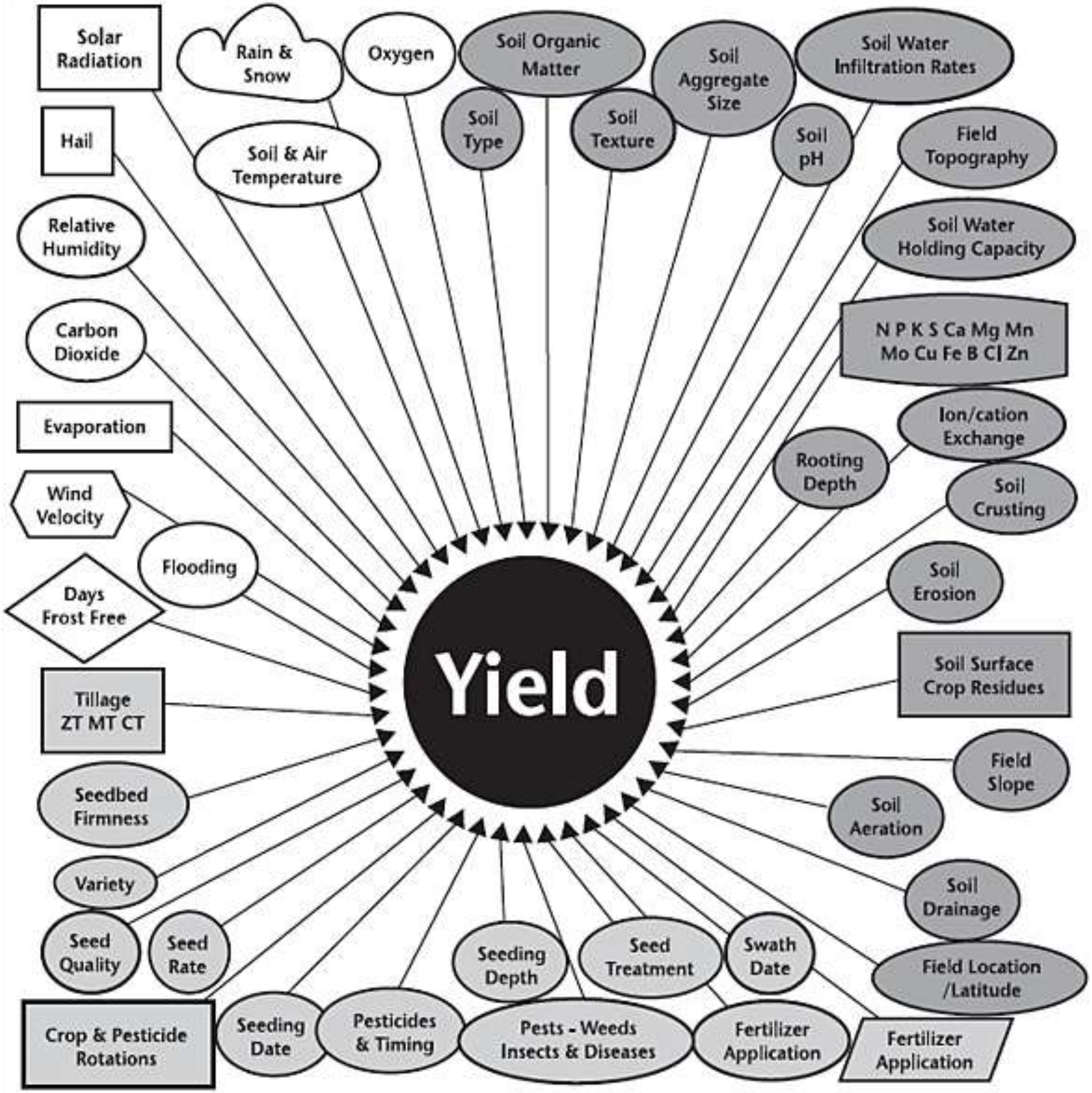
Ecology of Horticultural Plants

Light and Temperature

„The ability of green plants to manufacture, in the presence of light and clorophyll, complex organic chemicals on a gigantic scale from carbon dioxide, water, and other simple materials is responsible for life on Earth as we know it.”

I. A. Wolf (paraphrased)


Solar Radiation
Rain & Snow
Oxygen
Soil Organic Matter
Soil Aggregate Size
Soil Water Infiltration Rates
Hail
Soil & Air Temperature
Soil Type
Soil Texture
Soil pH
Field Topography
Relative Humidity
Soil Water Holding Capacity
Carbon Dioxide
N P K S Ca Mg Mn Mo Cu Fe B Cl Zn
Evaporation
Ion/cation Exchange
Rooting Depth
Wind Velocity
Soil Crusting
Flooding
Days Frost Free
Soil Erosion
Yield
Soil Surface Crop Residues
Tillage ZT MT CT
Field Slope
Seedbed Firmness
Soil Aeration
Variety
Soil Drainage
Seed Quality
Seed Rate
Seeding Depth
Seed Treatment
Swath Date
Field Location /Latitude
Crop & Pesticide Rotations
Seeding Date
Pesticides & Timing
Pests - Weeds Insects & Diseases
Fertilizer Application
Fertilizer Application

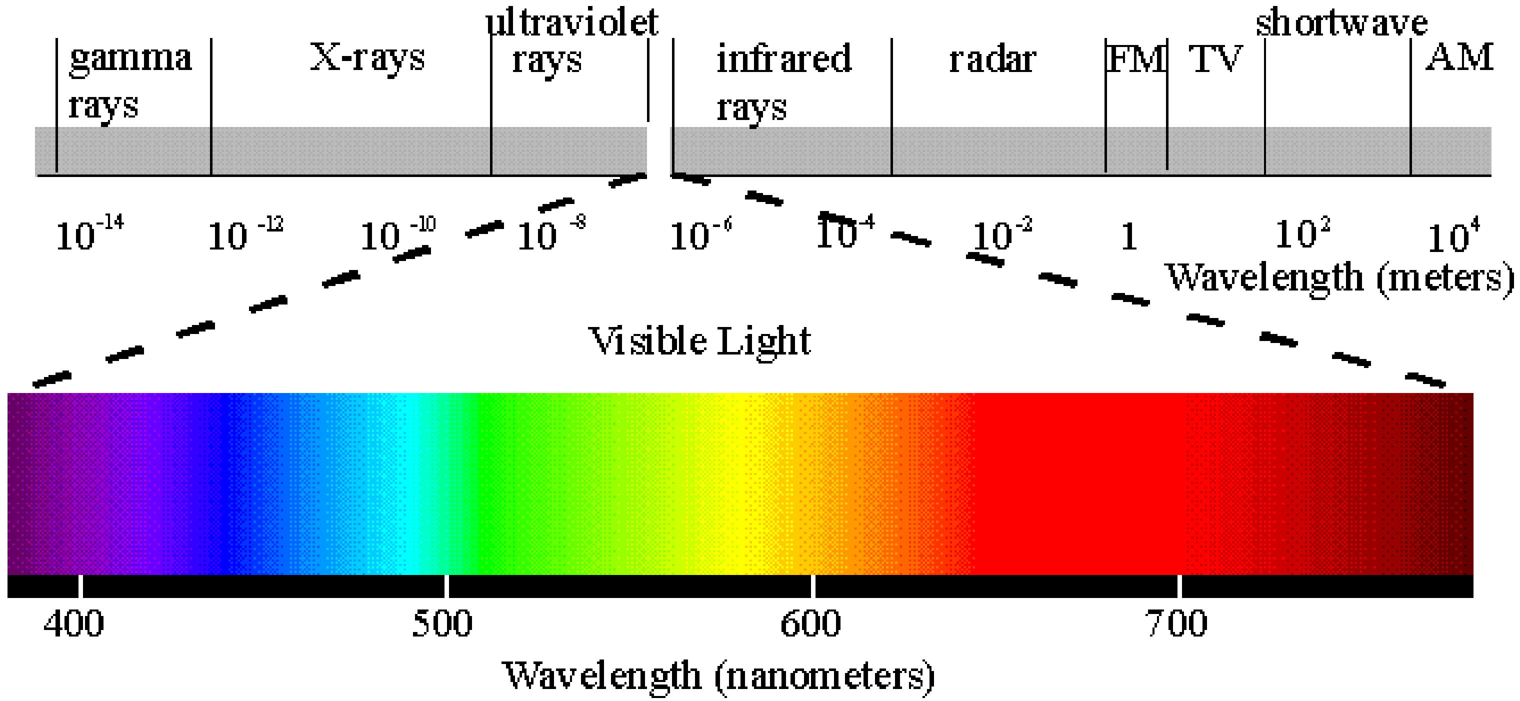
Light is important

- pigment (color) formation,
- plant growth habit,
- plant shape,
- plant size,
- flowering,
- fruiting,
- seed germination,
- onset dormancy,
- onset of plant hardiness,
- leaf movements,
- formation of storage organs,
- autumn coloration,
- defoliation of temperate zone trees.

Three characteristics of the light

- Quality – it corresponds to a specific range of wawelength.
- Quantity – amount ligth given off by a light source, or the amount of ligth that strikes an object.
- The photoperiod – the duration of the ligthed period and the relationship between the dark and lighted periods.

Light quality



Plant leaves absorb wavelengths at both ends of the visible spectrum. Chlorphyll a and chlorphyll b have major light absorption peaks between 400 and 500 nm (violet-blue) and between 600 and 700 nm (orange-red)

Carbon Dioxide Fixation

- C_3 plants – three-carbon pathway – most horticultural species.
- C_4 plants – four-carbon pathway – few important horticultural crops.
- CAM – crassulacean acid metabolism – succulent plants.

Examples of C_3, C_4 and CAM horticultural plants

C_3 plants	C_4 plants	CAM plants
Kentucky bluegrass 	corn	Agave americana 
beet	zoysiagrass	Jade plant 
spinach 	Bermudagrass	pineapple
lettuce	Bahiagrass	Spanish moss
bean	 	Sanseveria spp.
carrot	 	 
Creeping bentgrass		

Spacing and orienting plants for light interception

- Best use of available light.
- Desired plant quality.
- Accessibility by the grower.
- Air circulation.
- Disease control.
- Profitability.

Optimal spacing

- Minimize shading for optimum photosynthesis.

- Consider best plant growth habit.

Orientation issues

- Latitude can influence orientation.
- Wind direction needs to be considered.
- In garden different size of plants could help to make decision.

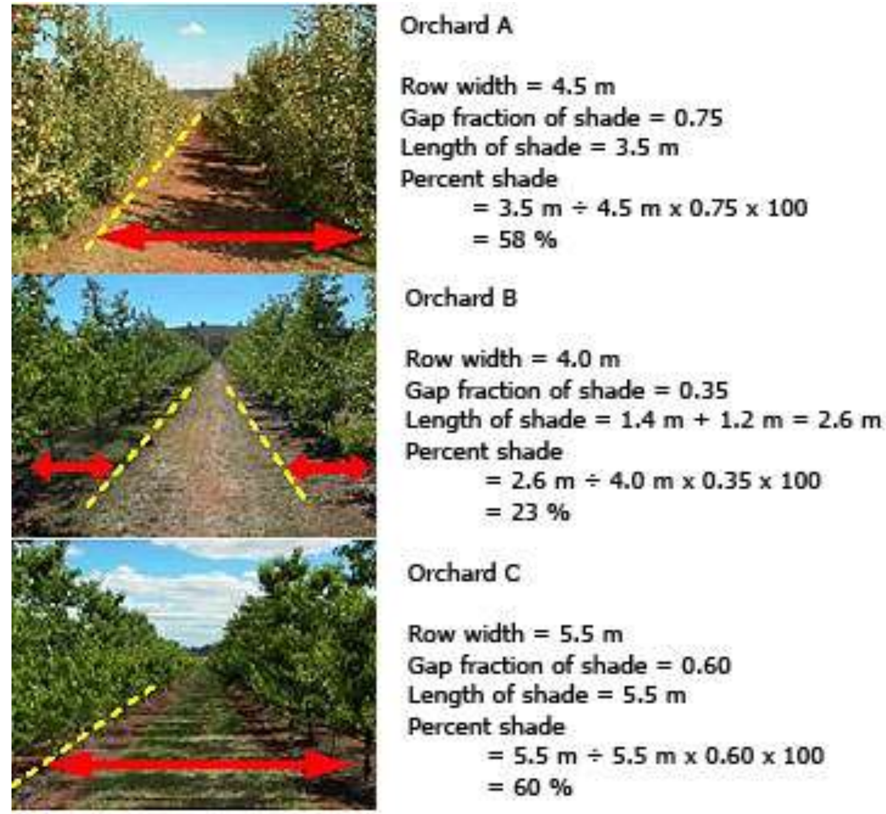


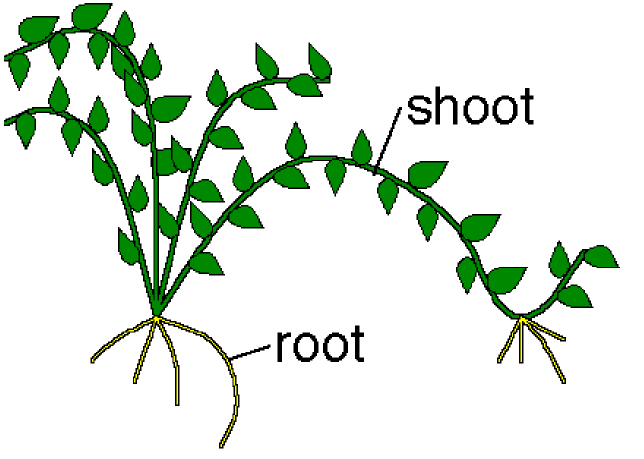
Figure 2. Visual estimates of the length of shade and the gap fraction to calculate percent shade for example orchards.

Etiolation

- When plants or plant parts are covered light or are moved to a location devoid light, the process is called blanching.
- Etiolation means the development of a plant or plant part in the absence of light.

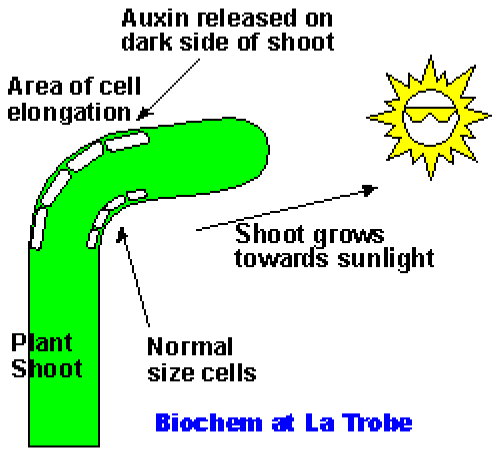
  - The stems and leaves are white to yellowish because light is required for chlorophyll biosynthesis.

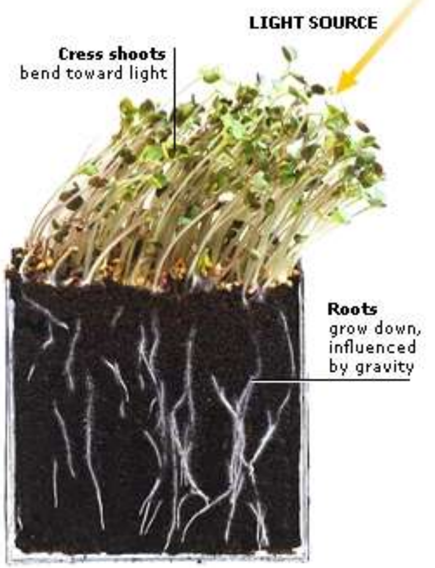
Practical use of blanching and etiolation in horticulture



Phototropism

- Phototropins are important light receptors.
- They are blue light photoreceptors.
- Plants are bending toward a light source, because of uneven elongation of the cells. Which cells are away from the light the hormon auxin increases the cell elongation.





Phytochromes

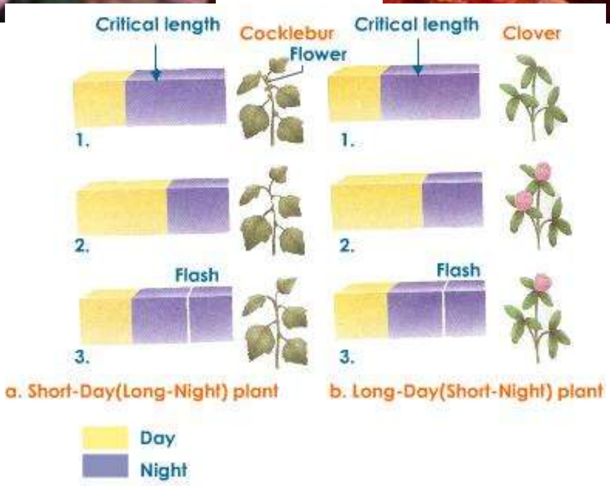
- Light absorbance at 660 nm, red light (R); and at 730 nm, far-red (FR) light.
- Important horticultural phenomena relate to R and FR:

  - gene expression, seed germination, branching, stem elongation, leaf expansion, chloroplast development, „sleep” movement of leaves, flowering, storage organ formation, fall coloration of leaves, onset of dormancy.

Photoperiodism

- Response to day length – that is the number of hours of light each day.
- Each species has its own requirement for a minimum number of inductive photoperiods.
- Flowering – Day neutral plants; Long-Day plants; Short-Day plants; Alternating day lengths.
- Formation of storage organs, like tubers.

Flower formation of Chrysanthemum in light and shaded conditions



Light quantity

Require full sunlight	Grow well in shaded area
Tomato	Salad Greens, such as leaf lettuce, arugula, endive, and cress.
Pepper	Broccoli
Sweet corn	Cauliflower
Peach	Peas
Grape	Beets
dahlia	Brussels Sprouts
iris	Radishes
pines	Swiss Chard
juniper	Leafy Greens, such as collards, mustard greens, spinach, and kale
	Beans

Light sources

- Sunlight.
- High-intensity discharge lamps.
    - mercury lamps,
    - metal halide lamps,
    - sodium lamps (high and low-pressure).
- Fluorescent lamps.

Light intensity

- Several measures of **light** are commonly known as ***intensity***. These are obtained by dividing either a *power* or a *luminous flux* by a *solid angle*, a planar *area*, or a combination of the two.

- **RadiometricPhotometricAngular**Radiant intensity, measured in watts per steradian (W/sr)Luminous intensity, measured in lumens per steradian (lm/sr), or *candela* (cd)
- **Areal**Irradiance, measured in watts per square meter (W/m2), called *intensity* in most branches of physicsSeveral quantities measured in lumens per square meter (lm/m2), or *lux* (lx):
- **Both**Radiance, commonly called *intensity* in astronomy and astrophysics (W·sr−1·m−2)Luminance (lm·sr−1·m−2, or cd/m2)

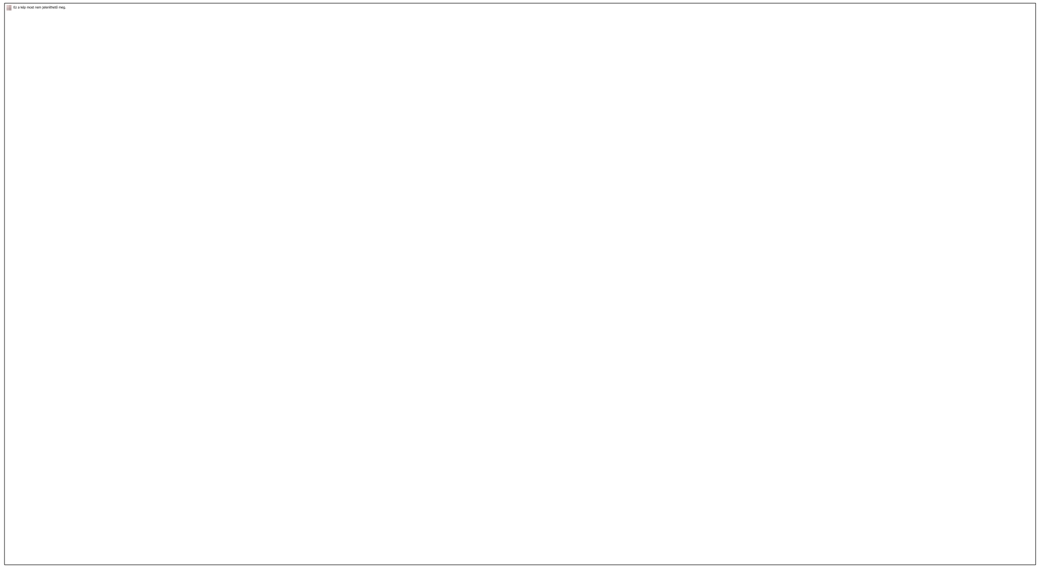
The indoor light intensity for different exposures

Full sunlight	10 760 lux
Morning sunlight	6 000 lux
Bright indirect sunlight	3 500 lux
North-facing window	2 000 lux
Two 40 Watt fluorescent lamps	645 to 8600 lux (depending on distance from source)

Type of plant	**Required light in lux**
Cut flowers	
Rose	4840-6450
Chrysanthemum	3760
Lilies	3760
Pot plants	
Begonia	3760
Cyclamen	3760
Orchids	4840
Nursery stocks	4840
Bedding plants	
Lettuce	4840
Tomatoes	11000
Cucumber	10-18000

Temperature

- Limits the distribution of plants on the planet.



Distribution of the Earth's Eight Major Terrestrial Biomes.
(Adapted from: H.J. de Blij and P.O. Miller. 1996. *Physical Geography of the Global Environment*. John Wiley, New York. Pp. 290.)

Temperature determined factors

- Plant growth, development, flowering, dormancy,propagation,color,yield,life,and death.
- The biological activities of plants are limited primarely in a narrow temperature range 0 ^{o}C to 50 ^{o}C.
- Most horticultural crops respond the best to temperatures of 10 ^{o}C to 30 ^{o}C.

Some examples of cool, intermediate, and warm season crops

Commodity	Cool season crops	Intermediate s. crops	Warm season crop
Vegetables	Pea	Tomato	Melons
	Radish	Potato	Squash
	Carrot		Sweet potato
Fruits	Apple	Peach	Banana
	Pear	Appricot	Citrus
	Raspberry	Almond	Coffee
Floriculture	Freesia	Poinsettia	Gloxinia
	Carnation	Rose	
	Snapdragon		
Woody ornamentals	Norway spruce	Rhododendron	Rubber plant

Growing Degree Days

- Predictions of when a plants will develop from one point to another in their life cycles can be calculated in time and temperature units.

$$\text{Degree days} = \frac{\text{Daily maximum air temperature} + \text{daily minimum air temperature}}{2} - \text{Minimum threshold temperatures}$$

The minimum temperature at which growth occurs is known as the minimum developmental threshold.

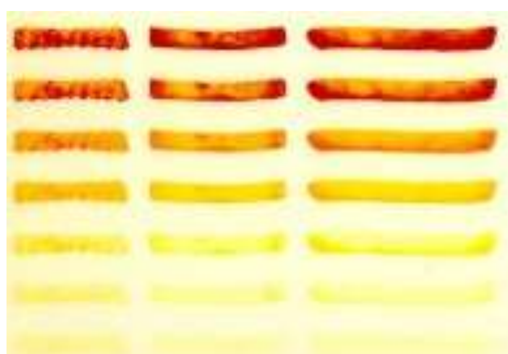
The maximum temperature at which growth will take place is called the maximum developmental threshold.

The number of GDD of different plants

Plant species	Days from bloom to harvest	GDD
Pea		1000 - 1200
Grapes	120-170	1955 - 3375
Apple	70 - 170	1400 - 2800

Sugar and starch conversions

$$\text{Sugar} \underset{\text{Cool}}{\overset{\text{Warm}}{\rightleftharpoons}} \text{Starch + Water}$$



Knowledge of the equation has important implications for the quality of horticultural food crops in the relation to the time of year and location where they are grown and their handling after harvest.

Soil temperature

- Influences
  - seed germination,
  - root growth,
  - plant growth and development,
  - water uptake,
  - disease susceptibility.
- Optimum is 15^o to $30\ ^oC$, depending on the species.

Temperature control in controlled environment

Vernalization

- The effect of low temperature on flower induction.
- For example biennials – beet, cabbage, celery, onion etc.

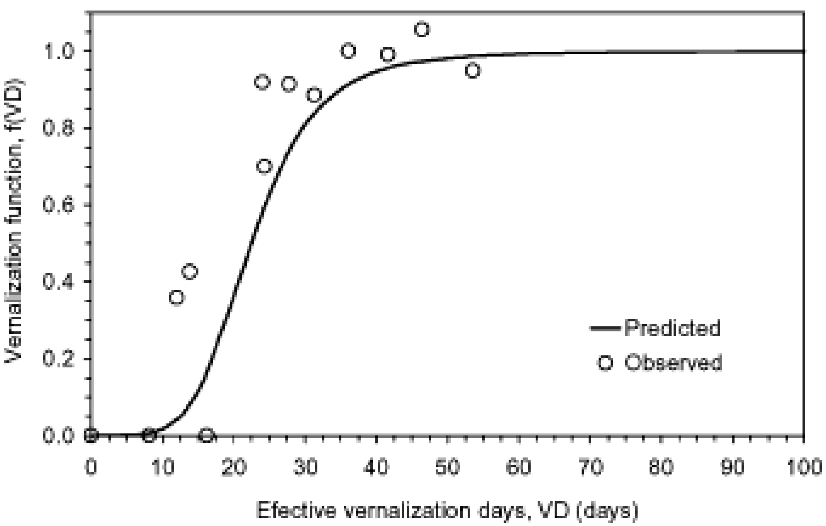


Figure 3 - The observed vernalization response of "Snow Queen" lily and the f(VD) predicted with the response function proposed by Streck (2002). Santa Maria, RS, Brazil, 2002/2003.

Dormancy

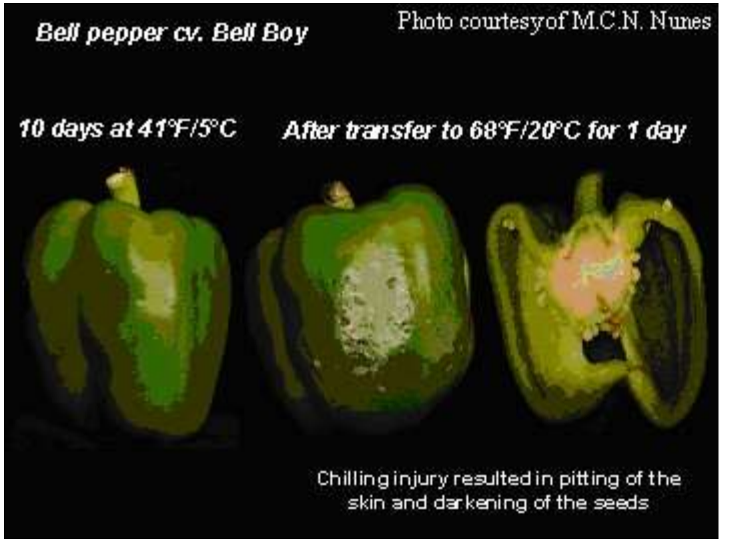
- Condition where germination or growth is inhibited by the plant physiological stage.
- Quiescent = ecodormancy.
- Knowledge of a plant's native ecology offers direction to the horticulturist.

	High chill	Medium chill	Low chill
Early maturity	Gala	Akane Gravenstein	Dorsett Golden (250) Anna (300) Ein Scheimer (400) 60-39 (400) 88-20 (375) Tropic Mac (300) Tropic Sweet (300)
Medium maturity	Delicious Golden Delicious Jonagold		
Late maturity	Fuji Braeburn	Granny Smith Sundowner Pink Lady	

Temperature stress

- Low-temperature effects.

  - Chilling Injury,



Temperature stress

- Low-temperature effects.
  - Chilling injury,
  - Freezing injury,

Temperature stress

- Low-temperature effects.
  - Chilling injury,
  - Freezing injury.




Temperature stress

- High-temeperature effects
  - heat stress,