Crop Schedules with Less Heat

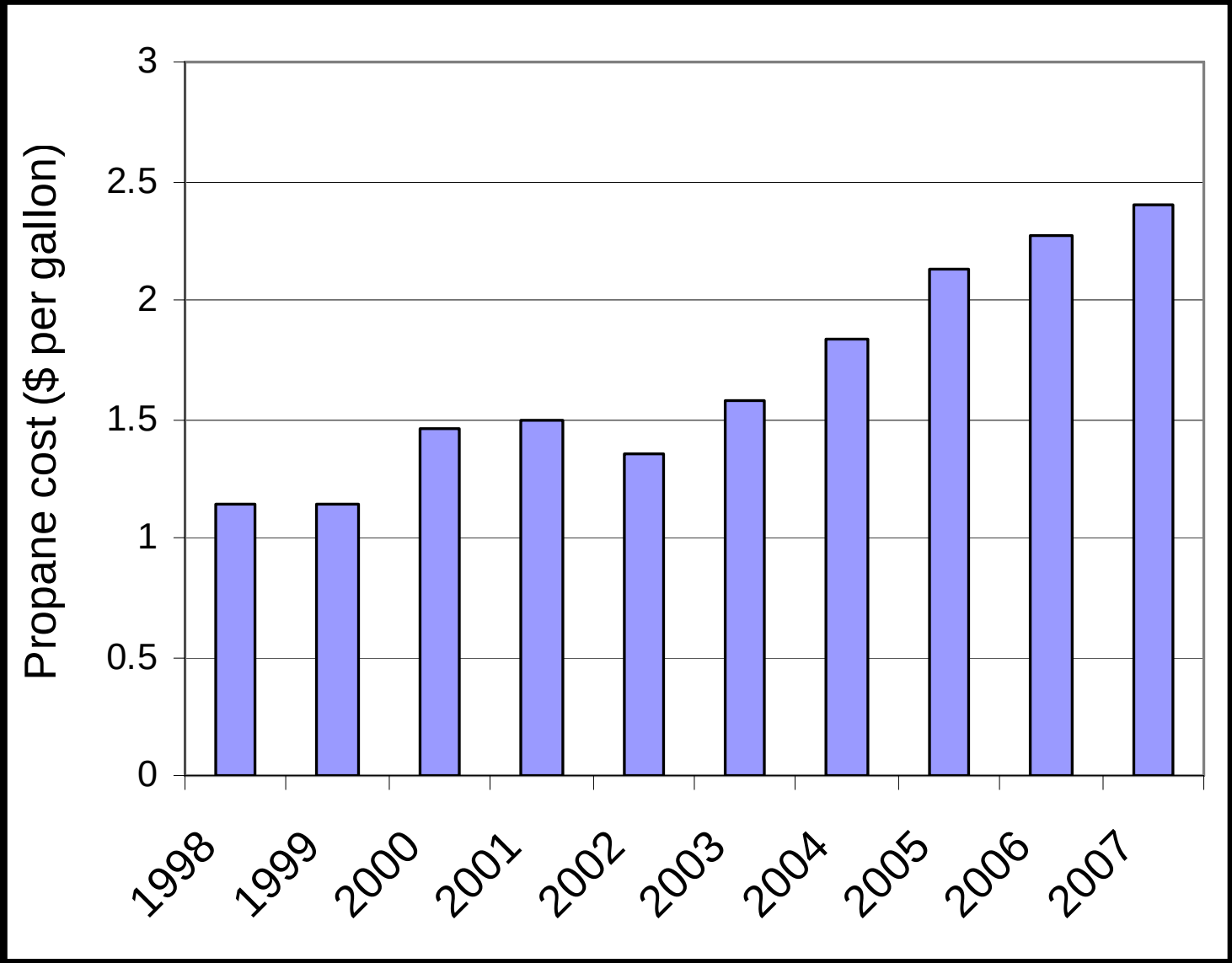
Neil Mattson

Assistant Professor, Floriculture

Department of Horticulture, Cornell University

nsm47@cornell.edu

The Problem: Rising Energy Costs



Source: U.S. Energy Information Administration

U.S. average fuel expenditures are expected to be higher for all fuels this winter

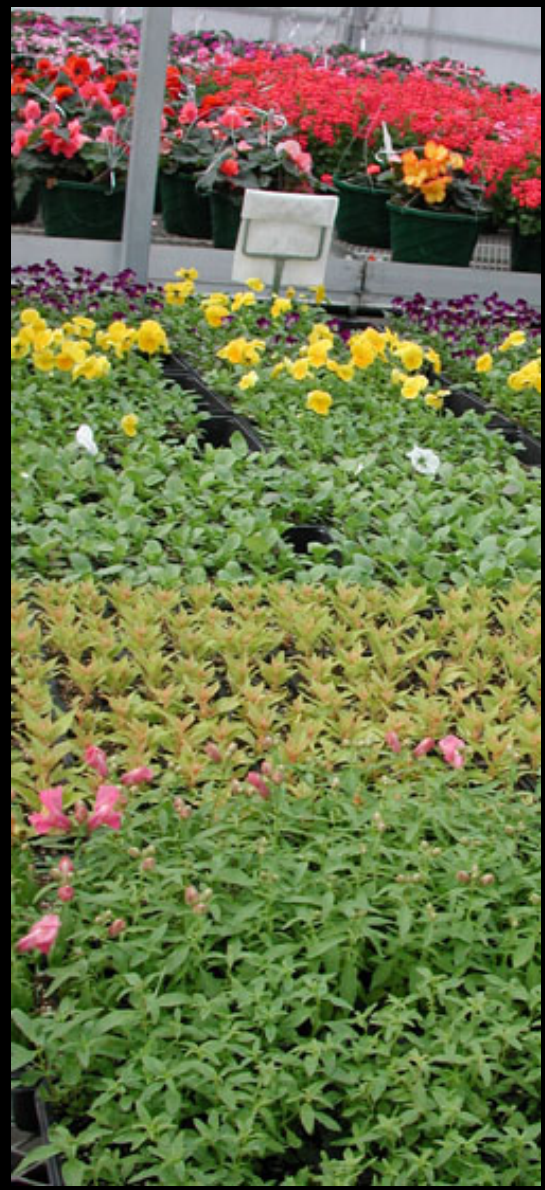
Fuel	Average Household Expenditures Percent Change from Last Winter		
	Base Case	If 10% Warmer Than Forecast	If 10% Colder Than Forecast
Natural Gas	**9.5**	-1.7	20.3
Heating Oil	**21.8**	9.8	31.6
Propane	**16.3**	4.3	27.7
Electricity	**3.9**	-1.3	7.2
Average Expenditures	**9.8**	0.1	18.4

Winter = October 1 through March 31.
Expenditures are based on typical per household consumption adjusted for weather. Warmer and colder cases represent 10-percent decrease or 10-percent increase in heating degree-days, respectively.
Source: U.S. Energy Information Administration

Outline

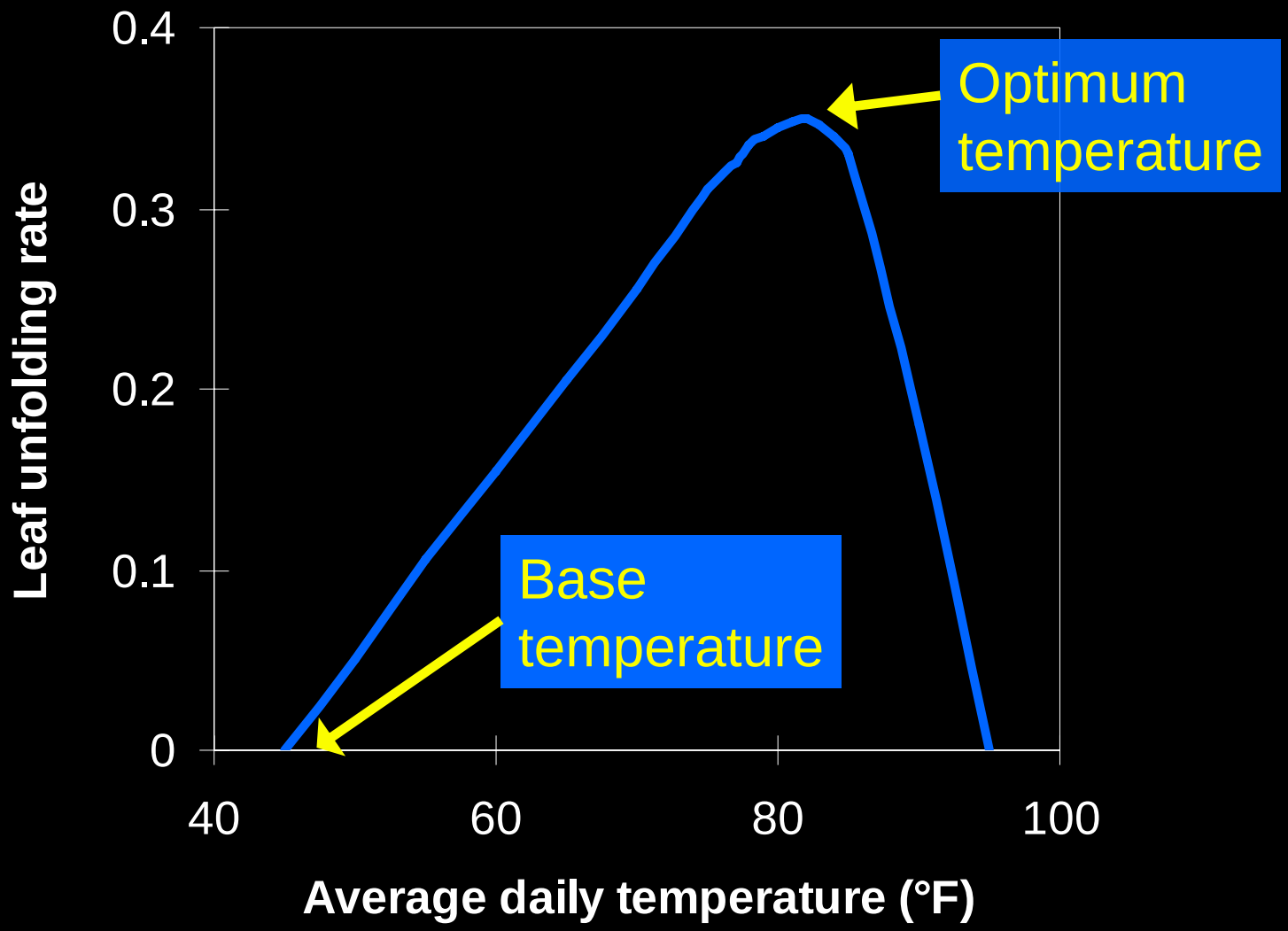
Can we grow plants with less heat?

- What drives plant growth?
- Growing cooler means growing longer
- Crop schedules
- Saving fuel by growing your crops more efficiently
- Saving fuel by looking at greenhouse heat losses



What Drives the Rate of Plant Development?

- Temperature



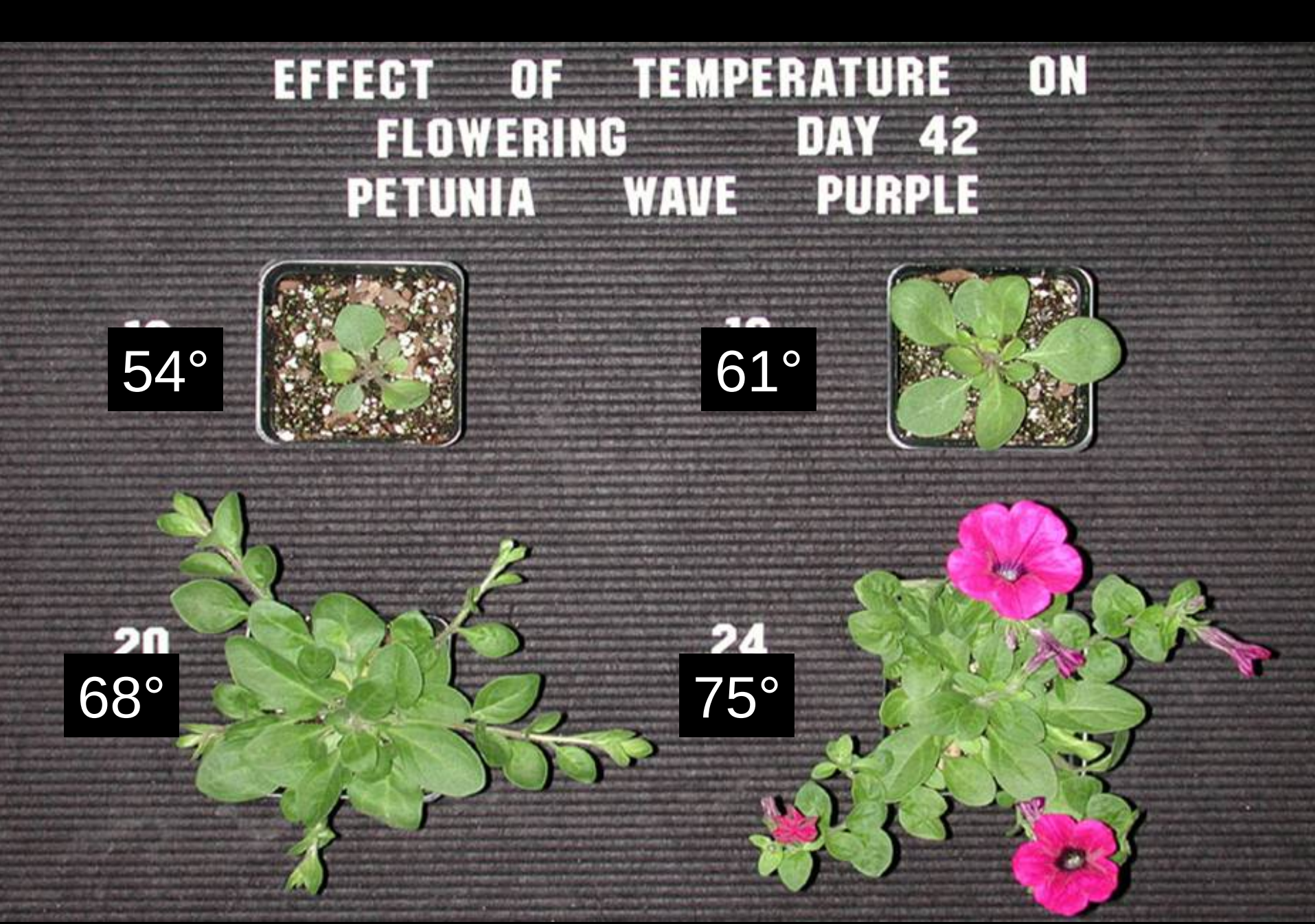


Photo: Neil Mattson, 2001

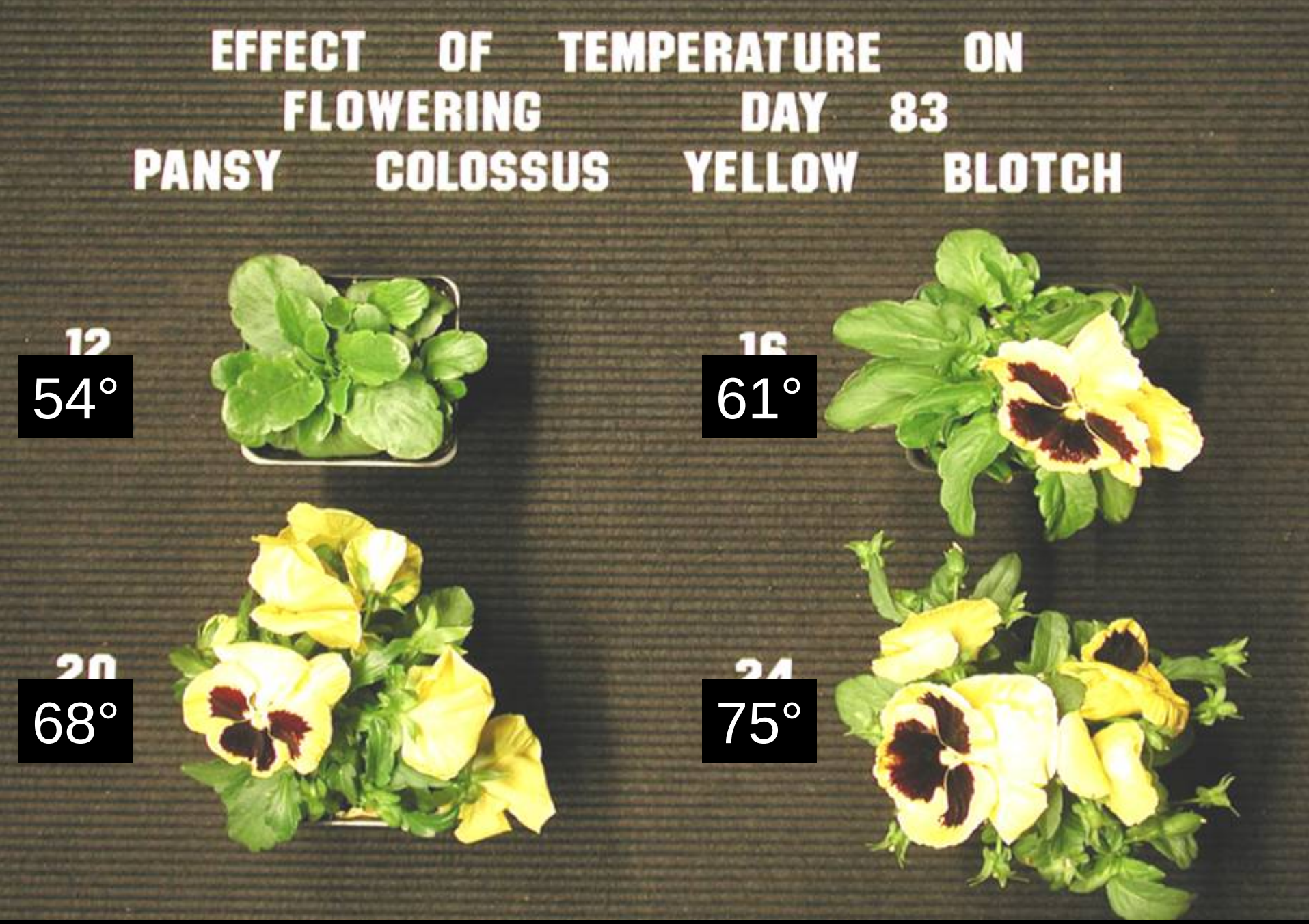


Photo: Neil Mattson, 2001

Average Daily Temperature is Important

- Day temp: 80 °F for 12 hours
- Night temp: 50 °F for 12 hours

Average daily temperature: 65 °F

- Day temp: 68 °F for 8 hours
- Night temp: 60 °F for 16 hours

Average daily temperature: 63 °F

(68×8)+ (60×16) = 1504

1504 / 24 = 62.7

Growing cooler means growing longer

Cultivar	Days from germination till flowering at average daily temperature of:				Delay in flowering if 24-hour temp is reduced 1 °F (days)
	54 °F	61 °F	68 °F	75 °F	
Impatiens 'Super Elfin Lipstick'	-	72	54	47	1.8
Petunia 'Avalanche Pink'	88	74	47	39	2.5
Petunia 'Dreams Rose'	84	67	46	37	2.3
Petunia 'Wave Purple'	112	88	57	45	3.3
Pansy 'Colossus Yellow Blotch'	95	82	63	58	1.9
Pansy 'Crystal Bowl Supreme Yellow'	72	63	51	46	1.3
Pansy 'Delta Pure White'	88	71	61	53	1.6
Pansy 'Sorbet Blackberry Cream'	68	60	50	45	1.1

Source: Mattson and Erwin, 2002. Acta Horticulturae. 624:191-197.

Plants categorized by their base temperature (the temperature at or below which crops stop developing). Plants with a base temperature of 39 °F or lower can be called “cold-tolerant” crops, and those with a base temperature of 46 °F or higher can be called “cold sensitive crops”. Information based on research at Michigan State University and published research-based articles.

Plants with a low base temperature (39 °F or lower)	**Plants with a moderate base temperature (40-45 °F)**	**Plants with a high base temperature (46 °F or higher)**
Ageratum	Calibrachoa	African violet
Alyssum	Coreopsis	Angelonia
Campanula	Dahlia	Banana
Cineraria	Impatiens (seed)	Begonia (fibrous)
Diascia	Salvia	Blue salvia
Easter lily		Caladium
Gaillardia		Celosia
Leucanthemum		Gazania
Marigold (French)		Hibiscus
Nemesia		New Guinea impatiens
Petunia		Pepper
Rudbeckia		Phalaenopsis orchid
Scabiosa		Poinsettia
Snapdragon		Purple fountain grass
Thanksgiving cactus		Rose
Viola		Vinca

Source: Erik Runkle, OFA Bulletin, November/December 2006

Temperature and Energy Costs

- “Rule of thumb” a decrease in greenhouse temperature of 1 °F decreases heating costs by about 3%
- Growers wish to save energy by decreasing greenhouse temperatures
- Will this result in any cost savings?

Relative heating cost: Petunia vs. Pansy

	Temperature	
	60	68
Relative heating per day	0.76	1

Petunia ‘Purple Wave’

- Days to flower at 68 °F: 57 days
  - Relative heating cost: 57 x 1 = 57
- Days to flower at 60 °F: 85 days
  - Relative heating cost: 85 x 0.76 = 65

Pansy ‘Sorbet Blackberry Cream’

- Days to flower at 68 °F: 50 days
  - Relative heating cost: 50 x 1 = 50
- Days to flower at 60 °F: 59 days
  - Relative heating cost: 59 x 0.76 = 45

Fuel cost to heat crops at different temps

Crop	April 1 Finish			
	57 °F	63 °F	68 °F	73 °F
Celosia	$6,035	$3,486	$3,158	$3,134
Impatiens	$2,411	$2,156	$2,050	$2,144
Salvia	$2,930	$2,592	$2,446	$2,381

10,000 square foot greenhouse in Grand Rapids, Michigan
Source: Erik Runkle, GMPro, January 2007

Fuel cost to heat crops at different temps

Crop	May 15 Finish			
	57 °F	63 °F	68 °F	73 °F
Celosia	$3,266	$1,667	$1,654	$1,742
Impatiens	$981	$1007	$1008	$1078
Salvia	$1,236	$1,241	$1,243	$1,262

10,000 square foot greenhouse in Grand Rapids, Michigan
Source: Erik Runkle, GMPro, January 2007

Temperature tips

- Never reduce temperatures during the germination stage (keep at 72°-76° F)
- Cooler temperatures can promote diseases – such as Damping off (*Pythium*)
- Lower night temperatures cause many bedding plants to stretch
- Lower temperatures improves the quality of many cold-tolerant plants (example: Geranium)

More temperature tips

- Keep plants off the ground (at least by 2 inches)
- Take advantage of day time heat
  - Let temperatures get up to 80 during the day
  - Change night temperature accordingly
- House within a house propagation structure (poly-tent with heated mats for root zone heat)

Crop Schedules

What affects the time required to produce a crop?

Weeks to finish from seed (at °68 F)

Marigold (French)	10 weeks
Impatiens walleriana	12
Petunia	13
NG Impatiens	15
Geranium (seed)	16
Begonia (fibrous)	18

Crop Schedules

What affects the time required to produce a crop?

- Type of plant material
- Temperature
- Light (intensity and daylength)
- Finished Container size
- Size of starter material

Crop Schedules

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Light intensity effects time to flower

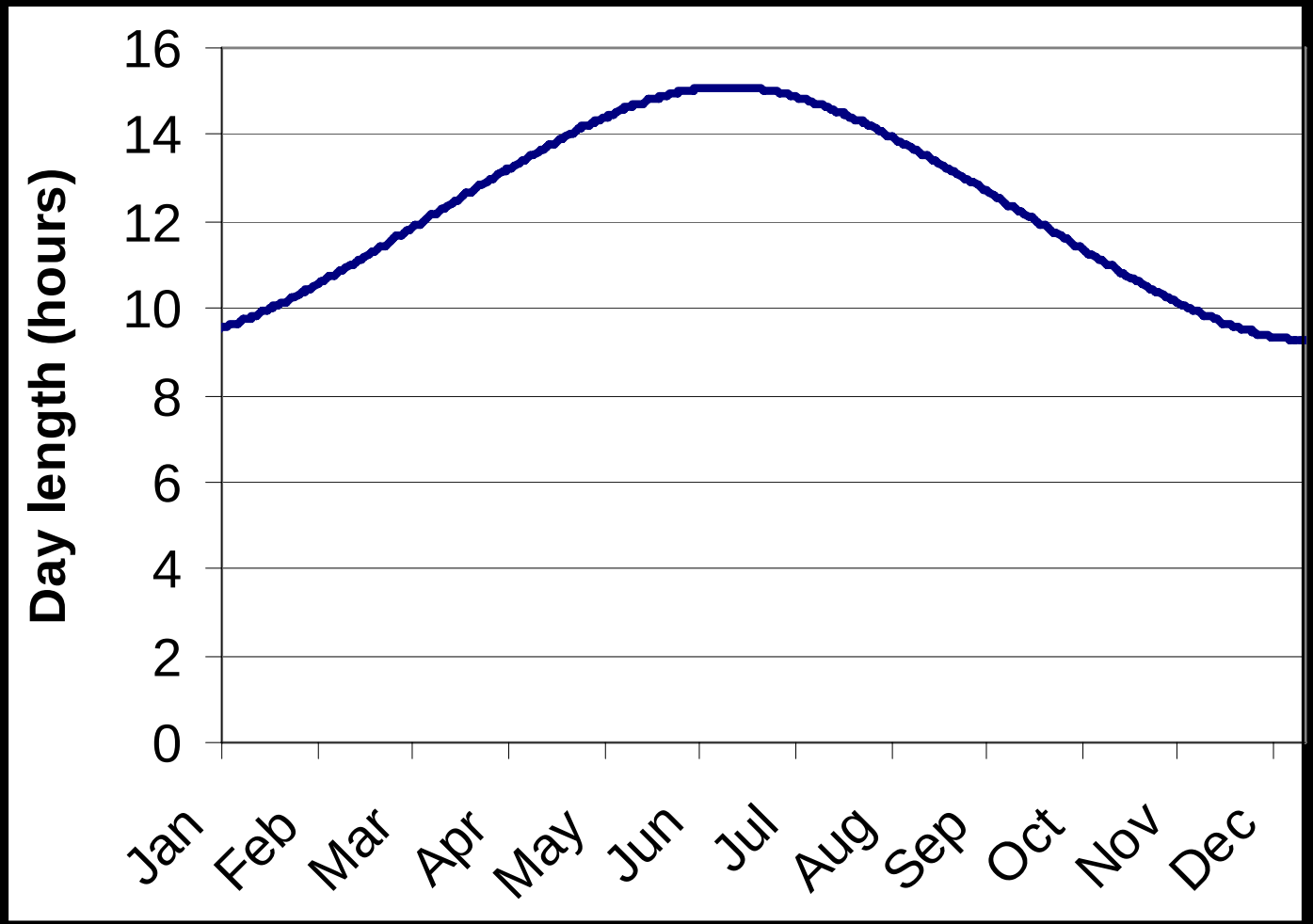
Pansy grown for 3 weeks under different lamps

Increasing light intensity

Photo: Neil Mattson, 2002

Daylength effects time to flower

Photoperiod = number of hours of light in one day



Crop Schedules

What affects the time required to produce a crop?

Weeks to finish from seed (Wave petunias at °68 F)

Finished container size

Flat	10-12 weeks
4-inch pot	12-14 weeks
10-inch container	14-16 weeks

Crop Schedules

What affects the time required to produce a crop?

128 Plug 5-7 weeks

Using larger plugs means heating for less days

Production times for Calibrachoa in 12-inch hanging baskets (72 °F day/67 °F night temperature)

Liner size	Weeks as liner	Weeks in basket	Total production time
105-count	4	8	12 weeks
50-count	6	6	12 weeks
18-count	8	4	12 weeks

Source: Paul Fisher, Greenhouse Grower, September 2006

Saving fuel by growing your plants more efficiently

Start heating your greenhouse as late as possible in the spring

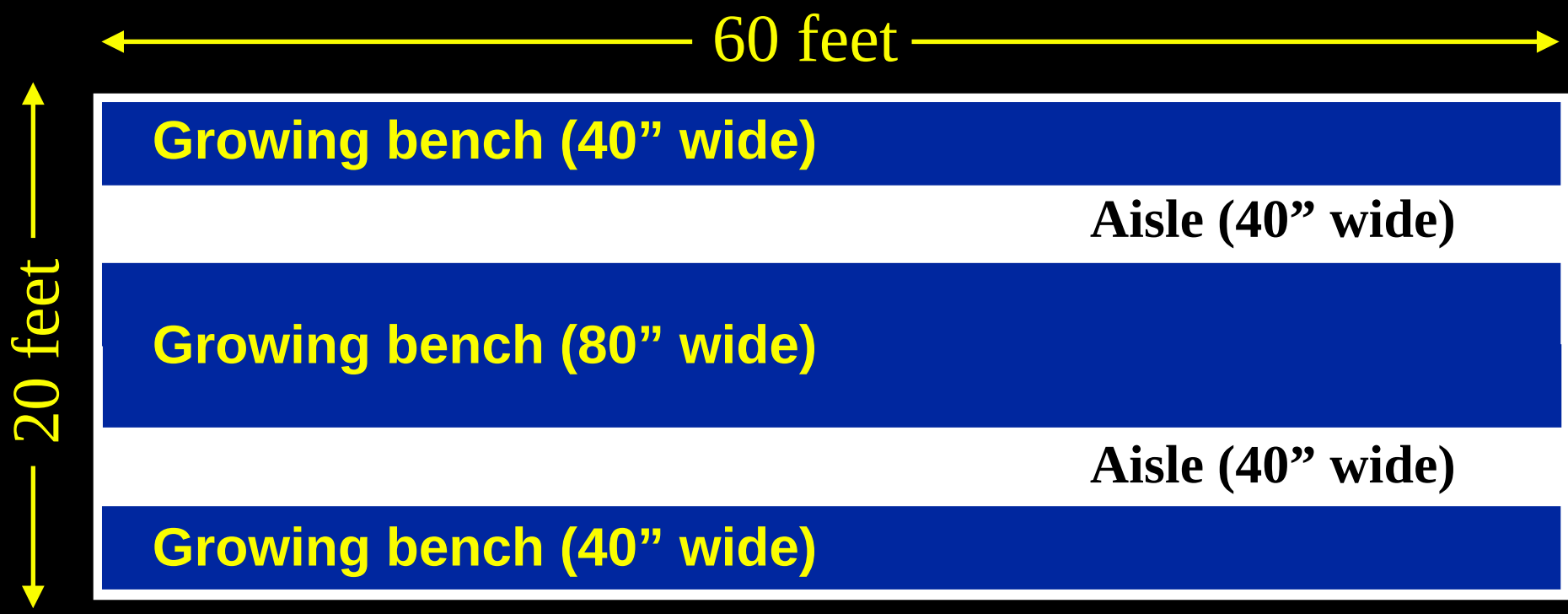
New York State Heating Degree Days	
Month	**Heating degree days**
December	1113
January	1296
February	1131
March	959
April	579
May	258

Space Efficiency in the Greenhouse

- Use as much space as possible for growing plants

Space efficiency longitudinal bench arrangement

Space efficiency longitudinal bench arrangement

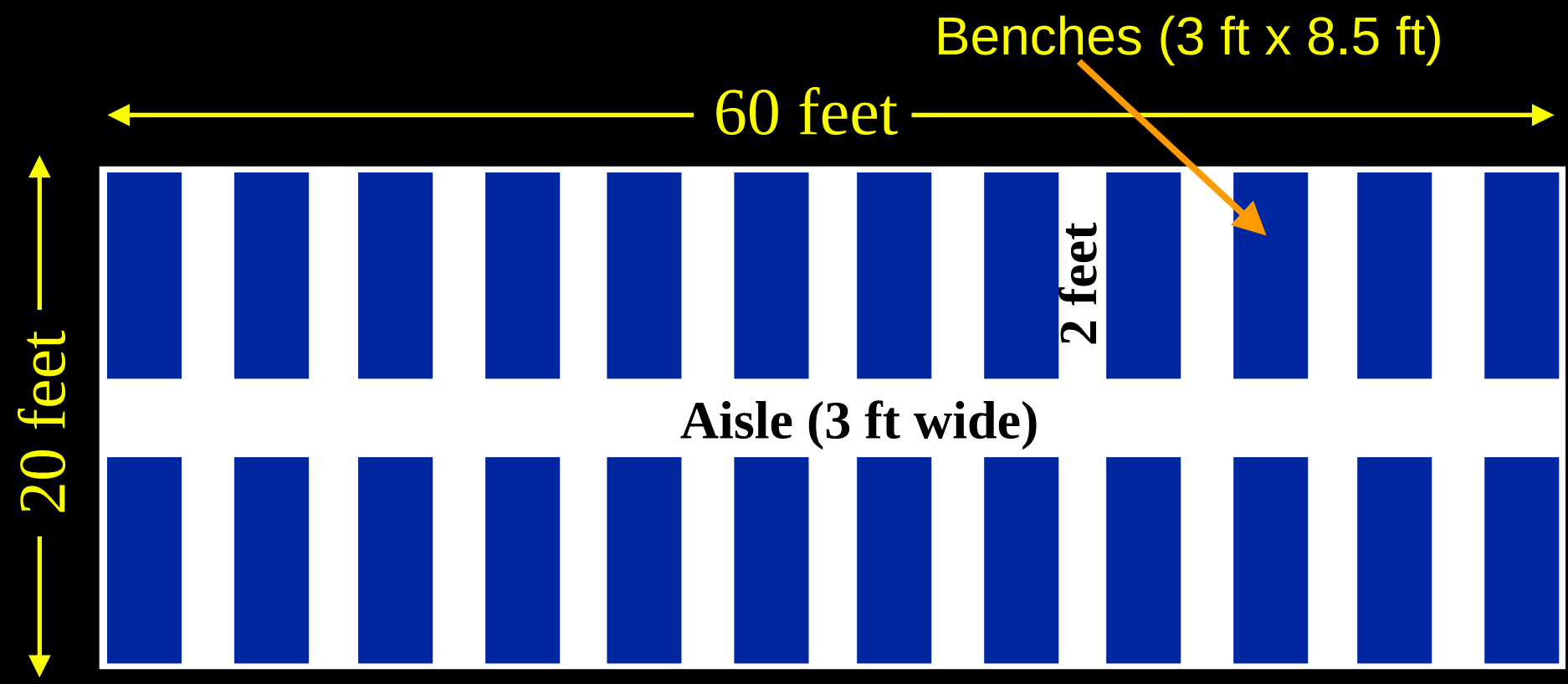


Greenhouse: 1200 square feet

Growing space: 800 square feet

Space efficiency: 67%

Space efficiency - benches across GH width



Greenhouse: 1200 square feet

Growing space: 612 square feet

Space efficiency: 50%

Rolling benches maximize space

Space Efficiency in the Greenhouse

- Use hanging baskets (but don’t reduce light too much)

Space Efficiency in the Greenhouse

- Only open up a greenhouse when it can be filled

Once a greenhouse is open you have to heat it whether or not it is full of plants

Space Efficiency in the Greenhouse

- If you have more than one greenhouse - grouping plants according to their temperature needs
  - Cooler house for cold tolerant plants
  - Warmer house for cold sensitive plants

Space Efficiency in the Greenhouse

- Using a warm house and a cooler house

Turn 1: Cold tolerant crops ready for May 1

- Buy in plugs and transplant Feb 15-28
- Start seed for turn 2 plugs on Feb 15
- Heat from Feb 15 to April 1
- Move to a poly-house with minimal heat on April 1

Turn 2: Heat loving crops for May 15-30

- Transplant turn 2 plugs April 1
- Heat from April 1 till sales

390 plugs transplanted in 36-cell flats

Space Efficiency in the Greenhouse

- Multiple crop turns in the same greenhouse

Turn 1: Cold tolerant crops ready for May 1

- Buy in plugs and transplant March 15
- Start vegetable seedlings for turn 2 on March 15
- Heat from March 15 – May 1

Turn 2: Vegetable transplants ready for June 1

- Transplant vegetable seedlings May 1
- Heat as needed

390 plugs transplanted in 36-cell flats

What does a basic schedule look like?

You will need to know:

- ❑ Greenhouse growing space available
- ❑ Temperature targets for the greenhouse

For each variety

- ❑ Time required to finish (from seed or plug)
- ❑ Amount you wish to produce (space required in greenhouse
- ❑ Target sales date

Production schedule example

- 20 x 60 foot greenhouse
  - Holds 576 flats (or 1728 4” pots)
  - Holds 120 hanging baskets (above aisles)
  - Average daily temperature 65 °F

Production schedule example

Finish by May 13

	Seed→Plug	Transplant→Finish
144 flats		
Petunia	7 weeks	4 weeks
Pansy	7 weeks	5 weeks
Dusty Miller	8 weeks	4 weeks
216 4-inch pots		
Geranium	7 weeks	9 weeks
Lobelia	7 weeks	9 weeks
60 hanging baskets		
Petunia	7 weeks	8 weeks
Impatiens	7 weeks	7 weeks

Production Schedule Example

Greenhouse #1 - average daily temperature (65 °F)					
Crop	**Seed date**	**Transplant date**	**Finish date**	**Container type**	**Number containers**
Petunia	Week 9	Week 16	Week 20	48-cell flat	144
Pansy	Week 8	Week 15	Week 20	48-cell flat	144
Dusty Miller	Week 8	Week 16	Week 20	48-cell flat	144
Geranium	Week 4	Week 11	Week 20	4-inch pot	216
Lobelia	Week 5	Week 12	Week 20	4-inch pot	216
Petunia	Week 5	Week 12	Week 20	Hanging	60
Impatiens	Week 6	Week 13	Week 20	Hanging	60
Space available in the greenhouse					
Flats (20"x10")					
4" pots					
Hanging baskets					

Greenhouse 1 (20' x 60')

800 feet of bench space = 576 flats

Hanging baskets = 120 (2 rows per aisle at 2 ft/basket)

Production Schedule Example

Mar-11	Mar-18	Mar-25	Apr-1	Apr-8	Apr-15	Apr-22	Apr-29	May-6	May-13
Week 11	**Week 12**	**Week 13**	**Week 14**	**Week 15**	**Week 16**	**Week 17**	**Week 18**	**Week 19**	**Week 20**
					144 flats	144 flats	144 flats	144 flats	144 flats
				144 flats	144 flats	144 flats	144 flats	144 flats	144 flats
					144 flats	144 flats	144 flats	144 flats	144 flats
216 pots	216 pots	216 pots	216 pots	216 pots	216 pots	216 pots	216 pots	216 pots	216 pots
	216 pots	216 pots	216 pots	216 pots	216 pots	216 pots	216 pots	216 pots	216 pots
	60 basket	60 basket	60 basket	60 basket	60 basket	60 basket	60 basket	60 basket	60 basket
		60 basket	60 basket	60 basket	60 basket	60 basket	60 basket	60 basket	60 basket
Space remaining									
Flats	432	432	432	288	0	0	0	0	0
Baskets	60	0	0	0	0	0	0	0	0

Saving fuel by stopping greenhouse heat losses

Choosing your greenhouse covering (Glazing)

- Insulation R-value ($ft^2 \cdot °F \cdot hr/Btu$) the ability to resist heat flow (loss)

Greenhouse Glazing Materials	R-value
Polyethylene (single layer)	0.9
Polyethylene (double layer)	1.6
Glass (single layer)	0.9
Styrofoam (polystyrene 1” thick)	4.0
Fiberglass insulation (6” thick)	19.0

Windbreaks

- A wind 15 mph can double the heat loss from a greenhouse.
- Windbreaks (fences, trees, buildings) , slow the wind and cut heat losses from the greenhouse
- Place the windbreak upwind of the greenhouse
- To avoid shading the greenhouse a windbreak should be 3-4 times the tree height away

Insulation

- Use 1-2” foam insulation board around the perimeter of the greenhouse
- Ideally would be dug in 1-2 feet and can extend up to plant height

Seal your leaks

- Look for gaps especially where the glazing attaches to the foundation, side walls, and end walls

- Weatherstrip doors

In Summary…

- Temperature drives plant growth
- Growing cooler means growing longer
- We have many tools to adjust crop production time (schedules)
- Scheduling can improve efficiency and save on heat
- Keep your greenhouse structure efficient to save on heat

Good luck this spring!

Neil Mattson
nsm47@cornell.edu
Phone: (607) 255-0621