INTRODUCTION TO HYDROPONICS

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What Is Hydroponics?

Growing plants in liquid nutrient solutions instead of soil

History of Hydroponics

- Hydroponics comes from two Greek words 'hydro' meaning water and 'ponos' meaning labor
- 1929 - Word Hydroponics was 1st used by Dr. Gericke, University of California
- 1939-1945 WWII – U.S. Army fed troops stationed in Pacific Islands
- 1950-Present - Modern Technology

Advantages of Hydroponics

- Grow crops where soil is unsuitable
- More control
- Faster growth rate
- Increased crop yields
- Use less water than soil grown crops
- Reduce soil related disease and insects
- No weeding

Disadvantages of Hydroponics

- Initial cost can be higher than soil culture
- Additional knowledge is needed
- Constant monitoring
- Disease spreads to all plants once it appears
- Water based micro-organisms
- Vulnerable to power outages

Basics

- Growing Systems
- Growing Substrates
- Nutrient Solution

Hydroponics Terminology

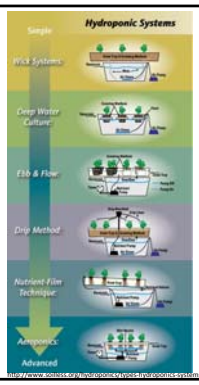
- Growing System
- Nutrient Solution
- Nutrient Reservoir
- Grow Tray
- Pump
- Airstone
- Growing Substrate or Media/Medium

Growing Systems

- Distinguished by the way the nutrient solution is applied
- Liquid or Aggregate
- Open or Closed
- Passive or Active

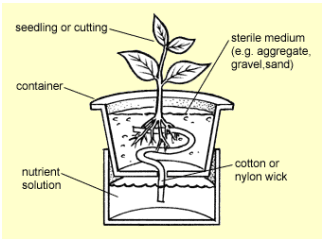
Types of Systems

- Wick
- Deep Water Culture
- Ebb and Flow
- Drip
- NFT (Nutrient Film Technique)
- Aeroponics

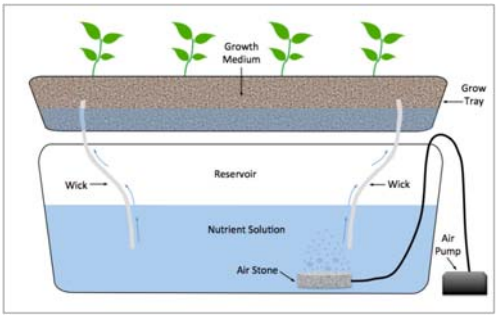


Wick System

- Simple Passive System
- Nutrient Solution is drawn up to plant roots through a wick in the growing media
- Smaller Scale
- Many options



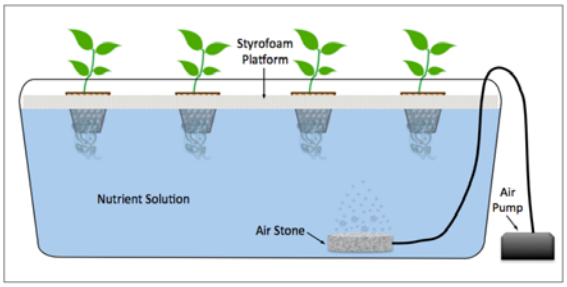
https://growerssupply.files.wordpress.com/2015/09/basic-wick_0.gif



https://offgridgorilla.com/off-grid-systems/food/hydroculture-hydroponics

Deep Water Culture

- Simple Active System
- Plant is suspended in platform above the nutrient solution in the reservoir
- Roots remain submerged
- Air pump or air stone supplies bubbles which provides oxygen to roots
- Small or Large Scale

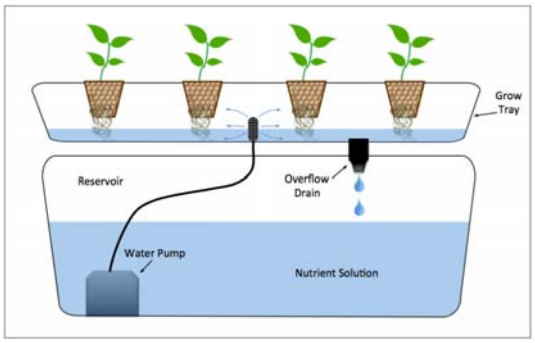


https://offgridgorilla.com/off-grid-systems/food/hydroculture-hydroponics/

http://www.homehydrosystems.com/hydroponic-systems/Water%20culture%20images/DWC-larg.jpg

Ebb & Flow (Flood & Drain) System

- Active System
- Uses a submerged pump to temporarily flood grow tray with nutrient solution and then drains solution back into reservoir
- Timer is set to come on several times a day – varies with size and type of plants, temperature, humidity and type of growing media
- Volume of solution to each plant can not be customized
- Works well for growing the same type of plant in each container
- Good for seedlings, small plants and cuttings

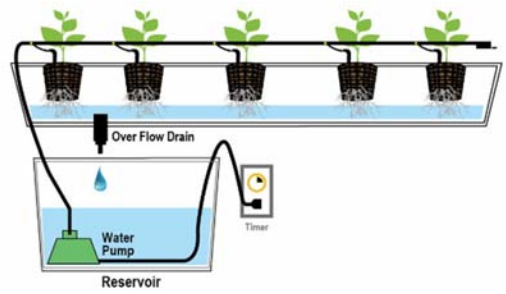


http://www.activeaquahydroponics.com/trays-reservoirs-systems/active-aqua-hydroponic-systems

Drip System

- Active System
- Timer controlled submersed pump
- Reservoir separate
- Drip lines to each plant
- Volume to each plant easy to control
- Nutrient solution is dripped directly on the base of each plant

http://www.instructables.com/id/Hydroponic-Drip-Garden-for-Vegetables-Herbs-or-Fl/

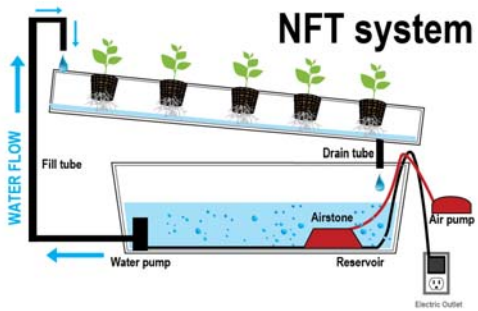


https://offgridgorilla.com/off-grid-systems/flood/hydroculture-hydroponics/

https://www.hydroempire.com/general-hydroponics-waterfarm-8-pack-drip-hydroponic-system/

NFT (Nutrient-Film Technique) System

- Active System
- Used Commercially
- Good for short harvest crops
- No timer required
- Nutrient Solution is in constant flow
- Pumped from the reservoir to the grow tray
- Grow tray is built with sufficient slope to allow solution to trickle down tray and not flood the tray
- Nutrients are recycled back to the reservoir



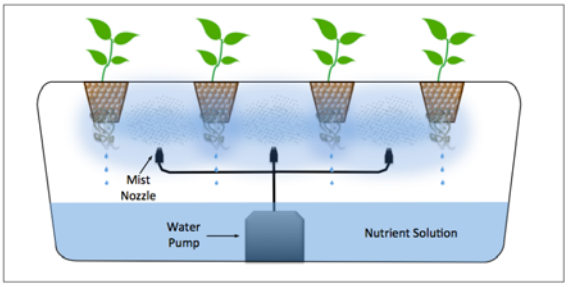
http://sdhydroponics.com/2012/05/11/how-to-grow-hydroponically-overview-of-grow-systems/

http://www.grozine.com/2014/05/05/american-hydroponics-nft-systems/

http://www.fullbloomhydroponics.net/hydroponic-systems-101/

Aeroponics System

- Active System
- Most technologically advanced
- Plants are suspended with roots hanging below
- Nutrient solution is pumped from the reservoir where a second higher pressure pump mists solution over the roots
- Advanced timer required - need to mist more often since each mist provides less than other systems
- Nutrient Solution moved around more making it more oxygenated allowing plants to grow faster



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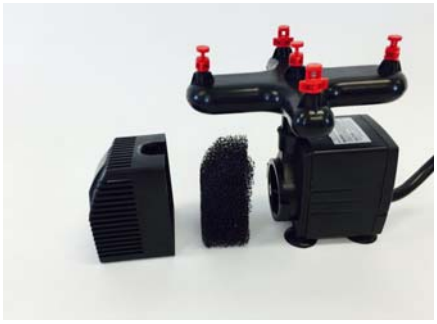


http://www.homedepot.com/p/Viagrow-Aeroponic-Clone-Machine-Replacement-Pump-Manifold-and-Misters-VCP160M/300044027cm_mmc=Shopping%7cTHD%7cG%7c0%7cG-BASE-PLA-D26P-Plumbing%7c&gclid=EAIaIQobChMI6O-_16rm1gIV1IqGCh3FQwOWEAQYBCABEgI1IPD_BwE&gclsrc=aw.ds&dclid=CNH_4Nqq5tYCFcUDPwodOmcDdQ

Nutrient Solution

- The sole source of nutrients to the plant
- Concentrated - already has nutrients added to it
- Soluble forms of these nutrients are available in different mixes

Nutrient Reservoir

- Where the nutrient solution is kept before it is fed to the plants
- Container can be plastic or glass
- Ability to hold large amounts of water
- Avoid metallic materials – can damage plants
- Keep covered to reduce evaporation, algae growth
- Keep nutrient solution temperature between 55°-60°F

Nutrients

- Make your own
- Purchase Liquid or Powder
- One or Two Part
- Conventional
- Organic

Nutrients

One Part Solutions

- Contains all the necessary nutrients
- Less mixing

Two Part Solutions

- Separates macronutrients from micronutrients
- Offer more control of nutrient solution

Macronutrients

- The primary nutrients used in large quantities by plants
- Vital to plant health and growth
- Nitrogen, Phosphorus and Potassium
- Need to know N-P-K ratio of bottle of nutrients
- 10-10-10 Fertilizer contains 10% N, 10% P, 10% K and 70% chelating agents, water and small amounts of micronutrients

Macronutrients

- Nitrogen (N) – Primary to foliage growth
- Phosphorus (P) – Helps build strong roots, vital for flower and seed production
- Potassium (K) – Increases chlorophyll in foliage and helps regulate stomata openings so plants use light and air more efficiently

Secondary Nutrients

- Nutrients that are required in lesser quantities than primary
  - Magnesium (Mg)
  - Calcium (Ca)
  - Sulfur (S)
- Important to note that primary and secondary refers to quantity needed and not importance to plant growth

Micronutrients

Required by plants in smaller quantities

- Zinc (Zn)
- Iron (Fe)
- Copper (Cu)
- Boron (B)
- Molybdenum (Mo)
- Manganese (Mn)
- Chlorine (Cl)
- Nickel (Ni)

Additives

- Products that make nutrients more readily available to plants, protect then from diseases and pests or stimulate growth

Mixing the Nutrient Solution

- Begin with a clean reservoir
- Use purified water to save time
- Add necessary amount of clean water to reservoir
- Determine amount of nutrient necessary for the volume of water
- Liquid fertilizers can be added directly to the water in the reservoir
- Powder or crystal – dissolve into a glass of warm water and mix, must be totally dissolved before adding to reservoir
- Always follow Manufacturer's Label and note some chemicals can not be mixed and will require two tanks
- 1-2 hours after mixing, check pH and EC and adjust accordingly

Nutrient Solution Disposal

- High in nitrates & phosphates
- Avoid runoff to surface water
- Disposal Options:
  - Send down sewer to waste water treatment plant
  - Apply to houseplants or garden plots
  - Commercial Growers
    - Recycle water
    - Construct wetland Remediation System

Nutrient Solution Maintenance

- Replenish regularly
- Water is used faster than nutrients
- Change solution weekly
- Top off reservoir with pH balanced water to keep balance (1-2 weeks)
- Never let the nutrient solution go for more than 4 weeks without draining and adding new solution
- Flush entire system with mild nutrient-solution mix for a couple of hours between reservoir changes

Managing The Nutrient Solution

- Water quality
- pH
- EC (Electrical Conductivity)
- Oxygen
- Temperature

First Step - Water Quality

- Water quality is essential for success
- PPM (Parts per million) or EC (Electrical Conductivity) measure salts in a solution
- Start with low PPM or EC and add nutrients – varies by crop
- Tap and Well water with less than 140 PPM of dissolved solids is safe for hydroponics
- Water with more than 300 PPM of dissolved solids must be filtered with reverse-osmosis filter

pH

- pH scale from 1 to 14
- Measures acid to alkaline balance
- With 1 being the most acidic, 7 neutral and 14 the most alkaline
- Most plants grow well in hydroponics with a pH range of 5.5 to 6.5
- pH in a nutrient solution can fluctuate a half point with no problems
- pH changes over time and affects nutrient uptake
- Check pH daily

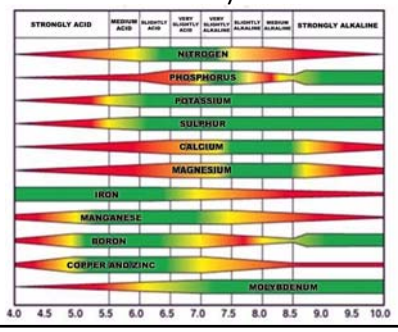
What can you test pH with?

- Digital pH meters
- pH meters
- pH Color strips

Adjusting pH

- Adjust pH levels with pH UP or pH Down
- pH in Hydroponic systems tends to drift down
- Measure the pH one hour after mixing nutrients

Nutrient Availability at Different pH



EC = Electrical Conductivity

- Nutrient concentrations are measured by their ability to conduct an electrical current
- More nutrients in the solution, the better it conducts electricity
- EC reading gives you overall strength (not exact N, P, K)
- Scales
  - PPM – Parts per million
  - CF – Conductivity Factor
  - TDS – Total Dissolved Solids
  - DS – Dissolved Solids

Measuring EC

- EC Meters
- Collect solution from reservoir
- Collect a separate sample from within the medium
- Nutrient solutions generally range between 500 and 2000 PPM
- Most plants grow best within a PPM range of 800 to 1200
- SAVE time and money by using a combined pH and EC meter

Dissolved Oxygen

- The measure of the oxygen content in the water
- Plants breath air through their roots
- Airstone – artificially keeps water oxygenated
- Growing Systems Differ
  - Deep Water Culture provides the least natural dissolved oxygen to roots
  - Nutrient Film Technique provides just enough liquid flow to allow roots to absorb nutrients and absorb oxygen
  - Aeroponics solves dissolved oxygen issues, plants have access to environmental oxygen

Temperature

- Daytime Temperature between 70° - 80° F
- Nighttime Temperature between 55° - 60° F
- Keep nutrient solution at 55° - 60°F
- 50% relative humidity is ideal for most crops
- Monitor with a digital maximum-minimum thermometer/hygrometer

Carbon Dioxide (CO_2)

- Occurs in the air at a rate of 0.035 to 0.04 %
- Rapidly growing plants can use up to 0.15 %
- More CO_2 = plants grow faster and bigger
- CO_2 below 0.02 % plant growth slows dramatically
- Mostly used by Commercial Growers
- CO_2 Emitter Systems
- CO_2 Generator Systems

Growing Substrates

- Provide support for the root system
- Hold and make available oxygen, water, and nutrients
- Texture, pH, and nutrient content contribute to roots' ability to grow
- Large particles permit good aeration and drainage
- Replace or wash salt build ups, root fragments and other debris

Types of Growing Substrates

- Rockwool
- Coconut Fiber
- Expanded Clay
- Perlite
- Vermiculite
- Peat Moss
- Pea Gravel
- Oasis cubes
- Grow stones
- Coarse Sand
- Synthetic foam
- Pottery

Common Hydroponic Substrates

http://www.nsoilsolutions.com/7-different-hydroponic-grow-mediums/

Rockwool

- Inert, Sterile, Porous, non-degradable
- Made from melted Basalt rock and Chalk
- Provides firm root support
- Suited for seedling, cuttings and larger plants
- Manufactured in variety of sizes
- Requires a pre-soak to lower pH

Oasis Cubes

- Made of foam
- Good for seed and cuttings
- Similar to Rockwool
- Does not need to be pre-soaked
- Neutral pH
- Versatile
- High water retention

Expanded Clay

- Hydroton/Grow Rocks
- Lightweight, inert, pH neutral
- Made by heating clay to over 2000° F
- Air pores inside round pellets
- Reusable (Wash and sterilize)
- Not ideal for starting seeds
- Can get too dry if used in Ebb and Flow Systems
- Use alone or mix with other mediums such as peat or coir to increase drainage

Coconut Fiber (Coir)

- Made from fiber just under the green husk that has been soaked to remove salts, natural resins and gums
- Biodegradable
- Natural pH is between 5.5 and 6.8
- Has good water holding capacity
- Available in a variety of sizes
- Compressed bricks can expand to 9 times original size
- Different Grades – be aware of salts and resins

Perlite

- Volcanic glass expanded by heating
- Porous - allows water to drain
- Improves aeration
- Mix 1/3 with other substrate

Vermiculite

- Mineral that breaks into small pebbles when heated
- Good water retention
- Ability to draw water upwards to plant roots
- Must balance water retention
- Good for Wick system

Rock

- Pea Gravel, Lava Rock, River Rock
- Cost effective
- Start with clean rock
- Works well in Ebb & Flow Systems
- Easy to clean and reuse
- Sun or lights can heat rock and raise the temperature of the nutrient solution
- Heavy

Net Pots

- Containers placed in grow tray to hold growing substrate and plants
- Can be used in most systems
- Variety of sizes available
- Allows fast flooding



Collar Inserts

- Hold cuttings in place until rooted
- Seal and cover net pots
- Foam, neoprene, coir

What can you grow?

- Vegetables
- Herbs
- Flowers
- Lettuce
- Tomatoes
- Cucumbers
- Peppers
- Basil
- Oregano
- Thyme
- Mint
- Strawberries
- Kale

Getting Started

- Best option for beginners is working with seeds
- Start seeds in a separate area with high humidity
- Soak seeds in water 12-24 hours prior to planting in growing medium
- Rapid Rooter plugs, Rockwool, Oasis Cubes
- Avoid peat pellets, jiffy pots or potting soil as they break down and clog the pump and contaminate the Hydroponic system
- Water every 1-3 days
- Once plant starts to develop, move to main hydroponic system

Rapid Rooter Plugs


https://www.hydroponics.net/i/111400

Lettuce

- Good option for beginners
- 30-85 days to maturity (depending on variety)
- Sequential plantings allow for continuous supply
- NFT good for commercial production
- Bibb, Loose-leaf, Head, Iceberg, Romaine

Lettuce

- pH: 5.5-6.5
- EC: 0.8 – 1.2
- General PPM 560-840
- Lower EC of 1.0-1.2 can cause calcium deficiency and tip burn
- Cooler months a higher EC recommended
- Summer months a reduced EC is recommended

https://i.ytimg.com/vi/Dy4YU8y-Cpc/maxresdefault.jpg

http://www.heraldextra.com/momclick/recipes/crunch-time-hydroponic-lettuce-is-the-crop-that-doesn-t/article_3a6ab4d6-4494-11e1-b0b0-001bb2f6f3f4.html

Tomatoes

- EC: 2.0-5.0
- General PPM 1400-3500
- pH range: 5.5-6.5
- Temperature: 55-85°F
- Trellising Required
- Need pollination
- Start from seed or transplant
- Drip or Ebb and Flow System
- Adjust Nutrient Solution according to growth stage

Table 6. Recipe for tomatoes in winter according to crop growth stage (units are ppm).

	Weeks 0–6 Higher N, Ca and Mg for vegetative growth	Weeks 6–12 Lower N, higher K for reproductive growth	Week 12+ Maintain balance of vegetative / reproductive growth
Nitrogen (N)	224	189	189
Phosphorus (P)	47	47	39
Potassium (K)	281	351	341
Calcium (Ca)	212	190	170
Magnesium (Mg)	65	60	48
Iron (Fe)	2.00	2.00	2.00
Manganese (Mn)	0.55	0.55	0.55
Zinc (Zn)	0.33	0.33	0.33
Boron (B)	0.28	0.28	0.28
Copper (Cu)	0.05	0.05	0.05
Molybdenum (Mo)	0.05	0.05	0.05

Source: Sunco, Ltd., and University of Arizona, Controlled Environment Agriculture Center, http://tinyurl.com/lj785/

http://www.greenhouse.cornell.edu/crops/factsheets/hydroponic-recipes.pdf

http://theseedsmaster.blogspot.com/2016/02/tomato-growing-methods-hydroponics-vs.html

Cucumbers

- One of the highest yielding plants grown in hydroponics
- Require high light
- EC: 1.7-2.5
- General PPM 1190-1750
- pH: 5.8-6.0
- Select self pollinating varieties
- Trellising required
- Require more spacing

http://gardenious.com/hydroponic-cucumbers/hydroponic-cucumbers-production/

Supplemental Lighting

- Factors to consider:
  - Type of plants
  - Temperature output
  - Cost of electricity usage
  - Ideal light spectrum recommended for various stages of growth
    - Plants in vegetative state need 15-18 hours of light
    - Plants in bloom stage need 10-12 hours of light

Types of Lighting

- High Intensity Lamps (HID)
  - Metal Halide (MH)
  - High Pressure Sodium (HPS)
- Fluorescent Lamps
- Incandescent Lamps (Not recommended)

High Intensity Lamps (HID)

Metal Halide (MH)

- Emits white/blue spectrum light
- Blue encourages vegetative growth and bushiness and discourages upward growth
- Use this bulb first during vegetative growth stage

High Pressure Sodium (HPS)

- Emits yellow/red/orange spectrum light
- Red stimulates flowering and fruit production
- Switch to this bulb when it is time to induce flowering or fruiting

Fluorescent Lamps

- Most popular fluorescent bulbs are 20 and 40 watts
- Perfect for growing low-light plants, seedlings and cuttings
- Seedlings & cuttings grow best with light spectrum similar to natural sunlight
- Flowering plants benefit from more reddish-yellow light

Incandescent Lamps

- Standard household bulbs
- Not recommended for growing plants
- Light spectrum produced is not ideal for plants
- Only have a 5% efficiency rate

Conclusion

- Options, Options, Options
- Need a growing system, growing substrate and nutrient solution
- Inputs are crop specific
- Start simple