The 2013 Educational Program Committee is pleased to share conference educational materials with you under the condition that they are used without alteration for educational and non-commercial use only. All materials are protected by copyright law. The authors kindly request their work is properly cited, including the date of publication.

For more information on Small Farms, visit our website at: http://smallfarms.ifas.ufl.edu/ or contact your local County Extension Agent.

For inquiries about this topic, please contact:
Danielle Treadwell, Educational Program Chair.
Phone: (352) 273-4775
Email: ddtreadw@ufl.edu

*Suggested Citation*: Author Full Name. Title of Presentation or Handout. 2013 University of Florida-IFAS and Florida Agricultural and Mechanical University-CAFS Florida Small Farms and Alternative Enterprises Conference. August 2-4, Kissimmee, FL.
A New Century of Sustainable Hydroponic and Aquaponic Food Production

Aquaponics Workshop
Florida Small Farms Conference 2013

Richard Tyson
UF/IFAS Extension
DO YOU KNOW WHERE YOUR FOOD COMES FROM?
YES - LOCAL FOOD SYSTEMS

- Food security
- Economic security
- Food safety
- Socially & Environmentally Responsible
Helpful Beginning Tips?

- If your main purpose is to grow plants then stick with hydroponics.
- If your main purpose is to grow fish then stick with aquaculture.
- Successful large operations need deep markets that require food safety audits.
- Small operations or school demos can be successful without the safety audits.
Foodbourne Diseases in the U.S.

- 76 million illnesses annually
- 325,000 hospitalizations
- 5,000 deaths
- Good Agricultural Practices (GAPS)
- Warm blooded animals can transmit salmonella and E. coli to humans
HYDROPONICS: Definition

- ‘Growing plants without soil’ in a liquid or soilless media with a mineral nutrient solution
HYDRO - PONICS = WATER WORKING

- Indoor or outdoor systems
- Clean - environmental and labor friendly
- High tech and low tech systems
- Crop sensitive - production/environment and cost factors to consider
WATER & NUTRIENT APPLICATION

- Re-circulating systems
- Flow through systems
- Flood and drain systems
- Non-circulating systems
GROWING MEDIA

- Perlite, rockwool and coconut coir (husk)
- Composted pine bark
- Peat and vermiculite
- L.E.C.A. (Lightweight Expanded Clay Aggregate) clay pebbles
BASIC RECIRCULATING SYSTEMS
(Nutrient Flow Techniques)
Rockwool vs Perlite vs Coconut Coir Media Systems
Nursery pots, Media mix raised beds, Upright plastic bags

- Potting mixtures of peat, perlite, vermiculite, compost, pine bark, or similar substrates...drip or overhead irrigated with no re-circulation.
FLOOD AND DRAIN

FLOOD TABLE
THRU-HULL
FITTING (3/4 ")
HOSE (3/4 ")

170GPH PUMP RESERVOIR
Greenhouse Herbs

- Popularity increasing
- Organic certification possible
Vertical Systems
HIGH TECH GREENHOUSE GROWN FLOATING LETTUCE BEDS
Low Tech Floating Raft Hydroponic Systems
Adapting...
Leafy Salad Crops and Herbs

- Bibb
- Boston
- Red leaf
- Green leaf
- Chicory
- Romaine
- Escarole

- Basil
- Watercress
- Mint
- Nasturtium
- Swiss Chard
- Impatiens
Most Common High Value Hydroponic Crops

- Leafy salad crops and herbs
- Tomato, all types
- Pepper, mostly sweet types
- Seedless cucumber, European, Beit alpha (mini cucs)
- Strawberry
Plant Requirements

- Hydroponic plants have similar needs as plants grown in the ground.

- Outdoor systems follow season guide in the Florida Vegetable Gardening Guide.

- Greenhouse systems may go year round with shade during hot months but recommend shutting down in summer.
WATER SOURCES

- Pond vs. no pond – nutrients low, contamination high

- Extensive, semi-intensive, Intensive

- Well and municipal water sources are safest - microbials and emitters
FERTILIZER / NUTRITION

- Certified Organic
- Using natural and organic materials
- Biorational
- Water soluble hydroponic fertilizer
PROTECTED AGRICULTURE

- High/low tunnels
- Shade houses
- Greenhouses
- Intensive indoor production
HIGH / LOW TUNNELS

- Poly plastic top with open sides that could be closed up during a freeze
North FL Hydroponic Pepper in a Shade House - 2004
Mixed Crops, Shade, Direct Market, in South FL (Oct-June)
2012 Single Row System, Trellis, Two Stems
## Total Marketable Yield (Boxes/A) NS

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Total Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>4288A</td>
<td>2,637</td>
</tr>
<tr>
<td>8302</td>
<td>2,426</td>
</tr>
<tr>
<td>9325</td>
<td>3,094</td>
</tr>
<tr>
<td>2815</td>
<td>2,611</td>
</tr>
<tr>
<td>Aristotle</td>
<td>2,385</td>
</tr>
<tr>
<td>Godzilla</td>
<td>3,127</td>
</tr>
<tr>
<td>Vanguard</td>
<td>2,299</td>
</tr>
<tr>
<td>Heritage</td>
<td>2,829</td>
</tr>
<tr>
<td>20896</td>
<td>2,667</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Total Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>50169</td>
<td>2,899</td>
</tr>
<tr>
<td>Olympus</td>
<td>2,255</td>
</tr>
<tr>
<td>20854</td>
<td>3,315</td>
</tr>
<tr>
<td>Tomcat</td>
<td>1,967</td>
</tr>
<tr>
<td>Crusader</td>
<td>2,659</td>
</tr>
<tr>
<td>Cutlass</td>
<td>2,394</td>
</tr>
<tr>
<td>Phoenix</td>
<td>2,475</td>
</tr>
<tr>
<td>Colossal</td>
<td>3,300</td>
</tr>
</tbody>
</table>
## Total Fancy Yield (Boxes/A)

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Total Fancy Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>4288A</td>
<td>1,651 bcd</td>
</tr>
<tr>
<td>8302</td>
<td>2,111 abc</td>
</tr>
<tr>
<td>9325</td>
<td>2,273 abc</td>
</tr>
<tr>
<td>2815</td>
<td>2,092 abc</td>
</tr>
<tr>
<td>Aristotle</td>
<td>1,599 cd</td>
</tr>
<tr>
<td><strong>Godzilla</strong></td>
<td>2,553 a</td>
</tr>
<tr>
<td>Vanguard</td>
<td>1,884 abcd</td>
</tr>
<tr>
<td>Heritage</td>
<td>2,246 abc</td>
</tr>
<tr>
<td>20896</td>
<td>1,836 bcd</td>
</tr>
<tr>
<td>50169</td>
<td>2,330 ab</td>
</tr>
<tr>
<td>Olympus</td>
<td>1,830 bcd</td>
</tr>
<tr>
<td>20854</td>
<td>2,271 abc</td>
</tr>
<tr>
<td>Tomcat</td>
<td>1,332 d</td>
</tr>
<tr>
<td>Crusader</td>
<td>1,896 abcd</td>
</tr>
<tr>
<td>Cutlass</td>
<td>1,722 bcd</td>
</tr>
<tr>
<td>Phoenix</td>
<td>1,833 bcd</td>
</tr>
<tr>
<td>Colossal</td>
<td>2,250 abc</td>
</tr>
</tbody>
</table>
Conclusions

- Open shade culture can serve to extend green bell pepper production into the summer in Florida.
- Combinations of plasticulture techniques make it possible.
- Fruit size decreases in late summer, may not meet standards for wholesale markets.
- Several cultivars performed similarly.
- Cultivar selection based on: yield, fruit quality, fruit size, seasonal vigor, disease tolerance, and plant height.
GREENHOUSES

- Structures covered with transparent material which can be heated and cooled
- Pad and fan house for cooling
- Natural ventilated house
Sustainable agriculture combines plant and animal production, integrates natural biological cycles, and makes the most use of nonrenewable resources (USDA 1990 Farm Bill).
Aquaponics

- Demonstrates multiple biological processes
- Plant production
- Fish production
- Nitrifying bacteria
- Considered a sustainable Ag technique
Aquaculture Systems

- Recirculating tank
- Solids filter
- Biofilter with nitrifying bacteria
- Air pumps
Aquaponic Systems

NFT

Floating raft

Bench Bed
So Why Aquaponics?

- The Water Budget!
- Plants transpire large amounts of water (1pt - 6 qt/d/pl).
- Recirculating aquaculture replaces 5 to 10% of system water/day to maintain water quality.
- Potential for low to zero discharge to the environment.
So Why Aquaponics?

- The Nitrogen Budget!
- Fish produce large amounts of harmful ammonia nitrogen as waste.
- Nitrifying bacteria change it to beneficial nitrate nitrogen for the plant.
- 100 lbs of fish will supply enough nitrogen for 4,050 lettuce plants or 540 tomato plants.
TAN = Total Ammonia Nitrogen

\[ \text{NH}_4^+ = \text{NH}_3 + \text{H}^+ \]

pH Determines Ammonia Equilibrium in Water

\[
\begin{align*}
\text{pH} & \quad 6.5 & \quad 7.5 & \quad 8.5 \\
\text{NH}_3 & \quad 0.2\% & \leftrightarrow & \quad 2\% & \leftrightarrow & \quad 18\%
\end{align*}
\]
Nitrogen from Fish Feed

- In aquaculture, the generation of Ammonia in water through fish waste is based on the fish feeding rate:
  \[ P \text{TAN} = \frac{F \times PC \times 0.092}{T} \]

  - \( F = \) feed weight, \( PC = \% \) protein content of the feed, \( T \) (time) = 1 d.

- 1 kg of fish feed with 30% protein will produce 27.6 g of N in 1 d

- 10% of the protein in the feed becomes nitrogen in the water!
Aquaponics Nitrogen Cycle

Figure 1. Nitrogen cycle in aquaponics.
The Dichotomy of pH Optima for 3 Organisms

Hydroponic Plants = 5.5-6.5

Aquaculture = 6.5-8.5

N. Bacteria = 7.5-9.0
NITRIFYING BACTERIA

- Nitrification maintains water quality by oxidation of ammonia to nitrate (*Nitrosomonas sp. + Nitrobacter sp.*)

- \[ \text{NH}_3 + \frac{3}{2} \text{O}_2 \rightarrow \text{NO}_2^- + \text{H}^+ + \text{H}_2\text{O} \]  Eq 1

- \[ \text{NO}_2^- + \frac{1}{2} \text{O}_2 \rightarrow \text{NO}_3^- \]  Eq 2

- Measure substrate loss, product accumulation
Water pH Affect on TAN Loss From biofilters Inoculated With Nitrifying Bacteria

Error bars represent ± SE (n=8).

Total Ammonia Nitrogen mg/L

Days After Inoculation

- pH 8.5
- pH 7.5
- pH 6.5
- pH 5.5
Biofilter Performance as measured by TAN Removal

![Bar chart showing biofilter performance by pH & production method. The chart indicates the amount of TAN removal for different pH conditions: 6-ac, 6-hc, 7-ac, 8-aqpon, 7-aqpon, and 6-aqpon. The y-axis represents pH & production method, and the x-axis represents g/m³/d.]
System Water Quality

- pH, 6.5 – 7.5
- Oxygen, 5 ppm or greater
- Ammonia, 1 ppm or less
- Sunlight + Nutrient water = algae
Water Quality Measurements

- pH
- Ammonia
- Oxygen
- Soluble Salts
- Alkalinity
- Nitrate
Soluble Salts

- Plants need balanced nutrition which can nearly be supplied by fish

- Recirculating vs. intermittent nutrient applications to roots

- Leafy salad crops & herbs vs fruiting crops
Ammonia Emergency

- Stop feeding
- Increase pH to 8.0
- Increase water discharge and replace with clean water to lower ammonia
- If persists, foliar or root feed plants to overcome deficiencies
Oxygen Emergency

- Backup pumps – water needs to keep moving
- Backup aerators – air/oxygen needs to be introduced into the water
- Backup generators
System Sizing – Triple Crop?
Crop and Fish Choices

- Leafy salad crops, herbs, tomato, pepper, and cucumber

- Tilapia, rainbow trout, largemouth bass, yellow perch, bluegill, Barramundi, koi and other ornamental fish
Marketing

- Don’t start until you know where you will be selling your crops and fish.

- Have multiple sources to market to.

- Staging crops and fish for year round supplies will enhance marketing success – which is difficult.
Marketing

- USDA wholesale price market reports – do not compete with field grown crops or pond/wild grown fish on the wholesale level.

- Get as close to retail pricing with on-farm sales, high end food stores, restaurants and farmers markets
Regulations - Aquaponics

- Farm food safety audits are currently required by big box stores & chain restaurants for vegetables.
- Crops may be sold to buyers who do not require the audit.
- Ensure that the vegetable part being eaten does not contact the water.
- Follow GAP’s and safety plans.
Regulations - Aquaculture

- Pond side whole – few
- Blue Tilapia – few, live or dead
- Nile Tilapia – should be dead unless buyer has a license from FDACS Fish & Game
- Any knife or filleted – Many food safety regulations for processing, handling & storage
Uncertainty, cost, regulations, do your research!

- Aluminum roof panels, multiple crops