1 Sustainable hydroponic crop production

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Topics

1. Sustainability
2. Historic overview of hydroponic crop production
3. Hydroponic vs field crop production: Advantages
4. Hydroponic vs field crop production: Disadvantages
5. Hydroponics and the environment
6. Hydroponic systems overview
What is sustainable agriculture?

With sustainable agriculture practices we want to improve the quality of life of farmers and the community by raising profitable crops and livestock while preserving the environment and natural resources.

We want to meet society’s food needs and make sure that future generations will have resources to meet their own needs.
Pillars of sustainable crop production

Sustainable crop production practices are focused on the 3 Pillars of sustainability:

- Profit over the long term
- Stewardship of our nation’s land, air and water
- Quality of life for farmers, ranchers and their communities
### How can hydroponics be sustainable

<table>
<thead>
<tr>
<th>Profitable</th>
<th>Preserving the environment</th>
<th>Quality of life</th>
</tr>
</thead>
<tbody>
<tr>
<td>More produce per square foot</td>
<td>Less land requirement</td>
<td>Natural areas preservation</td>
</tr>
<tr>
<td>Lower use of pesticides</td>
<td>Less risk of pesticide drift</td>
<td>Access to safe produce</td>
</tr>
<tr>
<td>Efficient water use</td>
<td>Lower use of water</td>
<td>Urban Agriculture</td>
</tr>
<tr>
<td>Less fertilizer use</td>
<td>Lower risk of pesticide and fertilizer leaching</td>
<td>Access to fresh local food</td>
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<tr>
<td></td>
<td></td>
<td>↑Profit=more taxes to serve the community</td>
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</tbody>
</table>
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What is hydroponics?

*Hydro* (Greek) *hudōr* = water

+ *ponic* (Greek) *ponos* = labor/work

Cropping system that uses an **inert medium** and delivers nutrients in the **nutrient solution**.

**It is a soilless system.**
History of hydroponics

Hanging Gardens of Babylon (605 BC)

Woodward (1699)

Von Sachs and Knop (1860s)

Gericke (1929)

Foto: National Geographic
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Advantages: No seasonality

Year round production is possible
Advantages: Short crop cycles

Lettuce ready to harvest in 35 to 45 days

Compared to more than 70 days in the field
Advantages: High yields

**Hydroponic tomato yield**
- 1975: 89 Ton/acre/year *
- 1990: 181 Ton/acre/year
- 2005: 300 Ton/acre/year

**Tomato yield on soil:**
- 2012: 3.6 – 6.5 Ton/acre/year
  (NASS, 2012)

*Based on a plant density of 10,000 plants per acre.*
Advantages: Food safety

Hydroponic Lettuce
• Lower risk of contamination
• 0 foodborne disease outbreaks from 2014 to 2019

Field Lettuce
• Higher risk of contamination
• 54 foodborne disease outbreaks from 2014 to 2019
## Resources

<table>
<thead>
<tr>
<th>Hydroponic Lettuce</th>
<th>Field Lettuce</th>
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</thead>
<tbody>
<tr>
<td>• Low land requirement</td>
<td>• High land requirement</td>
</tr>
<tr>
<td>• 166 Ton/acre/year *</td>
<td>• 15 Ton/acre/year</td>
</tr>
<tr>
<td>• Water: 2.4 gal for each pound per year*</td>
<td>• Water: 30 gal for each pound per year</td>
</tr>
<tr>
<td>• 11 kWh per pound per year*</td>
<td>• 0.14 kWh per pound per year</td>
</tr>
<tr>
<td>• Higher infrastructure costs</td>
<td>• Lower infrastructure costs</td>
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<tr>
<td>($2.5 to $5 per sq ft a year)</td>
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Disadvantages

• High energy use
• Investment: equipment and greenhouse
• Limited crop diversity

**HYDROPONIC LETTUCE**
Higher infrastructure costs
($2.5 to $5 per sq ft per year)
• Steep learning curve

**FIELD LETTUCE**
Lower infrastructure costs
($0.2 per sq ft per year)
Why are yields higher?

Higher yields are a result of the combined effects of:

• Varieties (indeterminate tomato)
• High control of the environment and plant nutrition.
• Efficient use of space (vertical farming)
Why is market demand increasing?

- Consumers want produce that uses less resources (water, soil, and fertilizers) while preserving natural ecosystems and biodiversity.
- Urban areas want fresh local produce.
- People want produce grown with less pesticides.
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Environmental impacts

- Preservation of soils and forests (Higher yields)
- Pollution: lower risk of fertilizer and pesticides runoff and infiltration
- Lower use of resources (water and fertilizers)
- Lower use of pesticides (no need to control weeds)
- Able to supply fresh locally sourced food
- High use of energy (renewable sources)
- High use of plastics
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Types of hydroponic systems

Liquid

Solid
Liquid systems

Floating raft/Deep water culture (DWC)
- Air pump
- Diffusor
- Nutrient solution
- Floating raft

Aeroponic
- Submergible pump
- Sprinkler/fogging nozzle

NFT
- Floating raft
- Nutrient solution

Deep water culture (DWC):
- Air pump
- Diffusor
- Nutrient solution
- Floating raft

Aeroponic:
- Submergible pump
- Sprinkler/fogging nozzle
Solid systems

Growing media
(potting mix, coir, perlite, etc.)

Dutch or Bato bucket

Submergible pump

Nutrient solution

Dripper

Ebb and flow

Fiber mat

Wick/mat

Fiber wick
Deep water culture (DWC)
DWC

✓ For leafy greens and herbs
✓ Plants won’t wilt if pump fails
✓ Simple construction requires less parts

× Needs aeration
× High water and fertilizer use
× Needs more time and resources to adjust the temperature, pH, and dissolved oxygen
Nutrient Film Technique (NFT)
NFT

✓ For leafy greens and herbs
✓ No need for aeration
✓ Use less water and fertilizers than DWC
✓ Easier to adjust pH and temperature than DWC

✗ Susceptible to leakage
✗ Driplines can clog
✗ Plants wilt immediately if pump fails or if the system clogs
Dutch/Bato bucket

Growing media
(potting mix, coir, perlite, etc.)

Dripper

Drainage

Submergible pump

Nutrient solution
Dutch/Bato bucket

• Ideal for vines and fruiting crops—tomato, cucumber, cantaloupe

• Needs trellis system to guide plant growth and support weight

• The irrigation frequency and nutrient/water retention will depend on the type of growing media
Growing media options

- Perlite
- Coir
- Expanded clay pellets
- Rockwool
- Gravel
- Potting mix

Any material that can be sourced locally?

Affordable
Sustainable
Locally sourced
Rockwool

- Water retention, good aeration, adaptable to several systems, and stable over time
- Requires prolonged saturation, difficult to decompose, not organic, and costly
Coconut coir

☑ Retains water and nutrients, good aeration, sustainable, cheap, and compostable
☒ Variable quality (depends on supplier) and not stable over time
Other growing media materials

- **Perlite**
  - ✓ Cheap, aeration
  - ❌ Low water retention, dust

- **Expanded clay pellets**
  - ✓ Cheap, stable over time
  - ✓ Reusable, stable over time
  - ❌ Low water retention, $$$, heavy

- **Gravel**
  - ✓ Cheap, stable over time
  - ❌ Low water retention, heavy

- **Commercial mixes**
  - Sustainable? (peat)
  - ✓ Retains water and nutrients
  - ❌ pH changes over time (constant monitoring) not stable over time
Aeroponics

Submergible pump

Micro sprinkler/fogging nozzle

Nutrient solution
Aeroponics

✓ For leafy greens, herbs, and strawberries
✓ No need for aeration
✓ Requires less water than NFT and DWC
✓ Adaptable to many designs

✗ Requires good water quality to prevent clogging
✗ Plants wilt immediately if pump fails or emitters clog
✗ Requires a pressurized irrigation system
Aquaponics

It’s not easy. The fish residues may not provide all nutrients and there is a lot of solid residues.
The Aquaponics Cycle

1. Fish
   - Fish produce waste
2. Microbes & Worms
   - Microbes & worms convert waste to fertilizer for plants
3. Plants
   - Plants filter water that returns to the fish

Fish

Microbes & Worms

Plants

Tomatoes

Parsley
Aquaponic systems

Coupled/cyclic

Sump
Fish tank
Solids removal
Mineralization*
*Optional

Hydroponic crop
Biofiltration

Decoupled/
linear

Fish tank
Solids removal
Biofiltration
Crops
Build your own system