



## The 72 Plant Vertical Garden

by [LancePenney](#) on December 30, 2011

### Table of Contents

The 72 Plant Vertical Garden .....	1
Intro: The 72 Plant Vertical Garden .....	2
Step 1: The Supporting Frame .....	3
Step 2: The PVC Grow Tubes .....	4
Step 3: The Nutrient Supply and Distribution System .....	5
Step 4: The Nutrient Drainage System .....	8
Step 5: Final Thoughts .....	9

## Intro: The 72 Plant Vertical Garden

This instructable will cover the details of the Vertical Garden built for my "Hydroponic, Automated, Networking, Climate Controlled Greenhouse Project". The vertical garden is a space saving way to grow up to 72 small plants (such as lettuce, spinach, strawberries and lots of different herbs) all with the plant health benefits of hydroponics. The Vertical Garden is designed with modularity in mind, to be brought into the greenhouse and installed as a single unit, with only connection to the existing plumbing required before you're ready to grow. The installation of additional Vertical Garden units should be quick and easy.

Other Instructables that cover elements of the "Hydroponic, Automated, Networking, Climate Controlled Greenhouse Project" are listed below with many more to come:

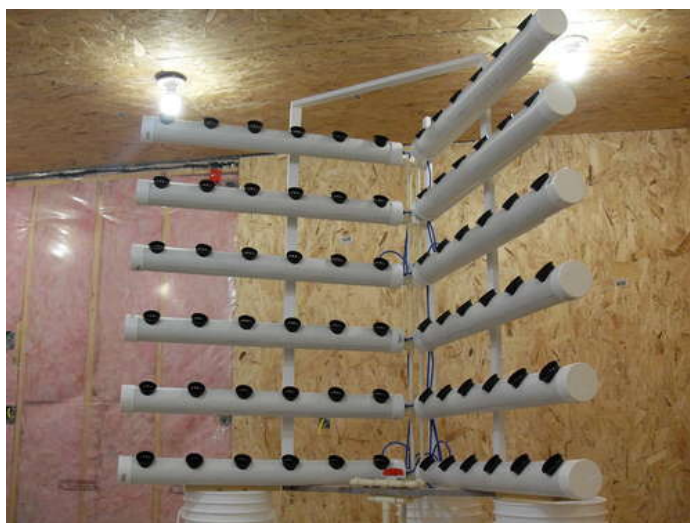
### Part 1: Construction of the Greenhouse

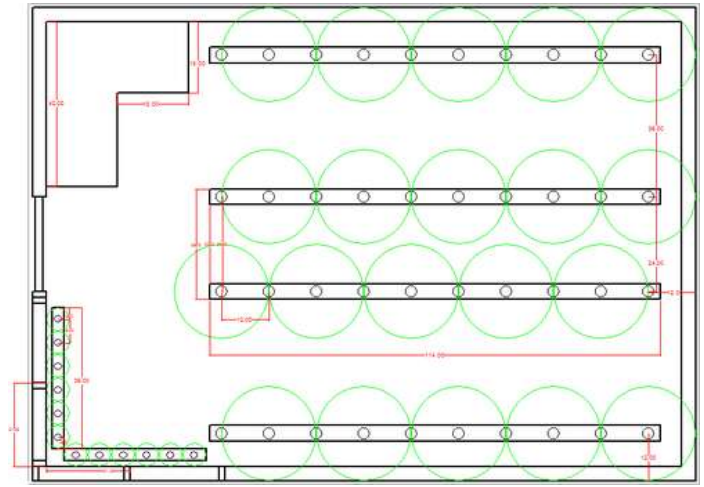
#### Part 2: The 72 Plant Vertical Garden

The greenhouse when completed should be equipped with a large, centralized hydroponics system capable of supporting up to 40 large plants (tomatoes, bell peppers, banana peppers, etc.) and up to 72 small plants (lettuce, spinach, strawberries, etc.) for a total of up to 112 plants. The greenhouse will be equipped with an arduino based climate control system capable of monitoring the indoor environment through a variety of sensors (temperature, light intensity, humidity, CO2 concentration, etc.) and automatically adjusting each variable by controlling different devices (exhaust fans, louvre doors, heaters, grow lights, solenoid valves, pumps, etc.). The readings from all the sensors as well as the on/off status of all of the devices should be sent out over the internet and be viewed remotely and in real time from any computer or mobile phone.

As of this moment the greenhouse's skeleton is all that is completed. I didn't get as much done over the summer as I had hoped because of the nasty weather. However, over the winter I am working on constructing most of the hardware to go inside the greenhouse including the climate control system. I hope to be up and running by the time it's warm enough to start growing.

Each major section of this project should be it's own instructable and when it's all finished I'll compile it into a guide. Right now I'll show you the features of the Vertical Garden ready for installation in the spring.





### Step 1: The Supporting Frame

Every good project starts with a frame, including the Vertical Garden. The frame is constructed out of 2 by 6 lumber that was ripped down into 1 1/2 by 3/4 inch strips. Every attachment was made first by gluing the joint and then fastening it with 18 gauge 1 1/4 inch brad nails.

Each horizontal piece holds one PVC grow tube, with a small machine bolt passing through the PVC pipe and the horizontal member and then secured with a nut and washer. Each PVC tube is secured with two fasteners. Each fastener is located near a hole for a mesh pot. That way a screwdriver can be easily inserted into the bolt head while the nut on the other side can be tightened with a wrench.

The vertical members are positioned so that they match up with the studs in the corner of the greenhouse. When the Vertical Garden is installed, it will be attached to the studs via these vertical members.

Finally, at the top and bottom of each outer vertical member is a diagonal cross member that keeps the whole structure from flexing while it is free standing. The bottom cross member is also a point of attachment for the supply manifold.





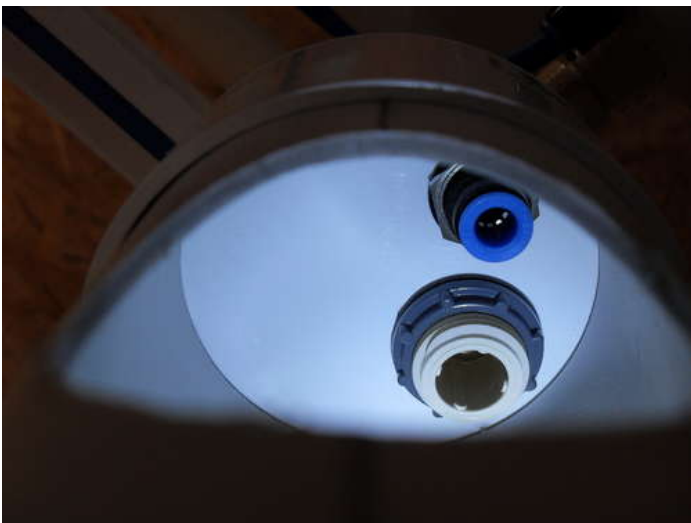
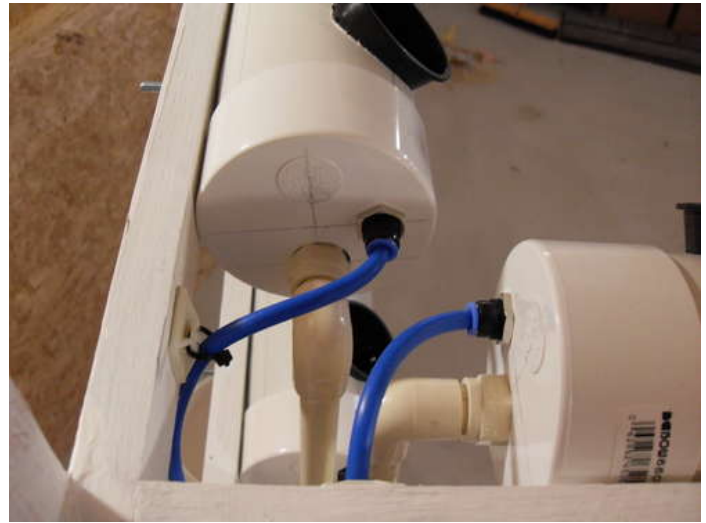
## Step 2: The PVC Grow Tubes

The grow tubes are made from 36 inch long pieces of 3 inch PVC sewer pipe. Each tube has 6 holes that are 1 and 7/8 inches in diameter to accommodate a 2 inch mesh pot. The holes are spaced 6 inches on center from each other and spaced 3 inches on center from the ends of the tubes.

On one end of the tube is a plain 3 inch PVC end cap. The end cap is not glued in place but still fits snugly on the end of the pipe and makes a watertight seal. The cap can be removed from time to time so a brush or similar item can be used to scrub out plant debris.

On the other end of the tube is another end cap with holes drilled for the water supply and drain lines. The fitting for the drain line is a CPVC 1/2 inch male threaded adapter. The threaded end of the adapter is inserted into the end cap and secured on the inside first with a rubber O-ring and then with a 1/2 inch PVC lock nut. The supply line connector is a 1/4 inch O.D. tubing bulkhead union also secured to the end cap with a rubber O-ring and lock nut.





### Step 3: The Nutrient Supply and Distribution System

The Nutrient Supply and Distribution system is designed to hook up to the main supply line for the whole greenhouse through a single plumbing connection and distribute fresh nutrient solution to each of the 12 grow tubes. The input for the system is a short vertical piece of 1/2 inch CPVC pipe at the bottom of the Vertical Garden unit. The actual connection to the main greenhouse supply line will be made with a Watt's 1/2 inch Push-to-Connect union.

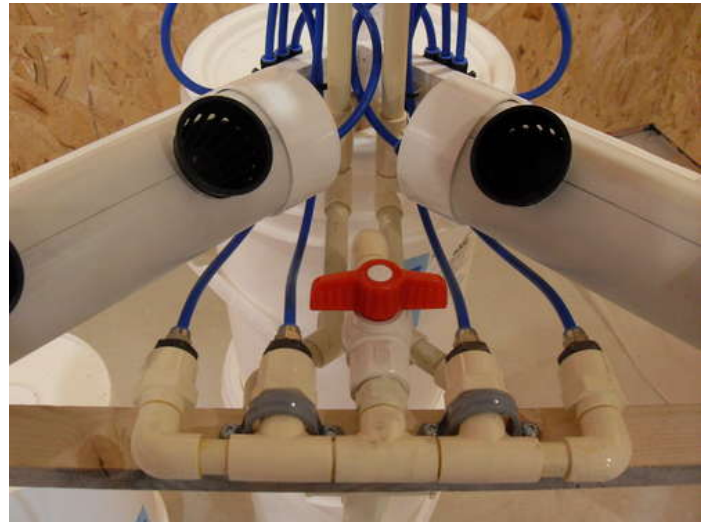
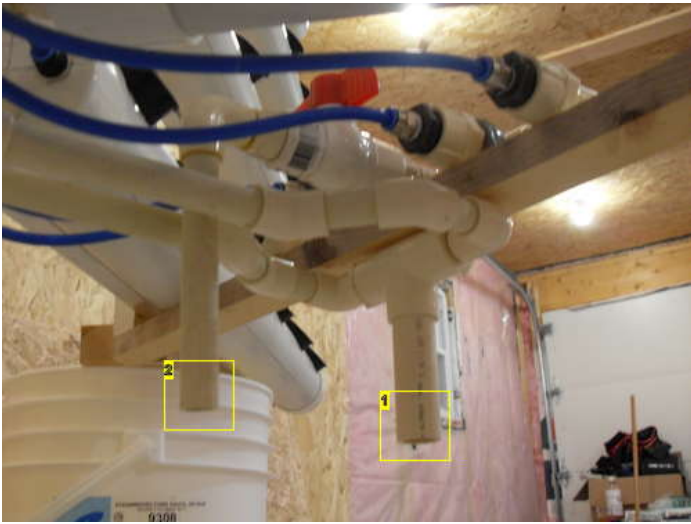
The main supply line leads into the main distribution manifold, with a 1/2 inch CPVC ball valve in between to provide flow control to the grow tubes. The main distribution manifold has four outlets, each of which supply 3 grow tubes. The outputs from the manifold are converted from 1/2 inch CPVC to 1/4 inch flexible tubing in the following steps:

- 1/2 inch CPVC pipe
- 1/2 inch slip by 1/2 inch female threaded CPVC adapter
- 1/2 inch male threaded by 1/4 inch female threaded galvanized bushing
- 1/4 inch male by 1/4 inch push-to-connect tubing fitting
- 1/4 inch flexible tubing

The 1/4 inch flexible tubing and push-to-connect fittings are extremely quick and easy. All you have to do to make a watertight connection is cut the end of the tubing off square with a utility knife and push it into the blue collet on the fitting. That's it. A ring of teeth inside the fitting hold the tubing in place with a watertight seal. To remove, all you do is press on the blue collet while the line is unpressurized and pull the tubing out. The tubing and fittings are ment for compressed air systems but I've seen them used for water in industrial applications so I think I'll be alright using them here.

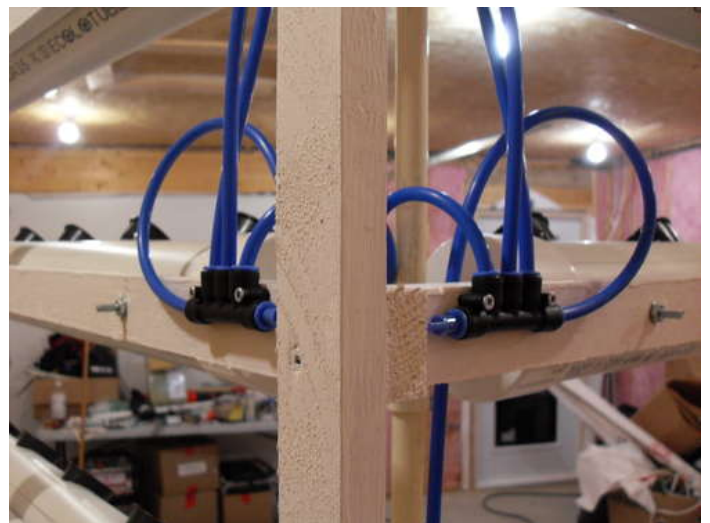
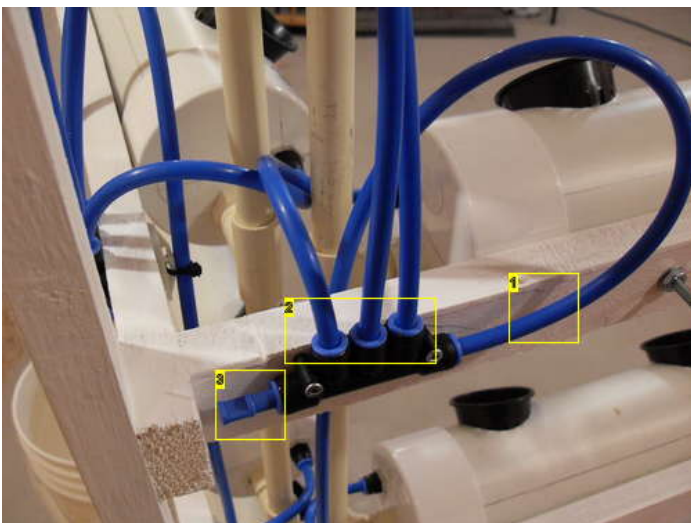
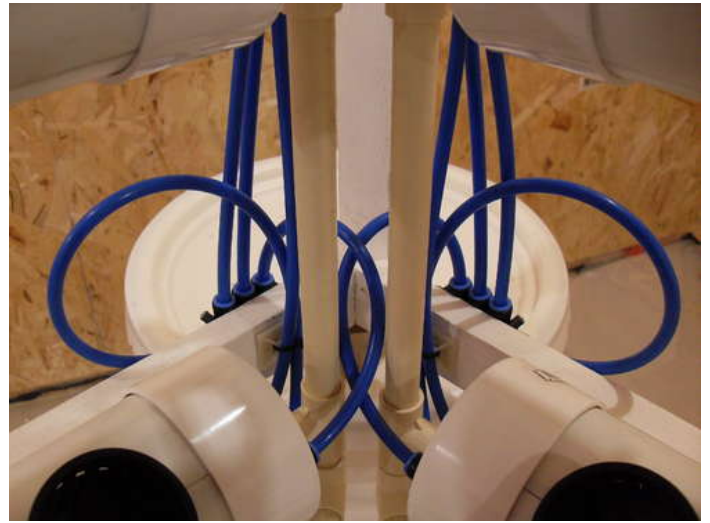
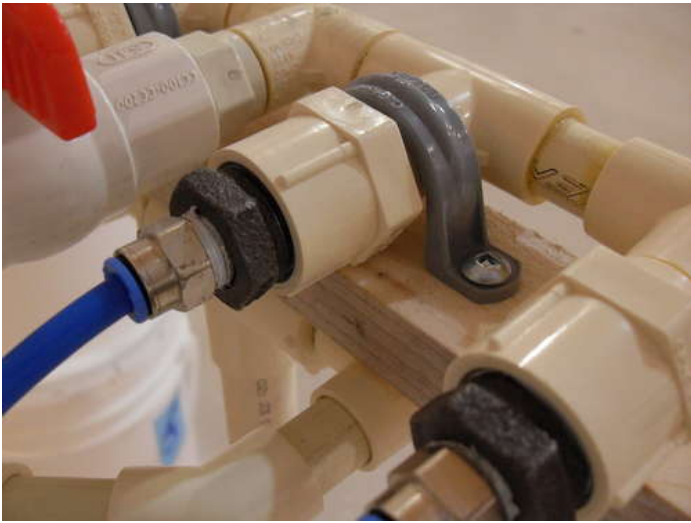
Each supply line from the main manifold in turn feeds a smaller manifold for a total of four. The smaller manifolds are actually a type of fitting you can buy for the 1/4 inch flexible tubing. It has one input and four outputs. One of the outputs is capped off with a 1/4 inch push-in plug while the other 3 each feed a grow tube.

Each grow tube is supplied with a single line of flex tubing that is connected via the 1/4 inch push-to-connect bulkhead union installed in the end cap. The push-to-connect union has a watertight connection for tubing both on the inside and outside of the tube. The plan is to take a piece of 1/4 inch tubing about the same length as the grow tube, poke a bunch of pinholes in it all down the length of the tubing, put a cap on one end and plug the other end into the push-to-connect bulkhead union inside the grow tube. The result will work kind of like a soaker hose that will hopefully spray water in every direction and get the plant roots nice and saturated.



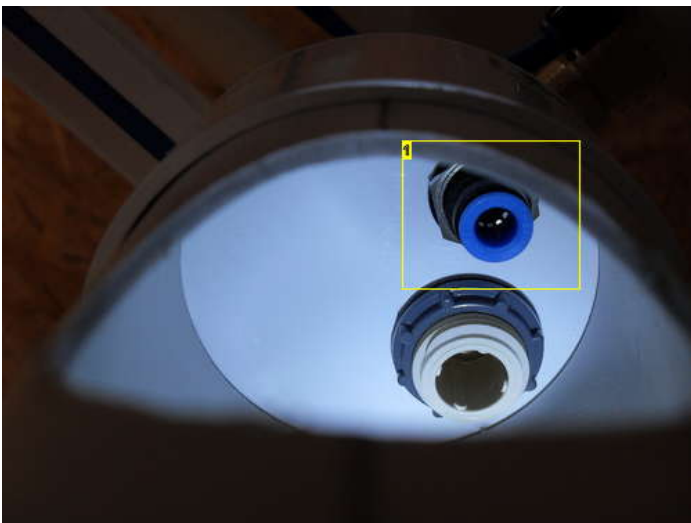
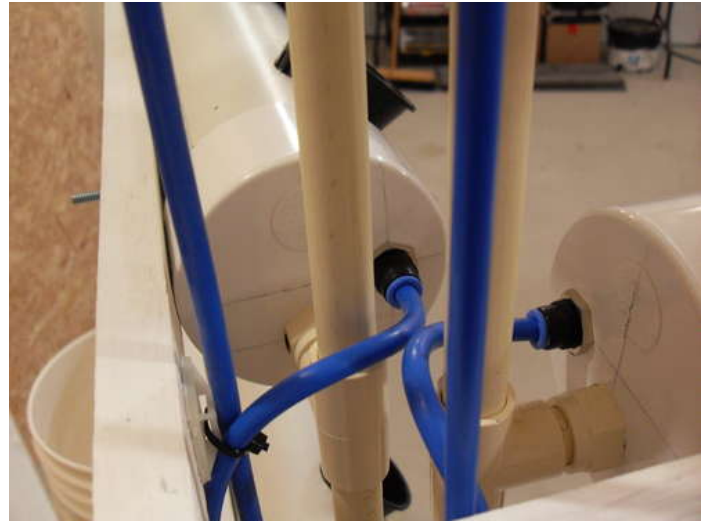
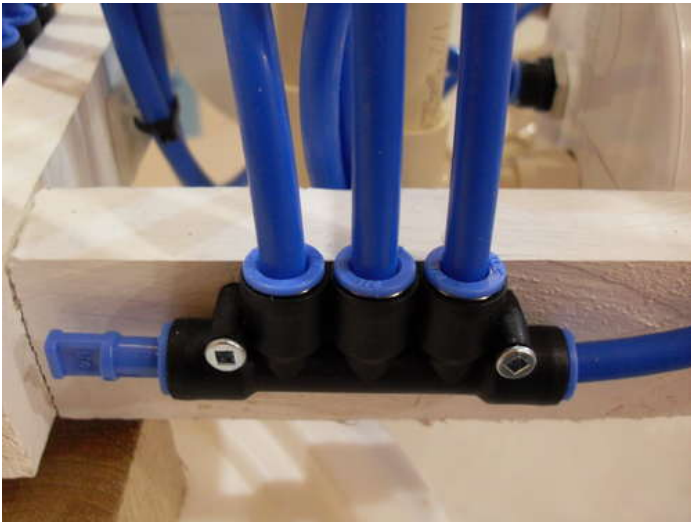
**Image Notes**

1. This is the drain output to the greenhouse plumbing
2. This is the supply input from the greenhouse plumbing.



**Image Notes**

1. This line is from the main manifold.
2. These 3 lines each feed a grow tube.
3. This plug caps off the end of the manifold.



**Image Notes**

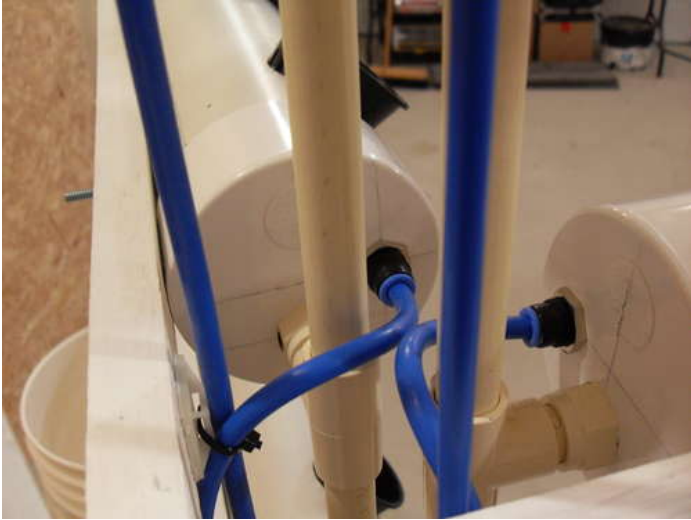
1. Here is the bulkhead union with the tubing connection on the inside of the grow tube.

#### Step 4: The Nutrient Drainage System

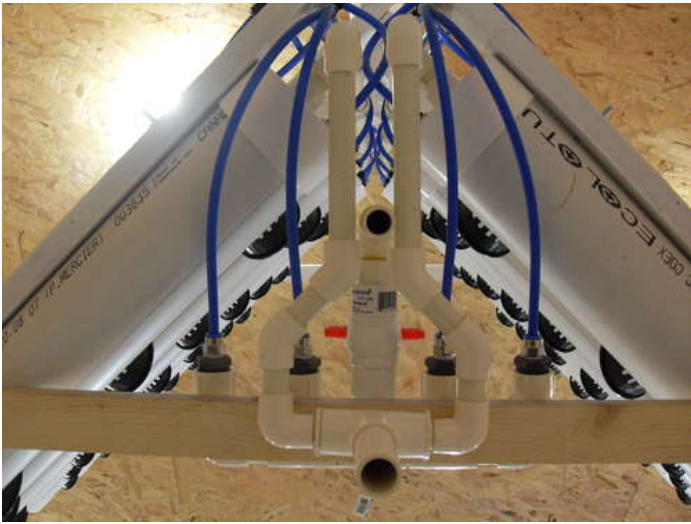
Each grow tube drains off excess nutrient solution via a network of 1/2 inch CPVC pipes. Inside the grow tube the connection to the drain network is made with a 1/2 inch male threaded adapter that is secured on the inside of the tube with a rubber O-ring and PVC locknut. The drain fitting is positioned about 1/2 inch from the bottom of the grow tube pipe so that some nutrient will remain in the tube without draining down. This is to keep the plants hydrated while the supply pump is not running.

A vertical drain manifold connects the 6 grow tubes of each column together. There are total of two drain manifolds. At the bottom of each manifold is an outlet. The two outlets are connected together via two 1/2 inch to 3/4 inch CPVC bushings and a 3/4 inch CPVC tee. The expansion from 1/2 inch to 3/4 inch at the connection point may or may not be necessary but since that 3/4 inch section of the drain will be handling the load from both manifolds I thought it's better safe than sorry.

Finally, the bottom of the 3/4 inch tee has a small length of 3/4 inch pipe that drops down a few inches. This will be the drain's connection point to the main drain in the greenhouse. From there nutrient solution will drain back into the greenhouse's reservoir. The connection to the greenhouse plumbing will be made with a Watt's 3/4 inch Push-to-Connect union.







### Step 5: Final Thoughts

Well that's it for now. I'll be sure to continue this article as soon as the Vertical Garden is installed in the greenhouse and I have it up and running. Right now I see a feature of the frame that would make it easy to attach 4 foot fluorescent light fixtures to it, maybe for use indoors in the winter. I have a large window facing south that I could set the garden up in front of as well. Hmm...

As always, I hope you enjoyed this article and please stay tuned for more updates soon. I welcome any constructive feedback and any questions you may have just leave it in the comments section so everyone can see and benefit from it. Happy New Year!



