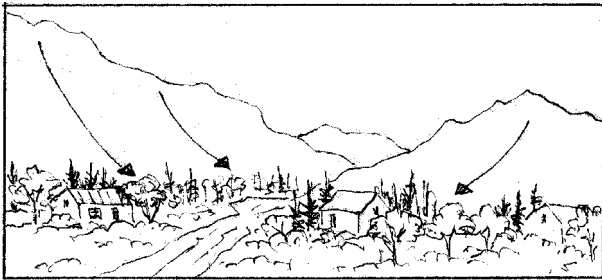


you are generally 4 degrees colder than the temperature reported at the airport).

- ▶ Cold air settles downward, flowing like water, to the lowest point. Hot air rises. Cold air may collect at the bottom of a slope.
- ▶ Cold winds compound temperature loss.



Understanding Plant Response to Cold

- ▶ The effects of temperature vary with plant species, stage of growth, age, general health and water content. Young, actively growing, flowering, and/or dehydrated plants tend to be most vulnerable.
- ▶ Cold temperatures and short day length slow plant growth and cause dormancy, making plants less susceptible to frost damage.
- ▶ Actively growing foliage is very susceptible to frost damage. If a freeze occurs when there has been no prior cold weather to "harden off" a plant, the damage will be more extensive. Therefore the heaviest damage from low temperatures generally occurs in late spring, early fall, or any time cold temperatures occur after a warm winter period.
- ▶ The lower the temperature, the longer the exposure, and the faster the temperature drops, the greater the damage to the plant.
- ▶ Common types of damage include: death of dormant flower buds, dieback of overwintering broad-leaved plants, frost damage to tender shoots, flowers, and fruits.

Understanding Heat Transfer

- ▶ Conduction: Heat is transferred through direct contact (e.g. a coffee cup to your hand).
- ▶ Convection: Transfer of heat by currents in gasses or liquids (e.g. the Santa Ana Wind).

- ▶ Radiation: Heat passes through the atmosphere with negligible impact on air temperature (e.g. sunlight).

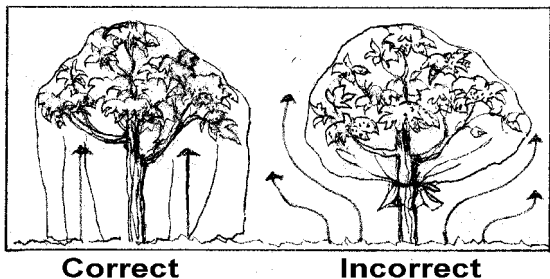
Preventing Frost Damage

- ▶ **Plant Selection**
 - Select frost tolerant plants.
- ▶ **Plant Placement**
 - Place frost sensitive plants in sheltered locations.
 - Western and southern exposures tend to be warmest.
 - Block walls, rocks and patios collect and reflect the heat of the sun.
 - Full sun is warmer than shaded locations (though night temperatures, the cause of most frost damage, will be impacted by other factors)
 - Place frost-tolerant plants that may blossom too early and thus risk flower and fruit damage in cold spots to prevent a premature break of dormancy.
- ▶ **Plant Care**
 - Keep plants well watered. Frost injury occurs when ice crystals form on the leaf surface drawing moisture from the leaf tissue. The damage from this dehydration will be less severe if the plant is not already drought-stressed.
 - Firm, bare, moist soil absorbs more heat and loses it more rapidly than soil that is loose, dry, or covered with mulch or vegetation.
 - Manage your irrigation carefully, keeping the moisture level as even as possible.
 - There are other products marketed to protect plants from frost damage. Read the label carefully.
 - Don't over protect! Plants are more frost resistant if kept hardened to cold weather.

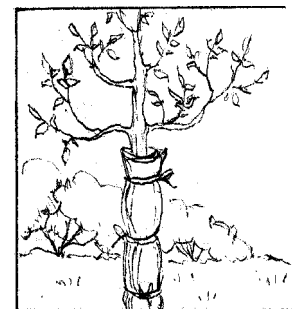
► **Reduce Heat Loss**

- Cover plants with cloth or paper (not plastic) to insulate. You can use sheets or blankets for minimal protection or use a frost cloth. A properly applied frost cloth can protect plants at temperatures down to 30° F, some down as low as 20° F depending on the fabric and the weave. Completely drape the plant from top all the way to the ground. Do not allow any openings for warmth to escape. This procedure will trap the heat radiating from the soil and maintain a more humid atmosphere around the plant foliage. Optimally, the drape will be supported by frame which does not allow it to touch the foliage. DO NOT gather the drape around the trunk of the tree. The goal is to trap heat being radiated from the ground, so ensure that the drape touches the ground at least as far out as the drip line.

If you use sheets or blankets, remove the coverings every morning when the temperature under the covering warms to 50° F. Permanently covering plants with sheets or blankets for the duration of the winter can be harmful and is not recommended in southern Arizona. Even if the temperature under the drape does not warm up enough to “cook” the plant, it is likely to warm up enough to cause the plant to break dormancy, begin actively growing, and thus become more susceptible to frost damage. Many of the frost cloths available may be left on for extended periods without risk of harming the plant.



- Wrapping trunks of young citrus and other frost sensitive trees is a practical way of preventing serious frost damage to their vital stem area.



Multiple layers of weatherproof paper or cloth provide good insulation against cold. Looser wrapping provides better insulation and should extend completely to the ground and at least up to the lower branches or limbs. This wrapping may be left on all winter (mid-November through mid-February).

► **Utilize Heat from the Immediate Surroundings**

- Walls and benches exposed to the sun during the day are good sources of heat at night.

► **Add Heat**

- 100- watt electric light bulbs, in an approve outdoor fixture, can provide supplemental heat to covered plants, if needed. Be sure to hang them below the foliage, allowing the heat they generate to rise (within the covered area) and warm the plant. Take care that the bulb is not so close to the trunk or a branch that it could burn.
- Apply running water (just a trickle) to the ground at the base of the tree late night and early morning for no more than three nights in a row (after that the detrimental effects of drowning the plant cancel out any frost protection benefits). When water is cooled, energy in the form of heat is released.
- Mulches insulate against fluctuating surface soil temperatures. They can help guard against too much daytime warm-up that, in turn, would activate plant growth and increase freeze risk.

Common Symptoms Of Frost Damage

- Death of fruit, flowers and dormant flower buds.
- Dieback of leaves, shoots, stems.

Treatment

- ▶ Do NOT prune frost-damaged, woody growth until the plant begins growing in the spring. Pruning might stimulate new growth which would be vulnerable to late frosts. The frost-damaged leaves and stems will continue to help trap warm air within the canopy. In addition, the damage is often not nearly as bad as it initially looked, new growth may come out of tissue that you thought was dead. Only after new growth starts in the spring, prune out dead wood.
- ▶ In grafted plants (many citrus), if the plant dies all the way back to the bud union (the initial graft), then the regrowth will be of the root stock and not the desired variety. Re-graft to the root stock or replace the tree.

What does not work

- ▶ Smudge pots: they block 90% of the radiant heat from the sun but trap only 20% of the heat stored by the earth.
- ▶ A large fire: creates updraft sending hot air above plants, sucking in cold air from surrounding areas.
- ▶ Mulch: Prevents the warming of the soil. This is helpful if you are trying to keep a deciduous fruit tree from breaking dormancy too early, but it prevents the capture of heat that could be harnessed to protect a frost sensitive plant like citrus.
- ▶ Chemicals: a variety of chemicals have been marketed with claims of changing the freezing point of the plant tissue; reducing the ice-nucleating bacteria on the crop (thus inhibiting ice and frost formation), or affecting growth (extending dormancy). To this date no commercially available material has withstood scientific scrutiny.

Art Work by Erin O'Dell

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