BASICS OF HYDROPONIC CROP PRODUCTION

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Horticulture and Hydroponics Crops Specialist

October 15, 2016
<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>2142</td>
<td>25</td>
<td>24</td>
<td>11</td>
<td>12</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Cucumbers</td>
<td>252</td>
<td>10</td>
<td>1</td>
<td>0.3</td>
<td>0.2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Herbs, cut fresh</td>
<td>318</td>
<td>1</td>
<td>2 (Z)</td>
<td>1</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lettuce, all</td>
<td>99</td>
<td>1</td>
<td>5</td>
<td>0.2</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Peppers, all</td>
<td>81</td>
<td>1</td>
<td>1</td>
<td>0.4</td>
<td>(D)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Strawberries</td>
<td>14</td>
<td>0</td>
<td>0</td>
<td>0.2</td>
<td>(D)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Tomatoes</td>
<td>978</td>
<td>6</td>
<td>10</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Other food crops</td>
<td>399</td>
<td>5</td>
<td>6</td>
<td>3</td>
<td>(D)</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations and Symbols:

(Z) Less than half of the unit shown
(D) Withheld to avoid disclosing data for individual operations
## STATISTICS – Indiana

### Horticulture Specialties Census: 2014
**Food Crops Grown Under Protection and Sold**

<table>
<thead>
<tr>
<th>Production % from hydroponics</th>
<th>Value of sales %</th>
<th>Total: U.S.</th>
<th>Value of sales %</th>
<th>Total: Indiana</th>
<th>Value of sales %</th>
<th>Total: Indiana</th>
<th>Value of sales %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>63.4</td>
<td>76.1</td>
<td>23.9</td>
<td>11.5</td>
<td>64.4</td>
<td>35.6</td>
</tr>
<tr>
<td>Herbs, cut fresh</td>
<td></td>
<td>20.9</td>
<td>99.4</td>
<td>0.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lettuce, all</td>
<td></td>
<td>56.9</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tomatoes</td>
<td></td>
<td>5.5</td>
<td>41.7</td>
<td>58.3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Abbreviations and Symbols**

(-) No information available
HYDROPONICS

• The word hydroponics technically means working water, stemming from the Latin words "hydro" meaning water, and "ponos" meaning labor.

• Hydroponics is a subset of hydroculture and is a method of growing plants using mineral nutrient solutions, in water, without soil.

• Two types of hydroponics, solution culture and medium culture.

• Solution culture types (only solution for roots)
  – Continuous flow solution culture, Nutrient Film Technique (Dr Alan Cooper, 1960’s)
  – Aeroponics

• Medium culture types (solid medium for roots, sub- or top irrigated, and in a container)
  – Ebb and Flow (or flood and drain) sub-irrigation
  – Run to waste (drain to waste)
  – Deep water culture, plant roots suspended in nutrient solution
  – Passive sub-irrigation, inert porous medium transports water and nutrients by capillary action. Pot sits in shallow solution or on a capillary mat saturated with nutrient solution.
SOILLESS PRODUCTION, key system features

NUTRIENT FILM TECHNIQUE

- Recirculating cultivation system
- Continuous flow of nutrient solution past roots
- Shallow stream (film) of water containing all dissolved nutrients is recirculated past the bare roots of plants in a watertight, dark channel.
- Roots develop at bottom of channel allowing for an abundant supply of oxygen to the roots.
- Slope of 1:100 recommended, but 1:30 and 1:40 are also used
- As general guide the flow rate is 1 L (0.26 gal.) per minute with an upper limit of 2 L (0.53 gal) per minute
- Channel length should not exceed 10-15 meters (33-49 ft.)
- Operator have to pay close attention to nutrient balances, water temperature and pathogens
NUTRIENT FILM TECHNIQUE, fixed channel

Photo: CROPKING

Photo: hydrocentre.com.au
NUTRIENT FILM TECHNIQUE, mobile channel system

Watch video, MGS by Hortiplan
www.hortamericas.com

Photos courtesy of Karlovec Media Group
Facility of Great Lakes Growers, Burton, Ohio
INDOOOR VERTICAL FARMS, growing with supplemental LED’s

Photos: Green Sense Farms

Photos: Growtainer

Photos: Freight Farms

Photos: FarmedHere
DEEP WATER CULTURE (DEEP FLOW), vegetable seedling production

Without seedling trays

With seedling trays

Photos: Petrus Langenhoven
VARIATION: GRAVEL FLOW TECHNIQUE, home gardener

Photos: Petrus Langenhoven
AEROPONICS, recirculating cultivation system
Roots are continuously or discontinuously kept in an environment saturated with a mist or aerosol of nutrient solution

Anthurium flower production

Potato Photos: Neiker-Tecnalia
http://www.basqueresearch.com/new/2172

Potato seed production

5-10 times more seed than potted systems, International Potato Center (CIP)
MEDIUM CULTURE
EBB AND FLOW, recirculating cultivation system
EBB AND FLOW, recirculating cultivation system - Heartland Growers, Westfield IN

Photos: Petrus Langenhoven
RUN TO WASTE (drain to waste), container with substrate, irrigated individually

Photos: Petrus Langenhoven
RUN TO WASTE (drain to waste), high tunnel

Photos: Petrus Langenhoven
RECIRCULATING, soil grown (Belgium)
RECIRCULATING, Rockwool slabs with 4 plants per slab

Photos: Petrus Langenhoven
### POPULAR AGGREGATES/SUBSTRATES

<table>
<thead>
<tr>
<th>Inorganic Media</th>
<th>Natural</th>
<th>Synthetic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td>Foam mats</td>
<td>Sawdust</td>
</tr>
<tr>
<td>Gravel</td>
<td>(Polyurethane)</td>
<td>Bark (Pine)</td>
</tr>
<tr>
<td>Rockwool</td>
<td>Polystyrene Foam</td>
<td>Wood chips</td>
</tr>
<tr>
<td>Glasswool</td>
<td>“Oasis”</td>
<td>Peat moss</td>
</tr>
<tr>
<td>Perlite</td>
<td>(Plastic Foam)</td>
<td>Coir</td>
</tr>
<tr>
<td>Vermiculite</td>
<td>Hydrogel</td>
<td>(Coconut fiber)</td>
</tr>
<tr>
<td>Pumice</td>
<td>Biostrate Felt®</td>
<td>Rice Hulls</td>
</tr>
<tr>
<td>Expanded Clay</td>
<td>(Biobased Product)</td>
<td></td>
</tr>
<tr>
<td>Zeolite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volcanic Tuff</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Photos: Petrus Langenhoven
CROPS
HYDROPOSIC lettuce and basil

Photo: Petrus Langenhoven

Photo: Rutgers Univ. EcoComplex
TOMATO AND CUCUMBER in soilless substrate

Photos: Petrus Langenhoven
PRODUCTION OF ALTERNATIVE HIGH VALUE PRODUCTS
(examples of baby squash)

Photos: Petrus Langenhoven
MELONS – Vertically trellised in a high tunnel or greenhouse
CROP: BASIL  -  Who is my customer?

Organic, Soil-grown herbs

Potted living herbs grown in soilless substrate

Hand-picked herbs grown in soilless substrate

Photos: Petrus Langenhoven

Photo: Kitchen Pick Living herbs
## INTERPRETING IRRIGATION WATER TESTS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Level of concern</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>EC</td>
<td>Above 1.5 dS m(^{-1})</td>
<td>Accumulation of specific salt which reduce crop growth</td>
</tr>
<tr>
<td>pH</td>
<td>Below 5.4 or above 7.0</td>
<td></td>
</tr>
<tr>
<td>Total Alkalinity (as CaCO(_3)), acid-buffering capacity</td>
<td>Below 30 ppm or above 100 ppm</td>
<td>pH 5.2, 40 ppm alkalinity; pH 5.8, 80 ppm alkalinity; pH 6.2, 120 ppm alkalinity</td>
</tr>
<tr>
<td>Hardness (amount of dissolved Ca and Mg)</td>
<td>Below 50 ppm or above 150 ppm</td>
<td>Equipment clogging and foliar staining problems above 150 ppm</td>
</tr>
<tr>
<td>Bicarbonate (HCO(_3)(^-))</td>
<td>Above 122 ppm</td>
<td>Increased pH and can lead to Ca and Mg carbonate precipitation</td>
</tr>
<tr>
<td>Chloride</td>
<td>Above 30 ppm for sensitive plants; above 70 ppm for most plants</td>
<td>Revers osmosis</td>
</tr>
<tr>
<td>Sodium</td>
<td>Above 50 ppm</td>
<td>Reverse osmosis</td>
</tr>
<tr>
<td>Sulfate</td>
<td>Above 90 ppm</td>
<td>High concentrations can lead to build-up of sulfur-bacteria in irrigation lines that could clog emitters</td>
</tr>
<tr>
<td>Boron</td>
<td>Above 0.5 ppm</td>
<td></td>
</tr>
<tr>
<td>Iron</td>
<td>&gt;0.3 ppm, clogging; 1.0 ppm, foliar spotting and clogging; above 5.0 ppm, toxic</td>
<td>Could lead to iron precipitates resulting in plugging of irrigation system emitters</td>
</tr>
</tbody>
</table>
Nutrient solution
Electrical conductivity (EC), affected by the concentration and valence of ions
Units may be confusing!

1 mmho cm\(^{-1}\)
1 dS m\(^{-1}\)
1 mS cm\(^{-1}\)
10 mS dm\(^{-1}\)
100 mS m\(^{-1}\)
1000 µS cm\(^{-1}\)
EC readings of a 2 mS·cm$^{-1}$ solution, affected by temperature

<table>
<thead>
<tr>
<th>Temp (°F)</th>
<th>Temp (°C)</th>
<th>EC (mS cm$^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>59</td>
<td>15</td>
<td>1.62</td>
</tr>
<tr>
<td>68</td>
<td>20</td>
<td>1.80</td>
</tr>
<tr>
<td>77</td>
<td>25</td>
<td><strong>2.00</strong></td>
</tr>
<tr>
<td>86</td>
<td>30</td>
<td>2.20</td>
</tr>
</tbody>
</table>
pH range of 5.2-6.5 for optimal nutrient availability

Source: www.taiwanhydroponics.com
MACRO NUTRIENT DEFICIENCIES

- N
- P
- K
- Ca
- Mg
- S

http://www.haifa-group.com/knowledge_center/crop_guides/tomato/plant_nutrition/nutrient_deficiency_symptoms/
13 weeks after transplanting

100% NO$_3^-$-N

40% NH$_4^+$-N

Blossom-end rot

9 weeks

Purdue University Cooperative Extension Service is an equal access/equal opportunity institution.
FERTILIZER AND NUTRIENT SOLUTION MIXING TIPS

- Use **high quality ingredients** for your nutrient solution
- If using mixed fertilizer, make sure the blend has a tag that shows the **analysis of the fertilizer**, the source used and company’s name
- Do **accurate calculations** and use accurate scales
- **Lukewarm water** will speed up the time for dissolution of the fertilizer
- **Stir** while mixing the fertilizer, mechanical or by hand
- Make sure **compatible fertilizer** are mixed in the same tank. Insoluble precipitates will form when mixed in concentrated form
- **Calcium phosphate**, from calcium nitrate and phosphorus materials; **calcium sulfate**, from mixing calcium nitrate and magnesium sulfate
- **Two-tank system**: calcium, iron and potassium nitrate in one tank and the rest in the other tank
- Keep solution in a **dark environment**
HIGH TUNNELS AND GREENHOUSES

Photos: Petrus Langenhoven
High tunnels are low-cost, passive, solar greenhouses which use no fossil fuels for heating or venting. High tunnels can provide many benefits to horticulture crop producers:

- **Modify growing environment** for crop earliness
- **Protect the growing crop** from environmental stress such as driving rain, wind, hail, extreme light intensity, and temperature extremes
- **Reduction** of insect and disease pressure
- Well suited for **producing** specialty crops, which require a specific growing environment
- Permit **intensive crop production** on a small area of land
- **Possible Uses**
  - Are used to **extend the growing and harvest season** of warm season vegetable crops, both in spring (starting in February) and fall (continuing through November); tomato, pepper etc.
  - **Winter harvesting** for cool season vegetables; baby salad greens, spinach, carrot, beet, leek, etc.
  - **High value specialty crop** protection; small fruit, cut flowers, potted plants, etc.
GREENHOUSES

The terms greenhouse, high tunnel, hoop house and cold frame are sometimes used interchangeably.

By definition, a greenhouse has a heat source other than solar energy

• To optimize plant growth the greenhouse climate is controlled by computer and equipment i.e. circulation and extraction fans, screens, lighting, heating, cooling etc.

• Structure can be covered by two layers of polyethylene film, with an electric inflation fan keeping the two layers separate for better insulation

• Other glazing materials such as polycarbonate and glass can be used

• Focus is usually on soilless production systems, but production in the soil is also popular
RELIABLE INFORMATION SOURCES

• Professional magazines

• Books
  – Greenhouse Technology and management, Nicolas Castilla
  – Greenhouse Operation and Management, Paul V. Nelson
  – Soilless Culture, Michael Raviv & J. Heinrich Leith
  – Growing Media for Ornamental Plants and Turf, Kevin Handreck & Niel Black
  – Plant Nutrition of Greenhouse Crops, Cees Sonneveld & Wim Voogt
  – Hydroponic Food Production, Howard M. Resh

• Trade shows and conferences
  – Aquaponics Conference, October 28-29, 2016 – Kokomo IN
  – Great Lakes Fruit, Vegetable and Farm Market EXPO, Dec 6-8, 2016 – Grand Rapids MI
  – Indiana Horticulture Congress, January 10-12, 2017 – Indianapolis IN
  – Indiana Small Farm Conference, March 2-4, 2017 – Danville IN
  – Indoor Ag Con, May 3-4, 2017 – Las Vegas NV
  – Cultivate’17, July 15-18, 2017 – Columbus OH

• University resources
THANK YOU

Questions?

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