GROWERTALKS

Cover Story

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Irrigation From the Ground Up

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Utilizing sub-irrigation systems in greenhouses has been a practice for as long as we've had commercial greenhouses. The basic premise of sub-irrigation is introducing water to the bottom side of the plant material and allowing it to permeate through capillary action into the media that the plant is rooting in.

The process has become very refined in the last 30 to 40 years, with multiple companies offering high-tech sub-irrigation solutions for growers of all sizes. Sub-irrigation has even been refined down to the individual plant containers themselves, where the container allows for a water reservoir at its base that can be filled, allowing the plant material to absorb water and nutrients into the media as needed. So commercial growers, along with consumers, have benefitted from this method of watering.

With this article, I'm going to explore four types of systems that are some of the most popular with commercial growers that I've worked with over the last 30 years: ebb & flood, cascade flood, ErfGoed and capillary mat. Outside of the ErfGoed system, these sub-irrigation methods can apply to both raised greenhouse benching and floors.

These systems vary in functionality, cost and implementation, but all provide similar advantages to growers:

• Allows automation of watering over large blocks of product

• Irrigation of large amounts of product quickly utilizing less labor

• Water through capillary action provides crop uniformity

• Avoids foliar leaf diseases by allowing overhead foliage to stay dry

• Promotes quicker plant root development

• Allows increased plant density

With ebb & flood, cascade and ErfGoed systems, there's also the added benefits of:

• Fertilizer and water savings through reclamation

• Can be ran as closed loop (zero runoff) systems that are environmentally friendly

Planning & installation

These systems can be as easy as installing capillary mats in existing areas to creating entire multi-acre flooding systems, but all should be approached with the same planning and organization to be successful. Hopefully, through the recent pandemic and supply chain challenges, growers have learned that these types of projects need advanced

planning. If the plan could be executed in eight to 10 months prior to the last few years, we now know that we need to double that. Contingency plans are paramount as well.

• These projects take a team, which should be cross organizational (Owner/CEO, Growing, Operations, Maintenance, etc.) meeting regularly throughout the whole process.

• Make sure the team agrees on the goal and all elements involved with accomplishing it (type of sub-irrigation, how it's implemented, scope and what crops will be utilizing the system).

• Be thinking ahead to future projects and expansion—can infrastructure be built in place that will save money for future expansion of the irrigation system (larger tanks, pumps, etc. to service future growing areas)?

• Create a working budget, knowing that it will have to be flexible across a longer time frame. Most labor and material pricing are rarely guaranteed past 15 to 20 days.

• Create a detailed timeline (I'm fond of Gant Charts) outlining everything that will need to be done. Start by working backwards from the optimum date you want to have plants utilizing the system. Aligning the steps of these projects and the contracted labor are what will make or break your deadlines. Make sure you're planning on being done well before the space is needed.

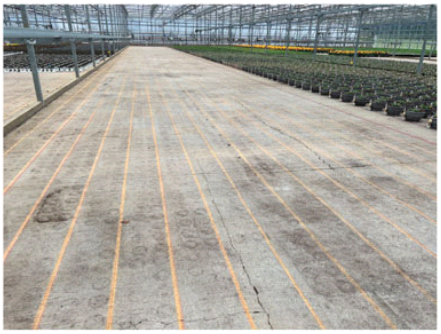
• Know your resources, what you can accomplish in-house versus using contractors. This can vary depending on what time of year you're doing these installations. Identify back-up resources as they might be needed.

• When using contractors, especially if utilizing concrete, make sure they're capable of the scope of work. This is especially crucial on concrete flood floors.

• Track all work toward timelines, having at least one person off your planning team who's onsite for the entire project, reporting progress.

Ebb & flood

Ebb & flood has been one of the most widely used systems for growers since the 1950s where they were first utilized as part of Dutch benching systems. Then through the '70s and '80s, companies introduced entire floor systems to be used in the greenhouse.



Pictured: A concrete flood floor with and without plants.

Focusing on the latter floor systems, the sub-irrigation is accomplished by installing a network of underground supply and spur line piping under the concrete. These lines are filled via pumps from centralized main tanks. Pneumatic valves allow the water into the specific flooding zones where they flood the zone via holes drilled into the spur lines through the concrete, and then recede to a holding tank via the same path. The irrigation is filtered, then treated before being pumped into the next designated growing zone. The flooding process can take anywhere from five to 15 minutes. The pneumatic valves can be operated manually or can be ran off of specific environmental control systems.

The greenhouse flood bays are poured either in a "V" shaped configuration with one centralized feed and return line or in a "W" shape where there are two feeding and receiving spur lines. Since the early 2000s companies offering these systems have introduced a variation "ebb & flow-thru" version that allows the flooding and draining to be done through separate

lines in order to allow the fill lines to be cleaned for filtered fertigation or water only. Some of the larger vendors for these systems are BioTherm and Zwart Systems (the latter of which recently became part of AdeptAg). These companies, along with other suppliers, have teams who'll help you with planning the size of water holding, pumping and filtering systems to match up with the size zones that you'll want your sub-irrigation divided into.

With all of the benefits they offer, the biggest hesitation to installing these systems has been justifying the cost. With some good cost analysis and understanding labor involved outside of just growing, these systems can have reasonable payoffs. I've worked for growers who I've helped install around 15 to 20 acres of traditional flood systems. For the operations side, these have had great advantages—for example, being able to increase plant density by not needing as much access space for hand watering results in dollars per square foot adding up fast.

Things I learned from installing traditional ebb & flood systems:

1. Concrete work needs to be meticulous. Puddling of water can be life and death for plant material. Grinding channels can be done into the concrete after the fact, but this is extra labor no one wants to pay for.

2. Really weigh out the benefits of above-ground storage and supply tanks versus underground tanks. They both have advantages and disadvantages depending on your situation. Above-ground tanks require space. Below-ground tanks, which are concrete formed, can provide challenges in ability to access and they may require being lined or spray coated over time due to effects of the concrete breaking down.

3. Plant material does flush back through the system in some volume depending on use. Filtering systems will be very important. There are several variants of filtering systems, from sand, to mesh screening and even paper. Many growers use paper filtering of return water (similar to coffee filter material) that's consumable to filter down to specific microns of material. The paper filter is an expense and consumption can be reduced by setting up a primary non-paper filter for larger debris material. This will be important in setting up your flood tank and filtering area.

4. Concrete residue can affect plant pH. It's important to clean the floor after installation thoroughly. Floor scrubbers running over the floor several times can help with this, but it can still take up to a year for the concrete residue to not affect plant material. This may not be a major effect, and in fact some plants can benefit from the pH level, but it's something to be aware of.

5. Overhead watering to establish crops is needed. Irrigation booms are the best at saving labor, but can be an expense. An alternative to this is space planning where plants aren't introduced to ebb & flood floors until they're established, but this requires adequate greenhouse room to accomplish (not so easy in the spring).

6. Your production departments and shipping teams will enjoy access throughout with plant racks. Utilizing automation, such as plant trimming machines that roll over the crop, work well on the concrete floors. This labor savings can add up quickly depending on the size of the area and how much time it can take to walk plants in and out. Shipping teams will also love the plant consistency for large order pulls.

7. Last-minute watering prior to ship can be facilitated much easier when using flood floors. Avoiding wet foliage going into a box or truck facilitates the shipping and logistics teams.

8. With greenhouses that have taller gutter heights, basket hanging systems will come into play. If not employing an automated system, such as Echos or boomerangs, having concrete to access these lines is a time saver, whether manually hanging the baskets or using a lift device. This is also of great help for your maintenance team if they have to access vents or roof repairs.

9. Cleaning the floors can be accomplished rather quickly and easily. However, yearly or between high risk crops you'll want to flush the system lines out. Some growers even use tools to put pressurized water down every spur

line hole to do a thorough cleaning.

10. When utilizing embedded rubber floor barriers that retain the water, avoid using plant moving racks that have floor braking systems (for truck shipping), as these can rip out the rubber strips causing the system not to retain the flooding irrigation water.

Cascade flood

The cascading flood floor system is based on continuously flowing water that's introduced via the same spur line system under the concrete and flows across the greenhouse floor to be received by the return spur line. The floor is sloped from one side to the other, creating the cascade effect.

The holding tanks, fertigation and filtering systems are similar to the traditional ebb & flood system. The advantages are quicker watering times, less water used (the running water only needs to be 0.5 to 1 in. in depth) and less opportunity for any diseases in the system, as the fill line is separate from the return line. Spot watering zones are easier and quicker. With flowing water, there's less debris in the centers of the floor.

Here's what I ascertained from installing and using a 75,000 sq. ft. cascade floor system:

1. Concrete has to be perfect. Even more so than with traditional flood floors. Less amount of water flowing can be greatly affected by high spots or low spots in the concrete.

2. This type of watering works best with uniform container sizes throughout.

3. With less water being used and reduced water height, be aware that containers being used have the drain holes in the lower half of the container for proper absorption.

4. Because of the debris going to one set of drain holes, the floor is cleaner, but there's way more collection of debris over the drain holes, which can cause some small amounts of puddling.

5. Less water volume and cascading irrigation allows quick touch-ups to plant material that can greatly benefit shipping or production teams needing to pick up product right away.

ErfGoed

Over the last 20 years, the ErfGoed system has become increasingly popular. This system is used in greenhouse settings, as well as many outdoor growing areas. ErfGoed can be 30% to 50% of the price of traditional and cascade flood systems due to not using concrete.

Pictured: Examples of ErfGoed floors with a black membrane (bottom) and a white (top).

The method of sub-irrigating is the same as that of traditional ebb & flood floors; however, in place of concrete, an aggregate (stone, granite, lava rock, etc.) is used as fill. This aggregate has to be tested and approved by ErfGoed's testing lab for its ability to pack tightly, while still allowing water flow, and most importantly, be inert to water and fertigation used.

The sub-irrigation piping and the aggregate sit above a membrane that retains the water within the aggregate and is topped off with a porous weedmat covering. (For the 200,000 sq. ft. system that I was involved in installing, we used crushed granite.)

Outside of the cost savings, ErfGoed is advantageous in that the system flows and fills very uniformly as it flows through the aggregate, and also drains uniformly. This alleviates concerns over puddling on the surface and plants sitting in water. The mat and the stone aggregate also allow for additional filtering before returning through the supply/drain pipe.

Considerations we learned in using ErfGoed were:

1. The ErfGoed company are the only installers of their flood systems. Advance planning to reserve the crews and installation equipment is vital.

2. Very uniform watering throughout the crop.

3. The filtering keeps plant material out of the system, but it's collected on the floor cover, so cleaning will need to be regimented. ErfGoed has specialized machinery for cleaning their floors that will need to be considered.

4. Have a good plan in advance for how plants are to be moved. If using Dutch trolleys or other plant racks, you'll want to have ErfGoed's metal trolley tracks installed to get in and out of the flood bays.

5. Overhead watering to establish material will work best unless space is available to move established product in later. Boom irrigation works well, but is an added expense.

6. Using fork systems to move plants is possible with large pneumatic-tiered lifts. We used an overhead fork system that worked off the boom rails.

7. If you have the higher greenhouse truss heights, hanging baskets can be accessed by using Echo or boomerang systems. If using stationary basket hanging lines, you'll need to work on a system of how to access them. Scissor lifts will require planking placed on the floor that ErfGoed can supply. We used a rolling scaffold that followed the boom rails.

8. If roof maintenance is required, you'll also want to have the plank system put down for access. This will add time for accessing repairs.

9. The original floor covering was black, which did cause some solar gain challenges in the heat of the summer. We didn't have a shade system.

10. Switching to a lighter colored floor covering cloth, algae was more apparent and required extra cleaning to keep it looking good. This could be specific to the plant material and length of time on the floor.

Capillary mats

Capillary mats consist of a fibrous water-absorbent material that, when irrigation is introduced, wicks evenly throughout its surface. The mats have a plastic underlayment to retain the water from leaching. The fibrous mat material is covered with a permeable plastic, nylon or similar matting that allows the irrigation water to contact the plant container.

Pictured: Capillary mat irrigation.

Some capillary mats are covered with a solid plastic sheet in which holes the size of the growing containers are cut to access the wicked water material. This requires uniform-sized containers, but can act as more of an algae barrier since the only water exposure points are at the containers. Some of the well-known capillary mat manufacturers are Water Pulse and Aquamat.

Capillary mat systems are the most widely accessible of the sub-irrigation systems aforementioned. Most greenhouse suppliers offer some version of capillary watering mat that can be fitted to any size area needed. Materials are available to build your own capillary mat system, as well as companies that can custom design and build them for you.

How irrigation water is introduced to the mat can occur by many methods, from a single source hose and multiple faucet points to drip irrigation laid on the mat itself. My recent experience with a capillary mat system was an approximately 8,000-sq. ft. installation into four Quonset hut greenhouse floors over a gravel base. This capillary mat system incorporated an internal drip tape system throughout for water uniformity and it ran off a series of automated solenoids that could be controlled from a central controller.

Notes from this system:

1. As with all capillary mats, the components do wear out and have to be fixed or replaced.

2. For 1-gallon shrub production, the system allowed better plant density and saved watering-related labor. However, these shrubs were established in an area with overhead irrigation watering prior to being placed on the capillary mat.

3. With the mats being over 100-ft. long, close attention had to be paid to making sure the internal drip tapes were run straight. We often had employees making sure these were straightened out and at the right distances apart.

4. Part of regular maintenance with the area was to remove the mats and level the gravel floors. This was to offset puddling on the mats. Even with letting the mats dry out they required a number of people to move them.

5. To access the areas with plant racks for both production and shipping, we installed the trolley tracking offered by ErfGoed. Plant racks with pneumatic tires worked, but not as well.

6. Methodical cleaning and disinfecting will be required in between crops. This also involves removing the mat, disassembling and using a mild fungicide.

7. Although this project didn’t have hanging basket production above it, careful consideration would need to be given to what type of basket system could be used due to access and watering above the capillary mat. Excess leach water or fertilizer from the baskets would affect the mat moisture levels.

Final thoughts

All four sub-irrigation systems have been successful and can be great options for your next greenhouse expansion, retrofit or upgrade. With the challenging workforce availability, growers should be contemplating these as a means

of increasing efficiency and quality of growing. Additional consideration to all greenhouse departments who'll be utilizing the areas of these sub-irrigation installations can further help with justifying the capital expense involved.

It's worth the time and resources to pull together a cross-organizational team, not only to evaluate each of these irrigation methods before implementing, but also to review your existing systems. This will not only prove to be of financial benefit, but also pull together your company's most valuable asset—your personnel to take ownership for the success of the endeavor. **GT**

Jeff Back has been in horticultural management for over 30 years, leading operations for some of the largest commercial growers in our industry.