Hydroponics for the Master Gardener

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Master Gardener Class of 2014

What is hydroponics?

Growing plants hydroponically means that:

Plants grow without soil…

…in a water-based nutrient solution

…in materials that give plants the support they need…to thrive in a growth chamber with a delivery system that gets the nutrient solution to the plant roots…

…with either natural or artificial lighting.

Hydroponics has been around for over 2000 years… but technologies give it a new spin today!

Hydroponic: Advantages & Disadvantages

1. Healthier plants – having a near-perfectly balanced diet
2. Healthier consumers – less need to use herbicides, fungicides, and pesticides
3. Higher Yields – without water and nutrient stresses, plants grow faster and can be grown more compactly
4. Conservation – preventing evaporation and runoff
5. Year-round production schedule

1. Initial set up costs can be high
2. Because plants share nutrient fluids, diseases and pests can quickly move from plant to plant
3. Maintenance requirements can increase, depending on the system used and crop
4. A power outage can destroy a crop
5. Initial set up requires technical knowledge, time, and commitment

Types of Hydroponic Systems

- Passive
- Water Culture
- Active
- Media-Based

PASSIVE SYSTEMS

These systems use no energy to move nutrients and water. They can be as basic as a perlite-filled flowerpot that is hand-watered regularly with nutrient solution. Passive systems often use a "wicking" material to draw up the liquid nutrients, or they simply suspend the plants in the solution with an air space around some of the root zone. They can be media-based or pure water-culture systems.

ACTIVE SYSTEMS

A hydroponic system is active if it relies on some type of energy (usually electricity via a pump) to move the nutrients in and out of the root zone area and to provide aeration. These systems, which can also be either media- or water-based, are generally used for larger plants (e.g., tomatoes and cucumbers) and tend to be more sophisticated. In recirculating or recycling systems, the nutrient solution is conserved by being recirculated either manually or electrically through the medium. These systems require closer monitoring of pH, nutrient concentration, and so on. Systems with pumps to aerate and deliver more oxygen to roots tend to produce healthier plants more quickly than do passive systems.

Passive System

Soda Bottle Passive Hydroponics System

Introduction:

These bottle systems are:

*Passive (no pumps or electricity)

*Closed (the nutrient solution remains in the system)

*Liquid/Aggregate

(Roots can grow initially in the aggregate then directly into the solution)

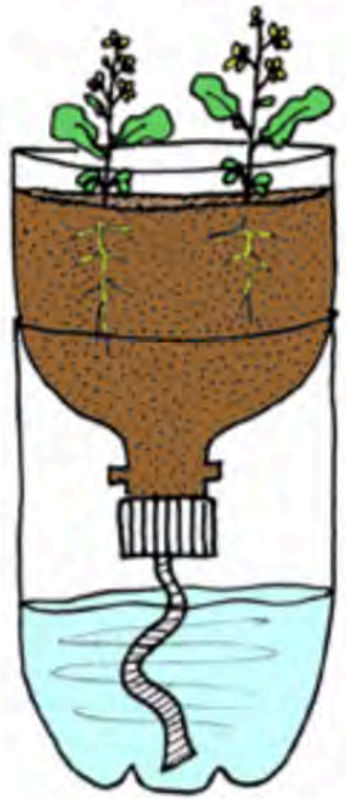

Image Credit: http://tlc.peoriaud.k12.az.us/Enviromental%20and%20Agricultural/Hydroponics/lesson6.htm

Active System

Media-Based Systems

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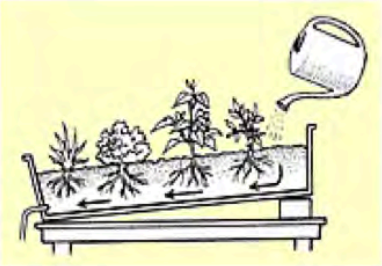
Source: KidsGardening.org

These types of hydroponic systems rely on some material, such as gravel, aggregate, perlite, vermiculite, or rockwool to support the plants and the roots in the nutrient solution. Such systems can be active or passive and may or may not recycle the nutrients.

Following are descriptions of some common types of media-based systems.

WICK SYSTEMS (PASSIVE)

This is probably the simplest media-based system and a good one for exploring capillary action. A nutrient mix is drawn into the medium through nylon or cotton wicks immersed in a reservoir. This is commonly used in schools where the biggest challenge is making sure the plant roots get sufficient air and that the nutrient mix is diluted with water when the level drops.

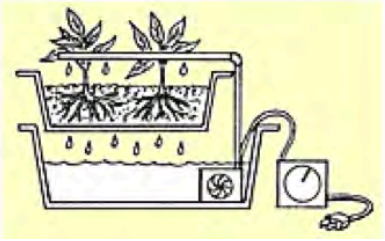


EBB AND FLOW SYSTEMS (ACTIVE)

The plants and medium are flooded up to six times per day with the nutrient mix, then allowed to drain. As it drains, the system draws oxygen into the medium. These systems often incorporate automatic timers, but can be flooded by hand if you are very consistent. After several cycles, you must wash the roots and tank to remove any built-up, crusted salts.

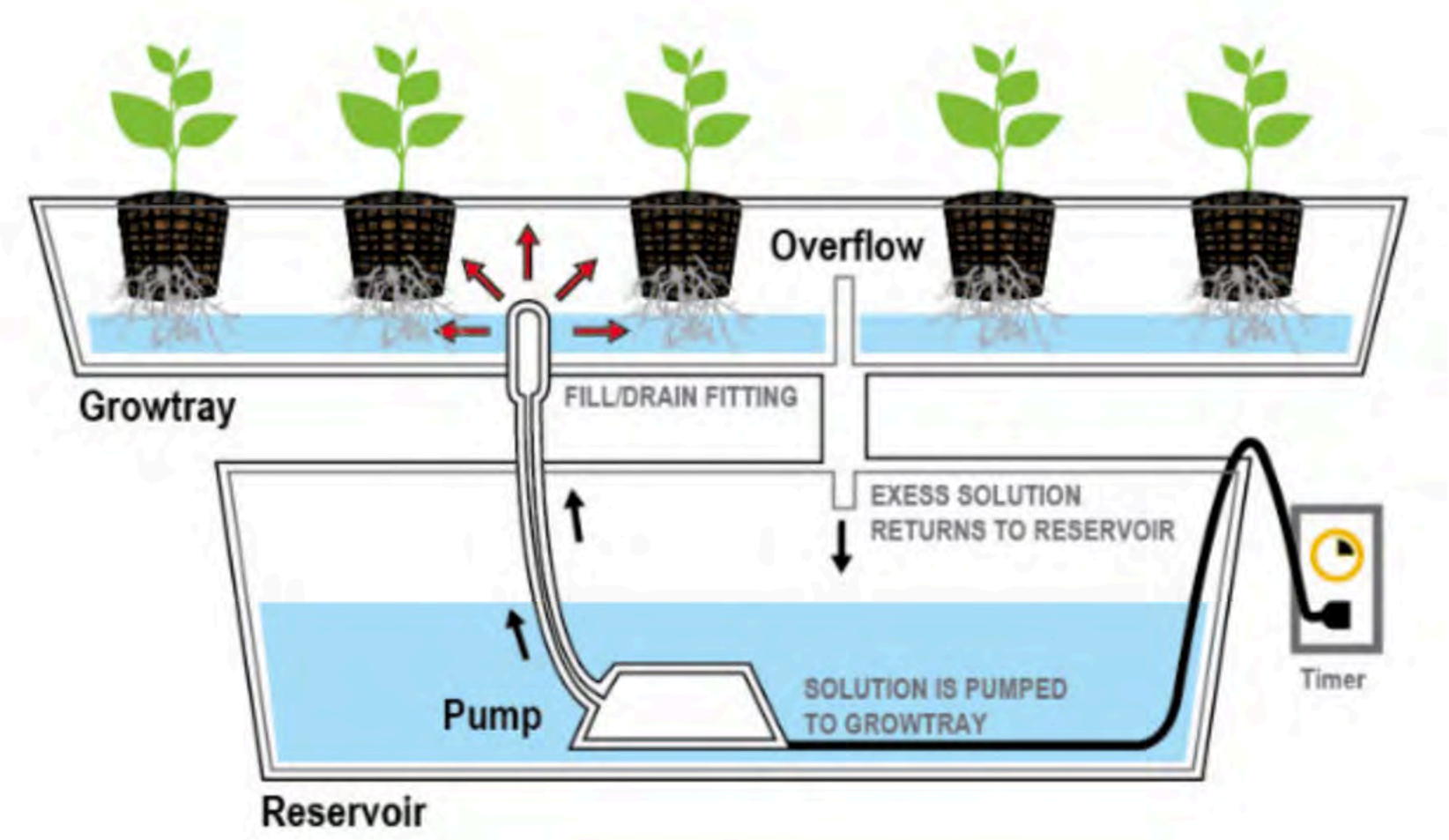
TOP-FEED OR DRIP SYSTEMS (ACTIVE)

A timer-controlled pump delivers the nutrient mix on a regular schedule through "emitters" (pipes with holes) to the top of the plant medium and allows the mix to drip down into a catch basin below.



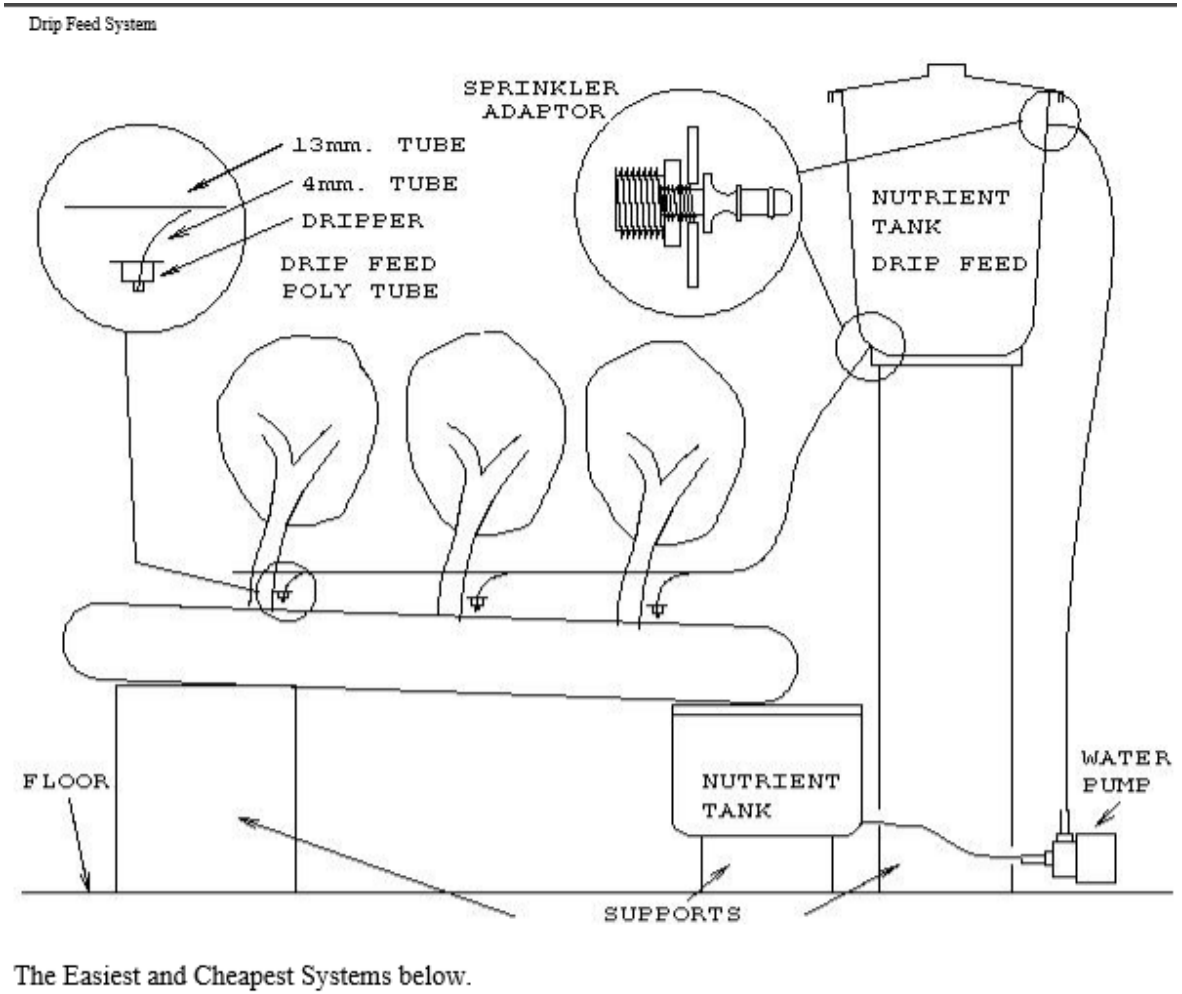
Wick-based Systems

Ebb & Flow System



Credits: http://hydroponicsgrower.org/introduction-to-different-types-of-hydroponics-systems/
http://gardenious.com/tag/ebb-and-flow-hydroponic-system-timing/

Drip System

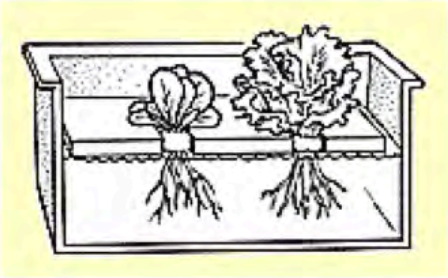


Source: http://doctorgardening.com/building-hydroponic-system/

Drip system

Water-Culture Systems

These systems do not use any medium other than water, so they require a support material such as wire mesh to keep the plants from drowning. These systems rely on regular contact between plant roots and the nutrient solution. Leafy crops like lettuce and herbs tend to do better in water culture than do fruiting crops like tomatoes, cucumbers, or peppers.

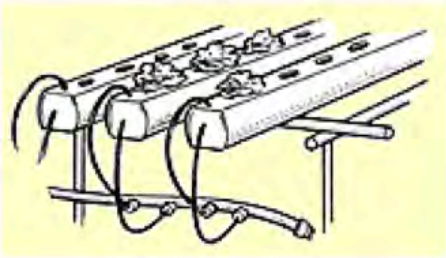


RAFT SYSTEM (ACTIVE OR PASSIVE)

In this system, plants float on rafts above a reservoir of nutrient solution. (Styrofoam rafts work well in the classroom.) The tips of the roots reach the liquid and the holes cut in the raft for the plants allow some air exchange. Many raft systems also aerate the water automatically, to provide the roots with greater exposure to oxygen.

NFT (NUTRIENT FLOW TECHNIQUE) (ACTIVE)

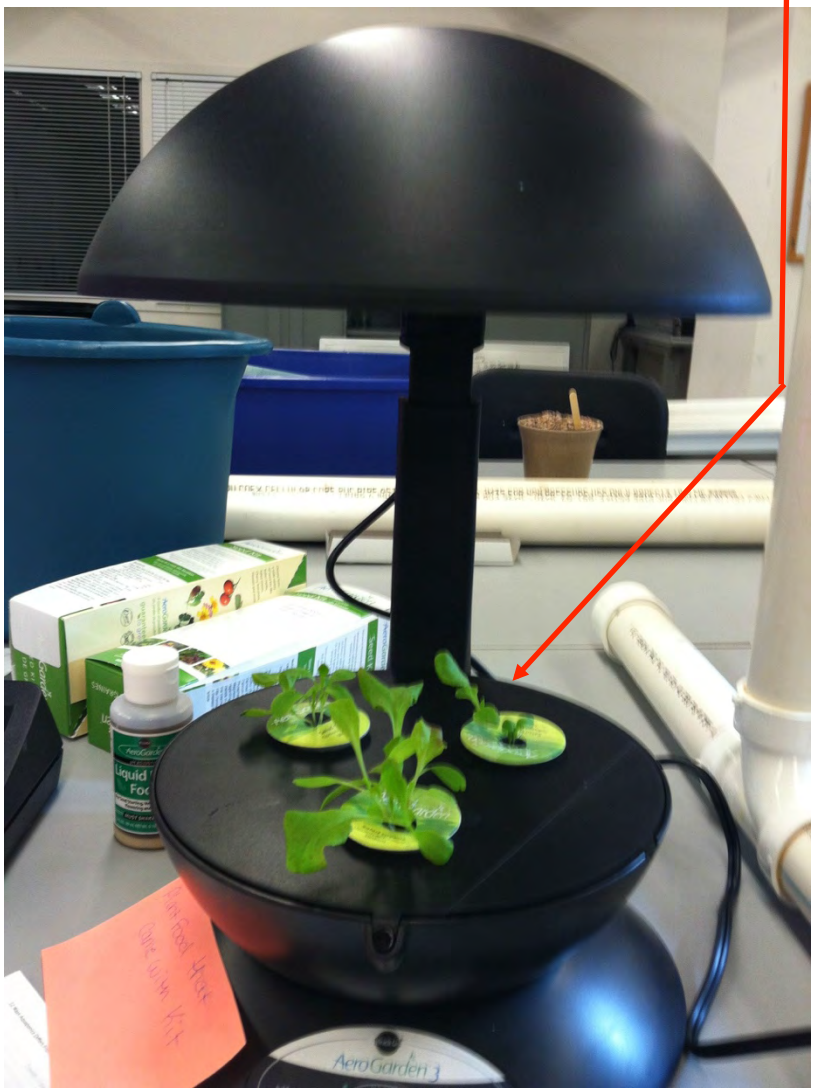
Plants are suspended in the nutrient mix, which is pump-circulated past the roots, aerating the solution. Commercial growers often place seedlings directly into rockwool cubes within holes cut in PVC pipe channels.



Bubbler Bucket System

NFT System

Active Raft System



How much would it cost to set up a hydroponic system?

- Low cost: $
- Moderate cost: $$
- Modest cost: $$$
- Large investment: $$$$

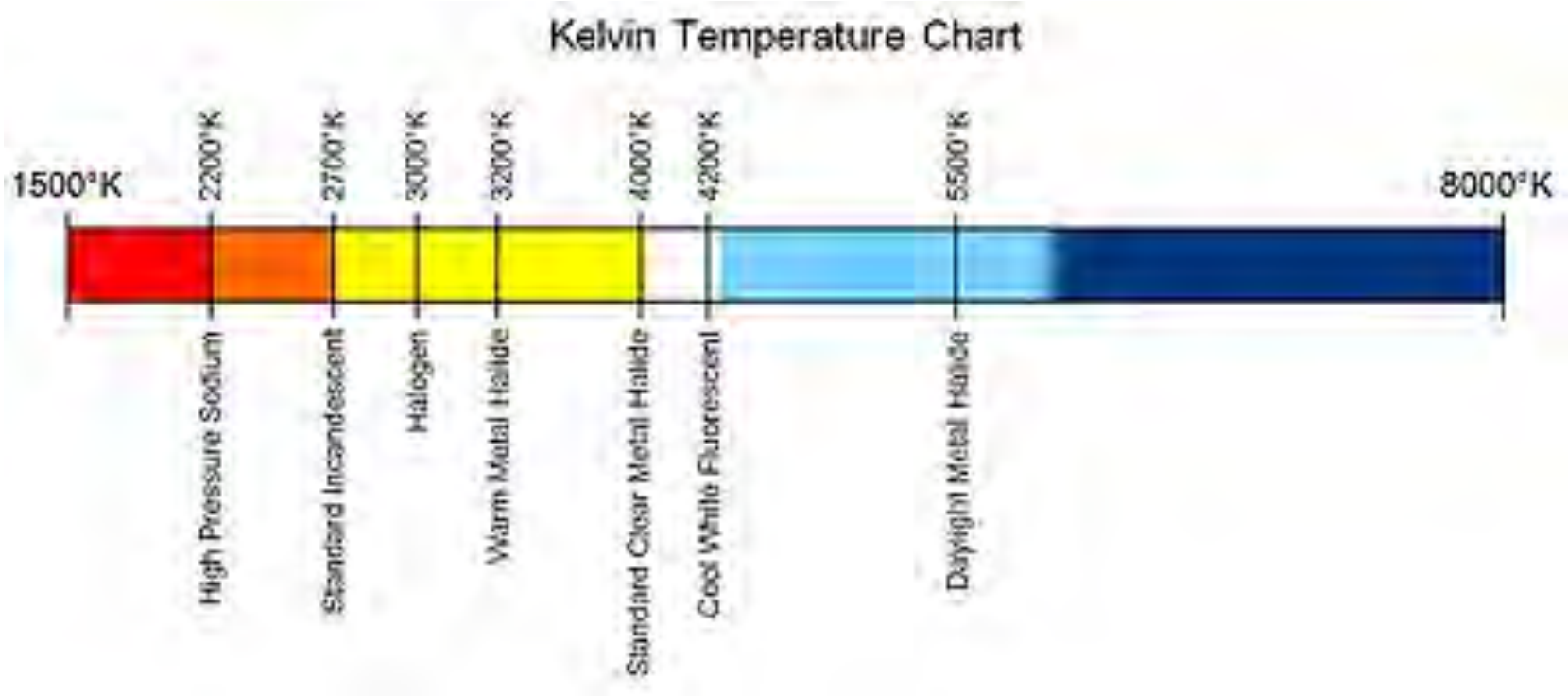
What to know to be successful with your hydroponic system

Lighting – Most Critical Factor

Choose lighting based on

- Type of plant
- Stage of plant cultivation
- Photoperiod required (or tolerance range)
- Range of light spectrum preferred by plant
- Optimum lumen & color temperature

Kelvin Temperature Chart



Source: Grow light - Wikipedia

Common types of artificial lighting

High Intensity Discharge (HID) lights
- Metal Halide (MH)
- Ceramic Metal Halide (CMH, CDM)
- Combina7on MH and HPS ("Dual arc")
- High-Pressure Sodium (HPS)
- Conversion bulbs
- Switchable ballasts

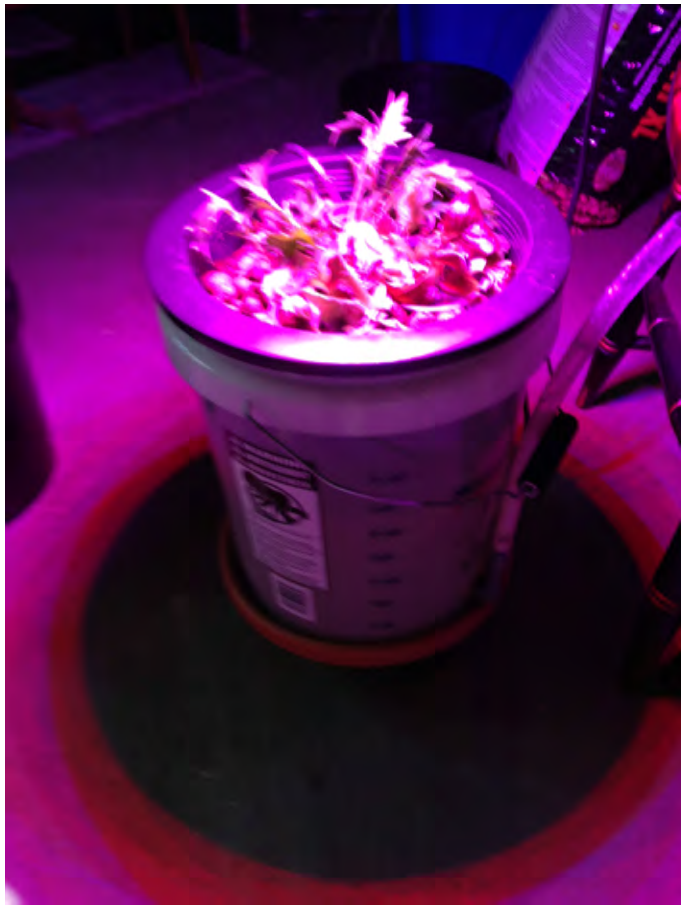
A 600W High Pressure Sodium bulb

LEDs (Light Emitting Diodes)

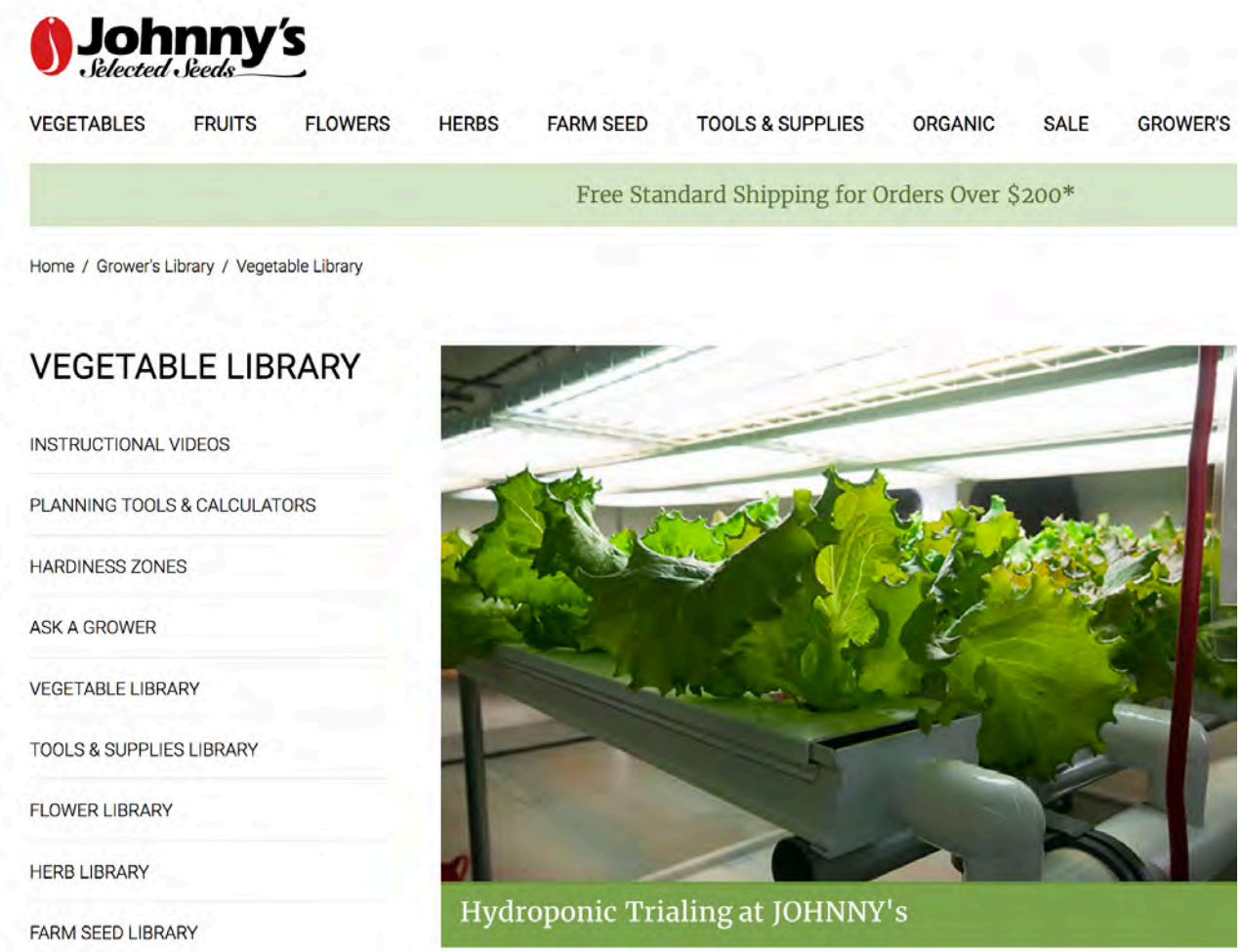
Fluorescent
- Tube-style fluorescent lights
- Compact Fluorescent Lights (CFLs)

Dual spectrum compact fluorescent grow light. Actual length is about 40 cm (16 in)

For example



Select seed varieties that do best in a hydroponic culture



Maintain optimum conditions for your plants

Consider plant's ideal…

- Temperature
- Light intensity
- Spacing

Investigate your plant's

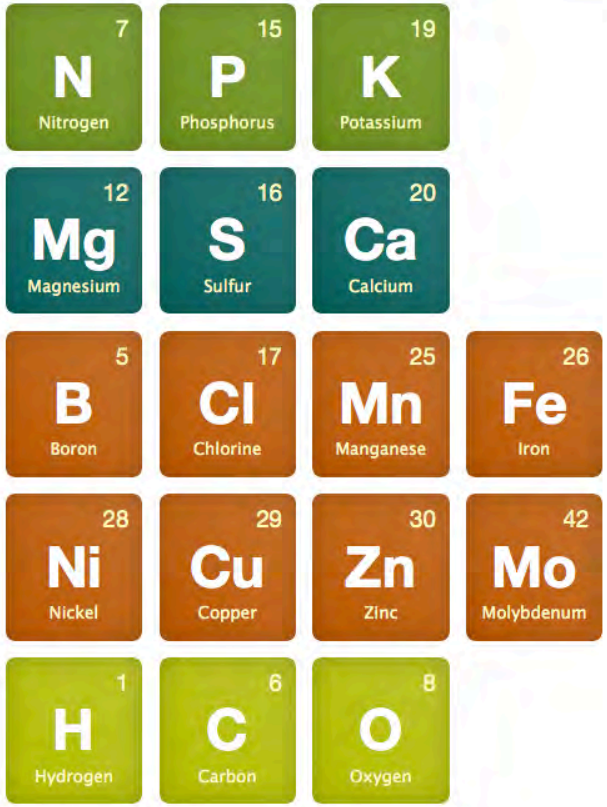
- life cycle,
- structural needs,
- pollination and reproduction processes, and
- disease/pest vulnerabilities/resistances

Explore plant mineral requirements

- The primary mineral nutrients plants require are **nitrogen** (N), **phosphorus** (P), and **potassium** (K).
- Secondary mineral nutrients include **calcium** (Ca), **magnesium** (Mg), and **sulfur** (S).
- Plants also need these micronutrients **boron** (B), **copper** (Cu), **iron** (Fe), **chloride** (Cl), **manganese** (Mn), **molybdenum** (Mo), and **zinc** (Zn).
- See interactive periodic table of plant nutrients at: http://www.cropnutrition.com/nutrient-knowledge

Periodic Table of Crop Nutrients

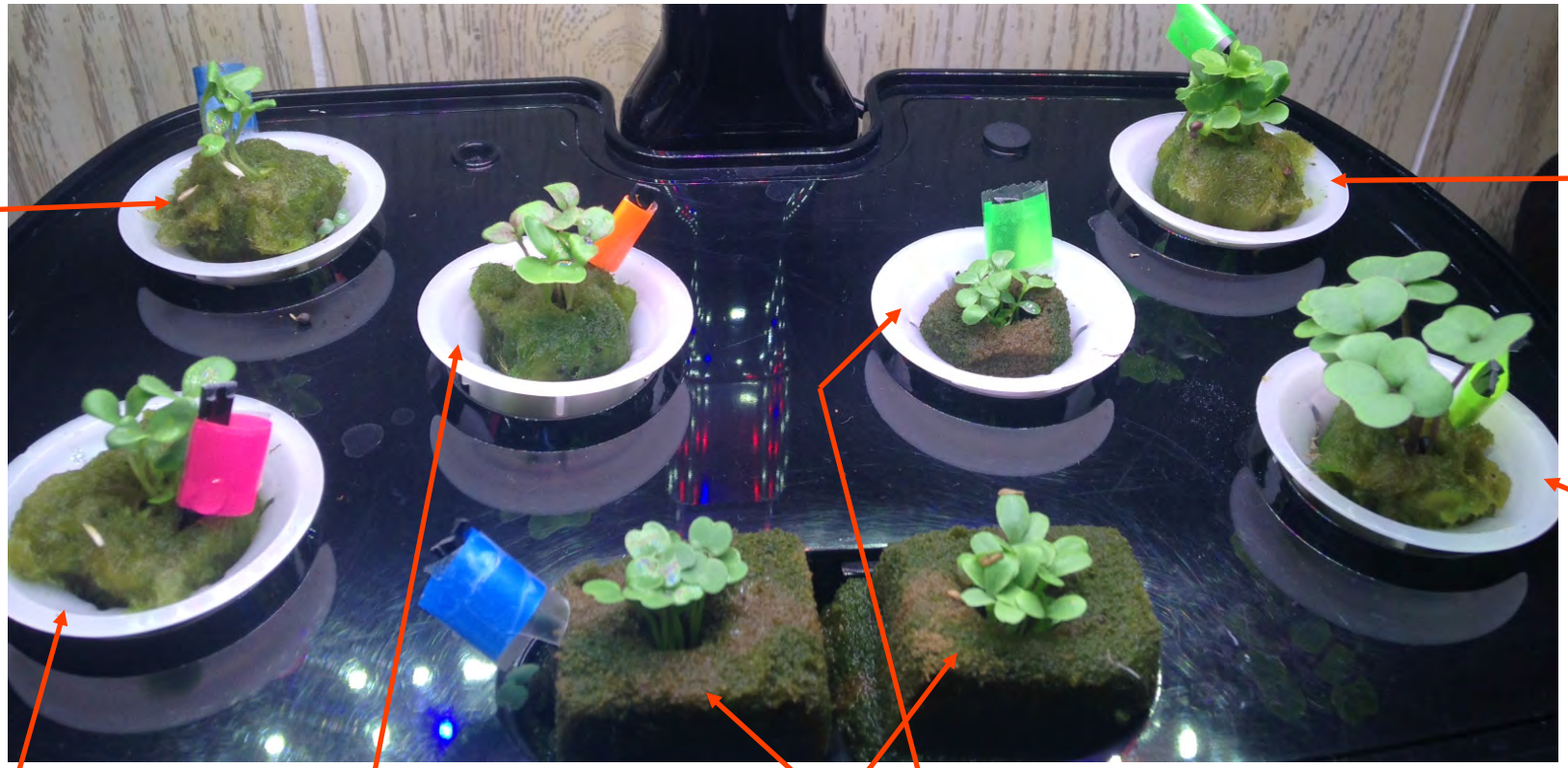
Learn about the 17 essential plant nutrients and their roles in plant health. All crops must have an adequate supply of each of these 17 nutrients to produce optimum yields. In accordance with The Law of the Minimum, if one or more nutrients are lacking in the soil, crop yields will be reduced, even though an adequate amount of other elements is available. Crop yields may be limited by the element that is in shortest supply, so it helps to understand the key nutrients that are needed to make your crop thrive.

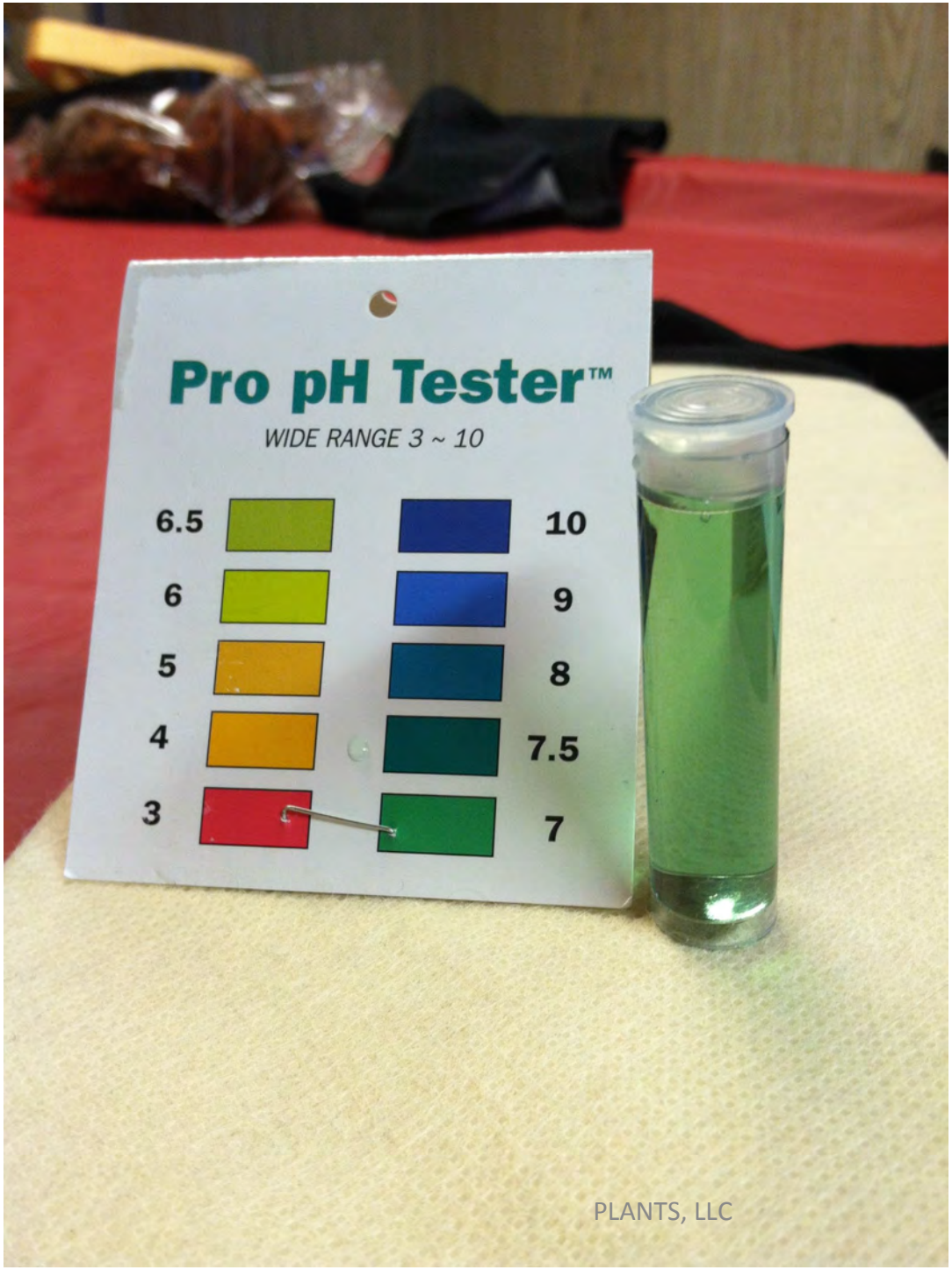


Click through the interactive Periodic Table of Crop Nutrients on the left to see the key benefits of each nutrient. Use the tabs to dig deeper into each nutrient, and see photos of nutrient deficiencies in common crops.

Explore using different materials to support plant growth.
For example, compare Vermiculite and Perlite as materials for seed germination.

Lettuce Seedlings





Explore water quality analysis using simple and/or more complex technology tools.

Temperature, EC, pH Meter, Programmable Timer

You may want to design your own **Arduino controls** to monitor hydroponic system functions and processes such as:

- pH
- Temperature
- Electrical conductivity
- Water level
- Data logging

Compare & contrast the characteristics of different plant species and varieties.

OUTREDGEOUS Romaine Lettuce
Lactuca sativa

ARUGULA - Arugula Rocket

NASA supports humans in space with the Veggie Machine on the ISS

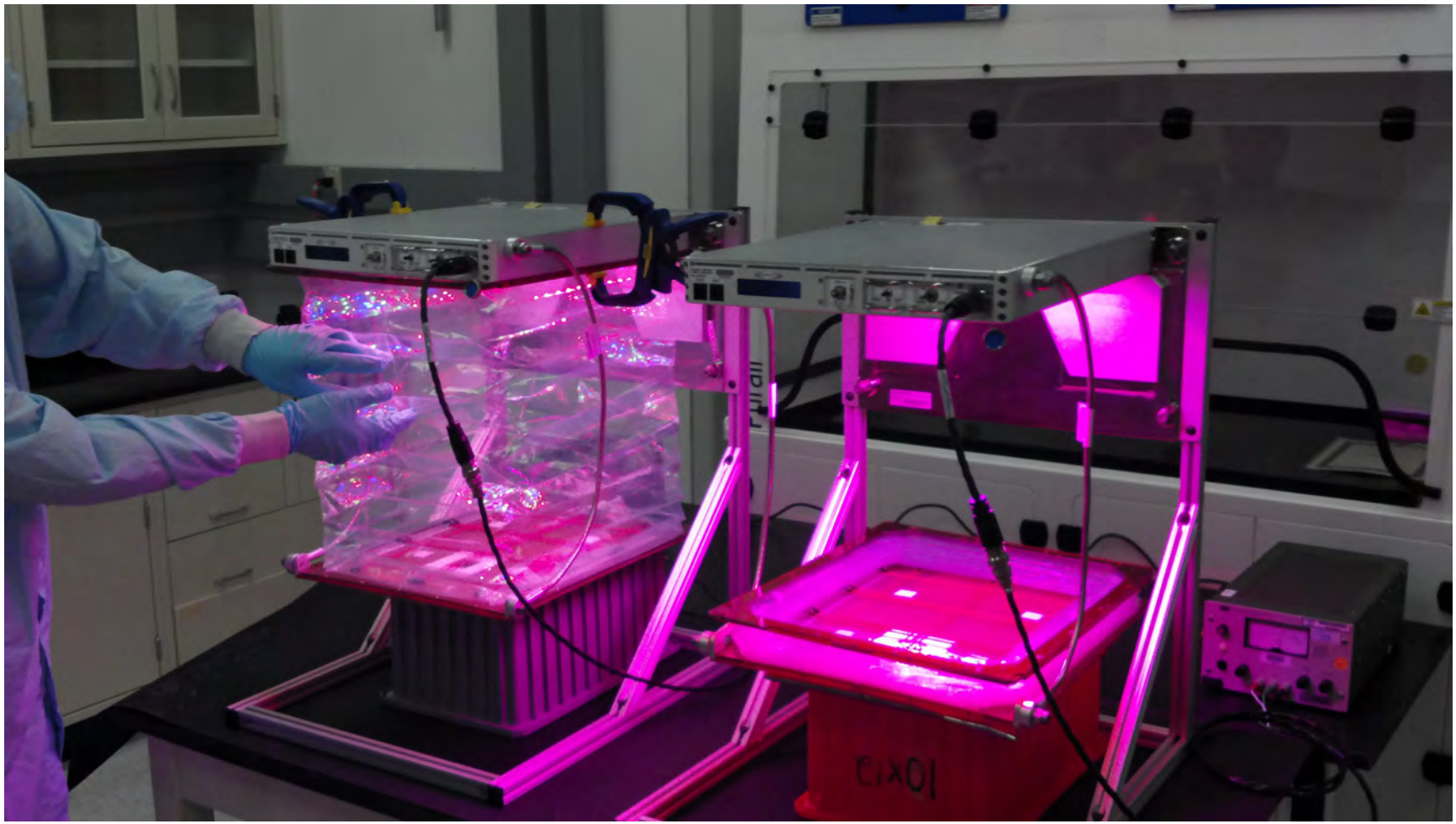


Image credit: [NASA Space Station Research]

Outredgeous Lettuce on ISS

Track Hydroponic Plant Growth

Germination of Lettuce Seeds						
Seed type	OUTREDGEOUS	DEFENDER MT0 OG	CELINET OG MT0	ARUGULA		Forellenschluss
	Romaine Lettuce	Romaine Lettuce	Summer Crisp Lettuce		Grand Rapids (leaf)	Austrian Heirloom Romaine
	Lactuca sativa	Lactuca sativa	Lactuca sativa	Arugula Rocket		LECHUGA Forellenschluss
	Lot: 43796	Lot: 41576	Lot: 48577	Lot: 3		Lot: 8
	1	2	3	4	5	6
Seed source	Johnny's Selected Seeds	Johnny's Selected Seeds	Johnny's Selected Seeds	BURPEE c/o Walmart	Plantation Products LLC	BURPEE
Expiration date				14-Nov	14-Dec	Nov-14
Days to maturity	28	28 BABY	28	35	40 to 60	55
USDA Organic? Or MOFGA	No	Yes	Yes	Yes	No	No
Conditions						
Temperature (water)	Est. 69 degrees F	Est. 69 degrees F	Est. 69 degrees F	Est. 69 degrees F	Est. 69 degrees F	Est. 69 degrees F
ECC	14	14	14	14	14	14
pH of water	4	4	4	4	4	4
pH of water with nutrient						
Water source*	dehumidifier	dehumidifier	dehumidifier	dehumidifier	dehumidifier	dehumidifier
Date/time	20 may 2015 at 12:45	20 may 2015 at 12:45	20 may 2015 at 12:45	20 may 2015 at 12:45	20 may 2015 at 12:45	20 may 2015 at 12:45
Media used	Vermiculite	Vermiculite	Vermiculite	Vermiculite	Vermiculite	Vermiculite
Nutrient added: FloraNova (7-4-10) Nitrogen, Phosphate (P2O5) Potash (K2O)						
Date/time	26-May-15	26-May-15	26-May-15	26-May-15	26-May-15	26-May-15
Light: Blue, Red & White LED	23-May-15	23-May-15	23-May-15	23-May-15	23-May-15	23-May-15
*water was aerated with fish tank pump before using in germination vessels						

Enjoy your harvests

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