Preventing Frost Damage in Vineyards

This leaflet reviews current cultural, management, and mechanical methods to prevent frost damage in California vineyards. One or all of the techniques described herein could be useful in the face of energy shortages and inevitably increasing costs. For more detailed economical considerations of frost prevention, consult *Frost Protection for North Coast Vineyards, Leaflet 2743*, University of California Division of Agricultural Sciences, or the U.C. Cooperative Extension Service in your county.

VALUE AND FEASIBILITY

Whenever air temperatures in grape vineyards drop to 31°F (the danger point for grapevines established by the National Weather Service), frost protection methods become necessary.

Prices of wine grapes have risen sharply in the past decade, and many growers have found it worthwhile and financially feasible to protect their vines against frost damage. In spite of recent drops in grape prices, it is more than likely that prices will become higher in the long run as the demand increases—especially for high-quality varieties. Frost protection can help to guarantee a continuous supply of these grapes.

Good cultural and management techniques alone may prevent frost damage. The cost of energy to operate various frost-reducing devices is rising, and, in view of a possible energy shortage, one or more of the following techniques may be needed: (1) late or double pruning to delay the time at which buds on the retained spurs leaf out; (2) growth regulators, such as gibberellin or alpha naphthylacetic acid, or sprinkling on sunny days in late winter and spring (both experimental) to delay leafing out of vine buds; (3) proper timing of cultural practices to enable soil to store heat during the day so that it is available at night; (4) removing obstacles to the natural air movement that prevents “frost holes.”

Mechanical devices for frost control that are most reliable are overhead sprinklers, orchard heaters, and blowers or wind machines. Select the method according to the frost severity and climatic conditions in your vineyard location. Capital outlay or operational costs are greatly influenced by the availability and fluctuating prices of energy and of water (if sprinklers are used).

Overhead sprinklers are now designed for optimum efficiency and use less water than those used for irrigation. An installation can prove especially valuable during the days of early summer, when there is danger of shrivelling of berries during extreme dry and windy hot spells. However, they require a considerable amount of water if needed on successive days.

Heaters may cost less initially, but they require more energy and attention.

Blowers or wind machines need little attention, but in severe frosts they require the support of additional heaters, which do need to be ignited. Wind machines use pollution-free energy, but they are sometimes noisy. Manufacturers are working to improve them.

CULTURE AND MANAGEMENT

Pruning

Late or double pruning not only will delay leafing out and thereby protect against early spring frosts, but in some coastal vineyards it will also protect against abnormal leaf symptoms and shoot growth (wide
pellolier stances of the lower leaves and zigzag and brushy shoot growth. While the cause of these symptoms has not been discovered, late or double pruning has been shown to restore normal growth and may even increase production by 15 to 25 percent—more than covering the costs of the pruning.

Late pruning. During the dormant season, the time of pruning generally has little or no effect on the time of leafing out, on the vigor of growth, or on the crop in the following years. Late pruning, however, after the buds on the apical parts of the canes have started to grow, delays the leafing out of the buds on the retained spurs and would protect vines from many early frosts. This delay may vary from 1 to 2 weeks, depending on the temperature. When it is very warm, the delay is short; when it is cold, the delay is longer. The shoots that grow mainly on the apical portions of the canes can be allowed to grow 3 or 4 inches without injuring the basal buds or the vine in general.

Delayed pruning in large vineyards until the apical shoots have grown 3 to 4 inches may present some labor problems—especially during seasons when vines burst into rapid growth. If shoots should grow considerably more than 3 or 4 inches before pruning, the vines may be weakened and the crop reduced.

Double pruning. Double pruning delays leafing out of the lower buds as effectively as late pruning and offers more advantages. During the dormant season, remove all canes except those to be used for spurs, and cut those back to 15 to 20 inches. In spring, after the apical buds on these half-long canes have produced shoots 2 to 4 inches long, cut back the canes to spurs of one to two buds according to their diameter. See photo above. Double pruning facilitates winter work, such as brush disposal and cultivation, and it doesn't require working under adverse weather conditions at a critical stage in growth, because the retained half-long canes can be cut back rapidly.

Double pruning should prevent frost damage up to about April 15. In most areas where grapes are now grown, frosts occur too seldom to justify such control measures. However, in areas similar to those in California and Helena where some frost damage often occurs every second or third year, protection offered by these measures would be very worthwhile. Although the most destructive frosts come later, records indicate that between 50 and 60 percent of the damaging frosts occur between April 1 and 15. The above measures will also offer some benefit beyond April 15, because vine growth will have been retarded, the depletion of reserve carbohydrates will be less, and the growth after a late frost will be more nearly normal, resulting in a higher recovery of crop.

Growth regulators

Leafing out may also be delayed by growth regulators. Various tests with gibberellic and naphthalene-acetic acid indicate the possibilities they afford; however, these materials have not been successful enough for use in commercial trials in California. Other chemicals that may be useful are ethephon, benzathine-2-cyclohexane carboxylic acid, and morphason.
MECHANICAL DEVICES

Overhead sprinklers

Sprinklers will protect the vineyard practically under all conditions caused by the prevailing winds. The movement of the droplets as they form an ice film around leaves and shoots provide the protection—not the ice film itself. This keeps the plants near the 32°F mark, although air temperatures may stay lower. One serious disadvantage that has not been reported in California, however, is apparent when frost is accompanied by wind of any direction. Sprinkling then would require 50 percent higher than normal water rates. A second action is frost around the bud break time, which will be discussed later.

In earlier years, growers used equipment designed for irrigation purposes. This Mostly was sufficient in light frosts. But protection was inadequate when severe frost threatened. The large sprinkler heads used then with their slow rotation speeds (2 to 3 minutes per revolution) applied water jets so infrequently that plant temperatures dropped critically during the wetting intervals. The water mist mixture was not maintained. The large sprinklers also were installed mainly in center strips, only six to eight per acre-casing poor overlap, and irregular and spotty area coverage.

The special impact sprinkler head (3/8 inch nozzle orifice diameter) was developed by California manufacturers and eliminates all previous shortcomings. Rotation speed is about 30 seconds. Because they are small, usually 28 to 30 of them are needed per acre, mostly installed in a triangular pattern of 32 x 48 feet. These spacings can be modified to produce a different rainfall rate than the usual 1.0 to 1.5 inches per hour, which is satisfactory in the coastal districts. Varying the pump pressure can also modify the application rate, but hardly more than 10 percent.

Application rates should be high enough to provide protection against the strongest frost possible in the particular vineyard. The required rates are given in the table for the two different rotation speeds and for different wind conditions.

When to start sprinkling is somewhat difficult to determine under certain weather conditions. Growers tend to judge by a sheltered air thermometer, and they may consider 31° F to be the critical air temperature. However, when the plants are wetted, they will tend to and approach the lower wet-bulb temperature at the beginning of the operation for several minutes due to evaporative cooling, before the protection of frosts sets in. The wet-bulb temperature (given by a usual thermometer covered by a wet wick) should, consequently, be observed, and 31°F (on wet bulb) would be the starting temperature. The grower can also determine the wet-bulb temperature by utilizing dry bulb readings and the dew point temperature. The latter is one of the many expressions for air moisture, and is in conjunction by the National Weather Service in conjunction with the frost warning. The ratio between these three magnitudes can be found in the standard psychrometric tables (except for column D) as follows: (A = dry bulb, B = wet bulb, C = dew point, D = starting temperature (dry bulb), all in deg F).

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When to terminate sprinkling. Air temperature outside the cold area should be at least 32°F before the water is turned off. If the dew point temperature is low (or the ice is dry), wait until the air temperatures have risen to 34°F. However, it is not necessary to wait until all ice has melted.

Heaters

Although 40 to 50 heaters per acre are recommended for the coastal area district, it is seldom that all of them need to be run at the same time. Protection of 35°F or more can be provided with heaters, depending on burning rate and installation, and a large enough area. Twenty-five heaters, for example, would give 35°F protection or more, under the same conditions. Light only one-third of the heaters when air temperature is 31°F. Keep watching the temperature, however, especially at spots farthest from any burning heater, to determine whether additional heaters should be lit. These spots, so-called "dark spots," are the most vulnerable to frost damage. Under medium frost conditions, therefore, at least 25 heaters per acre should be burned. Distribution of the heaters should always be even, except along edges where greater heat concentration is needed. This border heating is especially important for the nightly drainage flow or those where vineyards are exposed to adjacent ground, such as pastures and al痊 fields.

Unfortunately, while orchard heaters can provide complete protection against frost damage in all circumstances, even under the most adverse conditions, such as windy nights, their use is declining—for a number of reasons. Energy supply is decreasing, and its cost is going up. The high cost and shortage of manpower has forced many growers to modify their field equipment by installing pipelines for oil or gas or to abandon their heaters entirely. Furthermore, many types of heaters were damaged for fear of air pollution, and growers often find purchasing of replacement oil too costly, especially in areas where the fuel may be needed perhaps only once every five years. Many solid fuel heaters have been developed that use residues, such as petroleum coke or petroleum wax. Because they are small, more units per acre can be installed, providing more heat in a better distributed fashion. Few or no "dark spots" would occur under such conditions. However, state and county air pollution requirements may be difficult to pass.

Blowers

Blowers have become a substitute for heaters in several California areas. Two types are on the market—the tower mounted "wind machine," which is especially successful in citrus orchards, and the surface blower, which is often used instead of the wind machines in deciduous orchards and vineyards.

Blower action stirs the air, and the cold air near the ground moves away, while warmer air moves to the plants, which are 2° to 4° cooler even than the air near the ground. However, the cold air core of a blower is generally not so great or so evenly distributed as it is with heaters; they are fairly effective only within 150 feet of the blower. However, the greatest disadvantage is the variable degree of warm air (called inversions) available above the cold layer near the ground. Wind machines are sufficient in the coastal grape vine areas where many fruits are accompanied by inversions.
For stronger frosts, University of California tests have shown that adding a small number of heaters can provide more warming than might be expected. For instance, 8 to 12 heaters per acre to support a wind machine can provide an additional 1 1/2° or 2° F more than with the blower alone, because the blower distributes heat that otherwise would be partly lost by updraft from the heaters. The great advantage of the blower-plus-heater system is that it only a few heaters have to burn, and that they can be lit gradually one or two hours after the blower is started. The blower itself can be started above 31° F, since operational cost is low. In severe frost situations, 25 heaters should be installed as a safeguard. They should be distributed as evenly as possible over the vineyard. Where there is wind-tunneling or the like, the heaters could be arranged to form a square pattern - with some sacrifice of effectiveness, however. For instance, on a square of 600 x 600 ft, about 8 acres, 200 heaters could be spaced one every 20 feet for forming two squares of about 600 x 600 feet and 400 x 400 feet, one inside the other, with the wind machine in the middle. Grouping heaters more closely to the wind machine could result in too strong a concentration of heat. This concentrated heat would be lost by increased updraft, and the wind-machine effect could be reduced beyond the heater line.

Multiple installation of wind machines increases their effect. As the area response pattern usually is egg-shaped - elongated in the direction of the drainage flow - University of California studies found the following spacing to be advantageous: small blowers (about 25 HP) - 600 feet along drift, 400 feet across the drift; large blowers (70 to 160 HP) - 500 feet along drift, 700 feet across the drift.

Benefits from a "multiple installation" will be lost, however, with spacings larger than suggested. The closer settings are recommended, because adjacent wind machines help each other. The turbulence zone of one machine that reaches into the turbulence zone of another magnifies the total effect; for example, two neighboring blowers, working one at a time, will raise the temperature 1° F at a given spot. Working together, they will cause the temperature to rise 3° F.

Helicopters

Helicopters are used successfully where winds are hampered by difficult terrain or infrequent frosts. They have the advantage of flexibility in area coverage. One helicopter can be used over a large area for light frosts; one pass in 5 to 10 minutes can provide protection. With more severe frost conditions, more frequent passes over individual spots are needed which would reduce the area coverage one helicopter can provide.

On the other hand, the area to be covered by one helicopter could be enlarged in very mild frosts. Many regions in California have marginal danger conditions. In such areas, damage appears to be insignificant, because the air temperature remained hovering at the 31° F mark. However, field experience by forecasters of the National Weather Service indicates a tolerance of 31° F at maximum of 30 minutes duration. Under these conditions, therefore, one warm blast from one helicopter pass every 30 minutes might raise the temperature once every half hour. This assumes, of course, that an air-temperature drop below 31° F would not occur.

Successful operation of wind machines with or without heaters also requires constant thermometer reading. Two orchard minimum thermometers per 10 acres appear to be reasonable. When the thermometers are shielded, they show air temperature, and 31° F (air temperature) is considered the danger point. An unshielded thermometer, open to the sky (representing shoot temperature) would show about 27° F at the same time. Damageable temperatures were once experienced in the Napa Valley at sunrise when the drainage flow ceased before the first sunrays hit the ground. Especially careful watch, therefore, is recommended at dawn. For example, on April 22, 1950, between 5 and 6 A.M. (within one hour) the air temperature in a University of California test vineyard near St. Helena dropped from 32° to 28° F, and an unshielded thermometer showed drops from a safe 28° to 24° F - 3° below the danger point. Vines were 50 percent damaged.

COVERS

In one part of this same 1960 U. C. test vineyard, 4-foot-wide black polyethylene strips were rolled over the row, shielding the vines from the cold sky. Under these covers, no frost damage occurred and the unshielded thermometer did not drop below 27° F. A 3° protection was obtained, but strip covering cannot provide enough protection in stronger frosts. Besides, covering is not economically feasible for larger plantings.

Opaque covers of plastic, bubble, or paper might be practical for one or two-year-old vines, especially where they can be extended downward to the ground at night. Cap-type cover may be more useful than spritzless, heather, or wind machines - all of which are less rewarding when used for small and widely-spaced plant. Such covers, when double- or multi-layer, are highly frost-protective.

TREATMENT OF FROSTED VINES

Frost damage to grapevines becomes apparent within a few hours. However, one usually cannot accurately the degree of injury to clusters until after fruit set. In many frosted vineyards, it is best to do nothing, but in other shoot removal may be beneficial.

When vines are frosted, look to the secondary or tertiary buds or dormant lateral buds. Some crop can be expected from varieties where these buds are fruitful, even if shoots that develop from the primary bud are frozen. The latter shoots must be broken out at the base, so that the two lateral buds may be released. Unfortunately, breaking out of primary shoots more often fails to enhance growth from secondary growing points. When growth does occur, secondary and tertiary buds usually start growth in about two weeks. Shoots should be removed immediately after a frost; also, best results occur when shoots are less than 6 inches long when frozen. When longer primary shoots are broken out, the secondary and tertiary growing points are also removed or dried. Following a frost, one should break out shoots on which clusters have frozen but not died back to the base.

Thompson Seedless has no fruitful secondary or tertiary buds, and therefore treatment of frost-damaged vines is recommended. If clusters are killed by freezing, cuts may be made back to sprout to promote shoot growth and better canes for the following year. No treatment is beneficial for spurt-pruned vines with nonfruitful secondary or tertiary growing points such as in Empire. However, with spurt-pruned varieties with fruitful secondary and tertiary buds, such as Cardinal, Eliezer, and most wine varieties, shoot removal may sometimes increase yield.

Dormant and latent bud growth present at the base of spurs and canes of little benefit in commercial Thompson Seedless, but can sometimes increase yields in spurt-pruned vineyards. Suchcan be water sprouted except at bases of spurs and canes, can produce some fruit especially in wine varieties. If shoots are pruned off, only lateral buds near the base of the shoots develop, and these are not fruitful in Thompson Seedles.

REFERENCES


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