CMG GardenNotes #143

Plant Growth Factors: Temperature

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

Microclimates are small areas where environmental conditions may be different than the general surrounding area. 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°F drop in temperature.

Drainage – At night, cool air drains to low spots. Valley floors may be more than 10°F cooler than surrounding gardens on hillsides above the valley floor. That is why fruit orchards are typically located on higher ground rather than on the valley floor. [**Figure 1**]

Figure 1. This garden on a hillside above Steamboat Springs, Colorado (a mountain community with a short frost-free season) has good drainage giving it a growing season that is several weeks longer than down in town.

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. [**Figure 2**]

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

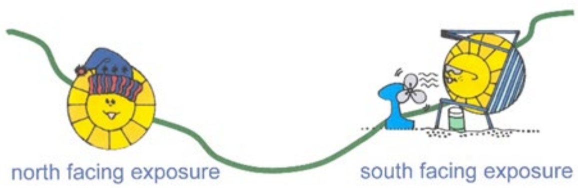

Figure 2. Temperatures and growing season vary greatly based on exposure. A north facing exposure will typically be cooler and moist. A south facing exposure will typically be hot and dry.

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 (particularly spring and fall soil temperatures) for enhanced plant growth. In lower elevations and latitudes, rock mulch can significantly increase summer temperatures and water requirements of landscape plants. [**Figure 3**]

In Phoenix, Arizona, the urban heat island effect created by impermeable surfaces and rock mulch has significantly raised day and night temperatures.

Figure 3. The sidewalks and stone walls of this intercity plaza creates a heat pocket with a frost-free period three months longer than the surrounding neighborhood.

Influence of Heat on Crop Growth

Temperature affects the growth and productivity of plants. The effect on individual plants depends on physiology, for example vegetables being a warm season or cool season crop dictate their performance at hot or cold temperatures.

Photosynthesis – Within limits, rates of photosynthesis and respiration both rise with increasing temperatures. As temperatures reach the upper growing limits for a plant, the rate of food used by respiration may exceed the rate at which food is manufactured by photosynthesis. Furthermore, photosynthesis becomes less efficient at higher temperatures. Some plants (many grasses and succulents, for example) have specialized photosynthetic pathways in order to allow them to grow at higher temperatures.

Temperature Influence on Germination

Seeds of cool season crops germinate at 40 degrees to 90 degrees. Warm season crop seeds germinate at 50°F to 105°F. In the spring, cool soil temperatures can be a limiting factor for plant growth. In 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°F.
- Blossoms drop when daytime temperatures are consistently above 85°F or nighttime temperatures are consistently above 70°F.
- 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.

Table 1 illustrates temperature differences in warm season and cool season crops.

Table 1. Temperature Comparison of Cool Season and Warm Season Crops

Temperature for:	**Cool Season:** broccoli, cabbage, carrots, etc.	**Warm Season:** tomatoes, peppers, squash, melons, etc.
Germination	40°F to 90°F, 65°- 85°F optimum range.	50°F to 105°F, 70°- 95° F optimum range.
Growth	**Daytime** • 65°F to 80°F preferred. • 40°F minimum. **Nighttime** • >32°F, tender transplants • > mid-20s°F, established plants.	**Daytime** • 75°- 85°F optimum. • 55°F minimum. • A week below 55°F will stunt plant, reducing yields. **Nighttime** • >52°F.
Flowering	Temperature extremes lead to bolting and buttoning.	• Nighttime <55°F, non-viable pollen (use blossom set hormones) • Daytime >95°F early in day; blossoms abort.
Soil	**Cool** • Use organic mulch to keep soil cool. • 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 or rock mulch to warm soil, increasing yields and earliness of crop.

Influence of Cold Temperatures

Plant 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.

In 2012, the U.S. Department of Agriculture released a new USDA Hardiness Zone Map. It can be found at https://planthardiness.ars.usda.gov/. It documents a climate zone creep, that is, zones moving northwards in recent years. Zones are based on a 10°F difference in **average annual minimum temperature.**

Average Annual Minimum Temperature
Zone 4, -20° F to –30° F.
Zone 5, -10° F to –20° F.
Zone 6, 0° F to –10° F.
Zone 7, 0° F to –10° F.

Much of the Colorado Front Range area falls into Zone 5, with higher mountain areas in Zone 4. Warmer locations in the Denver Metro area, the upper Arkansas valley, and southeast Colorado fall into Zone 6. Warmer areas of western and southwestern Colorado are in Zone 7.

Plant Hardiness

Hardiness refers to a plant's tolerance to cold temperatures. Low temperature is only one of many factors influencing plant hardiness. Other hardiness factors include:

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

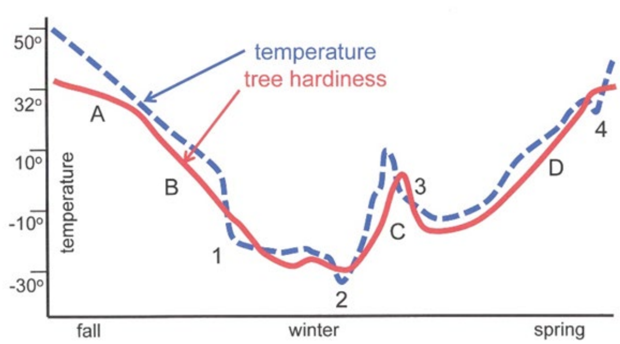

Figure 4. Influence of temperature change on winter hardiness of trees.

Figure 4. The solid line represents a tree's hardiness. Regions A-D represent various stages of hardiness through the winter season. The dotted line represents temperature. When the dotted (temperature) line drops below the solid (hardiness) line, damage occurs. Points 1-4 represent damage situations.

A. Increased cold hardiness induced by shorter daylength of fall.
B. Increased cold hardiness induced by lowering temperatures.

C. Dehardening due to abnormally warm mid-winter temperatures.
D. Normal spring dehardening as temperatures warm.

1. Injury due to rapid drop in temperatures with inadequate fall hardening.
2. Injury at temperatures lower than hardening capability.
3. Injury due to rise and fall of midwinter temperatures.
4. Injury due to spring frosts.

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 receive 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 predisposes 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. [**Figure 5**]

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.

Frost Crack – Vertical split on tree trunk caused by rapid drop in bark temperature. [**Figure 6**]

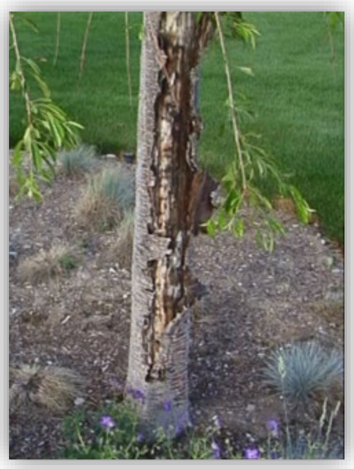

Figure 5. Southwest bark injury is common on trees that are drought stressed or that have thin, smooth bark.

Figure 6. Vertical frost crack is common on trees when the temperature drops rapidly. In Colorado it is common to go from a nice spring day back to cold with a 40 to 60 degree temperature drop in an hour!

Winter Injury on Evergreens

Winter drought – Water transpires from needles and cannot be replaced from frozen soils. It is more severe on growing tips and on the windy side of trees. [**Figure 7**]

Sunscald – Winter sun warms the needles, followed by rapid temperature drop rupturing cell membranes. It occurs typically on the 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.

Figure 7. Winter drought, sunscald, and photo-oxidization of chlorophyll are common on arborvitae. It's a poor plant choice for this windy site with little winter moisture.

Rest Period

An accumulation of cool units controls the flowering period of temperate-zone woody plants. The winter rest period (hours above freezing and below 45°F) required to break bud dormancy includes:

- Apples at 250-1700 hours.
- Apricots at 350-900 hours.
- Cherry, sour, at 600-1400 hours.
- Cherry, sweet, at 500-1300 hours.
- Peaches at 800-1200 hours.
- Pears at 200-1500 hours.
- Plums, European, at 900-1700 hours.
- Plums, Japanese, at 300-1200 hours.

Authors: David Whiting, CSU Extension, retired. Artwork by Scott Johnson and David Whiting. Used with permission. Revised July 2016. Reviewed March 2023 by John Murgel, CSU Extension and Sherie Shaffer, CSU Extension.

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