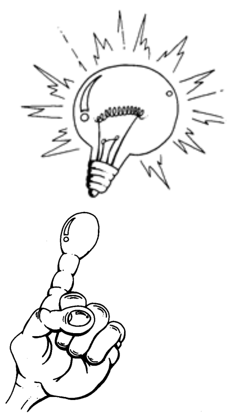
Colorado Master Gardener^{sm} Program
Colorado Gardener Certificate Training
Colorado State University Extension

GardenNotes #143

Plant Growth Factors: Temperature

Outline:



Thought questions

Explain the science behind the following gardening questions.

- Why did I have so much winter injury on my trees and shrubs? While it was dry and windy, temperatures were not extremely cold.
- My arborvitaes are bleached tan from the winter. Will they green-up with spring temperatures?
- With the rather hot summer, will the apple and peach crop be as sweet as normal?

Temperature Considerations

Temperature factors that figure into plant growth potentials include the following:

- Maximum daily temperature
- Minimum daily temperature
- Difference between day and night temperatures
- Average daytime temperature
- Average nighttime temperature

Microclimates

The microclimate of a garden plays a primary role in actual garden temperatures. In mountain communities, changes in elevation, air drainage, exposure, and thermal heat mass (surrounding rocks) will make some gardens significantly warmer or cooler than the temperatures recorded for the area. In mountain communities, it is important to know where the local weather station is located so gardeners can factor in the difference in their specific location to forecast

temperatures more accurately.
Examples of factors to consider include the following:

Elevation – A 300 foot rise in elevation accounts for approximately 1^o drop in temperature.

Drainage – At night, cool air drains to low spots. Valley floors may be more than 10^o cooler than surrounding gardens on hillsides above the valley floor. That is why fruit orchards are typically located on the benches rather than on the valley floor.

Exposure – Southern exposures absorb more solar radiation than northern exposures. In mountain communities, northern exposures will have shorter growing seasons. In mountain communities, gardeners often place warm season plants, like tomatoes, on the south side of buildings to capture more heat.

Based on local topography, buildings, fences, plantings, and garden areas may be protected from or exposed to cold and drying winds. They may also be exposed to or protected from warm and drying winds.

Thermal heat mass (surrounding rocks) – In many Colorado communities, the surrounding rock formations can form heat sinks creating wonderful gardening spots for local gardeners. Nestled in among the mountains, some gardeners have growing seasons several weeks longer than neighbors only a half mile away.

In cooler locations, rock mulch may give some frost protection and increase temperatures for enhanced crop growth. In warmer locations, a rock mulch can significantly increase summer temperatures and water requirements of landscape plants.
In Phoenix, Arizona, the urban heat island (with all their rock mulch instead of grass and trees) has significantly raised day and night temperatures. The upward convection of heat has become so strong that summer storms are going around the city and not raining on the urban heat island.

Impact of Heat on Crop Growth

Temperature affects the growth and productivity of plants, depending on whether the plant is a warm season or cool season crop.

Photosynthesis – Within limits, rates of photosynthesis and respiration both rise with increasing temperatures. As temperatures reach the upper growing limits for the crop, the rate of food used by respiration may exceed the rate at which food is manufactured by photosynthesis. For tomatoes, growth peaks at 96^o.

Temperature influence on growth

Seeds of cool season crop seeds germinate at 40^o to 80^o. Warm season crop seeds germinate at 50^o to 90^o. In the spring, cool soil temperatures are a limiting factor for plant growth. Mid-summer, hot soil temperatures may prohibit seed germination.

Examples of temperature influence on flowering

- Tomatoes
  - Pollen does not develop if night temperatures are below 55°.
  - Blossoms drop if daytime temperatures rise above 95° before 10 a.m.
  - Tomatoes grown in cool climates will have softer fruit with bland flavors.
- Spinach (a cool season, short day crop) flowers in warm weather with long days.
- Christmas cacti and poinsettias flower in response to cool temperatures and short days.

Examples of temperature influence on crop quality

- High temperatures increase respiration rates, reducing sugar content of produce. Fruits and vegetables grown in heat will be less sweet.
- In heat, crop yields reduce while water demand goes up.
- In hot weather, flower colors fade and flowers have a shorter life.

The table below illustrates temperature differences in warm season tomatoes and cool season cole crops.

Temperature for	**Cool Season:** broccoli, cabbage, and cauliflower	**Warm Season:** tomatoes, peppers, squash, and melons
Germination	40°-90°, 80° optimum	50°-100°, 80° optimum
Growth	Daytime • 65° - 80° preferred • 40° minimum Nighttime • >32°, tender transplants • > mid-20s°, established plants	Daytime • 86° optimum • 60° minimum • A week below 55° will stunt plant, reducing yields Nighttime • >32°
Flowering	Temperature extremes lead to bolting and buttoning.	• Nighttime <55°, non-viable pollen (use blossom set hormones) • Daytime >95° by 10 a.m., blossoms abort
Soil	Cool • Use organic mulch to cool soil. • Since seeds germinate best in warm soils, use transplants for spring planting, and direct seeding for mid-summer plantings (fall harvest).	Warm • Use black plastic mulch to warm soil, increasing yields and earliness of crop.

Heat Zone Map

A new concept in plant selection is ***heat zone mapping***, a measurement of the typical summer heat accumulation. It will help identify geographic areas that have adequate heat accumulation to mature various crops.

The American Horticultural Society's Heat Zone Map can be viewed on-line at: www.ahs.org/publications/heat_zone_map.htm.

Heat zones can be sorted by zip codes. To look up a heat zone by zip code, go on-line at www.ahs.org/publications/heat_zone_finder.htm.

It should be recognized that in mountain communities, minor changes in elevation and exposure (for example, south slopes versus north slopes) make significant differences in heat accumulation. A heat zone for a community's zip code may not reflect the actual growing conditions in any specific garden.

Impact of Cold Temperatures

Hardiness Zone Map

Hardiness zone maps indicate the average annual minimum temperature expected for geographic areas. While this is a factor in plant selection, it is only one of many factors influencing plant hardiness.

The U.S.D.A. Hardiness Zone Map was revised in 2003. Primary changes in the new map include the addition of four new zones in the sub-tropical area and the elimination of areas A and B for zones. Zones are based on a 10^{o} F difference in average annual minimum temperature.

	Average Annual Minimum Temperature
Zone 4	-20^{o} to –30^{o}
Zone 5	-10^{o} to –20^{o}
Zone 6	0^{o} to –10^{o}

On the 2003 Hardiness zone map, most of the Colorado Front Range falls into Zone 5, with cool mountain areas in Zone 4. Warmer locations in the Denver Metro, Fort Collins, El Paso and Pueblo Counties fall into Zone 6. Warmer areas of western, southwestern and southeastern Colorado are in Zone 6.

Hardiness zone maps can be viewed on-line at www.ahs.org/publications/usda_hardiness_zone_map.htm.

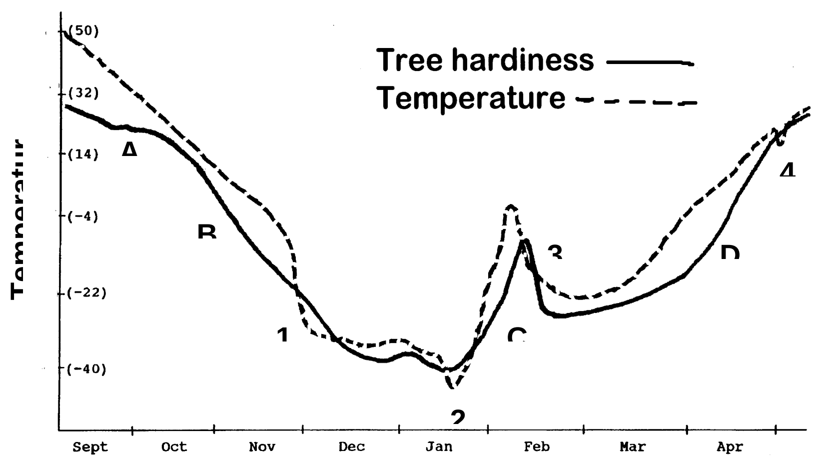
The new map was based on temperature data from 1987 to 2001 and does not reflect "normal low" (30 year base) or "record low" (all time low based on available records) used in weather reporting. On the new map, some areas of the nation are in a zone higher than on previous maps due to a warmer than normal weather period from 1987 to 2001 or due to growth in the urban heat island. When talking about Hardiness Zones Maps, it may be important to clarify whether the gardener is referring to an old version or to the 2003 version.

Plant Hardiness

Hardiness refers to a plant's tolerance to cold temperatures. Low temperature is only one of many factors influencing plant hardiness (ability to tolerate cold temperatures). Key hardiness factors include the following:

- Photoperiod
- Genetics (source of plant material)
- Low temperature
- Recent temperature pattern
- Rapid temperature changes
- Moisture
- Wind exposure
- Sun exposure
- Carbohydrate reserve

Impact of temperature change on hardiness



Hardiness changes through the winter period

A. Increased cold hardiness induced by short days.
B. Increased cold hardiness induced by low temperatures.
C. Dehardening due to abnormally warm temperatures
D. Normal spring dehardening
1. Injury due to inadequate fall hardening from rapid drop in temperature
2. Injury at temperatures lower than hardening capability.

Examples of Winter Injury

Bud kill and dieback – from spring and fall frosts

Root temperature injury – Roots have limited tolerance to sub-freezing temperatures. Roots have limited protection from soil, mulch, and snow. Under extreme cold, roots may be killed by the lack of snow cover or mulch. Street trees are at high risk for root kill in extreme, long-term cold.

Soil heaving pushes out plants, breaking roots. Protect with snow cover or mulch.

Trunk injury – Drought predisposed trunks to winter injury.

Sunscald – caused by heating of bark on sunny winter days followed by a rapid temperature drop, rupturing membranes as cells freeze. Winter drought predisposes tree trunks to sunscald.
Frost crack – vertical split on tree trunk caused by rapid drop in bark temperature.
Frost shake – separation of wood along one or more growth rings, typically between phloem (inner bark) and xylem (wood), caused by sudden rise in bark temperature.

Winter injury on evergreens

Winter drought – water transpires from needles and can't be replaced from frozen soils. It is more severe on growing tips and on the windy side of trees.
Sunscald – winter sun warms needles, followed by rapid temperature drop rupturing cell membranes. It occurs typically on southwest side, side of reflected heat, or with sudden shade.
Photo-oxidization of chlorophyll – foliage bleaches during cold sunny days. Needles may green-up again in spring.
Tissue kill – tissues killed when temperatures drop below hardiness levels.

Rest Period

An accumulation of cool units controls the flowering period of temperate-zone woody plants. The winter rest period (hours below 45^{o}) required to break bud dormancy includes:

Apricot	100-400 hour	Peach	800-1200 hours
Apple	250-1700 hours	Pear	200-1500 hours
Cherry, sour	600-1400 hours	Plum, European	900-1700 hours
Cherry, sweet	500-1300 hours	Plum, Japanese	300-1200 hours

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