2014

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Plant health and productivity of commercially grown greenhouse plants is improved when production occurs on raised benches where they can have optimal environmental conditions and uniform irrigation. This publication describes how to construct simple and economical growing benches as well as an irrigation system for the specialty crop grower.

Introduction

Container-grown plant producers who use protective growing structures, such as high tunnels and greenhouses, typically grow crops directly on the floor rather elevated on a bench system. Often, this is due to the costs associated with commercially available production benches and/or the time required to design and construct a system. Diminished plant productivity at floor level is the direct result of inadequate environmental conditions due to high humidity/moisture that may result from lack of air circulation. Elevating plants on growing benches allows air movement through the plant canopy, improves drainage of excess water from containers, and avoids cold temperatures as a result of temperature gradients inside the greenhouse/high tunnel. This publication describes how to construct a simple and economical bench and irrigation system for the small specialty crop grower.

Commercially Available Benching

Growing benches are readily available through many greenhouse manufacturers and horticultural suppliers. Pre-engineered benches are designed for portable, stationary, or rolling applications, and can be customized to meet specific grower requirements, such as size, live weight loading, or incorporation of sub-irrigation systems. Bench costs are correlated to the construction materials used, as well as the grade and thickness of each material.

The most affordable benches use steel tubing for supporting members, formed sheet metal for connectors, and welded wire for bench tops. The metals are galvanized to resist rusting but they can still deteriorate over time if continually wet or exposed to caustic chemicals like chlorine or acids. Galvanized bench costs begin at \$3 per square foot (ft^2) for a simple post structure with wire top, to more than \$11 ft^2 for rolling benches. There are additional costs for shipping and labor for installation.

Benches manufactured from recycled materials are often popular with small growers. These benches have a single molded design that incorporates structural support, growing surface, and leg support receivers in one unit. They are simple to construct, requiring no tools or construction knowledge to install. Since plastic has limited strength, sizes for these benches are typically small, averaging 2- to 3-foot wide and 6- to 8-foot long. The price for plastic benches is approximately \$7.60 ft^2 for a 3-foot by 8-foot using 30-inch legs.

Self-Built Benching

Some growers design and construct their own growing benches in an effort to control costs. Self-built benching may or may not be designed to proper structural specifications; its durability and safety are directly related to the selected materials and the skill of the builder. The following information gives an example of how to construct a simple growing bench that elevates container-grown plants from the floor and incorporates a sub-irrigation watering system suitable for any type of plant grown in a pot.

Block and Fence Bench Production System

Concrete blocks are used in many seasonal and permanent greenhouse production systems for supporting various bench surfaces such as cattle panel fencing or pallets. This is due to the economical price for new blocks and/or factory seconds/ used blocks (new 8-inch by 8-inch by 16-inch block is approximately $1.65 each). Blocks are good for creating stable bench support but are heavy and not easily moveable. Once the blocks are properly spaced and set firmly in position, there should be no need to move them unless the benches are only temporary.

The following block and fence bench design creates an economical yet strong and flat production bench (approximately $1.50 ft^2), which is suitable for placement of individual pots directly on the top without using growing trays. Additionally, the benches can be sized similarly to commercially available production benches, minimizing the loss of greenhouse aisle space while maximizing growing space and worker efficiency.

Bench Construction

Material List for one 6-foot by 50-foot Production Bench		
44 each- 8" x 8" x 16" Concrete blocks	$ 1.65 ea	$ 72.60
15 each- 2" x 4" x 10' Construction lumber	$ 2.95 ea	$ 44.25
11 each- 2" x 4" x 8' Construction lumber	$ 2.45 ea	$ 26.95
89 each- #7 x 3" Exterior deck screws	$ 8.95 100/box	$ 8.95
30 each- #7 x 1-1/4" Exterior deck screws	$ 3.95 100/box	$ 3.95
1 roll- 6' x 50' Greenhouse bench fabric (Lath)	$300.00	$300.00
(Southeastern Wood Products Company, Griffin, GA)		
	TOTAL	$456.70

NOTE: This bench example maximizes use of materials for a cost of $1.52 ft^2. Material pricing was gathered from a large, nationally recognized, home improvement store in May 2014. These prices do not include delivery costs but do include shipping for greenhouse bench lath. It is important that all materials be on hand before starting bench construction.

Bench Construction Steps

Step 1. Before constructing the production bench, the floor must be packed and firmly leveled. Soft spots under supporting blocks will result in an uneven production surface.

Step 2. Two rows of blocks are set in position, 4 feet apart from outside of block to opposing outside of block, placed horizontally on the floor with the length of the block in line with the bench length. Use a string line to create two straight rows of blocks (each row having 11 blocks) and spacing the blocks 5 feet apart from the starting location of the bench. The last set of blocks will be positioned at the end of the bench (*Figure 1*). Blocks should be verified for being accurately aligned, spaced, and level for the entire length of blocks used to support each bench.

Step 3. Set the remaining 22 concrete blocks vertically upon each of the previously positioned blocks on the floor. These should be positioned so that the blocks are flush with the bench terminal ends and "on-center" within the row. Confirm that the blocks are still properly positioned and level before continuing to top installation.

Figure 1. Blocks set in position on a level floor. Note end blocks held flush with terminating end of bench and "in line" blocks are centered for stability.

Step 4. Cut the 2-inch by 4-inch by 8-foot lumber in half, making two, 4-foot long pieces. These should be stacked and screwed together using four #7 by 3-inch exterior deck screws, evenly spaced along the length, to create a *cross arm* 3-inch by 3½-inch by 4-foot cross arm. A total of 11 cross arms are constructed and placed into position across each of the block rows (*Figure 2*).

Figure 2. Cross-arm positioning with bench top support members and woven bench fabric installed.

Step 5. Three rows of bench top support members are run the entire length of the bench, on top of the 3-inch by 3½-inch by 4-foot cross arms. Using the 2-inch by 4-inch by 10-foot lumber, position one on each end of the cross arm and a third 2-inch by 4-inch at the center of the cross arm. These are set end-to-end the length of the bench and fastened using the #7 by 3-inch deck screws at each cross arm location, resulting in the final bench top support framework. Be sure to verify the cross arms and bench top support members are level before installing the bench fabric top.

Step 6. Six-foot wide greenhouse bench fabric (lath) is centered and unrolled down the bench framework, extending 1 foot beyond the outer bench top support members on either side. Install three each of 1¼-inch deck screws at each end of the bench top support members to hold the woven bench lath taut from end-to-end. Install the remaining screws as needed to keep the lath straight over the entire length of the bench (*Figure 3*).

Figure 3. Completed block and fence bench. Note: bench fabric (fence) is centered on support members with 1 foot extending on either side and held taunt by deck screws installed at each end.

Sub-Irrigation Systems

Growers routinely irrigate plants overhead by using hand-held hoses, drip emitters, or spray nozzles. Watering uniformity is dependent upon the individual doing the watering and the design of the irrigation system. Sub-irrigation systems provide flexibility in crop type and spacing, save water, and reduce risk of water stress due to poor spray nozzle coverage or containers with missed or clogged drippers. Sub-irrigation methods include flood tray, flood floor, or capillary mat systems. Flood trays for use on top of benches cost approximately $7 per square foot, in addition to costs associated with water distribution, effluent drainage, or recycling and equipment installation.

Capillary mat systems utilize a thin, fabric-like material that lies directly on a flat surface that may be designed for sub-irrigation systems, or may be as simple as a polyethylene-covered bench top. The visual appearance of capillary mats differs between manufacturers due various coverings or colors. Seep tubes, known as drip tape, distribute water and fertilizer onto the fabric mat, saturating it to allow for uptake of water through the capillary action of the mix present in a given container. Light-colored capillary mats tend to develop algae. Algae growth can be managed by using chemical drenches, or by using a plastic covering in which holes are cut so that water can reach the bottom of the growing containers. Polyethylene plastic that has black and white on opposing sides, known as *Panda Film™*, is quite effective to control algae growth and creates a plastic sandwich that minimizes evaporation from the capillary mat. The black side is turned down toward the capillary mat, preventing light from allowing algae growth, and the white side is turned upward to reflect light into the plant canopy.

Capillary Mat Irrigation System for Bock and Fence Benching*

Material List for Capillary Mat Irrigation System		
Black plastic sheeting, 6 mil, 8' x 50'	.05 ft^2	$ 20.00
Capmat II™ Capillary matting, 6' wide	.40 ft^2	$120.00
Capmat II™ Distribution kit (for a maximum of 6' x 100' bench)		$ 75.76
Water supply line, manual valve, various fittings** (approximate)		$ 15.25
Screen water filter		$ 31.50
5 zip ties		
1 Sch 40 PVC pipe – ¾" diameter 6' long		
	TOTAL	$262.51
For the 6-foot by 50-foot bench example, cost is $.88 ft^2.		
For automated watering or fertigation, additional items needed include:		
Fertilizer injector (Chemilizer™ 1:100 or similar)		$285.00
Low-voltage solenoid valve (one per irrigation zone)		$ 24.00
Controller and connecting wiring (capable of six zone control)		$175.00

*It is important to draw out a preliminary plumbing design, clearly identifying each pipe, coupling, and fitting necessary to connect the water supply to the capillary mat distribution kit. Have all items on hand in order to complete installation in a timely manner.

** Specific fittings (such as tees, elbows, unions, connectors, and threaded nipples) and quantity needed are dependent upon individual situations. A suggested design is shown in *Figure 12*.

Capillary Mat Installation

Capillary mat irrigation system installation specifics will vary upon individual situations. The following information highlights key elements of a system that works effectively on the Block and Fence Bench described previously.

Step 1. Cover entire lath bench with a single sheet of the 8-foot wide, 6 mil black polyethylene sheeting. Make sure there are no cuts or seams in the plastic that will allow leakage of irrigation water. Given its strength between the lath gaps and tear resistance, 6 mil plastic is preferred. Leave approximately 6 inches of plastic hanging down on all sides of the bench to prevent the wood underneath from getting wet.

Step 2. Lay the 6-foot wide capillary mat fabric directly on top of the black sheeting, making sure that no fabric is allowed to hang over the edges of the bench top. Fabric that does hang over the edge would result in water gravitationally being drawn down and allowing water to drip on the floor (*Figure 4*).

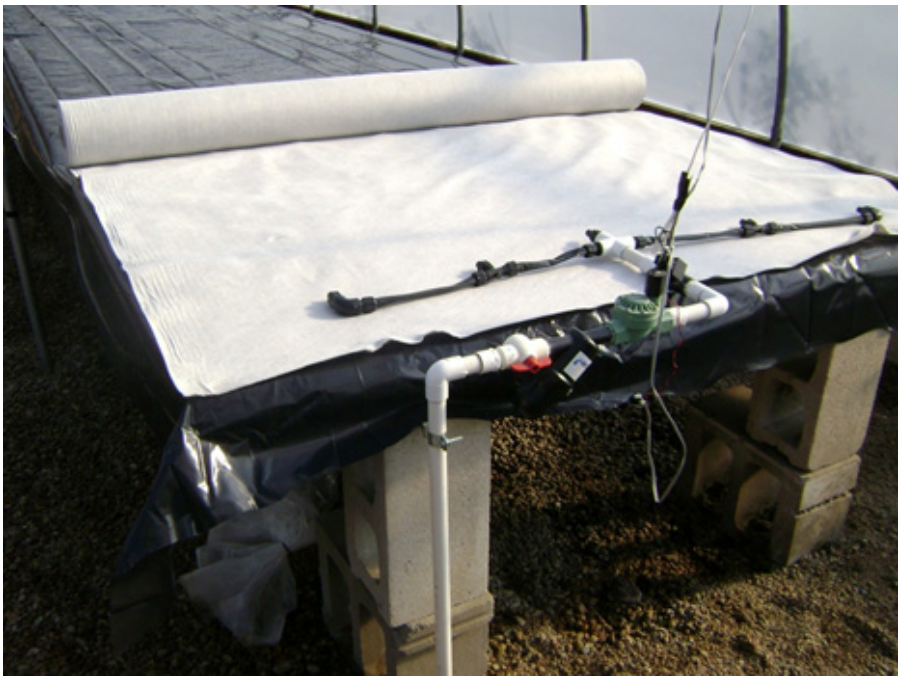

Figure 4. Black plastic shown covering woven lath bench top and capillary mat is being rolled down the length of the bench. Note Capmat II™ Distribution kit installed with manual and automated irrigation control valves.

Step 3. Assemble the Capmat II™ Distribution Kit at the supply end of the bench. For the 6-foot wide bench, the seep hose quick connectors should be installed on 12-inch centers. Roll the drip tape down the benches with the emitter holes facing down Tie off each hose by folding and making a single knot. Then attach the hoses to a PVC pipe with a zip tie to hold them in place and keep the tape straight (*Figures 5* and *6*).

Figure 5. Seep hose is laid in rows roughly 14 inches apart for uniform distribution of water across the entire capillary mat surface and connected to water supply using fittings supplied by the CapMat II™ Distribution Kit.

Figure 6. Ends of seep hoses are wire tied to ¾-inch PVC pipe to maintain spacing between each length.

Step 4. If containers are being placed "pot tight," no additional preparation is needed; however, for containers that are to be spaced apart on the bench, algae growth will occur and lead to fungus gnat infestation. The installation of a capillary mat covering will greatly reduce this problem. Roll a fused black/white plastic top cover (Panda Film™) over the capillary mat and drip tape distribution lines with holes cut where pots will be set (*Figure 7*).

Figure 7. Black/white plastic (Panda Film™) being positioned on top of capillary mat and seep hoses. Be sure that no more than 6 inches hangs over the long sides of the bench.

Step 5. Holes the size of the entire container bottom must then be stamped out or cut through the polyethylene top covering so that the pot sits directly on the mat. The use of a cutting jig speeds the hole cutting process (*Figures 8* and *9*).

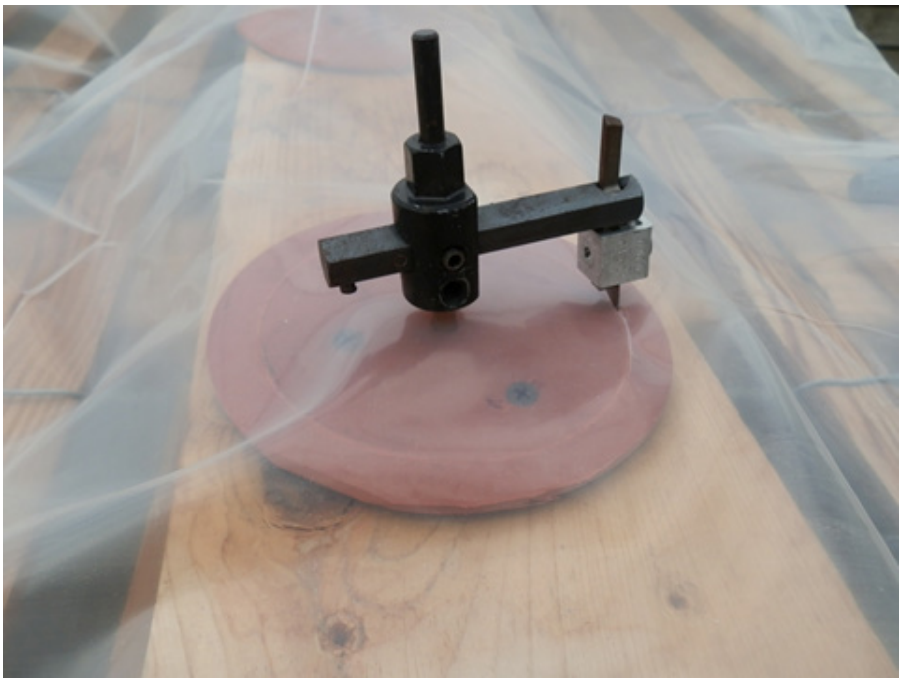

Figure 8. Polyethylene being cut using hole cutting jig (clear polyethylene demonstrated to show use of the DeBerg Hole Cutter Jig), shown using an adjustable wood hole cutter that was modified by replacing the steel blade with a replaceable X-acto™ blade.

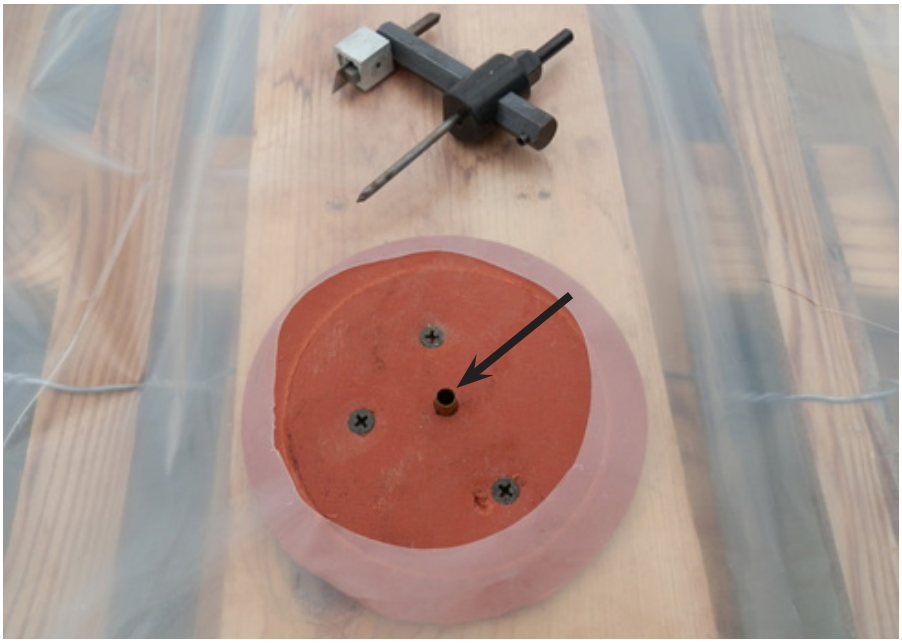

Figure 9. Completed hole in plastic suitable for 6-inch container bottom to set directly on capillary mat surface. To make the DeBerg Hole Cutter Jig, purchase a 1-inch by 6-inch by 6-foot board (the width of the bench). Starting at one edge, drill holes to accept insertion of 3/8-inch brass ferrules (hollow sleeve pieces shown by arrow) starting at one end – first 6 inches, and then every 12 inches for a total of 6 holes. This has the pots on 12-inch centers within the bench. A firm cutting surface is made by using hard floor tile or resistant material, which is either glued or screwed in and positioned at each location. An adjustable hole cutter is used to cut the holes by positioning the polyethylene firmly over the cutting board, inserting the center drill bit into the ferrules and turning the cutter by hand.

Step 6. Potted plants are set in position so the pot bottom is centered over the cut holes, allowing direct contact to the capillary sub-irrigation mat (*Figure 10*).

Figure 10. Strawberry plants being grown on completed Block and Fence Bench with capillary mat irrigation system. Note: wires shown going to pots are connected to soil moisture and light sensors.

Irrigation Controls and Automation

Hydrating the capillary mat for plant irrigation may be completed manually through the use of hand valves on the water supply at each bench, or can be automated by using solenoid valves and an irrigation timer (*Figures 11* and *12*). Additionally, by using an "in-line" fertilizer injector, soluble fertilizer may be added to the irrigation water. Drip tapes used in this capillary mat irrigation system require very little water flow and are regulated to a maximum of 10 psi (pounds per square inch). A single watering cycle for one bench is typically 1-4 minutes, just long enough to saturate the capillary mat. This strict control of water greatly improves the greenhouse environment during cloudy and cool periods when ventilation is not needed or desired.

Figure 11. Irrigation supply line with water meter and fertilizer injector shown.

Figure 12. Irrigation supply to individual bench includes manual shut off, 140 micron mesh screen filter, 24 volt solenoid valve, and 10 psi pressure reduction valve prior to the Capmat II distribution manifold.

Summary

The Block and Fence Bench concept offers growers an affordable alternative to pre-engineered growing benches. By combining this simple bench system with a capillary mat system and automation, growers can reduce water and fertilizer use while optimizing plant productivity. Through the use of this bench and irrigation design system, the grower may also determine future design specifics and cost estimates for more permanent benching and/or irrigation needs.

Product Information

CapMat II Matting and Distribution Kits- Phytotronics, Inc., Earth City, MO. *www.phytotronics.com*

Chemilizer- Hydro Systems Company, Cincinnati, OH. www.chemilizer.com

Southeastern Wood Products Company, Griffin, GA. *www.southeasternwood.com*

Google — "adjustable wood hole cutter" to find a vendors for this jig.

Panda Film (Black/white combination polyethylene sheeting) — Global Plastic Sheeting, Vista, CA. *www.globalplasticsheeting.com*

Additional Information

Greenhouse Floors and Benches. Schnelle and Dole. HLA-6703, Oklahoma Cooperative Extension Service.

Water Use and Runoff Comparisons of Greenhouse Irrigation Systems. Nealy and Henley, Proceedings of the Florida State Horticulture Society. 105:191-194. 1992.

This publication has been peer reviewed.