# Introduction to Aquaponics

**Joe Masabni**
**Overton Research and Extension Center**
**jmasabni@tamu.edu**

**Special Thanks to**
**Andrew S. McArdle, Aquaponics Specialist**
**for his original work**

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## What is Aquaponics??

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## Aquaculture + =

Recirculating Aquaculture
Raises fish in densely stocked tanks

Drawbacks:
- High amounts of waste produced
- Extensive Filtration Required

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## Aquaculture + Hydroponics =

Hydroponics
Farming of plants in a soil-less environment.

Drawbacks:
- Chemicals and fertilizers are provided in a nutrient solution (many of which are petroleum derived and can be expensive)

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## Aquaculture + Hydroponics = Aquaponics

Aquaponics
Culmination of both intensive aquaculture and hydroponic technologies in a recirculating system.

-Reduced Waste
-Hydroponic Fertilizers No Longer Required

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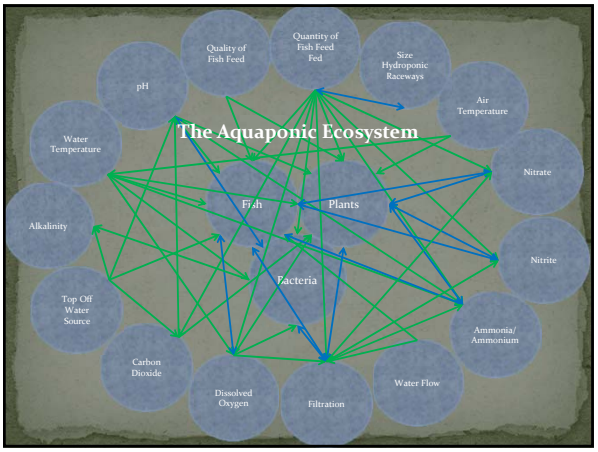


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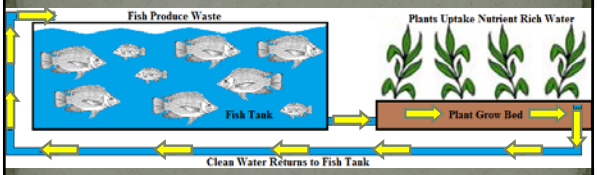
## The Idea

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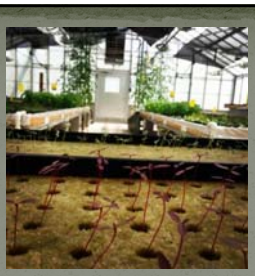

## Types of Aquaponic Systems

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## Media Bed

- Flood and Drain System
  - Media filled grow bed
    - pH neutral rock or expanded clay
    - Either continuously flooded OR flooded and drained

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## NFT – Nutrient Film Technique

- Nutrient Film Technique (NFT)
  - Suitable for smaller plant varieties – Leafy Greens
  - Larger plants clog gutters
  - Thin film of water
  - Can heat up very easily so chiller may be required
  - Good potential for commercial operation

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## DWC – Deep Water Culture Raft Method

- Raft System
  - Floats plants on top of water with roots suspended in the water column
  - Most practical commercial application

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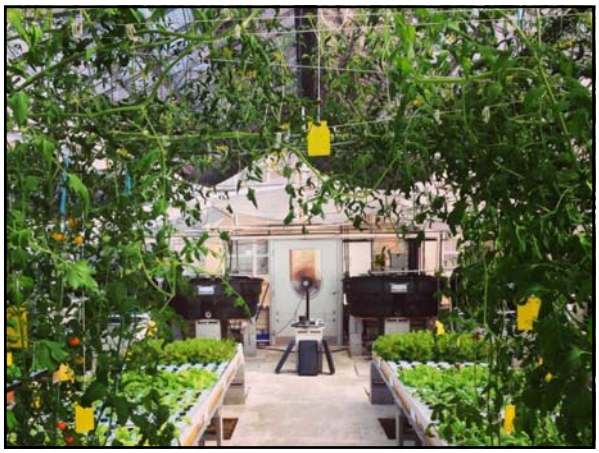

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Many system types … Professional to DIY




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## Key Elements

- Fish Culture Tanks
  - Size and number varies among systems
- Clarifier
  - Solids removal
- Filter Tanks
  - Depends on Size of system if required
- Degassing Tank
  - Vents out excessive amounts gases
- Biofilter
  - Nitrification process
  - Varies depending on system
    - Can be in own tank or within growbed for some systems
- Water Pump
  - Want to use no more than a single pump in your system
- Air blowers
  - Provides sufficient dissolved oxygen levels required by fish and plants
- Grow Beds
  - Primary difference between system designs
- Primary System Designs
  - Raft System
  - Nutrient Film Technique (NFT)
  - Flood and Drain System
- Water Flow
  - Gravity Fed – Typically from fish tanks to a sump with a pump.

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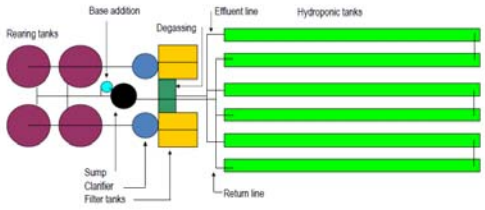
## UVI System Model




Total water volume - 29,000 gallons  Land area - 1/8 acre

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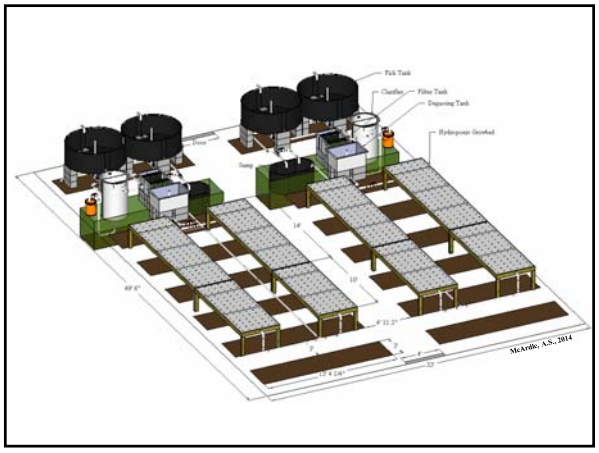


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Water Pumps!  Backup Generator!

Air Blowers!

## Backups! Backups! Backups!

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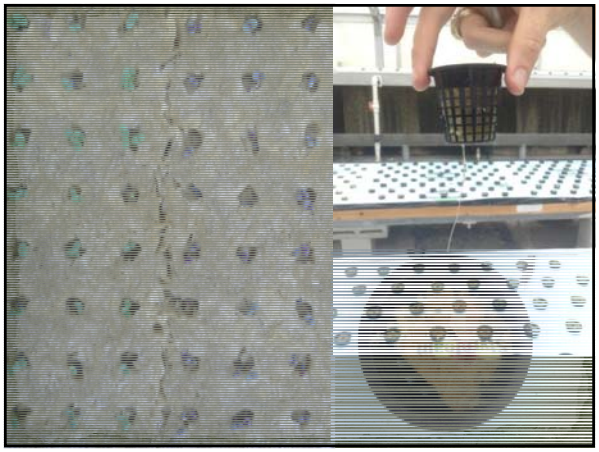

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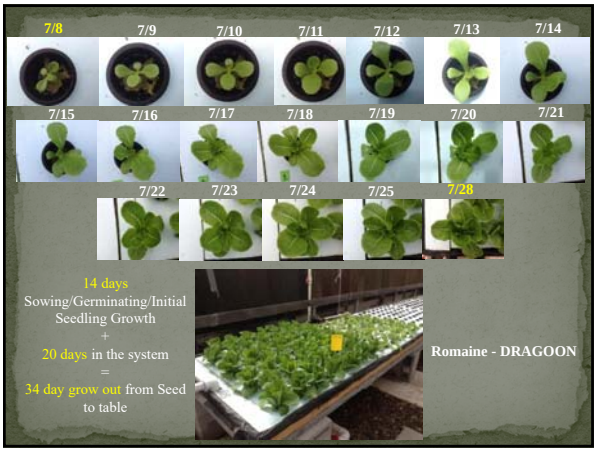


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## System Inputs

Nutritionally Complete Fish Feed
&
pH Adjusters

- Calcium Carbonate ($CaCO_3$)
- Potassium Bicarbonate ($KHCO_3$)

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## Production Potentials

- Fish
  - Harvest every 6 weeks with the use of four fish tanks.
  - 8.7 harvests / year
  - 150 lbs / harvest
  - 1,305 lbs / year

**Based on growing **tilapia** to 0.5 lbs / gallon**

**Ornamental fish such as Koi are different as they can be sold anywhere along the growth cycle depending on desirable size.**



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## Production Potentials

- Vegetables
  - Mini Lettuce Heads
    - 4 to 6 week growth period from transplant to harvest
    - 232-348 heads of lettuce / week
    - 12,064-18,096 heads of lettuce / year
  - Full Size Lettuce Heads
    - 4 to 6 week growth period from transplant to harvest
    - 144-216 heads of lettuce / week
    - 7,488-11,232 heads of lettuce / year

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| Item | Cost |
|---|---|
| Tanks | $ 3,824.96 |
| Hydroponic Raceways | $ 1,403.26 |
| Waterline Plumbing | $ 839.46 |
| Airline Plumbing | $ 1,299.15 |
| other | $ 3,750 |
| **Total** | **$ 11,116.83** |

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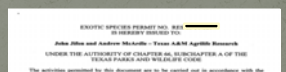
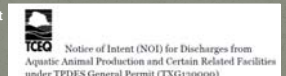
## Permits, Licenses, Certificates .....

Aquaculture License

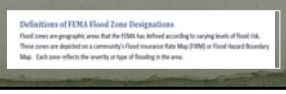
Exotic Species Permit



Waste water discharge permit




Flood zone declaration



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# HYDROPONICS CROP PRODUCTION

**Daniel I. Leskovar**

*Texas A&M AgriLife Research -Uvalde*

*College Station, May 23, 2014*

d-leskovar@tamu.edu

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## Hydroponics: History

- Hydroponics has been practiced for centuries.
- The floating gardens ("chinampas") of the Aztecs in Mexico were hydroponic in nature.

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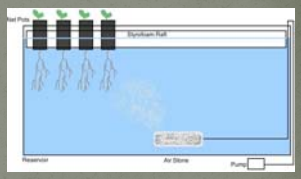
## Medium-less Hydroponic Systems

***Floating Hydroponics:***

Plant roots are suspended in a ***static***, continuously aerated nutrient solution.



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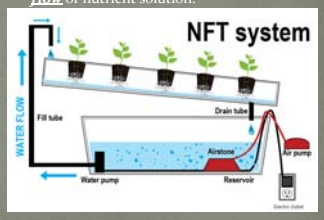
## Medium-less Hydroponic Systems

***Nutrient-flow-technique (NFT):***

Plant roots are in contact with a continuous ***flow*** of nutrient solution.

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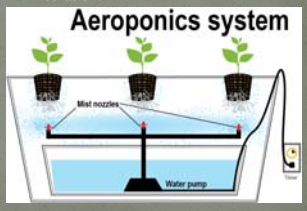
## Medium-less Hydroponic Systems

***Aeroponics:***

Plant roots are suspended in a continuous ***mist*** of nutrient solution.

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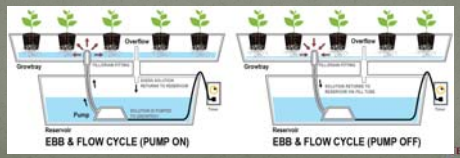
## Medium Hydroponic Systems

***Ebb-and-Flow System***

Mainly for hobby-home-type growing units.

Rooting medium: gravel, sand, volcanic rock, etc.

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## Medium Hydroponic Systems

*Drip/pass-through System*

Tomato plants growing on rockwool.

Cucumber plants growing in sand beds.

Cucumber & tomato plants growing on gravel beds.

Other media sources:
Sawdust, coco coir, peat, vermiculite, perlite, pumice, rice hulls...

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## Vertical Hydroponic Systems (medium or medium-less)

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## Vegetable Crops grown in hydroponic systems

- Leaf lettuce
- Tomatoes
- Peppers
- Cucumbers
- Strawberries
- Watercress
- Celery
- Herbs

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## Screening lettuce cultivars and other leafy-greens in our Research Center

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## Screening lettuce cultivars and other leafy-greens in our Research Center

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## Hydroponics: Advantages

1. Crops can be grown where no suitable soil exists.
2. Labor for many traditional practices is largely eliminated.
3. Maximum yields are possible, economically feasible in high-density and expensive areas.
4. Conservation of water and nutrients (reduction in pollution of land and streams).
5. Elimination or reduction of soil-borne plant diseases and insects.
6. Better control of the system (nutrition, watering, EC, pH, etc.).
7. Transplant shock is reduced.

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## Hydroponics: Disadvantages

1. Initial and operational costs are higher than soil culture.
2. Skill and knowledge are needed to operate properly.
3. Introduced soil-borne diseases and nematodes may be spread quickly to all beds on the same nutrient tank of a closed system.
4. The reaction of the plant to **good or poor nutrition** is fast. Daily supervision is important to catch any problems that may arise.

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## Hydroponic Nutrient Solution

There are commercial formulations available, easy to use, with nutrient composition and concentration according to the type of crop and growth stage.

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## Hydroponic Nutrient Solution

The composition and strength of the nutrient solution should be adjusted according to the crop and its growth stage.

✓Leafy greens (lettuce, celery, herbs)

✓Fruiting vegetables (tomatoes, eggplants, peppers, cucumbers, cantaloupes, strawberries, etc.)

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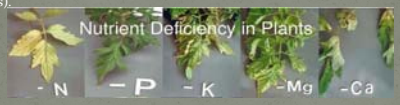
## Hydroponic Crops Nutrition: pH

- pH should be kept between **5.5 - 6.5**
- If pH drops below 5.0 or goes over 7.0, plant growth may be affected.

More critical in static solution (i.e. floating raft) than in flowing systems.

***Low pH***: macronutrient deficiencies & excessive uptake of micronutrients (possible toxicities).




***High pH***: micronutrient deficiencies (unavailable by precipitation).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## Hydroponic Nutrient Solution: pH

**pH:**

**Adjusting the pH of the nutrient solution:**

↑ Add alkalis, like solutions of Sodium Hydroxide (NaOH), or Potassium Hydroxide (KOH).

↓ Add acids, like Nitric, Sulfuric, or Hydrochloric Acid ($HNO_3$, $H_2SO_4$, and HCl, respectively).

There are pH control solutions commercially available.


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## Hydroponic Nutrient Solution: EC

**EC:** is an index of salt concentration that defines the total amount of salts in a solution. It is a good indicator of the amount of available ions to the plants in the root zone.

**EC values for hydroponic systems range from 1.5 to 2.5 dS/m**

In closed (recirculating) systems EC of the nutrient solution changes:

↓ Indicates root plants are removing nutrients from the solution. More fertilizer salts need to be added to replenish the nutrient concentration levels. (No individual nutrient loses can be determined).

↑ Indicates substantial quantities of water are being removed from the nutrient solution at a very rapid rate (during hot, low-humidity days). Lost water due to evapotranspiration should be replaced.

In medium-based systems measuring EC in leachates or in the retained solution can be used to determine leaching requirements.

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## Hydroponic Systems: Sanitation

**Preventing the introduction of pest problems is the simplest and most important pest control procedure.**

- Use clean or sterilized containers, plants, water, growth media, etc.
- Keep the growth area free of foreign plants.
- Keep tools, equipment, materials (including clothing), hands, and footwear free of disease organisms.
- Use resistant cultivars.
- Minimize exposure of the nutrient solution to light to prevent algae growth.

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## Hydroponic Nutrient Solution: T° and $O_2$

The most common root disease in hydroponic systems is root rot caused by the fungal-like organism, *Pythium*.

It spreads quickly in closed systems.

**Symptoms**
- Plants are stunted.
- Root tips are brown and dead.
- Plants wilt at mid-day and may recover at night.
- Plants yellow and die.
- Brown tissue on the outer portion of the root easily pulls off leaving a strand of vascular tissue exposed.


Healthy root system


Infected root system

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## Hydroponic Nutrient Solution: T° and $O_2$

Pythium root rot is difficult to control once rot has begun. ***Every effort should be directed toward preventing the disease before it begins.***

- Use heat-pasteurized potting mix (180°F/30 min; higher To or longer times will kill beneficial organisms).
- Store treated mix in an area free of contamination.

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## Hydroponic Systems: pests

Most hydroponic operations are conducted under protected structures like greenhouses. Some of the most common greenhouse pests are:


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## *Hydroponic Systems – gravel based*

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## *Hydroponic Systems – NFT*

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## Leafy Greens: field grown vs. hydroponics



- Kale
- Collard
- Spinach
- Lettuce
- Cabbage

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## *Lettuce grown in NFT at the Uvalde Center*

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## SUMMARY:

- ✓ Make sure you have a **good water supply** (consistent quantity and quality) for your hydroponic operation.
- ✓ Monitor closely and frequently (at least daily) the **pH and EC** of the nutrient solution to make timely adjustments if needed.
- ✓ Ensure to have proper and continuous **aeration** of the nutrient solution.
- ✓ Frequently inspect and **clean** filters, pipes, and hoses to prevent clogging. A few hours without water can be devastating, especially on hot, dry days.
- ✓ Use good quality (**disease-free** certified) plant materials.

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## SUMMARY: (cont.)

- ✓ Clean and disinfect **EVERYTHING** (trays, growing media, plumbing, tables, floors, etc.) before each growing cycle.
- ✓ Monitor daily **air and nutrient solution temperature**. Extreme temperatures or abrupt changes can affect plant growth considerably.
- ✓ Scout for **pests, diseases, and nutrient disorders** on a daily basis. In hydroponic systems the plants' responses to a problem are extremely quick.
- ✓ Maintain nutrient solution in the system **covered** at all times to prevent algae growth.

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