Hydroponics For Beginners

Tomatoes

What is Hydroponics?

Hydroponics is a method of growing plants in soilless cultivation. The plant nutrients normally derived from the soil are simply dissolved into water instead and taken up by roots suspended in soilless medium or net cups.

Benefits of Hydroponics

⇒ You can grow a crop anytime. All year production.

⇒ Rapid plant growth and short crop cycles (faster than in the soil).

⇒ Greater yield.

⇒ Uses less water use.

⇒ Greater control over production - nutrients, light, oxygen, temperature.

⇒ A way to avoid soil-borne pathogens or insects.

⇒ Allows crop production where there is poor soil or contaminated soil.

Hydroponics Drawbacks

⇒ High energy use.

⇒ No power = no water. Crops can wilt quickly.

⇒ Higher investment: more cost associated with setup.

⇒ Can require more management.

⇒ Limited crops can be grown in hydroponics.

Considerations for Hydroponics

Water: Quality water is needed for healthy plants. Test the water source. There are laboratories that can help assess the suitability of water for irrigation.

Light: The amount of light required varies. Fruiting crops need more light than leafy greens and herbs. In hydroponics, artificial light is needed: fluorescent or LED. A timer can be used to operate lights 16 to 24 hours a day.

Temperature: Warm-season plants such as tomatoes and cucumbers perform best when the temperature is between 70°F and 80°F during the day and 60°F to 70°F at night.

Air: Roots need oxygen to thrive and it is achieved by aerating the nutrient solution.

Nutrients: Plants grown hydroponically must get all nutrients and minerals from the nutrient solution. Focus on Primary macronutrients: nitrogen (N), phosphorus (P), potassium (K) and secondary macronutrients: calcium (Ca), magnesium (Mg), sulfur (S).

pH and EC: Must be tested and recorded daily.

⇒pH: How acidic or basic a nutrient solution is or the concentration of H+ ions. Each crop will have a preferred pH range so it is important to have a correct pH. Incorrect pH blocks nutrients from being absorbed by the plants.

⇒EC (electrical conductivity): Concentration of nutrients in the solution (mS/cm). This can be used as an indirect indicator of nutrients dissolved and can be measured to make sure the fertilizers are mixed accurately.

SARE Sustainable Agriculture Research & Education
USDA
Extension University of Missouri

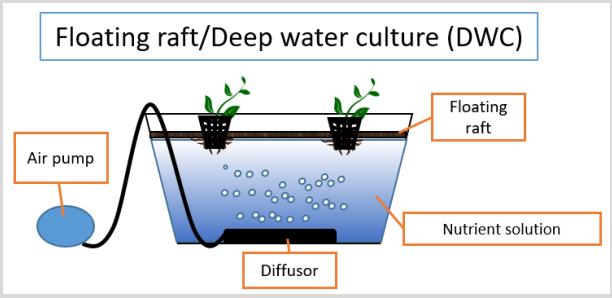
Home Hydroponic Growing Systems

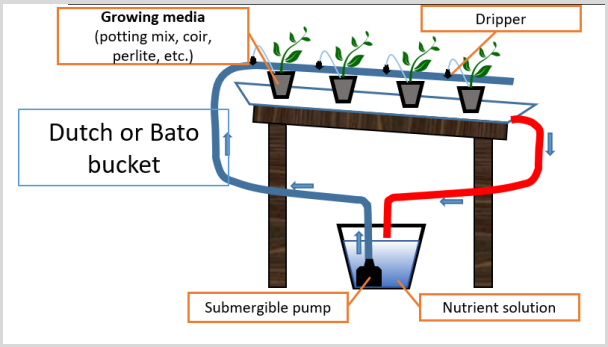
Floating Raft or Deep Water Culture (DWC): A passive system where the roots are saturated in water. Seedlings are started in soil-less media and transplanted into net pots supported by rafts. This is low cost and low maintenance. Great for leafy greens and herbs. Aeration is needed in the water by an air pump. Can be used for miniature tomato varieties. Cannot support large varieties well.

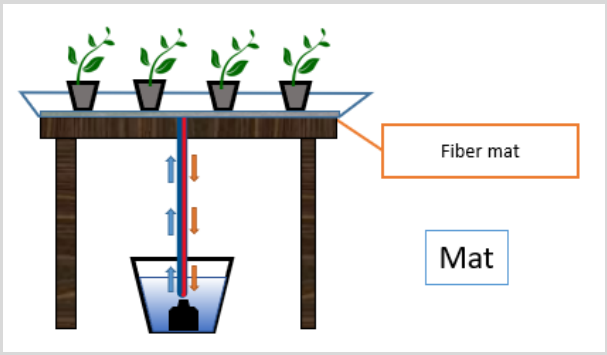
Dutch Bucket System or Bato Buckets: A closed hydroponic system (recirculating nutrient solution) with a reservoir and a submersible pump that moves the nutrient solution into grow buckets. An active system ideal for vines and fruiting crops such as tomato, cucumber and cantaloupe. The crops will need a trellis system to guide plant growth and support the weight of the plant and produce. Needs a submergible pump.

Capillary Matt System: The plants grow in pots that are placed on top of an absorbent capillary mat. There are driplines within the mat that deliver the nutrient solution. The nutrient solution flows from the saturated mats to the growing media by capillary action.

Types of Hydroponic Systems







Images by Juan Cabrera

System Preparation before transplant:

⇒ Clean debris from previous crop (if used)

⇒ Waterproof electrical outlets or power strips

⇒ Quality lights

⇒ Inspect system for leaks and broken parts by doing a test run before planting medium and plants are added to the system (image to the right)

⇒ Make sure all meters and materials are in stock:

- Fertilizers, acid and base for adjusting pH
- Conductivity and pH meters with calibrating solutions
- Air pump with diffusers or submergible pumps

It is wise to test run hydroponic equipment to look for leaks before adding plants.

There are several options for growing mediums in hydroponics. Selection of a growing medium depends on the type of plant, pH of irrigation water, cost and the type of systems being used.

Growing Mediums Options	Cost	Notes	pH	Image
For Seedling Production Media				
Rockwool: Stone wool from basalt (lava rock), heated to 1,500°C, spun into threads, and cooled. Varying sizes to accommodate plant size/stage.	Medium	Not Reusable Not Compostable	Basic	
Peat Pellet: Compressed peat in pellet form that absorbs water and increases in size. Seeds can be planted into a preformed divot.	Low	Not reusable Compostable	Acidic	
Oasis cubes: A synthetic material for starting seeds. Seeds can be planted into a preformed divot.	Medium	Polyurethane Not reusable Not compostable	Neutral	
Media for Growing Plants in Pots in the Hydroponics System				
Perlite: Silica mineral mined and heated forming small, sterile, lightweight kernels. No nutrient value. Rigid structure good for aeration.	Low	Reusable Dusty when dry	Basic	
Potting mix: Peat moss and perlite mix. Can be utilized for seed starting or transplanting.	Low	Compostable	Basic	
Vermiculite: Mica mineral that expands forming porous, spongy, sterile kernels. Lightweight and high water holding capacity. Contains some available Magnesium and potassium.	Medium	Reusable Dusty when dry	Basic	
Expanded Clay Pellets: Expensive, but could be sterilized between plantings. Utilized at transplanting into hydroponics.	High	Reusable	Neutral	
Coconut coir: Ground-up coconut palm husks. Good air capacity, capillarity and moisture retention. Potentially sustainable and renewable.	Low to Medium	Not reusable Compostable	Neutral	

Crop Timeline for Tomatoes

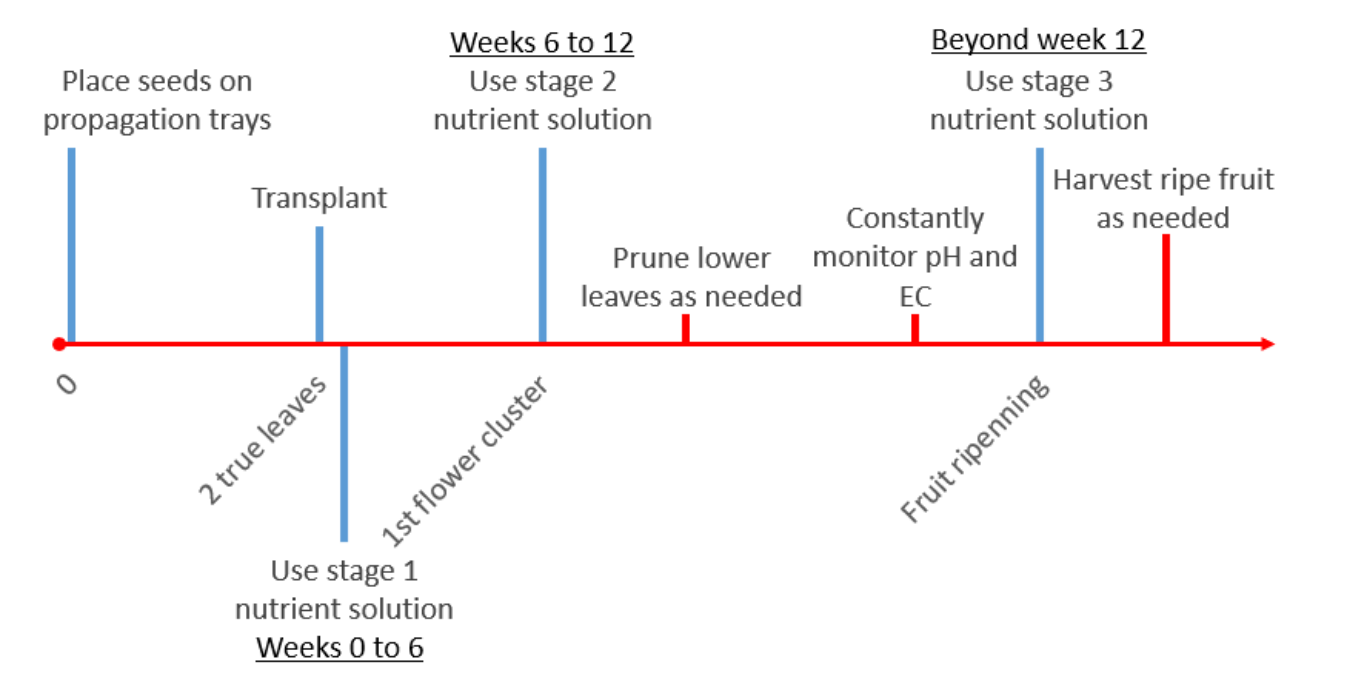
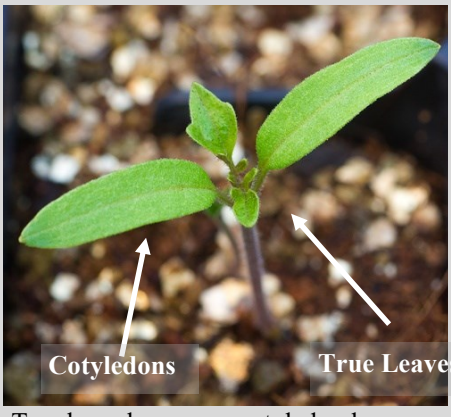


Chart created by Juan Cabrera

Starting Seedlings for Hydroponic Systems

1. Choose desired varieties (preferably bred, selected and trialed in hydroponic systems.
2. Choose your medium. Saturate the media with water without fertilizer.
3. Place the seeds on the media. Close media over seeds if possible. Place in a leakproof tray.
4. Keep seeds moist with plain water.
5. Cover the seeds for 24 to 48 hours with a plastic dome to keep humidity high (or place in a dark room) for germination.
6. Maintain optimal temperature for germination based on crop.
7. Once seedlings start to emerge, remove the cover and place seeds under lights and keep them moist using a 75 ppm N nutrient solution.
8. Seedlings will be ready to place in the hydroponic system when the first pair of true leaves. are fully expanded. About 2 weeks after germinating.
9. Place the seedling in the system.

Seed placed in divots in rock wool (top) and peat pellets (bottom).



Two large leaves are cotyledon leaves and two smaller center leaves are true leaves.

Nutrient Solutions for Hydroponic Tomatoes

In hydroponics systems, most plant nutrients are supplied through nutrient solutions. Fertilizer recommendations come in many ways:

⇒Fertilizer program offered by hydroponic retailers that offer a complete nutritional program (macronutrients and micronutrient). Program varies by crop and are easy to use. Requires little math.

⇒Nutrient Solution Recipes require amounts of each nutrient to make the nutrient solution. They are crop specific and can be found through Extension services, websites, and books. Growers calculate how much fertilizer to put in the nutrient solution based on the amounts required on the recipe. Adjustments can be made for nutrients already existing in the water source. Math skills needed.

⇒Complete fertilizer include macronutrient and micronutrients in one additive and typically fertilizer rates are based on the nitrogen needs of the crop. Complete fertilizes are readily available on the web. Unfortunately, only using a complete fertilizer may not provide the proper balance of nutrient for the plants.

Example Nutrient Solution Recipe for Tomatoes

A specific nutrient balance needs to match each crop stage. With tomatoes we have three stages.

- **Stage 1** (weeks 0 to 6) → Nutrients need to support strong stems and many leaves, so the solution needs to supply a lot of nitrogen
- **Stage 2** (week 6 to 12) → Nutrients need to kickstart blooming and fruit set. Plants will need increased Nitrogen, Phosphorus and Potassium.
- **Stage 3** (week 12 and beyond) → Nutrients need to focus on the fruits. Increased potassium is needed.

Tomato Stage 1

- Use until you see the first cluster of flowers (approx. 6 weeks)
- For every 10 gallons add:
  - 0.8 oz (23 grams) of 5-12-26
  - 1 oz (29 grams) of 15.5-0-0
  - 0.4 oz (11 grams) of Epsom salts
- Dilute fertilizers separately
- Measure pH and EC
- Adjust pH

Tomato Stage 2

- Use until you see the fourth cluster of flowers (weeks 6 to 12)
- For every 10 gallons add:
  - 1.5 oz (43 grams) of 5-12-26
  - 1.2 oz (34 grams) of 15.5-0-0
- Dilute fertilizers separately
- Measure pH and EC
- Adjust pH

Tomato Stage 3

- Use when you see the fruits ripening (plants older than 12 weeks)
- For every 10 gallons add:
  - 2 oz (57 grams) of 5-12-26
  - 1.4 oz (39 grams) of 15.5-0-0
- Dilute fertilizers separately
- Measure pH and EC
- Adjust pH

Managing the Nutrient Solution

To monitor nutrient solutions, measure the *electroconductivity* (EC) and *pH* of the solution in your system regularly.

- Use an electrical conductivity meter to detect the level of total dissolved nutrients in the hydroponic solution expressed on a scale of *milliSiemens per centimeter* (mS/cm). You will see the EC drop as plants take up the nutrients. EC can also increase as salt concentrate from fertilizers and the solution will become toxic for plants.

- Use a pH meter to measure the acidity of the water. Plants do best when growing in water with a pH of 5.4 to 7.0. PH will need to be adjusted based on each crop's requirements.

- Check pH and EC will need to be adjusted between nutrient solution changes and then every other day during the growing cycle.

Meters from Hannah Instruments test for pH and EC in one unit. No endorsement is implied. Used only for example.

Checking EC (Electrical Conductivity)

1. Fill the nutrient tank with tap water and add fertilizer. Based fertilizer rate on manufacturer recommendation.
2. Calibrate the EC meter probe using the buffer solution.
3. Stir the nutrient solution and allow the reading to stabilize which may take a few minutes.
4. Take the EC reading. If the reading is higher than the optimum level for the crop, dilute the solution by adding more water. Repeat testing in step 3.
5. If the reading is below the optimum level, add fertilizer concentrate until the optimum level is reached by testing on step 3.
6. After optimum reading is reached, rinse the probe in tap water and store in probe-cleaning fluid.

Checking pH

1. Check and adjust the proper EC value for the crop.
2. Calibrate the pH meter probe using the buffer solution.
3. Stir the nutrient solution and allow the reading to stabilize which may take a few minutes.
4. Take the pH reading. If the reading is higher than the optimum level for the crop, add phosphoric acid, citric acid, vinegar or pH down products slowly. Repeat testing.
5. If the reading is below the optimum level, add potassium hydroxide, potassium carbonate or a pH up product slowly. Repeat testing.
6. After optimum reading is reached, rinse the probe in tap water and store in probe-cleaning fluid.

Choosing Varieties Suitable for Hydroponics

For tomatoes

- Indeterminate varieties work best for hydroponics since these tomatoes keep growing, blooming and producing over the life of the plant. Determinate tomatoes tend to behave similar to annual plants where they stop growing, set blooms, and the produce ripens all at once.
- Heirloom varieties can be successful when flavor is important. Keep in mind that the skins can be thin and the fruit easily bruised - handle the fruit with care.
- Miniature tomato varieties can be used in smaller hydroponic systems. These include cherry, patio, grape and current tomatoes.

Care of Tomatoes During the Growing Cycle

After planting care

- As the tomato plants are growing, remove any suckers that develop.
- Remove any lower leaves no longer needed for production which are all leaves under the first fruit cluster.
- Provide trellis or string system to clip vines to as the plants grow. This provides better air circulation, less disease pressure and ease of picking tomato fruit.
- Measure pH and EC every two days and adjust pH when necessary.
- Tomatoes need pollinators to increase yield and fruit size. You can order a box of bumblebees that will last for 12 weeks. You can also tap the trellis wire twice a day for at least 3 days a week or use an electric air blower every day for 5 seconds.
- Walk through and observe the plants for insect damage, diseases, yellowing or abnormal growth.
- Place sticky traps near vents, doors and at the canopy level of the crops to monitor for insects.
- Replace nutrient solution when needed.

Tomatoes growing on a string trellis (top). Remove any suckers (middle). Tomato stem attached to trellis system using small plastic clip (bottom).

Putting It All Together...

1. Determine the hydroponic system desired.
2. Test water quality.
2. Determine the desired crop(s) for the hydroponic system.
3. Start seeds.
4. Determine nutrients requirements for desired crop and calculate fertilizer for nutrient solution.
5. Prepare nutrient solution.
6. Do you need aeration of some type? (if a submergible pump will not be used.)
7. Measure and adjust pH of nutrient solution
8. Measure EC.
9. Place seedlings into unit then into nutrient solution.
10. Adjust lighting over plants.
11. Check pH and EC of the nutrient solution regularly (daily).

Homemade NFT system for greens and herbs. Two runs of 4 inch PVC capable of 7 plants each. This system has a 800 GPH submergible pump that recirculated the nutrient solution throughout the system. Nutrient solution is stored in the grey can. Large PVC pipes at 1% slope help the nutrient solution return back to the reservoir.

Resources:

- Water Analysis, University of Missouri Extension https://extension.missouri.edu/programs/soil-and-plant-testing-laboratory/spl-water-analysis
- *Hydroponics*, Oklahoma Cooperative Extension Service https://extension.okstate.edu/fact-sheets/hydroponics.html
- *Electrical Conductivity and pH Guide for Hydroponics*, Oklahoma State University https://extension.okstate.edu/fact-sheets/electrical-conductivity-and-ph-guide-for-hydroponics.html
- *Hydroponics Systems: Nutrient Solution Programs and Recipes*, PennState Extension https://extension.psu.edu/hydroponics-systems-nutrient-solution-programs-and-recipes
- *Home Hydroponics*, Illinois Extension https://extension.illinois.edu/sites/default/files/illinois_extension_hydroponics_handouts.pdf
- *Homegrown: DIY Hydroponics for All Gardeners*, University of Illinois, https://extension.illinois.edu/blogs/know-how-know-more/2020-02-18-homegrown-diy-hydroponics-all-gardeners
- *Set it and Forget it Hydroponics*, University of Florida, https://blogs.ifas.ufl.edu/orangeco/2020/04/09/set-it-and-forget-it-hydroponics/

Written by: Donna Aufdenberg, Field Specialist in Horticulture, aufdenbergd@missouri.edu
Juan Cabrera, State Horticulture Specialist, jcabrera-garcia@missouri.edu

Extension
University of Missouri

Issued in furtherance of the Cooperative Extension Work Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Director, Cooperative Extension, University of Missouri, Columbia, MO 65211 • MU Extension provides equal opportunity to all participants in extension programs and activities and for all employees and applicants for employment on the basis of their demonstrated ability and competence without discrimination on the basis of race, color, national origin, ancestry, religion, sex, sexual orientation, gender identity, gender expression, age, genetic information, disability or protected veteran status. • 573-882-7216 • extension.missouri.edu