

Protecting Avocados from Frost and Then What

The long-range forecast for no or little rain in Southern California. A dry winter often means a cold winter. A winter when frost and freeze can occur -

<https://www.californiaavocadogrowers.com/sites/default/files/greensheet-pdfs/Greensheet-Nov-2-2020.pdf>

The following is an outline of how a grower can prepare for cold events. Some require considerable advance preparation – plant the right variety – and some can be instituted right away – protection of young trees with palm fronds. The guidelines here are specific to avocado, but for the most part apply to lemon and other cold sensitive citrus.

Frost damage reduces tree growth and fruit yields. Thus, it presents a problem to the avocado grower who must develop and maintain high production to have a profitable business.

Before choosing frost protection equipment, however, the individual grower should ask the question: “Will the fruit and foliage saved pay for the trouble and expense of protection?” In some places, a small amount of damage may not fully justify the installation and operation of frost protection equipment. In other places, avocados can be grown only if expensive heating is done. Nearly all locations have sufficient cold to cause the grower to take into account probable frost damage, possible methods of protection, and the long-range economic effect of his frost situation.

How Frosts and Freeze Occur

Before considering the methods of frost protection, one should understand the conditions under which low temperatures occur. To differentiate between the two major sources of the cold, the terms *local radiation frost* and *freeze* are used.

Local radiation frost

Frosts are caused by a cooling of the objects on the earth’s surface during the night. This loss of heat from the foliage and soil is called *radiation*. Heat accumulated from sunshine during the day is radiated to the sky during the night. The cooled objects chill the surrounding air and usually the coldest zone is near the ground surface. Air temperatures are warmer as one goes higher until a height is reached where they are at a maximum for that location. This is called the *ceiling*. The temperature and height of the ceiling is different for each place and situation.

When the ceiling is low, warm air is nearer the ground than when the ceiling is high. This phenomenon, occurring frequently in Southern California, is called *temperature inversion* and accounts for this area’s ability to protect its orchards.

Colder air settles near the ground and then moves (flows) down the slope to still lower ground resulting in what is called the *drift*.

Terrain features and winds influence its direction and velocity. A strong drift maintains air temperatures higher than those existing when little or no drift is present.

Freeze

The other type of freezing weather occurs when a large mass of cold air moves in from the north. Fortunately, these freezes have not occurred frequently. The major ones were in 1913, 1922, 1937, 1949, and 1950. Under freeze conditions, temperatures usually go below those experienced during local radiation frosts. When this cold air moves in, high ground is no warmer than lower ground and there is little or no ceiling. Orchard protection at such time is difficult, and methods employing the addition of heat are most effective.

Measuring Temperatures

Orchard temperatures are usually measured with a specially designed self-registering minimum thermometer mounted in a standardized shelter. In this way, readings are comparable and experience allows the grower to use these air temperature readings in judging his hazard and operating his equipment. The height of the thermometer above ground should be five feet in mature orchards and two feet in nurseries and recently planted orchards.

Most orchards have areas which are colder than other areas. You should have enough thermometers to measure temperatures in each of these areas. In establishing thermometer locations in a new orchard, set up one thermometer in a permanent reference location. Move the other thermometers around every few nights until you find the cold spots. With this experience, you can locate and determine the number of thermometers needed. The range in numbers will be from a minimum of two or three for small groves to one for each three to five acres in larger orchards.

Types of Injury

Fruit damage

Fruit damage consists of frozen stems, frozen fibers inside the fruit, or frozen flesh and skin, depending on the temperatures and their duration. This damage appears slowly and is difficult to appraise accurately.

For some varieties, principally in the case of the 'Hass', the first evidence of damage will show up as a browning on the stem a few days after a frost. If this is the only damage, mature fruit might be picked and marketed. This all depends on the packer. The problem often is assessing how extensive the damage is. Unless this fruit is harvested, it will fall from the tree. Frozen fruit of other varieties, particularly the Guatemalan types, may never show the browning but will drop anyway.



Stem Damage

Frozen fruit fibers (vascular bundles) turn black and California law prohibits the marketing of all seriously damaged fruits. Before you pick mature frosted fruit, you should call in your marketing organization representative and local agricultural inspector to help you determine how much of the fruit should be harvested. By cutting representative fruit, they can tell whether it is within the legal tolerance or not, and guide you in marketing your fruit.

Severely frozen fruit may show brown water-soaked spots in the skin, gray areas in the flesh, and may even crack or split. It is unmarketable and will drop from the tree in time.



Water soaked and frosted neck, Mary Lu Arpaia



Brown vascular bundles, Mary Lu Arpaia

Tree damage

Frozen blossoms, leaves, and twigs turn black within a few days. But larger wood, although frozen, may never turn black. Great variation occurs in the location of tree damage. In some cases, only the lower part of the tree will be frosted, while in other cases only the top part is affected. Sometimes, only a limb on one side will be frosted. Thus, it is impossible to evaluate accurately the extent of wood damage until new growth comes out the following spring and summer.

Trees suffering moderate wood damage usually will not bloom properly and will produce a reduced crop the following season. Occasionally, trees have been killed all the way to the ground by severe freezes.

Tree Resistance

The resistance of the fruit and trees to freezing temperatures helps determine whether a grove must be protected or not. Then, too, both the minimum temperature and the duration of damaging temperatures affect the amount of injury. For example, three or four hours of 29 degrees may injure an orchard more than a brief drop to 25 degrees.

Frost susceptibility varies greatly from situation to situation. Adequate appraisal of each situation should include consideration of the following variables.

Age and crowding

Young trees (up to 3 years of age) and recently top-worked trees of all varieties may be killed by temperatures which would only cause minor damage to nearby mature trees. Protection for such trees is a wise practice, even in warm locations.

In general, older trees of a given variety are more resistant, except in orchards where they are crowded. Where the soil is shaded during the day, it cannot absorb the sun's heat and thus has little heat to give off during the night. Crowding also restricts the drift through the grove and increases the difficulties of orchard heating. For these reasons, thinning groves is often advisable to reduce their frost hazard.

Health

Weak trees are more subject to frost damage than healthy ones. Be sure your trees go through the whole year with an adequate supply of moisture; withholding irrigation water in the fall to "harden them up" can actually weaken trees and make them more susceptible.

Growth flush

Occasionally avocado trees are in a growth flush (a period of rapid new growth) when freezing temperatures occur. This is not usual, but unseasonably warm weather may stimulate a tree into abnormal growth in the winter. To avoid stimulation, pruning should be delayed until early spring. When tender growth occurs in the winter, growers may have to provide additional protection or sustain damage.

Size of crop

Trees with large crops are more susceptible to frost. To save this fruit, temperatures would have to be maintained one or two degrees higher than would otherwise be necessary.

Varieties of avocado

A wide range of susceptibility occurs among avocado varieties. To classify them according to their resistance is difficult because of the variations already mentioned. But the races of avocados do exhibit differences and can be used as frost resistance indicators.

The *Mexican race* is the most resistant, and is able to withstand temperatures about as well as orange trees.

The *Guatemalan race* is the most susceptible grown in California. Some varieties are slightly more resistant than others, so the race can be divided into tender and very tender classifications. Because the fruit is immature during the winter, the crop may be lost while the trees will suffer only minor damage. Lower temperatures will seriously damage trees and affect their future productivity.

The *hybrids*, as typified by the Fuerte, are intermediate in their frost resistance, and are in about the same class as lemon trees. Because of the Fuerte's importance, it has become the standard measure of

frost resistance. Protection is usually provided to save the Fuerte crop since the fruit is mature in the winter months.

As a guide to inexperienced growers, Table I gives a basis for establishing frost protection practices. The critical temperatures listed are for mature healthy trees. Other tree conditions might move these figures one or two degrees higher. Also, the duration of the damaging temperatures would affect the degree of injury. It is still not clear how much cold ‘GEM’ variety can handle.

Table I – Variety Frost Resistance		
Race	Typical Varieties	Critical Temperature Below Which Fruit and/or Trees are Subject to Damage
Mexican	Duke, Topa Topa, Mexicola, Zutano, Bacon	25 Degrees F
Hybrids	Fuerte, Puebla	28 Degrees F
Guatemalan (Tender)	Ryan, Hass, MacArthur, Nabal, Edranol, Rincon, Lamb Hass, Sir Prize	29 Degrees F
Guatemalan (Very Tender)	Anaheim, Dickinson, Carlsbad, Challenge, Hellen	30 Degrees F

Need for Protection

Frost protection is an expensive and disagreeable job which requires careful consideration by all growers. Each grower must determine his own needs. No one can predict accurately the frost hazard for a given location. Information can be obtained by installing the proper thermometers on the property. Observing adjoining orchards and talking with neighbors will give good background information.

The topography of the orchard and the surrounding land enters into the evaluation. Land on hillsides with steeper slopes is usually warmer than lower valley land. Locations with strong prevailing drifts, or exposed to winds, usually are warmer than sheltered areas having little air movement. Tall dense windbreaks can make a grove one or two degrees colder, but the lower branches of the windbreak can be trimmed to overcome this. Coastal areas usually have less frost hazard because the relative humidity is higher, and ceilings are lower than in interior areas.

As mentioned in the beginning, your final evaluation should answer this question: “Will the fruit and foliage I save pay for the trouble and expense of protection?” Often it is possible to take some damage every few years and still have a more profitable orchard than if equipment were purchased and operated. On the other hand, an investment in equipment, if properly operated, will save your trees and crops. The decision should be based on a long-range economic estimate, balancing the money lost by damage against the costs of protection. This same evaluation will determine the type of protection to provide, if needed.

In some counties and communities, smoke ordinances regulate the type of equipment and methods of operation to reduce smoke output. When you purchase new orchard heater equipment, it should be the most smokeless available in order to comply with possible future expansion or tightening of these ordinances. The trend toward eliminating smoky orchard heaters in most areas will affect the grower’s choice of equipment.

Methods of Protection

Mature orchards

Only two general methods of protecting avocado groves have proved satisfactory – heaters and wind machines. A combination of these two also is used. Many makes and designs of heaters and wind machines are offered for sale and they must be compared on the basis of protection provided and cost of installation and operation. This publication is limited to their general application in avocado groves. Their actual operation is discussed in other available publications of the University of California.

Orchard heaters

Experience has shown that a large number of small fires burning throughout the orchard provide better protection than a few large fires concentrated in spots. The value of heaters is noted below to provide a basis for selecting the general type of protection needed.

Their advantages are:

- They usually furnish more adequate protection than wind machines. However, in extremely cold conditions they, too, can be inadequate.
- Only enough heaters to maintain safe temperatures need to be lighted.
- Additional heaters and oil can be stored in the field for emergency conditions.
- They distribute heat to all parts of grove.

Their disadvantages are:

- Smokiness. However, certain types have low smoke output when properly operated.
- Relatively high costs of investment and operation (Table II).
- Fire hazard due to mat of leaves beneath the trees.
- Trouble and work of operation and maintenance.
- High labor requirements.

For colder locations and positive protection, orchard heating is the only proven method. Pie line heaters, using either heater oil or natural gas under pressure from permanently installed pipelines, are efficient but very expensive. Economical and effective heating is provided by heaters with 9-gallon capacity bowls and improved designs of stacks burning a low grade of diesel oil. Usually 45 to 90 heaters are used per acre depending on the frost hazard.

Wind machines

In certain locations, wind machines have provided economical protection. Their effect is essentially that of a large fan which mixes the air within and above the orchard so that the average air temperature near the ground is raised.

Their advantages are:

- More economical than orchard heaters (Table III)
- Low labor requirements for operation
- Adequate protection against local radiation frosts when temperatures go only 2 or 3 degrees below the damaging point.
- Useful in increasing air movement in groves where dead air occurs.
- Increase effectiveness of heaters.

Their disadvantages are:

- Inadequate protection with freeze conditions or when temperatures go 4 or 5 degrees or more below the damaging point.
- Inadequate protection in locations where little or no ceiling occurs.
- Unequal protection throughout grove
- Less effective in young plantings.

Machines providing at least 5 horsepower per acre should be selected on the basis of cost and ease of operation. The location of the machine or machines in an orchard depends on the drift, the topography, and the other variables.

Combination heaters and wind machines

Usually 8 to 25 heaters per acre uniformly scattered throughout the grove are sufficient when used with an effectively installed wind machine. The combination provides adequate protection for even the colder locations. The wind machine will protect the grove for some of the nights by itself, but for the

very cold nights, the heaters are available to add heat and thus provide positive protection. Usually the heaters are lighted whenever the wind machines cannot maintain the temperatures above the danger point.

This combination method has the advantage over heaters used alone in that it is cheaper, while providing as complete protection.

A great many other types and methods of protection have been tried but because of one or more faults in each, they cannot be recommended.

Protecting Young Trees

Orchard heaters and wind machines are less effective in protecting young trees in their first two or three years in the orchard than other methods which are usually cheaper, anyway. The first consideration in protecting newly planted trees is to have the trees as large as possible. Planting and topworking should be done in the spring so the trees will make the maximum growth during the summer and fall, before low temperatures occur in the winter.

In locations having serious frost hazard, you might try the practice of planting Mexican seedlings in place in the field and permitting them to grow for 2 to 3 years before topworking. Then if the topworking is done early in the spring, the young trees will have made enough growth to better withstand the cold of the following winter.

Protection for young trees is best accomplished by sheltering them from radiation heat loss. Shelters for this purpose are of many types. In cold locations, young trees may require several types of protection; they may be wrapped with paper, mounded with dirt, or surrounded with corn stalks.



Use of palm fronds for both sun and frost protection, Leo McGuire.

Care of Frost Damaged Trees

Determining the amount of damage is often a difficult job and cannot be done accurately for some months following the freeze. It is usually better to let the tree recover by itself.

Sunburn prevention

Exposed limbs can be badly damaged by sunburning. Whenever defoliated trees have not grown enough new leaves to protect the limbs before hot weather occurs, you should provide protection.

Protection is best provided by spraying or painting all exposed limbs with either a cold-water white latex paint or a whitewash. The paint needs to be white enough to reflect the light, but thin enough to flow through a sprayer. With latex paint, a 2-part latex to 1 part water is usually adequate.

Irrigation

Do not irrigate frosted trees until the soil in the root zone approaches dryness. The loss of leaves reduces the use of water so the soil will remain wet longer than with unaffected trees. Careful, frequent examination of the soil is necessary to prevent excess moisture from normal irrigations. Avocado root rot occurs in soils with excessive moisture when the cinnamon fungus is present, and growers must guard against this disease following frost damage.

Pruning

Do no pruning until you know how much of the tree has been killed. New foliage will grow from the remaining live wood and the tree will recover better without pruning.

When new shoots are at least two or three feet long, you can remove the dead wood. This will usually be mid-summer, 6 to 8 months following the frost. At the same time, suckers should be thinned out to select the new limbs to replace those lost.

Decisions about pruning

Dictated by the amount of freeze damage

Light Damage	Medium Damage	Severe Damage	Extreme Damage
Where only the foliage and small twigs are injured, pruning is not required.	Where a considerable part of the top has been killed but the trunk and main crown limbs show little damage, branches should be removed back to living wood above vigorous sprouts	Where the top and crown are severely damaged but there are sprouts above the bud union, the tree should be cut back to the uppermost sprout.	Where trees are killed to the bud union or the rootstock has been girdled, the trees should be removed and replaced with new trees.

Care of young trees

Badly frozen young trees usually develop strong sucker growth which can be used to form a tree as good as a replanted tree. If these suckers are from above the bud union, you can develop a new top by thinning and training. On young trees frozen back to below the bud union, strong root suckers can be budded or grafted to the desired variety the following spring. If the sucker growth is weak, the tree should be removed.

Severely frozen mature trees

The handling of severely frozen mature trees where they have been killed back to the large scaffold limbs, to the trunk, or to the ground, presents many problems. Each tree should be considered separately. Often growers should topwork badly frozen trees to a more resistant or productive variety.



Whitewashed and topworked frozen tree