

# Aquaponics: Plant Production

Charlie Shultz

Aquaculture Boot Camp 2

OSU South Center

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# Crop Families

- Compositae
  - Lettuce\*, endive\*
- Cruciferae (cole)
  - Broccoli, cabbage\*, cauliflower, brussel sprouts, pak choi\*, mustard\*, turnips, radish
- Cucurbits (melon)
  - Cucumber\*, squash\*, melon\*
- Lamiaceae
  - Mint\*, basil\*, lavender, thyme, oregano
- Chenopodiaceae
  - Spinach, beet, chard\*
- Solanaceous (nightshade)
  - Tomato\*, pepper\*, potato
- Liliaceae (lily)
  - Onions\*, leek, garlic, chives\*
- Gramineae
  - Corn
- Leguminosae (legume)
  - Beans\*, peas

# Nutrients Required for Plant Growth

- Macronutrients

- C Carbon\*
- O Oxygen\*
- H Hydrogen\*
- N Nitrogen
- K Potassium\*\*
- Ca Calcium\*\*
- Mg Magnesium
- P Phosphorus
- S Sulfur

- Micronutrients

- Cl Chlorine
- Fe Iron\*\*
- Mn Manganese
- B Boron
- Zn Zinc
- Cu Copper
- Mo Molybdenum

\* Supplied by  $\text{CO}_2$  and  $\text{H}_2\text{O}$     \*\* Typically must be supplemented

# NPK Nitrogen, Potassium, Phosphorous

- N - Nitrogen - shoots
- P - Phosphorous - roots
- K - Potassium - flowers and fruit
- Use 9-45-15 for seedling production
  - Promotes strong root formation



# Identifying Nutrient Deficiencies

- Mobile Nutrients (N,P, K, Mg, Mo, Cl)
  - Will show symptoms first on older leaves
- Immobile Nutrients (B, Ca, Cu, Fe, Mn, Ni, S, Zn)
  - Will show symptoms on younger leaves.

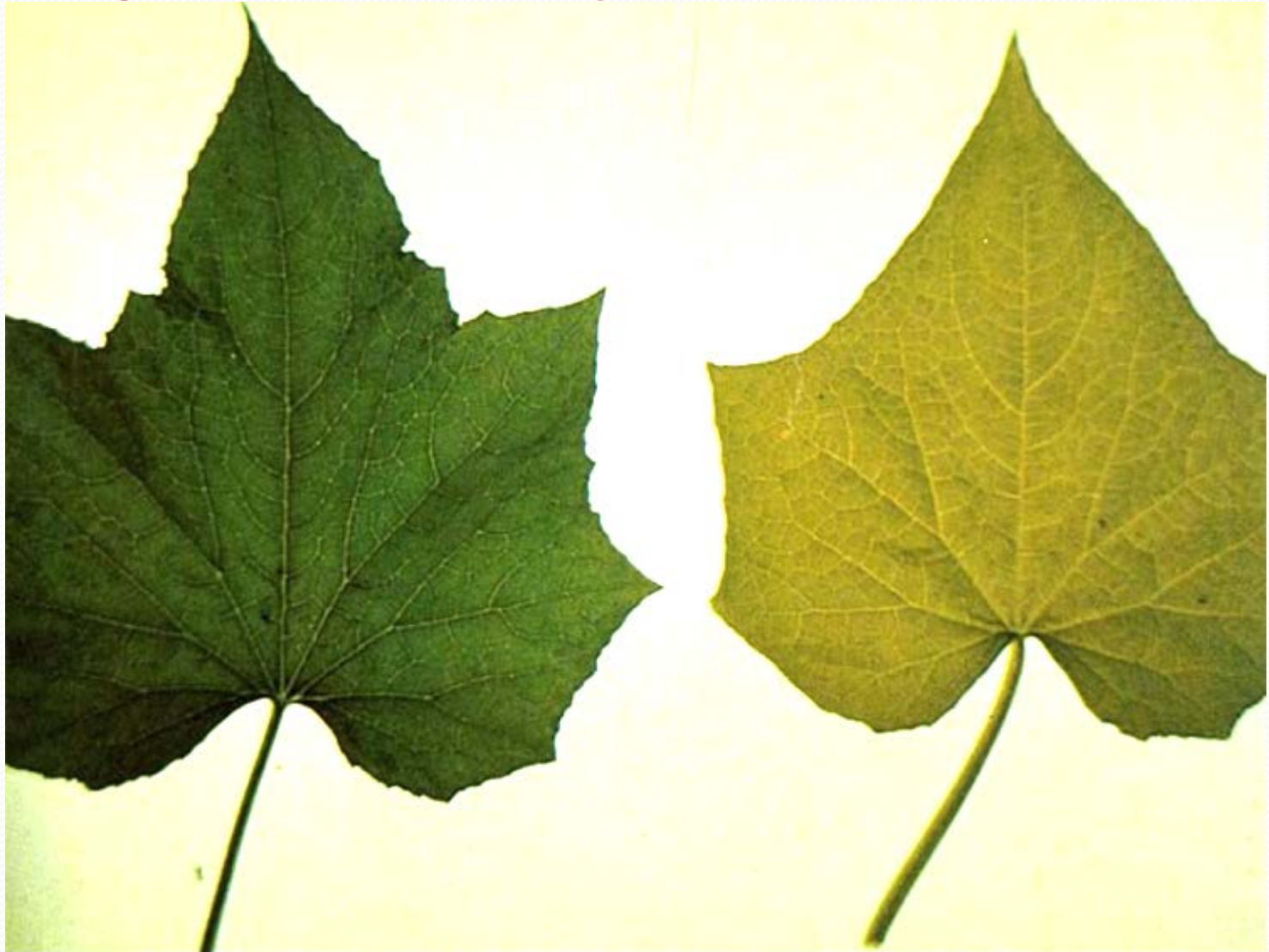
GET TO KNOW YOUR EXTENSION AGENTS!!

Send samples for Tissue Analysis

# Nutrient deficiencies in aquaponics



# Nitrogen Deficiency

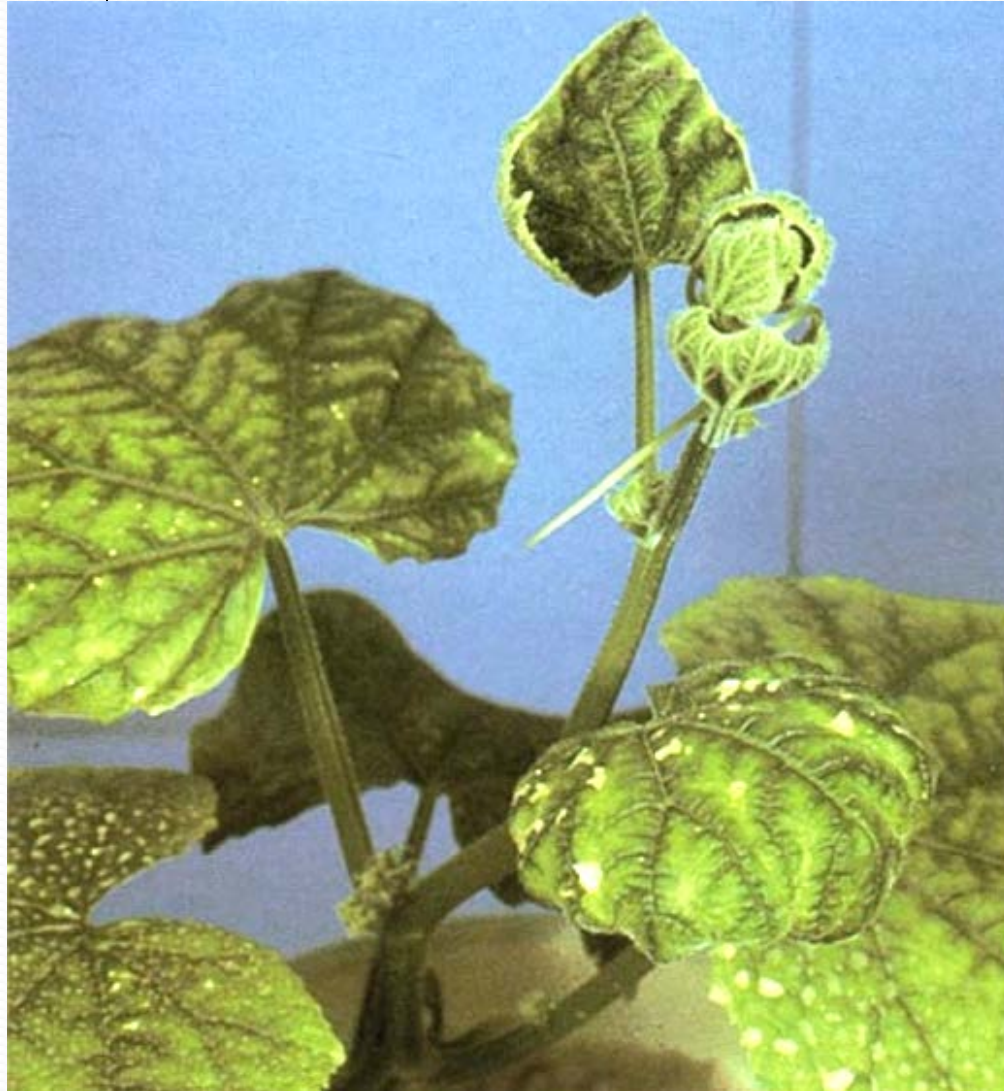




# Phosphorous Deficiency



# Calcium Deficiency





# Potassium Deficiency



# Magnesium deficiency





# Other Nutrient Disorders



*Excessive Soluble Salts*



*Manganese Deficiency*



*Iron Deficiency*



*Molybdenum Deficiency*



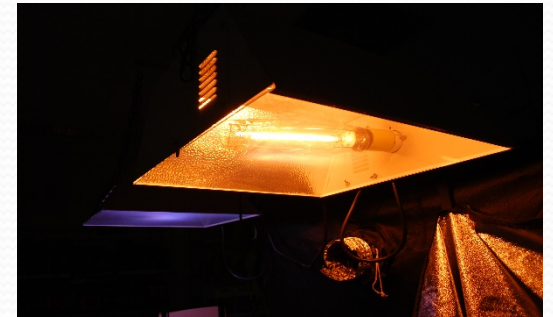
# Lighting Sources

- High Intensity Discharge Lighting (H.I.D.)
  - Metal Halide (MH)
  - High Pressure Sodium (HPS)
  - Combination Arc (Dual-Arc )
- Fluorescent
  - T5, T8, T12, CFL
- Light Emitting Diodes (L.E.D.)
  - Red, Blue, White, UV
- Plasma
- Induction
- Incandescent
  - Generally Not Appropriate



# High Intensity Discharge Lighting

- Workhorse Equipment
  - Ballast, Reflector have long lifespan
  - Generally rugged
  - Work on generators and 240v
  - Brand names Sun System, HydroFarm
- Popular
  - Technology 25+ years in use
  - Used to grow plants by education, commercial, R&D and hobbyists
  - Readily Available and serviced throughout N.A., Europe, Australia, Asia
  - Most widely accepted plant lighting across varied concerns



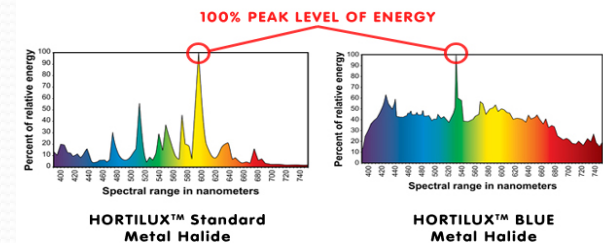
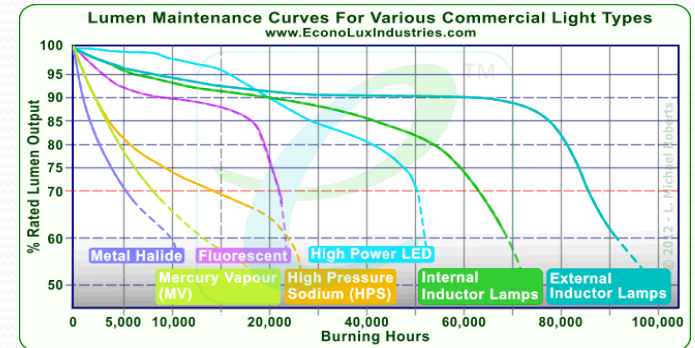
# H.I.D. Lighting Components

- Ballast
  - Accepts current from wall outlet / circuit
  - Delivers altered current to lamp
  - Specific wattage, bulb type
  - Electronic vs. Magnetic ballast
- Reflector
  - Vertically / Horizontally houses bulb
  - Air Cooled / Open Fixture
  - Directly attached or remotely wired to ballast
- Bulb
  - Metal Halide, High Pressure Sodium, Dual Arc
  - Discharges current across specialized arc
  - Some bulbs must be fired in horizontal position



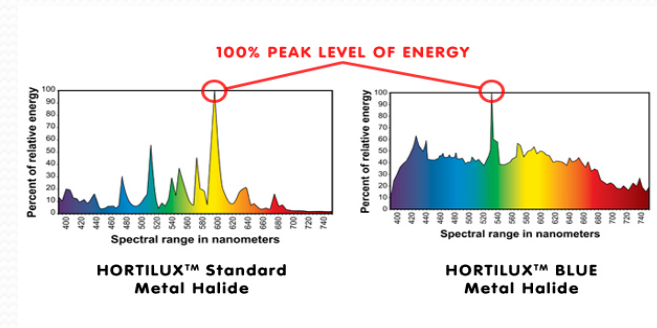
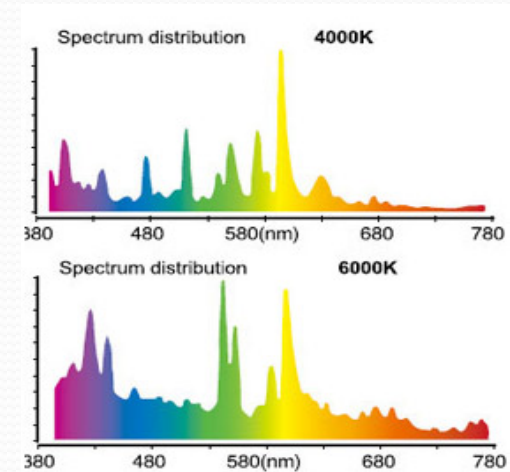
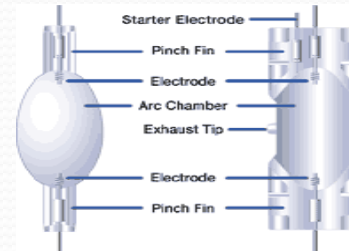
# H.I.D. Drawbacks

- Bulb Lifespan
  - MH and HPS short life
- Bulb Toxicity
  - Mercury and other heavy metals
  - Breakage over food crop?
- Generated Heat
- Efficiency
  - Magnetic Ballasts achieve .8 factor
  - Electronic ballasts claim to have .9+ factor
  - Bulb produces wasted energy
- Operation Considerations
  - Hot Start
  - Power Supply
  - UL Listing
    - Required for educational use



# Metal Halide vs. High Pressure Sodium

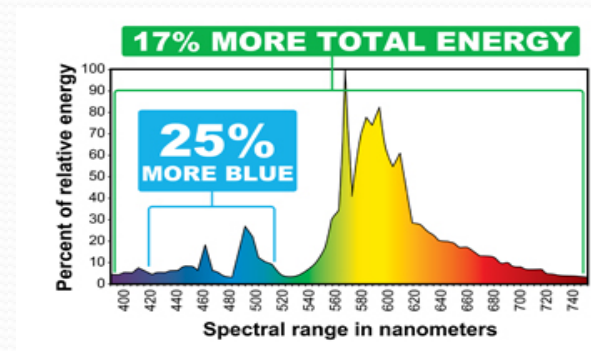
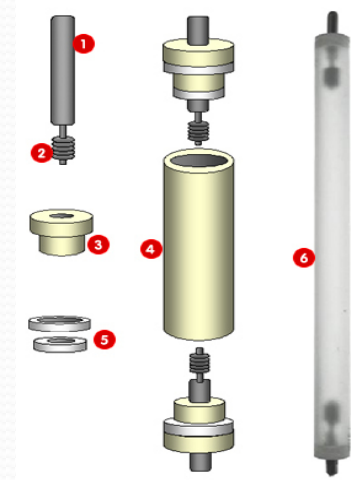
- Metal Halide
  - Burning Position
    - Universal or Horizontal
    - Box will state
    - Must be in enclosed fixture for UL listing
  - Cool Burning
    - Deeper Blue, U.V.
    - Often used for reefs
    - 6400K, 10,000K, 20,000K
    - Excellent for vegetative crops
  - Warm Burning
    - Daylight
    - Used to flower plants on MH ballast
    - Phosphorous coating
      - Creates red spectrum
      - Burns off in 6 months





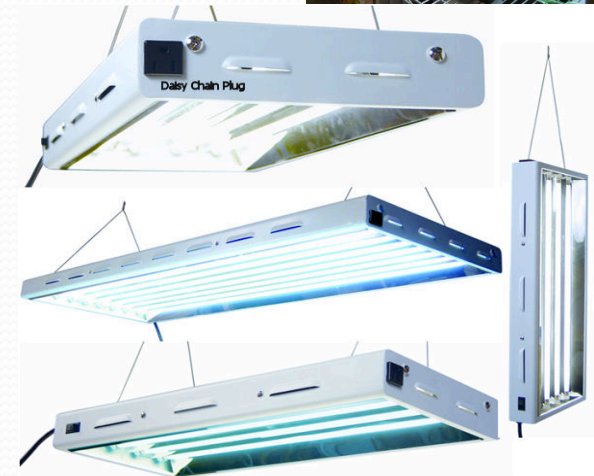
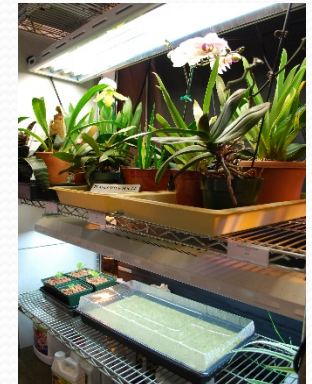
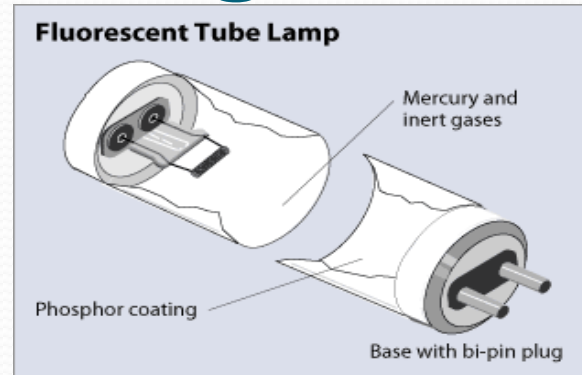
# MH vs. HPS cont.,

- High Pressure Sodium
  - Most Widely Used Bulb for Flowering
  - Red Spectrum 2100K
  - Standard
    - Parking lot lamps
    - Yellow/Orange
    - Cheap
  - Enhanced Spectrum HPS
    - Added metals produce extra blue
    - Costly



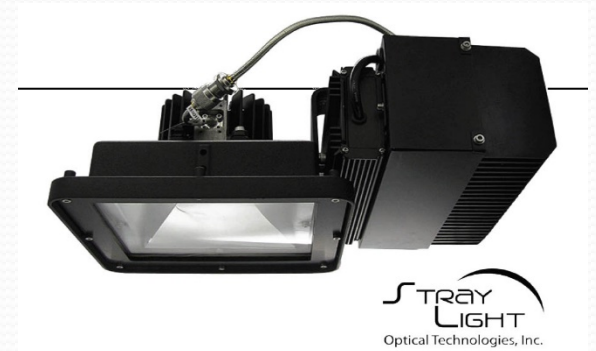
# Fluorescent Lighting

- Simple Components
  - Fixture plugs into wall
  - Ballast on board
  - Several bulb sizes
  - Excellent lifespan (2 years)
- Varying Sizes of Fixtures
  - 2',3',4'
  - Multiple Bulb Arrays
  - T5
    - HO, VHO
- Drawbacks
  - Low Output
    - Does not penetrate plant canopy
  - Bulb Toxicity
    - Cannot be put into waste stream



# Plasma and Induction Lighting

- Plasma
  - New technology on the market
  - May require red supplement
- Induction
  - Invented by Tesla
  - No moving parts
  - No direct electrical contact
  - Magnetic field excites bulb





# LED Lighting

- Light Emitting Diodes
  - Limited Spectrum
    - Red, Blue, White diodes
    - Plays to the tune of PAR
  - Many Wattages
    - Many manufactures
    - Efficient use of electricity
- Arrays
  - Small to Large
    - Many sizes for all applications
    - Expensive to cheap home made
  - Arrange diodes on panels
    - Panels have heat sinks
    - Some panels are dimmable / adjustable spectrum



# LED Pros and Cons

## Pro

- Long unit life span
  - LumiGrow claims 7 years
- No toxic chemicals exposed to crops
- Little Heat
- No Wasted Electricity
- Adjustable Spectrum
  - LumiGrow and StealthGrow
- Low power consumption
  - LumiGrow claims 330wLED will compete w/1000wHPS

## Con

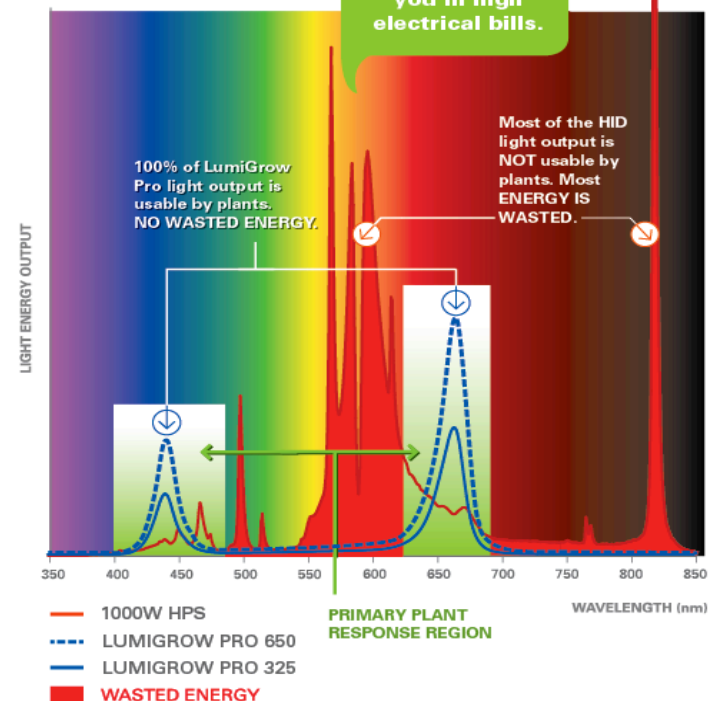
- Expensive
  - 1000w equivalent costs upwards of USD\$1400
- Replacement
  - Entire unite must be replaced (ballast, fans)
- Low penetration of plant canopy
- Hanging distance
  - Supplemental can be upwards of 6 feet
  - For stand alone lighting 18 inches max
- Limited Spectrum
  - 460nm 680nm

## Targeted Spectral Output

All light emitted by the LumiGrow Pro™ series triggers healthy plant responses, boosting your yield and reducing your costs.

HID radiates infrared energy that does nothing but release uncontrolled heat, evaporate water and burn plants.

**Excess light from HIDs costs you in high electrical bills.**



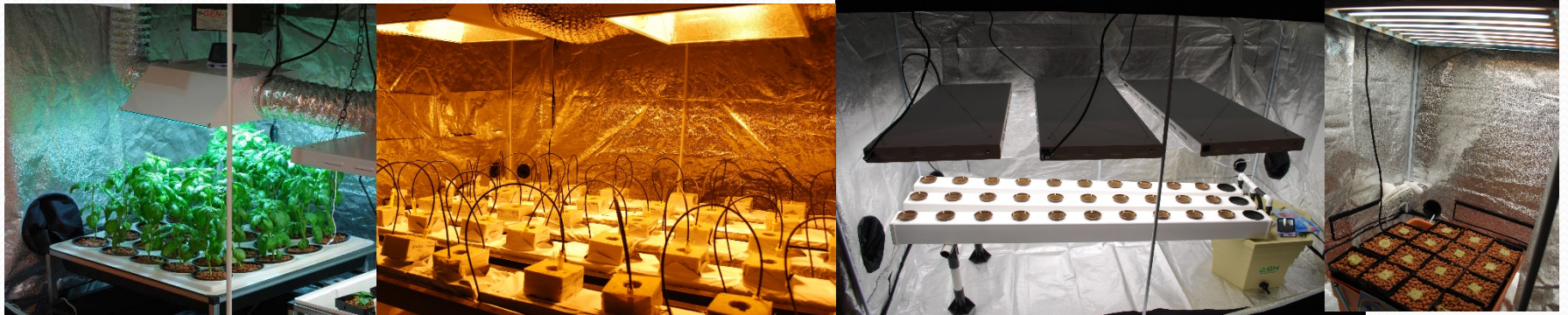
# Greenhouses

- Consider supplemental light
  - Day length elongation
  - DLI targets
- Recommend HID to start
  - Ballast on board
  - HPS or MH with LED
- LED may improve in future



# Indoor Gardens

- HID continue to be the preferred hobbyist choice for bringing mature plants to harvest
- Some consumers choose fluorescents for smaller specimens, seedlings and vegetative crops.



# Load Considerations

- Master Controllers
  - 120V or 240V
  - Master time sequence
  - Delayed starts
  - Protections
- Dedicated Service Lines
  - 240v line from panel box
  - More efficient
    - Max 1x1000w on a 15amp 120v circuit
    - 20amp 240v can service 4x1000w





# Production Methods

- Staggered
  - Allows weekly harvests
  - Facilitates market development
  - Maintains uniform nutrient uptake
- Batch
  - Easier management
  - Can deplete nutrients

# Seedling Production

- Greenhouse or shade house
  - Protected area
- Keep it clean
  - Metal tables
  - Install drain if concrete floor
  - Weed barrier if gravel floor
- Planting media and dead plant material can harbor insects and disease

# Planting Media

- Peat potting mix (i.e. Promix BX)
  - Inexpensive
  - Readably available
  - Contains micronutrients for seedling growth
  - Can have pythium spores
- Jiffy peat pellets
  - Expensive
  - Easy to use
  - Can have pythium spores
- ◆ Oasis root cubes
  - Expensive
  - Requires additional nutrients
  - Dries out quickly in greenhouse
- ◆ Rockwool
  - Expensive
  - Non-biodegradable



# Planting Media

- Soilless potting mix
- Coir (coconut fibers) + Vermiculite
  - 60% + 40% mix
  - Free from pythium
  - Requires fertilizer supplementation
  - Labor required to prepare mix









# Watering Equipment

- Fogg-It Nozzle
  - 4 gpm
- Damm 400 Water Breaker
  - 400 tiny streams of water



# Watering Equipment

- Hozon Siphon Mixer
  - 1:16 proportioning device





# Plant Potential Production

Variety	Density (plants/m <sup>2</sup> )	Area planted (m <sup>2</sup> )	Yield (ea.)	Cases (24/case)
Sierra leaf	20	26.7	535	22.3
Parris Island romaine	16	26.7	428	17.8
Total		53.5	963	40.1

- ◆ Production of both varieties was superior in cool winter months
- ◆ Production declined when water temperatures were warm and *Pythium* killed roots which suppressed plant growth.

# Production Value

Variety	Density (plants/m <sup>2</sup> )	Growth Period (weeks)	Value (\$/head)	Value (\$/m <sup>2</sup> )	Value (\$/m <sup>2</sup> /week )
Parris Island romaine	16	4	2.00	32.00	8.00
Sierra leaf	20	4	1.50	30.00	7.50
Boston Bibb	30	3	1.00	30.00	10.00

- ◆ High density and frequent harvests has higher value even when individual value is low.

# Other greens

Variety	Density (plants/m <sup>2</sup> )	Growth Period (weeks)	Yield (kg/m <sup>2</sup> )	Value (\$/kg)	Value (\$/m <sup>2</sup> )	Value (\$/m <sup>2</sup> /week)
Pak choi	30	3	8.00	3.30	26.40	8.80
Kale	30	3	0.89	6.59	5.86	1.95
Collards	30	3	0.45	6.59	2.96	1.48
Swiss Chard	30	3	1.44	6.59	9.49	3.16
Basil	16	4	1.80	22.05	39.60	9.90

- ◆ Leafy green crops take advantage of abundant nitrogen in the system and easy nutrient management.



# Production Management

- pH maintained at 7.0
  - KOH
  - $\text{Ca}(\text{OH})_2$
- Chelated iron
  - 2 ppm (mg/liter)
  - Chelated iron is 13% pure so multiply by 7.7  
(i.e., 15.4 mg of product gives 2 mg of iron)
- Manage net tanks with cleaning schedule to control nitrate levels
- Biological pest control
- Integrated pest management







# Lettuce

- High nitrogen levels promotes leafy growth
- Short production cycle generates steady cash flow
- Strong demand

# Lettuce Production Cycle

## Greenhouse Phase

- Week 1
  - Day 0: seed
- Week 2
  - Day 7: thin flat
  - Day 7, 10, 13: fertilize
- Week 3
  - Day 14, 16, 19: fertilize

## Aquaponic System Phase

- Week 4
  - Day 21: transplant to aquaponic system
  - Day 23, 26: spray with BT
- Week 5
  - Day 30, 33: Spray with BT
- Week 6
  - Day 37, 40: Spray with BT
- Week 7
  - Day 42, 45: Spray with BT
  - Day 49: Harvest







# Lettuce Harvest Procedures

- Move sheets with mature plants to one end of the raft
- Lift sheets to harvesting stand or harvest in place
- Cut off lettuce stalk with a sharp knife and remove lower poor quality leaves
- Discard any poor quality lettuce
- Pack 24 lettuce heads to a box
- Weigh several randomly selected boxes minus the empty box weight to calculate total harvest weight and average weight per head of lettuce.
- Count box to determine total lettuce number and percentage of marketable yield

# Lettuce Harvest Procedures

- Lettuce that is not distributed immediately should be stored in a moist refrigerated room
- Surface of the sheets should be washed with dechlorinated water to remove any dead leaves and quickly returned to hydroponic tanks
- Plants roots and growing media should be removed from net pots and discarded
- Cleaned net pots should be disinfected by soaking them in water containing bleach, rinsed and then dried before they are used again































# Basil Production

- 48 plants/sheet
- Staggered production
- Complete harvest recommended
- Cut and come again at 4 week intervals is alternative
  - Grow for 3 months
  - Harvest (cut) three times then remove
  - Reduces survival and increases pythium
- Seedlings
  - 3 weeks in greenhouse

# Basil

- Genovese
- 16/m<sup>2</sup>, 48 per raft
- Market value  
\$10.00/lb
- Value  
\$515/m<sup>2</sup>/yr  
\$110,210/system/yr



# Okra Production

- 5-month production cycle
- Continuous flowering after 4 weeks
- Frequent harvests required for tender pods
  - Delayed harvest produces unmarketable product
- Seedlings
  - 2-3 weeks in greenhouse







# Okra

- Clemson spineless
- 3.7/m<sup>2</sup>, 11 per raft
- 5 months
- Market price  
\$0.50/lb)
- Value  
\$15/m<sup>2</sup>/yr  
\$3,210/system/yr

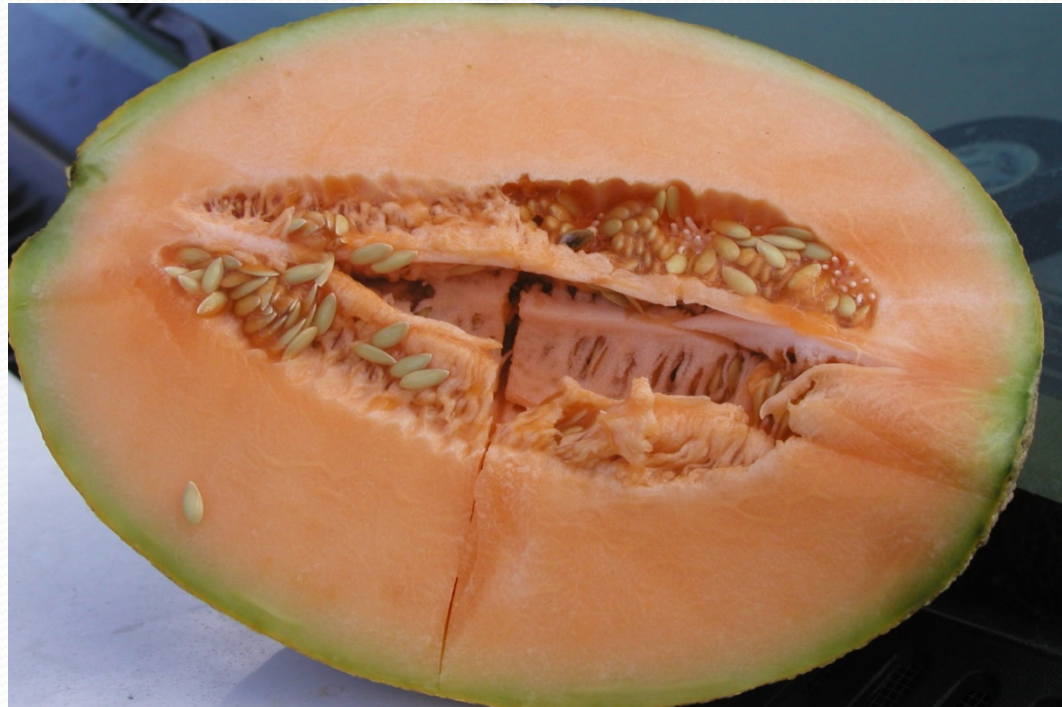


# Melon Production

- 2 plants/sheet
  - Use one side only and allow plants to run on ground
  - Plant other side with companion crop
  - Or construct narrow hydroponic tanks
- < 3 month crop
- Plants die as melons ripen on the vine
- Seedlings
  - 1-2 weeks in greenhouse

# Cantaloupe

- Jaipur
- $0.67/\text{m}^2$ , 2 per raft
- Market value  
\$3.99 each
- Value  
Each:  $\$46.28/\text{m}^2/\text{yr}$   
 $\$9,900/\text{system}/\text{yr}$







**Jaipur**

**Main Season Variety**

**42 days**



The best biological  
control  
is the farmer's shadow





# Plant Pest and Disease Control

- No synthetic chemical pesticides
- Biological controls used to control insects
- IPM to reduce pest pressure



# *Pythium spp.*

- Root fungus
- No IPM control
- ◆ Low temperature reduces growth and impact of some *Pythium* species
- ◆ Select resistant varieties



# Biological Controls

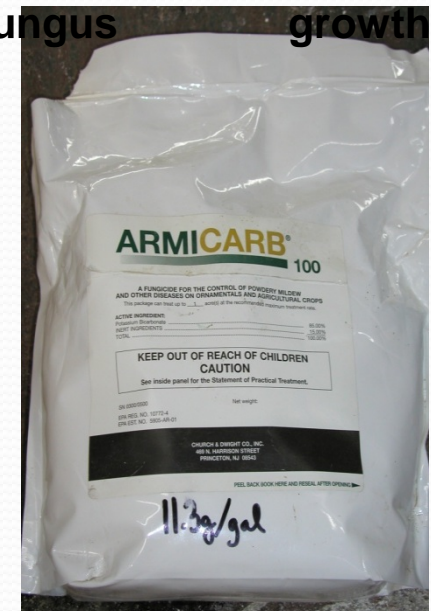
**Dipel**  
Bacteria  
Controls  
caterpillars



**Soap Spray**  
Fungus  
Controls soft bodied  
insects (white flies,  
aphids)



**Armicarb**  
Potassium  
bicarbonate  
Controls fungus,  
powdery mildew.  
Changes pH of leaf  
surface making it  
unsuitable for  
fungus growth







Application  
of Dipel with  
gas powered  
backpack  
sprayer



# Soaps and Oils

- Coats insect causing death
- Kills all insects  
Including beneficial  
Ladybugs, wasps, bees



# Barriers

Shade cloth

Tangle foot





# Bug Light

- Attracts/kills moths and night flying insects

May draw insects from far away





# Thank You!



## Charlie Shultz

[aquaponics@hotmail.com](mailto:aquaponics@hotmail.com)