Integrated Aquaponics
Water & Soil Fertility
November 15, 2014
By: Phil Reasons
Executive Director
Morning Star Fishermen
Agenda

• (Review)
• Plant Nutrients / Deficiencies
• Other Plant Needs
• Pest / Diseases
• Aquaponic Waste Water
• Soil / Compost
• Irrigation
The 5 Essential Components to a Successful Aquaponic System

- **FISH**
- **SETTLEING**
- **BLO-FILTER**
- **PLANTS**

“*The FARMER*”
Sizing your System

• Stocking density
  1:5-1:10

• Plant Bed Ratio
  5.6 grams feed daily per sqft grow space

• Flow Rates
  Cycle rearing tank once per 1-4hrs
# Water Quality Parameters

- **Optimum Water Temperatures**: 75-86
- **Dissolved Oxygen**: 3 ppm
- **Carbon Dioxide**: Don’t worry about it
- **pH**: 6.8 pH
- **Total Ammonía Nitrogen (TAN)**: 0-3 ppm
- **Nitrites**: 0-3 ppm
- **Nitrates**: 0-300 ppm
- **Iron**: 1 ppm
- **Potassium**: 150-300

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
<tr>
<td>Nitrates</td>
<td>0-300 ppm</td>
</tr>
<tr>
<td>Iron</td>
<td>1 ppm</td>
</tr>
<tr>
<td>Potassium</td>
<td>150-300</td>
</tr>
</tbody>
</table>
Feeding Procedures

- Very Important: Use a test amount, or handful and observe behavior first.
- Then feed modest amounts continually.
- And slow as the fish slow down.
- Feed all they will eat in 10-15 minutes.
- You must net out and remove excess feed!
Sexing
Conditions for Egg Laying

- 76°F to 86°F (25°C to 30°C)
- 12 or more hours of sunlight.
- Relatively un-crowded conditions.
- Fish are >90 days old
- Ample food supply
- Good water quality
Overpopulation

Overcrowding your system will stunt or slow the growth of the fish.

PERMANETLY

Because Tilapia spawn at a early age, your pond or tank can become overpopulated with a variety of fish sizes if reproduction is not controlled.
Growth Rate

- Raised in a controlled environment, growth rates of 3% of their body weight per day can be achieved. However 2% is average.

- A efficiently raised fish should gain one pound for every 1.7 pounds of food.

  \textsf{1:2 \textit{feed conversion} is more realistic}

- Typically in efficient controlled conditions they can be marketed at 1.5 to 1.75 lbs at 6 months of age. (8 – 12 mo. is more realistic)

- Normal death rates are 10% to the fingerling stage (1-2 months) and 0.5% to selling size.
Essential Trace Minerals

- Potassium
- Magnesium
- Calcium
- Phosphorus
- Chlorine
- Sodium
- Zink
- Iron
- Manganese
- Copper
- Iodine
- Selenium
- Molybdenum
- Cobalt

1. Immune system weakens, illness.
3. Missing, body won’t respond to treatment, death.
Seeds smaller than a $\frac{1}{4}''$ plant at a $\frac{1}{4}''$ deep. If the seed is larger than a $\frac{1}{4}''$, plant the seed double the seeds width.
Plant Nutrients / Deficiencies
# Plant Nutrients

<table>
<thead>
<tr>
<th>Name</th>
<th>Chemical symbol</th>
<th>Relative % in plant*</th>
<th>Function in plant</th>
<th>Nutrient category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen</td>
<td>N</td>
<td>100</td>
<td>Proteins, amino acids</td>
<td>Primary macronutrients</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>P</td>
<td>6</td>
<td>Nucleic acids, ATP</td>
<td>Primary macronutrients</td>
</tr>
<tr>
<td>Potassium</td>
<td>K</td>
<td>25</td>
<td>Catalyst, ion transport</td>
<td>Primary macronutrients</td>
</tr>
<tr>
<td>Calcium</td>
<td>Ca</td>
<td>12.5</td>
<td>Cell wall component</td>
<td>Secondary macronutrients</td>
</tr>
<tr>
<td>Magnesium</td>
<td>Mg</td>
<td>8</td>
<td>Part of chlorophyll</td>
<td>Secondary macronutrients</td>
</tr>
<tr>
<td>Sulfur</td>
<td>S</td>
<td>3</td>
<td>Amino acids</td>
<td>Secondary macronutrients</td>
</tr>
<tr>
<td>Iron</td>
<td>Fe</td>
<td>0.2</td>
<td>Chlorophyll synthesis</td>
<td>Micronutrients</td>
</tr>
<tr>
<td>Copper</td>
<td>Cu</td>
<td>0.01</td>
<td>Component of enzymes</td>
<td>Micronutrients</td>
</tr>
<tr>
<td>Manganese</td>
<td>Mn</td>
<td>0.1</td>
<td>Activates enzymes</td>
<td>Micronutrients</td>
</tr>
<tr>
<td>Zinc</td>
<td>Zn</td>
<td>0.03</td>
<td>Activates enzymes</td>
<td>Micronutrients</td>
</tr>
<tr>
<td>Boron</td>
<td>B</td>
<td>0.2</td>
<td>Cell wall component</td>
<td>Micronutrients</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>Mo</td>
<td>0.0001</td>
<td>Involved in N fixation</td>
<td>Micronutrients</td>
</tr>
<tr>
<td>Chlorine</td>
<td>Cl</td>
<td>0.3</td>
<td>Photosynthesis reactions</td>
<td>Micronutrients</td>
</tr>
<tr>
<td>Observed Nutrients Concentration in UVI’s Aquaponics System</td>
<td>Recommended Nutrients Concentration in Rebecca Nelson’s (aquaponics.com) Aquaponic Food Production book</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>----------------</td>
<td>---------------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>mg/l (ppm)</td>
<td>mg/l (ppm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NO₃ - N</td>
<td>0.4 – 82.2</td>
<td>70 - 300</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HH₄ - N</td>
<td>n/a</td>
<td>0 -30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>0.3 – 192</td>
<td>200 - 400</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>0.4 – 15.3</td>
<td>30 - 90</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ca</td>
<td>10.7 – 82.1</td>
<td>150 - 400</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>0.1 – 23.0</td>
<td>60 - 330</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mg</td>
<td>0.7 – 12.9</td>
<td>25 - 75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fe</td>
<td>0.13 – 4.3</td>
<td>0.5 - 5.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>0.01 – 0.23</td>
<td>0.1 - 1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mn</td>
<td>0.01 – 0.19</td>
<td>0.1 - 1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zn</td>
<td>0.11 – 0.80</td>
<td>0.02 - 0.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mo</td>
<td>0.00 – 0.17</td>
<td>0.01 - 0.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cu</td>
<td>0.01 – 0.11</td>
<td>0.02 - 0.2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Plant Nutrients

**Mobile Nutrients**
Can be translocated from older leaves to younger leaves, deficiency symbols appear on bottom of plant on older leaves.

Nitrogen (N), Phosphorus (P), Potassium (K), Magnesium (Mg), Zinc (Zn)

(Remobilized nutrients may not be as useful as freshly absorbed nutrients.)

**Immobile Nutrients**
Deficiency symbols appear on younger leaves.

Iron (Fe), Calcium (Ca), Sulfur (S), Manganese (Mn), Boron (B), Copper (Cu)
## Plant Nutrient Deficiency Symptoms

<table>
<thead>
<tr>
<th>Element</th>
<th>Leaves to first show deficiency</th>
<th>Symptom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen</td>
<td>Old</td>
<td>Leaves turn yellowish</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>Old</td>
<td>Premature leaf fall-off  (Similar to nitrogen deficiency)</td>
</tr>
<tr>
<td>Calcium</td>
<td>New</td>
<td>Damage and die off of growing points. Yellowish leaf edges</td>
</tr>
<tr>
<td>Magnesium</td>
<td>Old</td>
<td>Yellow spots</td>
</tr>
<tr>
<td>Potassium</td>
<td>Old</td>
<td>Yellow areas, then withering of leaf edges and tips</td>
</tr>
<tr>
<td>Sulfur</td>
<td>New</td>
<td>Similar to nitrogen deficiency</td>
</tr>
<tr>
<td>Iron</td>
<td>New</td>
<td>Leaves turn yellow.  Greenish nerves enclosing yellow leaf tissue.  First seen in fast growing plants</td>
</tr>
<tr>
<td>Manganese</td>
<td>New</td>
<td>Dead yellowish tissue between leaf nerves</td>
</tr>
<tr>
<td>Copper</td>
<td>New</td>
<td>Dead leaf tips and withered edges</td>
</tr>
<tr>
<td>Zinc</td>
<td>Old</td>
<td>Yellowish areas between nerves, Starting at leaf tip and edges</td>
</tr>
<tr>
<td>Boron</td>
<td>New</td>
<td>Dead shoot tips, new side shoots also die</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>Old</td>
<td>Yellow spots between leaf nerves, then brownish areas along edges.  Inhibited flowering</td>
</tr>
</tbody>
</table>
Plant Nutrients

Nutrient Toxicity / Deficiency Symptoms

• **Chlorosis** - yellowing of plant tissue due to limitations on chlorophyll synthesis. This yellowing can be generalized over the entire plant, localized over entire leaves or isolated between some leaf veins (interveinal chlorosis).

• **Necrosis** - death of plant tissue sometimes in spots.

• Accumulation of anthocyanin resulting in a **purple or reddish color**.

• Lack of new growth, **stunting** or reduced growth - new growth continues but it is stunted or reduced compared to normal plants.
# Plant Nutrient Deficiency Symptoms

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Type</th>
<th>Visual symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen</td>
<td>Deficiency</td>
<td>Light green/yellow appearance of leaves, especially older leaves; stunted growth; poor fruit development.</td>
</tr>
<tr>
<td></td>
<td>Excess</td>
<td>Dark green foliage which may be susceptible to lodging, drought, disease and insect invasion. Fruit and seed crops may fail to yield.</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>Deficiency</td>
<td>Leaves may develop purple coloration; stunted plant growth and delay in plant development.</td>
</tr>
<tr>
<td></td>
<td>Excess</td>
<td>Excess phosphorus may cause micronutrient deficiencies, especially iron or zinc.</td>
</tr>
<tr>
<td>Potassium</td>
<td>Deficiency</td>
<td>Older leaves turn yellow initially around margins and die; irregular fruit development.</td>
</tr>
<tr>
<td></td>
<td>Excess</td>
<td>Excess potassium may cause deficiencies in magnesium and possibly calcium.</td>
</tr>
<tr>
<td>Calcium</td>
<td>Deficiency</td>
<td>Reduced growth or death of growing tips; blossom-end rot of tomato; poor fruit development and appearance.</td>
</tr>
<tr>
<td></td>
<td>Excess</td>
<td>Excess calcium may cause deficiency in either magnesium or potassium.</td>
</tr>
<tr>
<td>Magnesium</td>
<td>Deficiency</td>
<td>Initial yellowing of older leaves between leaf veins spreading to younger leaves; poor fruit development and production.</td>
</tr>
<tr>
<td></td>
<td>Excess</td>
<td>High concentration tolerated in plant; however, imbalance with calcium and potassium may reduce growth.</td>
</tr>
<tr>
<td>Sulfur</td>
<td>Deficiency</td>
<td>Initial yellowing of young leaves spreading to whole plant; similar symptoms to nitrogen deficiency but occurs on new growth.</td>
</tr>
<tr>
<td></td>
<td>Excess</td>
<td>Excess of sulfur may cause premature dropping of leaves.</td>
</tr>
<tr>
<td>Iron</td>
<td>Deficiency</td>
<td>Initial distinct yellow or white areas between veins of young leaves leading to spots of dead leaf tissue.</td>
</tr>
<tr>
<td></td>
<td>Excess</td>
<td>Possible bronzing of leaves with tiny brown spots.</td>
</tr>
<tr>
<td>Manganese</td>
<td>Deficiency</td>
<td>Interverinal yellowing or mottling of young leaves.</td>
</tr>
<tr>
<td></td>
<td>Excess</td>
<td>Older leaves have brown spots surrounded by a chlorotic circle or zone.</td>
</tr>
<tr>
<td>Zinc</td>
<td>Deficiency</td>
<td>Interverinal yellowing on young leaves; reduced leaf size.</td>
</tr>
<tr>
<td></td>
<td>Excess</td>
<td>Excess zinc may cause iron deficiency in some plants.</td>
</tr>
<tr>
<td>Boron</td>
<td>Deficiency</td>
<td>Death of growing points and deformation of leaves with areas of discoloration.</td>
</tr>
<tr>
<td></td>
<td>Excess</td>
<td>Leaf tips become yellow followed by necrosis. Leaves get a scorched appearance and later fall off.</td>
</tr>
</tbody>
</table>
Plant Nutrient Deficiency

Complete Nutrient Deficiency
Nitrogen Deficiency
Phosphorus Deficiency
Potassium Deficiency
Calcium Deficiency
Phosphorus Deficiency  Cold Root Zone, Poor Fertility

Symptoms:
Phosphorus deficiency is most often manifested as purpling of the leaves, particularly the leaf veins. In severe cases the whole plant may take on a purple hue. Tomato roots growing in cold soil, either in the greenhouse or the field, take up phosphorus poorly. Deficient plants lose vigor and yield poorly.
Potassium Deficiency

Symptoms:
"Bronzing" due to brown spotting, and scorching of leaves. Leaflets bluish green, slight intervenal chlorosis and backward curling of margins; intervenal spotting, marginal scorching. Growth tends to be squat and bushy; leaflets bluish green and slight intervenal chlorosis, marginal scorch and brown spots on under surface.
Potassium Deficiency – slight symptoms
Iron Deficiency

Symptoms:
Young leaves strongly chlorotic; veins may remain green; margins and tips develop brown patches. Stunted new growth with spindly stems. Flowers drop off before opening.
Potassium & Iron Deficiency

Symptoms:
Young leaves chlorotic due to iron deficiency; older leaves brown spotting and scorch due to potassium deficiency.
Calcium Deficiency

Symptoms:

New growth affected first; shoots become thin, root tips turn brown and die. Hard, stiff new leaves with dead in-curled edges and brown or scorched spots; tips of leaflets die. Stems are stunted and woody, blossoms fall off. Little or no fruit.
pH and Nutrient Adjustment

• The natural process of nitrification breaks down ammonia-nitrogen (produced by the fish as a metabolic waste product) into nitrite and then nitrate.

• This process produces acids that lower the pH of the water and consumes alkalinity.

• The optimum pH to maintain is 6.8-7.0

• This is a compromise between the optimum level for nitrification (7.5) and the optimum level for plant growth (6.5).

• To maintain pH at 6.8-7.0, base chemicals or acid are added.
pH and Nutrient Adjustment

• The best bases to use in the system are potassium, and calcium.

• These are best because they do not increase the sodium salts in the system (which are toxic to the plants and can cause tip burn) and these bases provide essential nutrients to the plants.

• The frequency and amount of base needed to maintain pH at the optimum level, is determined by the buffering capacity of the water.

• Base should be added on a daily or every-other-day basis if the source water has low alkalinity.
The addition of base, potassium or calcium, counteract the acids produced in the nitrification process.

Add base slowly (trickle) at point in the system where it will be diluted before reaching the plants or the fish.
**Effect of pH on Nutrient Availability**

<table>
<thead>
<tr>
<th>strongly acid</th>
<th>medium acid</th>
<th>slightly acid</th>
<th>very slightly acid</th>
<th>very slightly alkaline</th>
<th>slightly alkaline</th>
<th>medium alkaline</th>
<th>strongly alkaline</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>nitrogen</td>
<td>phosphorus</td>
<td>potassium</td>
<td>sulphur</td>
<td>calcium</td>
<td>magnesium</td>
<td>iron</td>
<td>manganese</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>boron</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>copper &amp; zinc</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>molybdenum</td>
</tr>
</tbody>
</table>

**pH Scale:**
- 4.0 to 4.5
- 5.0 to 5.5
- 6.0 to 6.5
- 7.0 to 7.5
- 8.0 to 8.5
- 9.0 to 9.5
- 10.0
Effect of pH on Nutrient Availability

- The pH of a solution affects the solubility of nutrients, especially trace metals.

- Essential nutrients such as iron, manganese, copper, zinc and boron are less available to plants at a pH higher than 7.0.

- The solubility of phosphorus, calcium, magnesium and molybdenum sharply decreases at a pH lower than 6.0.

- Compromise between nitrification and nutrient availability is reached in aquaponic systems by maintaining pH close to 7.0.

- Higher pH levels, up to pH of 8, will still “work”, but only if all ammonia is converted to nitrate.
Other Plant Requirements - Oxygen

Plant roots require the same D.O. levels as fish

- Oxygen is needed at the root zone for **nutrient uptake**
- Proper levels of oxygen **increase your plants tolerance** to bacterial and fungal infestations, such as pythium
- Plants under **high light levels require more oxygen**.
- **Oxygen is a macro nutrient**, high levels are **required for optimum plant growth**.
- Thin film systems allow better oxygenation of water than deep raft systems, but tend to clog.
- Place air diffusers every 2 to 4 ft. under floating rafts.
- Remember, warmer water holds less dissolved oxygen, and encourages the growth of more viruses, fungi, and anaerobes.
Other Plant Requirements – Water Temp.

Water temperature is far more important than air temperature for hydroponic plant production.

- 75 °F water is ideal for most hydroponic crops.
- Optimum temperature range for fish growth is 78 – 86 °F.
- At 75 °F Tilapia grow only half as fast as they do at 82 °F.
- For most common garden crops water temperature can go as low as the mid-60s, and slightly lower for winter crops such as cabbage, Brussels sprouts and broccoli.
- Heating is required during winter in temperate regions.
- Evaporative cooling of greenhouses, water chillers, shading and foam insulation are often used to maintain the water cool in tropical regions.
Other Plant Requirements - Humidity

Most plants cannot function properly if the surrounding air is consistently dry.

- Plants need a climate with sufficiently high relative humidity so that their surfaces are never dry.
- Plants “transpire”, a process analogous to perspiration in human beings, drawing water out of themselves and releasing it into the air in an attempt to increase the level of humidity.
- Under continuous conditions of extremely low relative air humidity the plants will not be able to transpire enough water and will begin to droop, to fail, and become parched looking.
- Lacking water, the plant will be unable to carry out the many processes by which it manufactures the energy to grow.
- Ideal range is 40% to 60% relative humidity.
- Relative humidity greater than 60% is not directly damaging to plants but favor growth of molds and mildew.
Other Plant Requirements - Light

- Determine how much light a plant will require - consider where and how it grows best in its natural environment.

- Most vegetables, grow best in full sunlight – provide as much light as possible to vegetables grown indoors.

- Most plants and vegetables need about 10 to 12 hours of light to promote growth. Plants that produce fruits or flowers will show improvement with up to 16 hours a day of supplemental light.

- Plants need dark periods. Light (called photo-periods) and dark periods and their relative lengths have an effect on plant maturity, flowering and fruiting.
Other Plant Requirements - Light

• Direct sunlight on a clear day is approx. 10,000 footcandles

• The rate of photosynthesis is proportional to the intensity of the light received by the leaf up to 5,000 footcandles – 100% efficiency.

• Light intensity above this measurement has little added benefit - heat, undue drying of the plant

• Most plants require a minimum of 10,000 footcandles each day (available light intensity times the hours of exposure to light source) to survive.

• Plants that thrive in full sunlight, like most vegetable crops, require upwards of 20,000 footcandles of full spectrum sunlight each day to grow, develop and produce to it’s maximum potential
Other Plant Requirements - Light

- **Color Temperature**
  Expressed in degrees Kelvin (°K) it is the degree of warmth or coolness of a light source, not with regards to the physical temperature, rather to the “visual” temperature of the light.

- The higher the degree K, the more blue, or "cooler" the lamp appears.

- The lower the degree K, the more "warm", or red the light appears.
Sunlight

Photosynthetic Active Radiation

% Photosynthetic Activity

ULTRA VIOLET  VISIBLE LIGHT  INFRA RED
<table>
<thead>
<tr>
<th>Range</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>200 - 280 nm</td>
<td>UVC ultraviolet range which is extremely harmful to plants because it is highly toxic.</td>
</tr>
<tr>
<td>280 - 315 nm</td>
<td>Includes harmful UVB ultraviolet light which causes plants colors to fade.</td>
</tr>
<tr>
<td>315 - 380 nm</td>
<td>Range of UVA ultraviolet light which is neither harmful nor beneficial to plant growth.</td>
</tr>
<tr>
<td>380 - 400 nm</td>
<td>Start of visible light spectrum. Process of chlorophyll absorption begins. UV protected plastics ideally block out any light below this range.</td>
</tr>
<tr>
<td>400 - 520 nm</td>
<td>This range includes violet, blue, and green bands. Peak absorption by chlorophyll occurs, and a strong influence on photosynthesis. (promotes vegetative growth)</td>
</tr>
<tr>
<td>520 - 610 nm</td>
<td>This range includes the green, yellow, and orange bands and has less absorption by pigments.</td>
</tr>
<tr>
<td>610 - 720 nm</td>
<td>This is the red band. Large amount of absorption by chlorophyll occurs, and most significant influence on photosynthesis. (promotes flowering and budding)</td>
</tr>
<tr>
<td>720 - 1000 nm</td>
<td>There is little absorption by chlorophyll here. Flowering and germination is influenced. At the high end of the band is infrared, which is heat.</td>
</tr>
<tr>
<td>1000+ nm</td>
<td>Totally infrared range. All energy absorbed at this point is converted to heat.</td>
</tr>
</tbody>
</table>
Artificial Light

Horticultural lighting systems allow you to extend the growing season by providing your plants with an indoor equivalent to sunlight

- **Incandescent lighting** - A very poor choice because of their inefficiency and even those that are labeled as a "grow light" have very little use.

- **Fluorescent lights** - A little better choice. Twice as efficient (lumens of light output per watt).
  - Excellent for starting seedlings
  - Also are excellent for leaf lettuce, spinach, and herbs.
  - The trick is to keep standard fluorescent bulbs no further than 4 inches away from the tops of the plants.
Artificial Light

- **T5 HIGH OUTPUT FLUORESCENT LIGHTING**
  - have an extremely high lumen per watt rating
    - 92.59 lumens/watt.
    - normal fluorescent F40 cool white lamp: 31.5 lumens/watt.
Artificial Light

- **H.I.D. (High Intensity Discharge)** - the most efficient and effective lamps that have suitable light spectrums (color range) and intensity for plant growth.

- Two types of H.I.D.
  - **MH (Metal Halide)** lamps are rich in the blue light spectrum, similar to full summer sun.
  - **HPS (High Pressure Sodium)** lamps are rich in the red/yellow spectrums, similar to the color of the fall sun.


**Artificial Light**

- **Metal halide** is the best type of light to be used as a primary light source (if no or little natural sunlight is available).

- MH (Metal Halide) bulbs produce a light that is very close to full summer sun, with a spectrum rich in the blue end.

- **Promotes fast vegetative growth** and compact, stocky plants with short internodal leaf spacing.
Artificial Light

- MH (Metal Halide) are very efficient and produce between 70 and 125 lumens of light output per watt of electricity used (Compared to 39 lumens per watt with standard fluorescent lights and 18 lumens per watt for standard incandescent bulbs.)
- Average lifespan is about 10,000 hours.
- Come in sizes from 70 to 1500 watts with the 250 w, 400 w and the 1000 w being the most popular sizes for gardening.
Artificial Light

- **High Pressure Sodium - HPS**
  - It is a more economical choice.
  - Lifespan is almost twice that of metal halides.
  - HPS bulbs are very efficient. They produce up to 140 lumens per watt.
  - Their disadvantage is they are *deficient in the blue spectrum*, most plants would grow up thin and lanky.
Artificial Light

- High Pressure Sodium - HPS
  - High in the red and yellow parts of the light spectrum, this imitates the fall sun.
  - Triggers hormones in plants to promote increase flowering/ budding.
  - There are color corrected HPS (High Pressure Sodium) bulbs designed specifically for indoor horticulture, and have a more balanced color spectrum.
Artificial Light

**High Pressure Sodium - HPS**

- Contain a mixture of sodium, mercury and xenon gas.
- Range from 35w to 1000w, with the 250w, 400w, 600w and 1000w being the most popular for horticulture use.
- Like the Metal Halides, High Pressure Sodium bulbs also slowly lose their brightness over time, so to maintain proper light intensity the bulbs must be changed before the end of their rated life.
**HID Plant Grow Lights**

- **High Intensity Discharge**

<table>
<thead>
<tr>
<th>Light Output</th>
<th>Primary Growing Area</th>
<th>Supplemental Growing Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 watts</td>
<td>2' x 2'</td>
<td>3' x 3'</td>
</tr>
<tr>
<td>250 watts</td>
<td>3' x 3'</td>
<td>5' x 5'</td>
</tr>
<tr>
<td>400 watts</td>
<td>5' x 5'</td>
<td>8' x 8'</td>
</tr>
<tr>
<td>600 watts</td>
<td>6' x 6'</td>
<td>10' x 10'</td>
</tr>
<tr>
<td>1000 watts</td>
<td>8' x 8'</td>
<td>12' x 12</td>
</tr>
</tbody>
</table>

- Due to the heat that is emitted from these types of fixtures, you should hang them according to size.
  - 100 and 250W - 2 to 3 feet above plant tops
  - 400 and 600W – 3 to 4 feet above plant tops.
  - 1000W and up - 4 to 6 feet above the plant tops
LED Plant Grow Lights

• Growing with Light Emitting Diode (LED) lighting is new.
  - A decade of research by universities and NASA started in 1990’s.
  - LED Plant Grow Lights are still in the early developmental stages.
LED Plant Grow Lights

• 100% plant-absorbed-light; compared to HID lighting which only produces 25% visible light, the rest is invisible heat.

• Operate at a fraction of the cost; draws just 6 watts of power, while giving off the equivalent of 100 watts of High Pressure Sodium light.

• Eliminating wasted light (green/yellow) and heat (infra-red); 90% power savings, and 98% less heat.

• 7-10 year life.

• Directional light; needs no reflector.
LED Plant Grow Lights

LED Light benefits:
- Extremely low power consumption -
- Emits only light that the plant actually uses for photosynthesis, ideal for all phases of plant growth
- Low heat generation
- Less Pollution
- 80,000+ hours compared to HID 10,000 hours

LED Light drawbacks:
- poor color rendering
- comparatively high initial cost
- limited depth penetration.
Artificial Light Summary

- Incandescent lights have very little use as "grow light".
- Standard fluorescent lights are excellent for starting seedlings and cultivating leaf lettuce, spinach, and herbs.
- The trick is to keep fluorescent bulbs close to the plants.
- Metal halide is a highly efficient light source the closest to the natural sunlight.
- LED 100% plant-absorbed-light, at a fraction of the cost of other lights. Pricey but long lasting.
Other Plant Requirements

- Adequate Spacing
- Adequate Support & Protection
  - Protection from wind
- Pruning & Training
10 Minute Break
Plan for problems before you plant.

Choose pest resistant varieties.

Early detection and prevention are key to maintaining the health of your plants. Regularly check for pests.

The first step in environmentally-responsible pest management is the correct identification of the problem.

Sanitation is the best control procedure – most pests come from inside the garden/greenhouse.

- Sanitize/clean equipment after use
- Ensure crop debris is removed
Pest Insects
Beneficial Insects

Lady bugs and Lacewings
Feed on aphids and other soft-bodied insects
Beneficial Insects
Beneficial Insects

Bees & wasps pollinate fruiting plants. Some wasps feed on caterpillars and other pest insects.
Caterpillars
Bugs, Beetles, & Flies
Aphids
Onion & Western Flower Thrips

*Thrips tabaci Frankliniella occidentalis*

**Symptoms:**
Thrips are small, elongate clear-bodied insects most often found scurrying about in opened flowers. Direct plant damage from thrips is minimal (except on onions), but they are known to readily transmit viruses. Thrips are ubiquitous pests of ornamental and weed species where they are never controlled. They also may be found on small grains that are frequently used as wind breaks.
Mealybug *Planococcus sp.*
Symptoms: Spider mites are barely visible with the naked eye, but their characteristic damage is easily recognized. Leaves subjected to mite feeding are described as "bronze" or "silver" because of the damage to the green tissue and a characteristic web is often present on leaves and young shoots. Populations of mites increase rapidly during hot weather.
Leaf Miner Damage

Symptoms:
Leaf miner larvae tunnel through the lamina of the leaf eating the chlorophyll-rich mesophyll cells as they go. This leaves an irregular track of dead tissue that eventually causes the leaf to stop functioning.

Control:
Follow labelled recommendations for the chemical control of leaf miner
Whitefly *Bemisia tabaci*

**Symptoms:**
Whiteflies are very small (about 1 mm in length), winged insects that appear as white dots on the underneath surface of the leaf, easily recognized as they take flight when leaves are rustled. They reduce plant vigor by sap feeding and allow growth of "sooty" mold on the honeydew exuded during feeding. Infested leaves also take on a chlorotic look in severe cases.

**Control:**
Whitefly populations can build up to damaging levels in the absence of natural predators, and pesticide resistance is a common problem with this pest.
Bacterial Speck  *Pseudomonas syringae pv. tomato*

**Symptoms:**
Bacterial speck is widely distributed. Symptoms may appear on any plant part. Leaves of infected plants are covered by small, dark brown, irregular patches of necrotic tissue that are surrounded by yellow halos. Disease severity is increased by leaf wetness, from sprinkler irrigation, rain, or heavy dews.

**Control:**
Minimize wetting of the leaves by using drip or furrow irrigation. Copper sprays provide effective control.
Tomato Spotted Wilt Virus

Symptoms:
Fruit are malformed, with raised yellow, red, and green mottled bull's eye rings. Plants from which fruit are harvested are stunted, with older leaves turning yellow. Leaves show yellow speckling, with dark streaks along the petiole. Growing tips of the leaves may die.

Control:
The virus is carried by flower and onion thrips that have carried the virus from infected weeds and ornamentals. Elimination of plants that serve as hosts to thrips is the most important control measure. Clean cultivation, with special attention to border strips is important. Locate production away from large grain fields.
Cucumber Mosaic Virus

**Symptoms:**
Virus-infected plants are stunted, often with poorly expanded leaves. Plants are bushy in appearance. Leaves may be mottled, and often have a "shoestring" appearance. Fruit are small and misshaped.

**Control:**
Aphids often are virus vectors, so an attempt to control the aphids is the first step. Eliminate weeds and remove infected plants from the field as soon as they are seen.
Leaf Mold *Cladosporium fulvum*

**Symptoms:**
Symptoms appear as light green patches on upper surfaces of older leaves. Underneath the leaves in these areas, a purplish or olive-green patch of mold growth is visible. Infected leaves turn yellow and drop off the plant.

**Control:**
Fungus is spread by wind currents. High humidity and warm temperatures encourage mold growth. The problem is especially severe in greenhouses, where adequate ventilation and air movement reduce disease severity by lowering moisture at the leaf surface. Fungicides are effective controls.
Powdery Mildew  *Leveillula taurica*

**Symptoms:**
Powdery mildew is first noticed on older leaves as a yellow spotted appearance, that upon closer inspection has a whitish-gray powder on the surface. The leaves will eventually die, but usually remain attached to the stem. The disease is worse under warm, dry conditions.

**Control:**
Sulfur dusts or wettable sulfur sprays are effective preventative controls. The established disease will require one of the labelled mildew fungicides.
**Late Blight** *Phytophthora infestans*

**Symptoms:**
Lesions on leaves appear as large watersoaked areas, that eventually turn brown and papery. Lesions may be surrounded by a white ring of mold if leaf wetness is high. Green to black irregular lesions are also present on the stems.

**Control:**
The fungus develops during periods of cool wet weather. Fungicide sprays as a preventative measure during these periods may be needed if the crop is being grown near large areas of tomato relatives (Solanaceous weeds, potatoes).
**Pythium Root Rot**

- A very common problem caused by zoospore infection of the plants root system by fungi like organisms of the genus *Pythium*, - water moulds.
- They infect a large range of hosts.
- Sanitation is the best control procedure for pythium,
- Nutrient deficiencies, low D.O. levels, and high temperatures predisposed the plants to phythium infection. (Some phythium sp. are favored by cool temp.)
- Increase aeration/circulation
- Use resistant plant cultivars
Companion Planting

- Benefits from companion planting:
  - Masking or hiding a crop from pest.
  - Producing odors that confuse and deter pests.
  - Serving as trap crops that draw pest insects away from other plants.
  - Acting as “nurse plants” that provide breeding grounds for beneficial insects.
  - Providing food to sustain beneficial insects as they search for pests.
  - Creating a habitat for beneficial insects.

When nature is in balance, you'll find a mixture of good and bad insects in your garden. A close look at the underside of a cabbage leaf reveals a whitefly infestation, hover fly eggs, and a hover fly larva, in the center, getting to work on those whiteflies.
Repel with Smell

- **Marigolds**
  - Keep in mind the unscented marigolds will not work.

- **Mints**
  - Cabbage pests and aphids dislike catnip and other flavors of this family.

- **Rue** *(sometimes a reaction from the oil of these leaves gives a poison-ivy like rash)*
  - Deters Japanese Beetle.
  - You can scatter leaf clipping near beetle-infested crops.
Repel with Smell

- **Basil**
  - Control tomato hornworms.

- **Sweet Basil - Ocimum Basilicum**
  - Inter plant or chop and scatter the leaves to repel aphids, mosquitoes, and mites.
  - It also acts as a fungicide and slows the growth of milkweed bugs.

- **Tansy - tanacetum vulgare**
  - Repels, cucumber beetles, Japanese beetles, ants, and squash bugs.
Plant Beside:

- **Asparagus** beside **Tomatoes**, **Parsley** or **Basil** help control asparagus beetles.
- **Cabbage** beside **Tomatoes** or **Thyme** to control:
  - Flea beetle, cabbage maggots, white cabbage butterflies and imported cabbageworms.
- **Catnip** beside **Eggplant** to deter flea beetles.
- **Nasturtiums** beside **Cucumbers** to control the cucumber beetle.
  - Nasturtiums also deter whiteflies and squash bugs, but they are more often used as a trap crop for aphids.
Bring in the Beneficials

• Aphids a problem
  • To get a jump on early spring aphid activity, plant a small flowering plants that will grow in the early season cool weather. (Beneficial insects need a series of blossoms to sustain them from spring until fall.)
  • Fennel, dill anise, coriander...produce broad clusters of small flowers that attract beneficials.
Plants that Lure Beneficial in!

- Angelica – *angelica archangelica*
  - Lady beetles, lacewings
- Evening Primrose - *oenothera biennis*
  - Ground beetles
- Goldenrod – *solidago*
  - Lady beetles, predaceous beetles, parasitic wasps.
- Yarrow - *achillea*
  - Bees, parasitic wasps, hover flies.
Non-Pesticide Pest Control
FLY-BARR Insect Barrier

- Plastic filter, approximately 3/8" thick, with a net backing be used over greenhouse cooling pads, vents and shutters.
- Installed in the air flow such that the fiber filter is always forced toward the support netting.

Yellow Silky Traps – (sticky traps)

- Whiteflies prefer to feed on the tender, new growth of plants and are attracted to the color yellow. Also attract and trap flying aphids, fungus gnats, leafminers, thrips and many other insects.
Natural Plant Disease Control

Potassium bicarbonate;

• Serves as a fungicide to cure and prevent powdery mildew, blackspot, downy mildew, blights, molds and other plant diseases.

• Dissolves in water and is sprayed on leaves, flowers, stems and branches.

• Spray more often during rainy weather or during periods of high relative humidity.
Composting
The Benefits of Using Worm Tea

• Worm Tea will out-perform chemical fertilizer. Increasing both plant size and yield. This is due to interaction of Worm Tea microbes with the soil microbes and protozoa, soil particles and the roots of the plant itself.

• Worm Tea used as an inoculant for potting soil will suppress airborne pathogenic fungi that can readily infect sterile potting medium. The organisms in Worm Tea also produce hormones, vitamins, nutrients, enzymes, amino acids and minerals needed by seedling cuttings and young plants. Inoculation should be done two weeks prior to planting.

• Plants grown in soil treated with Worm Tea are healthier due to the symbiotic relationship between the plant and the microbes in the root zone. Plants feed the microbes and the microbes produce or make available all of the food and medicine the plant needs to thrive.

• Plants grown in soil treated with Worm Tea are more nutritious than plants grown in soil treated with chemical fertilizer. The food value of these plants is increased due to the availability of minerals, vitamins, enzymes and amino acids.

• Worm Tea can remediate soil that has been damaged by agricultural chemicals. With repeated application the microbes will adapt to the soil as well as convert and metabolize organic and inorganic chemicals. They will also sequester heavy metals not required by plants.
• Worm Tea can treat lawns affected with thatch, which is a condition caused by sterility in the underlying soil. Chemicals usually cause sterility. Worm Tea will repopulate the soil with microbes, enrich the roots and break down the thatch turning it into food for the grass.

• Worm Tea applied to the soil improves water retention. Many of the microbes manufacture protective mucus that acts as glue to agglomerate soil particles. Microbial colonies also make a bio-slime that is mostly water and is retained to protect the colony. The water retentive property of healthy soil can be 3-4 times greater than unhealthy soil.

• Worm Tea applied along with insoluble granulated or powdered minerals such as granite, limestone, rock phosphate, etc will supply 95% of everything the soil needs.

• The microbes in Worm Tea turn organic matter into humus, storing energy for later use. This is the basic unit of soil fertility.

• The microbes in Worm Tea feed other organisms in the soil food chain. Protozoa and nematodes feed on bacteria and fungi directly while worms ingest bacteria laden soil particles. All life in the soil depends on microbes, directly or indirectly.

• Worm Tea applied as a foliar spray will act as a fertilizer. Plants will produce more foliage and larger stems. This is a good treatment for plants that are stressed or lacking enough sun.

• Worm Tea applied to a compost pile will accelerate the breakdown of plant material reducing the amount of time to make compost. It can also be used to re-inoculate the pile after it has gone cold.
COMPOST ONLY

Fruit and vegetable scraps
Paper towels
Tea bags
Coffee grounds and filters

Do not include:
Meat, dairy, grains
Paper cups or paper plates
Plastic or metal

If in doubt, throw it out

Questions? Contact the Multnomah County Sustainability Program
recyclinginfo@co.multnomah.or.us
or http://MINT/recycle
PLANTING BY THE MOON: The Synodic (waxing and waning) cycle

Working with the appropriate phase of the Moon will increase quality as well as quantity in your crops. Farmers and herbalists use this system and producing vastly more potent medicinal and culinary plants. The Moon phase is the dominant influence in lunar planting. The days of Full Moon and New (or Dark) Moon are best avoided.

NEW MOON PHASE -
The sap is rising. Plant, graft and transplant annuals that produce above ground, especially those of a leafy kind that produce seeds outside the fruit, also cereals and grains. Don't pick anything as it rots too easily at this time.

FIRST QUARTER PHASE -
The sap is still rising - this is a good phase for starting anything. Plant, graft and transplant annuals that produce above ground, especially of a vine-type with seeds produced inside (like beans, peas, peppers, squash and tomatoes).

FULL MOON PHASE -
Peak sap flow and then a slow withdrawal as the Moon wanes. Plant perennials, biennials, bulb and root crops and anything that produces below ground. The sap flow is downwards into the roots. Pruning is most successful now, and it is an excellent time to harvest all crops. Medicinal herbs and plants are most potent when picked now.

LAST QUARTER PHASE -
This is the barren phase. It is great for cultivation - pulling weeds, turning the earth, pruning, spraying. This is the best phase for harvesting crops that you want to store for a period of time without rotting or losing flavor. Transplant close to the end of this period for an easy recovery with little trauma.