Food Production Workshop:
Greenhouses, Hydroponics & Aquaponics
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Schedule for today

- Greenhouses
- Hydroponics
- Lunch (on your own)
- Aquaponics
Do you own a greenhouse?
Do you use hydroponics to grow food crops?
Do you have an aquaponics system?
Any commercial growers in the audience?
Any teachers or educators in the audience?
Please don’t build this greenhouse!

Visqueen plastic
PVC frame
Sits on the ground
Inexpensive, but....
Why not?

• Snow
• Wind
• Intense sun
• Frost zone

• Best option:
  – Specifically designed solar greenhouses
Solar Greenhouse Principals

1. Orientate to collect most solar heat
2. Store the heat
3. Insulate all other areas
4. Minimize heat loss to leaking
5. Maximize natural ventilation

Adapted from Solar Greenhouses, ATTRA publication #IP142
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Light

• Know the sun’s path in all seasons

• Why?
  – Consider winter shadows

• How?
  – Observation
  – Solar Pathfinder
  – Sun path chart
    – Available online
    – Many different formats
    – Same concept
Know the sun’s path in all seasons

SUMMER ALTITUDE = 73 1/2°
@ SOLAR NOON — JUN 21

WINTER ALTITUDE = 26 1/2°
@ SOLAR NOON — DEC 21

Solar path at 40° north latitude

Roof Angle

• 45° to 60° slope of the glazing
• Rule of thumb add 10° to 15° to latitude
• Longmont greenhouse:
  – 50-55° slope of south facing glazing
Cheyenne Botanic Garden

Summer
Sun is higher in the sky and casts a shadow over the water-filled tubes and drums of the Botanic Gardens greenhouse helping to keep the greenhouse cool.

Winter
Sun is lower in the sky shining directly into the Botanic Gardens greenhouse directly illuminating and warming the water-filled tubes and drums. This helps keep the greenhouse warm.
Glazing-which to choose?

- Glass (regular or tempered)
- Polyethylene sheeting (single or double layer)
- Acrylic
- Polycarbonate (single, double, triple wall)
- Fiberglass
Polycarbonate

- Different thicknesses
- Double-wall
- Triple-wall
- Requires crating & freight shipping = $$$

Photo: growersupply.com
Tradeindia.com
Polyethylene Sheeting
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Dark, non-reflective barrels

- Fill with water
- Milk jugs can also be used—more surface area
- 5 gallons per sq ft of glazing
Water wall

Photo: www.crestedbuttefarm.com
Phase change materials?

- Disodium phosphate dodecahydrate
- Sodium thiosulfate pentahydrate
- Paraffin
- Glauber’s salt (sodium sulphate decahydrate)
- Calcium chloride hexahydrate
- Fatty acids

From Solar Greenhouses, ATTRA publication #IP142
Rock wall

- 80-200 lbs per sq ft of glazing
- Low heat holding capacity than water
Soil heat storage
• Perforated, corrugated polyethylene tubing (4” diameter)
• Hook up to fan and force warm air into soil
• Could also use water or phase change material
Yampah Mtn H.S., 22’ dome
Roaring Fork H.S., 42’ dome
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Wall and Floor Insulation

• All non-glazed walls should be insulated
• Consider adding plastic film as vapor barrier
• 1-2” of foam on outside of foundation
• Strawbales?
  – Use with caution due to high moisture
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Venting

- Very Important!
- Vent area = 1/5 to 1/6 of floor area
- Manual or automatic
- Rely on wind?
Solar Powered Vent Openers

- ~$60
- Set to open between 55-75F
- Wax cylinder contracts/expands
- Weight limits
- Freedom!
Fresh Air Exchange

- Plants need carbon dioxide
- Especially in winter when greenhouse closed

\[ \text{Sun} \quad + \ 6 \text{ CO}_2 + 6 \text{ H}_2\text{O} \quad \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 \]
Other considerations
Fertilizing options

**Organic**
- Fish Emulsion
- Compost
- Guano
- Kelp
- Blood meal
- Molasses
- Yeast
- Etc.

**Non-organic**
- Water soluble
  - Miracle Grow
  - Peters
- Controlled release
  - Osmocote
  - Sierra
Soil testing

• Electrical conductivity (EC) and pH pens
  – EC measurement of soluble salts
    • K, Na, Cl, NO₃, NH₄
  – <$160 for handheld combo meter
  – Calibration is important

• Full nutrient analysis
  – Send to lab for best analysis
  – CSU Soil, Water and Plant Testing Lab
  – Check “Alternative Soil Testing Laboratories” publication by ATTRA
Irrigation water testing

• Check for EC, pH, hardness, salinity
• Send to testing lab
  – Colorado Analytical Labs, Ward, others
• At home kits
Water Based on Need not Calendar

• What are the plants’ irrigation needs?
• Depends on:
  – Evaporation
  – Frequency
  – Amount
  – Method of water application
  – Type of media
  – Plant cultivar
  – Environmental conditions
Harmful Gases

- Natural gas
  - Leaky heating system
  - Epinasty
- Ethylene
  - Reduced blooms
  - Epinasty

Photo: B. Whipker
Wood preservatives

• No treated wood in certified organic
• Direct toxicity (roots in contact)
• Gases given off
• Common preservatives
  – Pentachlorophenol
  – Creosote
• Can paint over with special paint B-I-N®
Season extension resources
Row Covers

Spun-bonded Fabric

Hoops

Photo: MN Institute for Sustainable Ag
Planting Methods

• Intercropping
• Succession planting
• Some plants can be harvested multiple times—Spinach, leaf lettuce, herbs
• Others only once—carrots, head lettuce, etc
Planting Schedules

• Depends on light and temperature
  – Slowed growth in the winter
• Grower research will be required
• Resource: The Winter Harvest (Eliot Coleman)
Adapted from The Winter Harvest Handbook, E. Coleman
Greenhouse vs. Field Varieties

• Not all varieties perform as well in greenhouse conditions
• Personal research will be needed
• Talk to other growers & attend meetings
• List serve:
  http://listserv.ksu.edu/web?A0=HIGHTUNNELS
Pollinating Concerns
Hybrid, Heirloom, Open Pollinated?

• Hybrid/F1: specifically bred/crossed for certain traits, can’t save seed
• Heirloom: Adapted over time to conditions where they have been grown, can save seed
• Open pollinated: May or may not be heirloom, can save seed but may not be true unless plant is isolated
Vertical growing

• Saves space
• Need structure that can support weight