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

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

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
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

Drip System

- Active System
- Timer controlled submerged 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
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
**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

**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 (CO₂)

• Occurs in the air at a rate of 0.035 to 0.04 %
• Rapidly growing plants can use up to 0.15 %
• More CO₂ = plants grow faster and bigger
• CO₂ below 0.02 % plant growth slows dramatically
• Mostly used by Commercial Growers
• CO₂ Emitter Systems
• CO₂ 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.nosoilsolutions.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
  - Basil
  - Oregano
  - Thyme
  - Mint
  - Strawberries
  - Kale
- Herbs
- Flowers
- Lettuce
- Tomatoes
- Cucumbers
- Peppers

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

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

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**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

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**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**
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