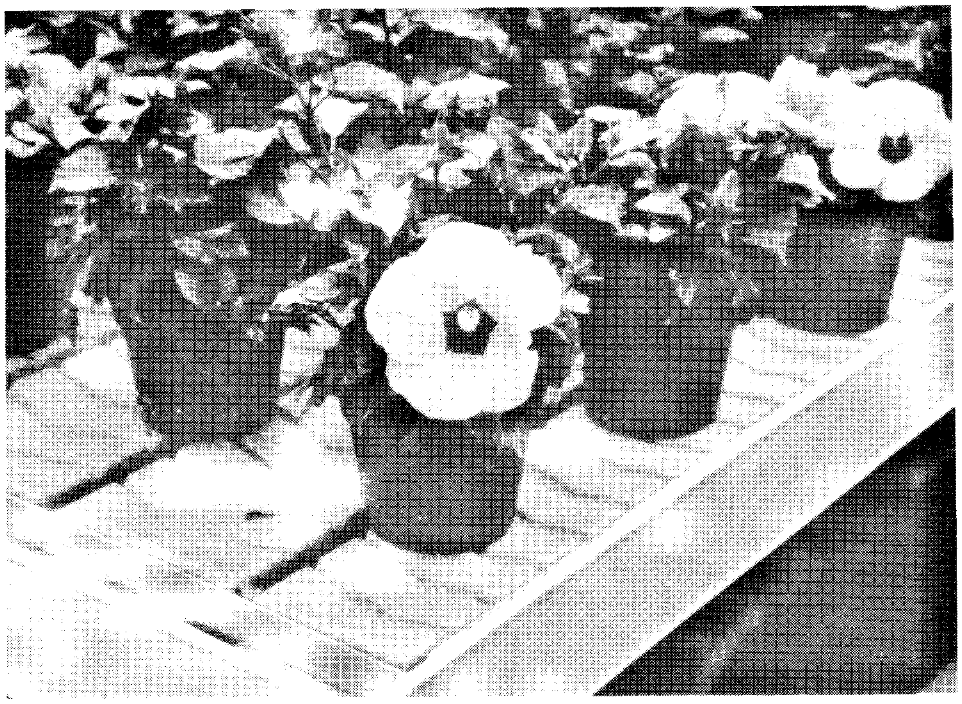

Figure 1a & b. *Potted plant production in an Ebb and Flow benching system.*

4. Most growing media are suitable for use in ebb and flow systems.
5. Easy to change pot sizes from one crop to the next.
6. In retail areas, the turnover of pots does not reduce the efficiency of automated ebb and flow systems.
7. Increased productivity per unit area.

Disadvantages

1. High initial costs.
2. Plastic benches lose integrity over time due to exposure to sunlight.
3. Each bench must have pots of the same size with media with the same water uptake rates.

4. Plants on the same bench must require the same irrigation frequency; plants must be at the same stage of growth and development.
5. Relative humidity may be high and this may promote foliar diseases.
6. This system is well defined for container plant production but its application to cut flower production is poorly understood.

Nutrient Film Technique

This system has been in use for several years, with early commercial use beginning in the early 1970's. Nutrient Film Technique (NFT) consists of smooth channel which has a 1% slope along its length but which is level across its width. The channels are water tight and are covered to reduce water loss through evaporation, prevent algal growth and aid in controlling root zone temperatures. Plants to be used in NFT culture are usually propagated in foam or rock wool cubes so plants can be placed in the system so roots hang in a continuously flowing nutrient solution (Figure 2). Recent advances in the development of in-line pasteurization systems, make NFT a viable closed irrigation system for the production of cut flowers and hydroponic vegetables.

Advantages

1. Plants can be grown at higher densities without adverse effects on quality.
2. Eliminates the need for equipment for pasteurization of substrates.
3. Very efficient use of fertilizers, uptake of nutrients by plants is optimized.
4. System can be easily automated.

Disadvantages

1. In systems which use plastic film to line channels, the disposal of the film is difficult.
2. High initial cost.
3. Requires greater technical skill to maintain the proper nutrient balance and produce a quality crop.
4. Greater management of the crop at all phases of production is essential (there is a greater chance for major problems to occur).

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Slab Substrates

Slab substrates include materials such as rock wool, glasswool, peat slabs or one of the many foams. The most familiar material is rock wool. Rock wool is produced by burning a mixture of coke, basalt and limestone. At a temperature of 2,900°F the rock melts and the liquid is drawn from the furnace as a high speed stream of air used to draw the droplets into threads which are compressed into the familiar rockwool slabs.

Rock wool culture can be used in an opened or closed culture system and has been widely used in greenhouse vegetable and cut flower production. In this system plants are planted directly into the rock wool slab and nutrient solution is delivered to the system by drip emitters placed on top of the slab. Once a slab is saturated prior to planting, rose plants require as little as 15 ml nutrient solution per plant per watering. Currently, Len Busch Roses (Plymouth, MN) has a large portion of their cut rose production area in an open rock wool system which has been very successful for producing high quality cut roses.

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Advantages

1. Very efficient use of water and nutrients.
2. Reduces average growing space per plant.
3. Lightweight and easy to handle.
4. Self-contained.
5. No need for pasteurization of substrate.

Disadvantages

1. Cost
2. Aside from vegetable, rose, carnation and cut gerbera production, use in other floral crop production systems may be limited.

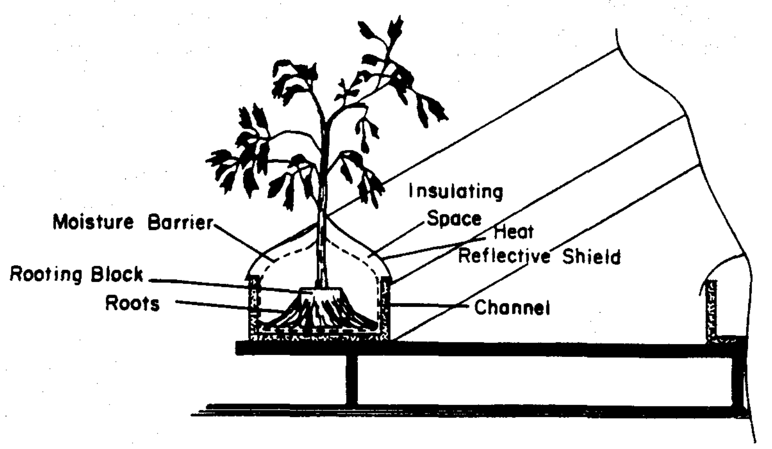

Figure 2. *A cross-sectional view of a trough showing plant placement and the arrangement of the plastic film barrier and the optional thermal barrier. (adapted from Greenhouse Operation and Management, Nelson, P.V. 1991)*

3. Disposal may become a problem in the future.
4. Some reports that rock wool particles may be carcinogenic.

Closed Recirculation Floors

A watertight floor of the greenhouse is covered with a suitable growing medium and the crop is planted directly in the floor just as in a ground bed system. Plants are watered using trickle or sprinkler irrigation and the solution is collected and recirculated through the system.

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Advantages
1. Low initial costs.
2. Highly suited for cut flower production.

Disadvantages
1. High yearly maintenance cost due to steam pasteurization between crops.
2. Further testing necessary to determine the economic feasibility of the system.

Pulse Watering

Pulse watering is not an irrigation system; it is a water management strategy.

Pulse watering is not an irrigation system; it is a water management strategy. For this reason pulse watering does not require a change in irrigation equipment but rather a change in irrigation practices. In conventional open irrigation systems plants are watered until 10% run-off occurs. This is done to allow for lateral wetting of the medium in the container and prevent the build up of soluble salts in the medium due to the greater uptake of water over fertilizer salts. Often the actual run-off is 20-30% due to improper timing or application of water, using traditional watering procedures.

With pulse watering, the idea is to apply only enough water to thoroughly wet the medium with little or no run-off. This is accomplished by applying the water or nutrient solution in several short applications instead of one long application, as with conventional watering practices. The several short pulses of water or nutrient solution allow for lateral movement of liquid through the medium. Water or nutrient solution is applied 5 - 6 times a day at 30 minute intervals with decreasing amounts of liquid with each subsequent application. In this way, the entire medium can be wetted with little or no leaching from the pot. As mention above, the plant takes up water much faster than fertilizer salts, thus it is important that after 4 days of nutrient solution applications it is necessary to apply clear water in the same manner for the next 3 days with no leaching from the pot. During this time the fertilizer salts will be used by the plants.

Advantages
1. No cost to adopt this water management strategy.
2. No new equipment necessary.

3. Can be used with any irrigation system.
4. Reduces nitrate effluent by 90%.
5. Reduces water leachate by 77%.
6. Reduces water use by 30%.
7. Reduces fertilizer use by 50%.
8. The nominal level of effluent from the pots will facilitate the collection of run-off, should this be necessary, in the future. A small amount of effluent will be much easier to deal with if it must be treated before disposal or re-use.

Disadvantages

1. Soluble salt build up does occur and levels must be monitored regularly. Improper watering practices can result in SS damage.
2. This is a new concept that will require constant adjustment for each type of crop and irrigation system and information on what is suitable for your crop may not be available.
3. May not meet future regulation on effluent levels allowed from production systems. However, it does meet current standards.

This is a brief overview of the various closed and one open system that have promise for providing economical and practical methods for controlling the amount of contaminated effluent occurring from greenhouse crop production. The system most suited to your needs will depend on the type of crops you produce and your current cultural systems.

At this time ebb and flow seems to be the best system for container grown crop production, plug production and propagation systems. Rock wool culture appears to be the best system for cut flower and greenhouse vegetable production. These systems combined with in-line pasteurization systems offer a very economical and practical way to produce high quality crops using a closed irrigation system. Both the grower and the environment will benefit from the adoption of these systems in commercial greenhouse operations.

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Literature cited

Nelson, P.V. 1991. Greenhouse Operation and Management. Prentice-Hall, Englewood, New Jersey. pp. 317-343.