
for the Western New York Greenhouse Programs

With suggestions from:
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Monroe & Ontario Counties
Agenda

- Structures you grow in?
- Age of structures?
- Tips & tricks
- Fuels you use?
- Cropping implications
- Budget implications
Heating Energy

- Fuel costs rising substantially since year 2000
- Suggestions for reduce energy consumption
  - Proper controls
  - Alter crop development plan
  - Improve space efficiency
  - Structural changes with some capital investment
  - Fuel selection
- Result, return on investment can be significant, especially in New York
Controls

- Placement
- Check for temperature gradient
- Response lag?
- Set point offset?
Heat distribution

- Air unit heaters
  - Clean
  - Direct air stream down
  - HAF
- Pipes
  - Clean
  - Latex, oil, not aluminum paint on iron
  - Insulated to outside walls
  - Reflective metal between pipe and outside
Structure

- Air leaks? (w/ bee smoker)
- Insulate foundation walls, pipes
- Double glaze side & end walls
- Super insulate north walls
Structural Options

- Vertical curtains
- Retractable energy/shade curtain
  - 20-60% reduction in fuel use
- Improve insulation
  - gaps near fans, doors, roof, wherever
    - 20% waster, plug ‘em and save 3-10%
  - Insulate north walls w/ reflector insulation
  - Sidewall insulation save 10%
  - Foundation insulation save 5%
  - Seal off exhaust fans, another 5%
HAF & Cycling

- Mix air
- Increase uniformity
- Your fan position?
- Dead band
  - Reduces cycling
- Set point
- Monitor average daily temperature, adjust to stay on schedule.
Lighting

- Reflectors
- Clean
- Directed to plants, not aisles
Plug Size

- Larger plug reduces final crop timing
- Finish stage, fewer plants per ft\(^2\) (compared to plug stage)
- Heat and light costs \textit{per plant} are lower (higher density)
- Partial budget size & origin
Saving heat?

- Crop timing increases as temperature decreases
- Lower temperatures, begin earlier
- Result: start heating greenhouse earlier
- Energy consumption *per crop* grown in the spring can be higher w/ cool grown corps, heated longer
Cropping Strategies

- Not all plants respond to temperature the same way
- Separate cold-tolerant and cold-sensitive crops
  - vinca and celosia grow very slowly at 60F
  - ageratum, pansy and ivy geranium continue to grow moderately well at 60F
- Open up a full greenhouse
Temperature ABCs

- Temperature controls timing
- Plants respond differently to temperature
- Above their base plants grow faster and faster
  - Base temperatures differ
    - AKA petunia cooler, vinca warmer
Cold-tolerant/cold-sensitive

- Difference relates to crop’s base temperature
- Low base temperature = “cold-tolerant”
- High base temperature = “cold-sensitive”
  - Cold-sensitive plants more sensitive to lower greenhouse temperature than cold-tolerant species
- Middle ground plants (base temperature between 39°F and 46°F)
- All plants respond to temperature during all development stages
**Salvia ‘Vista Red’**

- 288-cell trays

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Weeks to Finish</th>
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</thead>
<tbody>
<tr>
<td>57°F</td>
<td>6.5</td>
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<tr>
<td>79°F</td>
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</table>

- Under low light, transplant to first flowering 12 days longer at 63°F than at 73°F
## Effect of Temperature on Impatiens, Petunia & Pansy

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>54°F</th>
<th>61°F</th>
<th>68°F</th>
<th>75°F</th>
<th>delay in flowering if 24-h temp is reduced 1°F (days)</th>
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<tbody>
<tr>
<td>Super Elfin Lipstick</td>
<td>72</td>
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<tr>
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<td>51</td>
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<td>71</td>
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<tr>
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<td>60</td>
<td>50</td>
<td>45</td>
<td>1.1</td>
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</table>
Quality & Temperature

■ For most crops, quality increases as temperature decreases
  ■ thicker stems
  ■ greater branching
  ■ more roots
  ■ more, larger flowers

■ Exceptions, heat loving plants
  ■ AKA hibiscus

■ Benefit of growing cool = overall plant quality improves, although delayed

■ Watch for chilling injury
Lights

- Provide long days to long-day plants
  - Many annuals and perennials long-day plants
    - Flower earlier when grown under a long photoperiod
    - Examples: ageratum, blue salvia, dianthus, pansy, petunia, Rudbeckia, snaps, and tuberous begonia
    - Spring photoperiod short until April
    - Flowering of early long-day crops delayed without artificial long days

- Supplemental lighting
  - Pack energy to plugs or seedlings
Photoperiod

- Accelerate flowering of long-days plants with LD
- Extended days or night break
- ‘Wave’ petunias
- Retard flowering of short-day plants with LD
- Extended days or night break
- *Cosmos* and *Zinnia*
Photo Energy

- High quality light (daily light integral, or DLI)
- Early flower development, fewer leaves
- Higher plant temperature accelerating growth
Lights

■ DLI is an investment
■ High pressure sodium
■ Photoperiod lighting, less so
  ■ Incandescent or high-pressure sodium
  ■ ~10 foot-candles
Media °F $f_x$ of air °F

- Cooler air = cooler media
- Nutrition $f_x$ of °F
- Water uptake $f_x$ of °F
- Smaller plants > impact (plugs)
- Optimum 60-65 °F
- Media $\sim < 10$ °F with overhead heat
  - > when growing on ground
  - > with cold water
  - Evaporation cools soil
- *What is your media temperature?*
Media Temperature Remediation

- Warm irrigation water
- Grow off the ground, only pallet height?
- Air circulation, open benching vs flood
- Propagate with tent versus mist or fog
Tips for Growing Cooler

- Separate crops by thermal demand
- Cool crops with established root systems
- Grow off the floor (unless floor heated)
Nutrition

- Phosphorus (P) deficiency symptoms
  - Stunting, purpling of stems, leaf petioles and undersides of leaves
- cold media
- Low °F influences water (other nutrients) uptake
- Inactive roots = water uptake = wilting
- AND...
- Low temperatures = higher Rh
- Calcium (Ca) moves with water uptake
- Lacking root action = Ca
Nitrogen

- Ammonium Nitrogen (NH$_4^+$) converts to Nitrate Nitrogen (NO$_3^-$) by bacterial action
- $@ < 60 \, ^\circ\text{F action}$
- Result = NH$_4^+$ toxic build up
- Remedy = use NO$_3^-$ fertilizer
Oxygen

- Low temperatures = low H₂O use = oxygen starvation
- Remedy... well drained media, large pore space
- Prepare to adjust water practice when changing media composition
Insects & Growing Degree Days (GDD)

- Two spotted spider mite 50°F
  - Optimum development 85°F and 95°F
- Western flower thrips 50°F
  - At 78-82°F life-cycle from egg to adult 12 - 14 days (cooler = slower)
- Whitefly 47°F
  - Greenhouse vs. silverleaf = 7 days @ 70°F
- Green peach Aphid 39°F
  - Proportional development with temperature

Cool Temps = Aphids!
Diseases

- *Botrytis cinerea* higher Rh favors development
- Sanitation is prime management tool
- Decree (brown residue)
- Chipco 26019
- Daconil 2787 (& others containing chlorothalonil)
- Compass
- Medallion (pricey, some plants injured)
Firm one

Variable Costs = ? % of Sales

- Labor 45%
- Seeds and Plants 16%
- Soil Mix Components 8%
- Packaging Materials 5%
- Heating 13%
- Seeds and Plants 18%
- Soil Mix Components 9%
- Packaging Materials 5%
- Other Variable Costs 14%
- Heating 7%
- Other Variable Costs 13%
Firm one

- **Gross ~$750,000**
  - **Scenario 1:**
    - Fuel nearly doubles, no other changes
    - Result: profit 5% to -0.19%
    - Net Income ~$35K to -$1,350
  - **Scenario 2:**
    - 2X fuel & Sales up 5%
    - Result: $\Pi$ now 9.6%
  - **Scenario 3:**
    - 2X fuel & Sales up 1%
    - Result: $\Pi$ now 0.9%
Firm Two

- Gross ~$160,000
  - Scenario 1
    - Double fuel, no other changes
    - Result: $\Pi$ now 5.64% to −1.7%
  - Scenario 2
    - 2X fuel & Sales up 5%
    - Result: $\Pi$ now 2.9%
  - Scenario 3
    - 2X fuel & Sales up 1%
    - Result: $\Pi$ now −0.61%
Firm Three

- Gross ~$550,000
  - Scenario 1
    - Double fuel, no other changes
    - Result $\pi$ 20.8% to 15%
  - Scenario 2
    - 2X fuel & Sales up 5%
    - Result $\pi$ now 19%
  - Scenario 3
    - 2X fuel & sales up 1%
    - Result $\pi$ now 15.8%
Firm Four

- Gross $500,000
  - Scenario 1
    - Double fuel, no other changes
    - Result $\pi$ 24% to 9%
  - Scenario 2
    - 2X fuel & Sales up 5%
    - Result $\pi$ now 14%
  - Scenario 3
    - 2X fuel & Sales up 1%
    - Result $\pi$ now 10%
<table>
<thead>
<tr>
<th>Fuel</th>
<th>$/unit</th>
<th>1,000 BTU/$1</th>
<th>Efficiency %</th>
<th>Yield 1,000/BTU/$1</th>
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<tbody>
<tr>
<td>Wood pellet</td>
<td>120/T</td>
<td>141</td>
<td>60</td>
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<tr>
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<td>240/T</td>
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<td>Nat. gas</td>
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ENERGY COST COMPARISONS, $/Million BTU

- Kerosene: $24.14
- # 2 Fuel Oil: $22.64
- Propane: $33.89
- Natural Gas: $8.82
- Electricity - Resistance: $35.17
- Electricity - Heat Pump: $17.58
- Coal: $10.10
- Firewood: $10.67
- Wood Pellets: $18.29
- Shelled Corn: $12.25
More Information

- MSU GH Energy Fact Sheet
  - http://msucares.com/pubs/infosheets/is1618.html

- U Mass GH Energy Fact Sheets
  - www.umass.edu/umext/floriculture/fact_sheets

- Penn State web site
  - http://energy.cas.psu.edu/

- Energy Conservation for Commercial Greenhouse
  - NRAES-3 www.nraes.org or 607-255-7654
In Closing...

- What’s new?...Nothing!
- Sweat the small stuff, for energy savings
- Labor is the largest cost

Questions?
Comments

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