Retrofitting and Operating Tobacco Greenhouses for Alternative Crops Production

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Greenhouse Types - Homemade
- Inexpensive
- Often used in soil culture
- Difficult to heat
- Difficult to ventilate

Greenhouse Types - Quonset
- Moderate expense
- Unusable production space on edges
- Machinery utilization difficult

Greenhouse Types - Short Sidewall
- Moderate expense
- Less unusable space on edges than Quonset houses
- Equipment utilization (?) – dependant on height of sidewalls

Greenhouse Types - Sidewall
- More expensive
- Load Rated structure - 80 mph / 20 lb/ft²
- Long Life
- $20,000 plus

Greenhouse Types – Gutter Connect
- More expensive
- Load Rated structure
- Long Life
- $20,000 plus
- Good for multiple houses
Greenhouse Size

Length
- 96 ft.
  - Ideal
- < 96 ft.
  - Increases your expense
- > 96 ft.
  - Makes air movement and ventilation difficult

Width
- Freestanding
  - 30 – 32 ft.
- Gutter Connect
  - < 24 ft.
  - 30 – 32 ft.

Overall
- 24 ft. X 96 ft. (gutter)
- 32 ft. X 96 ft. (free)

Tobacco Greenhouse Size

Generally:
- 30 – 32 ft wide
- Width is okay
- 150 – 200 ft long
- Over 150 ft
  - Too long to pull air for ventilation
    - Tomatoes
    - Cucumbers

Solutions
- Use for lettuce production
- Use for transplant production
- Shorten houses to 100 to 150 ft long
  - Tomatoes
  - Cucumbers

Retrofitting Tobacco Greenhouses

Many tobacco greenhouses in out part of the world have float beds.
- Gravel
- Sand

If soil or sand, then could use for in ground production
- May need to rev
If gravel, may be limited to:
- Hydroponic production
- Transplant production

Greenhouse Coverings

Plastic
- 4 mil. (no!)
- 6 mil.
  - Single layer (no!)
  - Double layer
  - Affordable

Fiberglass (no!)
- Yellows and reduces light penetration

Polycarbonate
- Single layer (no!)
- Twin wall
- Triple wall
- Expensive
- Good for end walls

Greenhouse Heating

Heat need equations
- Heat required = U x A x (T_{inside} – T_{outside})
- Where
  - U = heat flow coefficient
    - Single layer of plastic = 1.2
    - Double layer of plastic = 0.8
  - A = surface area of the greenhouse
  - T = temperature rise

Greenhouse Plastic Inflation

Position to keep about 2 inches of air between the layers of plastic

Use outside air to reduce condensation

Use jumper hoses for end walls

Do not over inflate
- Cancels the effect of the dead air space
- Makes the plastic more prone to wind damage

Allen Straw, VCE Area Specialist, Glade
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Greenhouse Heating Example

- Parameters
  - U = 0.8 (double layer plastic)
  - A = 4,600 ft² (32 ft. x 96 ft.)
  - T = 60 degree rise
- Heat Requirement = 0.8 X 4,600 x 60 = 220,800 btu’s
- 80% efficiency = 276,000 btu’s
- Two (2) - 150,000 btu furnaces

Heaters

- Issues
  - Some of the earliest tobacco greenhouses used unvented heaters
  - Will not work for tomatoes
  - One half ppm ethylene can knock off blooms

Heat Sources

- Traditional
  - Forced Air Heaters
    - Natural Gas
    - LP Gas
    - Fuel Oil
  - Coal Stoves
  - Wood Stoves
- Alternatives
  - Corn (?)
  - Dual Sources
    - Wood and Gas
    - Wood and Fuel Oil
  - Central Boilers (Hot Water)
    - Wood
    - Coal
    - Dual Sources

Caution

- Be careful with petroleum heaters
  - Do not use ventless heaters
  - Regularly inspect the heat exchangers in forced air furnaces
  - Use heaters designed for greenhouse use

Ethylene Damage

- About 0.5 ppm at the “wrong” time will knock blooms off of tomatoes

Heaters (cont.)
### Outside Wood Stoves

- **Image of wood stove**

### Greenhouse Ventilation/Cooling

- **Minimum of 1 air exchange / minute**
- **Calculate ft.\(^3\) of the greenhouse**
  - \(32\text{ ft.}\times 96\text{ ft.}\times10\text{ ft.}\)
  - \(<30,000\text{ ft.}^2\)
  - Two 15,000 cfm fans
    - 48 in. fans
    - \$800 each

- **Inlets**
  - \(\text{ft.}^3/700\) (wind velocity at inlet in ft/min.)
  - \(30,000/700 = 43\text{ ft.}^2\)
  - Two 5 ft. square shutters
    - \$215 each
    - \$70 each (motors)
  - Rule of thumb
    - Inlet shutters should be 1.25 to 1.5 times larger than fan dia.

### Greenhouse Cooling (cont.)

- **One air exchange per minute**
  - 11 degrees F warmer than the outside air temperature
- **Two air exchanges per minute**
  - 7 degrees F warmer than the outside air temperature

### Fans and Shutters

- **Cool Pads or Cool Cells**
  - Can be used to provide more cooling
  - Works best in low humidity (desert)
  - Evaporative cooling
  - Helps, but not as effective in the humid Mid-Atlantic or Southeastern U.S.

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  - Rule of thumb
    - Inlet shutters should be 1.25 to 1.5 times larger than fan dia.
Many tobacco Greenhouses were equipped with side curtains for ventilation.
- These might work for:
  - Lettuce
  - Transplants
- They might work when tomato / cucumber plants are small.
- Are not effective when plants get larger.

Horizontal air flow fans
- 12 to 18 in.
- 4 in the house
- Make a race track
- ½ way in from side walls
- ¼ to 1/3 way in from endwalls

As low as possible
- Optimum
  - < 60 – 70%
- Realistic
  - < 80 – 90%
- Humidity control fan
  - Switch
  - Timer
  - Humidistat
Support
- Support
  - Greenhouse itself
  - Separate frame
  - Provide overhead support - wire
  - Nylon twine
    - Clipped to base of the plant
    - Tied to a wire or cable

Wood – Treated 4” X 4”

Overhead Wire

Irrigation
- Solar Grow Timer
  - Davis Engineering
  - Available through Hydro-Gardens
    - Water by sunlight intensity
    - $600

Solenoid Valves
- Used to turn water on and off
- Allows zoning
  - Limited water supply
  - Different watering time
  - $20 each

Injection System
Two Important Equations

- **Bulk Tank**
  \[ \text{ppm} = (\% \text{ fertilizer}) \times (\text{lb added to tank}) \times (16 \text{ oz/lb}) \times (0.75) \times (100 / \text{gal of bulk tank}) \]

- **Injector System**
  \[ \text{ppm} = (\% \text{ fertilizer}) \times (\text{lb added to tank}) \times (16 \text{ oz/lb}) \times (0.75) \times (100 / \text{gal of concentrate}) \times (1 / \text{ratio of injector}) \]

Bulk Tank Example

- (0.5 lb of 3 – 15 – 28)
  \[ \text{(N)} \]
  \[ \text{ppm} = (\% \text{ fertilizer}) \times (\text{lb added to tank}) \times (16 \text{ oz/lb}) \times (0.75) \times (100 / \text{gal of bulk tank}) \]
  \[ \text{ppm} = 3\% \times 0.5 \text{ lb} \times 16 \text{ oz/lb} \times 0.75 \times 100/100 \]
  \[ \text{ppm} = 18 \]

Injector System Example

- (25 lb of 3 – 15 – 28)
- 50 gallons of concentrate
- Injector ratio of 1:100
- \((\text{N})\)
  \[ \text{ppm} = (\% \text{ fertilizer}) \times (\text{lb added to tank}) \times (16 \text{ oz/lb}) \times (0.75) \times (100 / \text{gal of concentrate}) \times (1 / \text{ratio of injector}) \]
  \[ \text{ppm} = 3\% \times 25 \text{ lb} \times 16 \text{ oz/lb} \times 0.75 \times 2 \times 1/100 \]
  \[ \text{ppm} = 18 \]

Two Things to Keep in Mind

- \(\text{P} \times 2.291 = \text{P}_2\text{O}_5\)
- \(\text{P}_2\text{O}_5 \times 0.437 = \text{P}\)
- \(\text{K} \times 1.205 = \text{K}_2\text{O}\)
- \(\text{K}_2\text{O} \times 0.83 = \text{K}\)

- There is no exact "recipe" greenhouse cucumber production
  - Each crop is different
    - Light intensity
    - Temperature
    - Etc.
NFT – Nutrient Film Technique

Inexpensive NFT Systems

Lettuce NFT System

Thank You!

Questions?

Allen Straw, VCE Area Specialist, Glade Spring, Feb. 25, 2010