VINEYARD FROST PROTECTION

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Low Temperature Effects

In parts of California both spring and fall low temperature injury are common. Temperatures that cause winter kill of fully dormant vines, 10° F. or -12° C., rarely occur in grape growing regions of California.

Spring frosts which injure developing shoots and reduce the current seasons crop are the most often considered type of low temperature damage. Cold injury to green growth begins at air temperatures of 31° F. for a duration of 1/2 hour, the air temperature being measured by a sheltered minimum thermometer four feet above the ground.

Air temperatures of 26-28° for a duration of several hours will kill all actively growing green parts of the vine, including buds that have begun to open.

There are often degrees of damage: shoot tips may be killed but clusters may remain intact; shoots, including the cluster, may be killed back - but leaving several viable basal buds on the damaged shoot; or, the shoots may be killed back entirely.

Spring and fall cold injury to the trunks of young vines may be severe. Damage usually occurs during the first fall or spring following training up the stake. Damage is mainly confined to the live bark and may range from very obvious to quite subtle. In the more obvious cases, spring shoot growth quickly becomes stunted or very irregular. Longitudinal cracks appear in the bark, and in many cases aerial grown gall infection takes place in the bark cracks. Vines injured by low spring or fall temperatures will often sucker profusely at the crown, which becomes an important indicator of trunk damage.

Occasionally, fall frosts occur before harvest. Such early frosts are often relatively light and may only present a problem with the harvest at hand. All leaves usually drop from frosted vines within a few days and within ten days the berries begin to shatter from the clusters.

What Causes Cold Damage

It is generally agreed that cold damage is caused by the rupturing or injury to plant cells or cell membranes when their contents freeze and expand. When freezing occurs, the contents of the cell expand by 8-9% while other plant tissues tend to contract as they get colder. Following freezing, the damaged cells can no longer control their liquid contents and dehydration takes place.

The formation of ice crystals in tissue is by no means consistent, being dependant on several factors besides the air temperature and it's duration. Under certain conditions actively growing grape tissue can be super-cooled to temperatures below freezing without the formation of ice crystals and without subsequent damage.

The amount of stored carbohydrate in the tissue plays a part in retarding ice formation and is often referred to as "anti-freeze".

It has also been recently understood that ice crystals in plant tissue require nuclei, and the presence or absence of substances which act as nuclei influences the point at which ice crystallization takes place. The discovery that certain bacteria provide a nucleus for ice crystal formation has led to one entirely new approach to frost protection through the elimination of the bacteria.

Variations In Cold Damage

Cold damage in the vineyard is often quite irregular, varying from vine to vine and among shoots on the same vine. The most commonly considered variable in vine susceptibility to low temperature damage is lack of carbohydrate reserve, sometimes called lack of maturity.

Vines growing on gravelly or sandy soils may suffer from water stress and be unable to store carbohydrates. Vines in wet spots may have impaired root systems and often do not mature either their fruit or their wood.

Excessively vigorous vines which continue to grow actively in the fall may fail to store carbohydrates in favor of making new growth. Cabernet Sauvignon is well known as a vigorous variety which starts growth late in the spring and tends to grow late in the fall. Establishment of Cabernet on fertile soils in districts where early November frosts occur can be quite difficult.

Spring "T" budding has resulted in fall cold damage due to delayed vine maturation. Fall low temperature injury sometimes goes unrecognized on established vines. Dead and dehydrated spurs which fail to grow in the spring may be the first symptom of trouble that is noted. At pruning injured wood is lighter green in cross section and appears dry, but these symptoms are easily overlooked.

Vineyard Frost Protection

For many California grape growers the question of whether or not to go into frost protection or not is difficult. In some districts and favored locations within districts, frost losses are infrequent. In the North Coast spring frosts are generally frequent enough and winegrapes valuable enough to have made frost protection almost universal.

With the development of overhead sprinkling for frost protection, grape production has been expanded into areas that could not otherwise be considered for grape production. The need for frost protection ranges from little or none to absolutely essential.

The projection of a cost benefit ratio for a frost protection system must include variables such as: the probability of future frosts and their severity, the future price and availability of fuels and energy and the price of wine grapes. Given these kinds of variables it is difficult to make a cost benefit projection with confidence.

As the need for frost protection varies so do the methods, which include relatively simple cultural practices, furrow and limited sprinkler irrigation, wind machines (sometimes augmented by diesel burning heaters) and continuous over-vine sprinkling.

Cultural Practices

Spring radiation frosts can be modified by 1-2° F. by improving the daytime heat absorbing potential of the vineyard soil. This amounts to storing more of the heat radiated by the sun during the daytime for release at night. A clean, firm and moist soil absorbs and radiates heat best. Early spring cultivation followed by rain or irrigation produces the desired surface. Ideally, the top one foot of soil should be moist.

Cold air is heavy and tends to flow like water and trees bordering a vineyard may act as cold air dams. Air movement of only 3-4 miles per hour mixes the warmer air above the vineyard with the colder air close to the ground. The removal or thinning of border trees helps promote air movement and usually reduces the frost hazard.

Double pruning can delay bud break on selected buds for a week. The success of this procedure depends on the fact that buds at the tip of a cane will begin growth first while those at the base of the cane are retarded. On spur pruned vines the vine is pruned normally except that instead of two bud spurs, a cane of 6-10 buds is left. After the tip buds on the cane begin growth, but before they are 1/2 inch long, the vines are repruned back to the desired two or three basal buds which have not yet begun to grow.

Following spring frost damage the removal of certain damaged shoots has not been shown experimentally to improve yields versus leaving damaged shoots alone. The decision to remove damamged shoots should be based on cost versus the prospect of limited additional secondary fruitfulness.

After trunk damage to young vines the process of retraining should be delayed until vigorous regrowth indicates where the damage is. It is best to retrain young vines with healthy new shoots than to encourage and wait for the healing of damaged tissue.

Frost Protection Methods

Permanent set overhead sprinklers have emerged as the method of choice for difficult conditions. These systems derive their effectiveness from the heat of fusion, which is given up as water turns to ice. As long as there is a mixture of ice and water on the vines the temperature of the ice-water mixture and the tissue below it will remain at 32° F., just one critical degree above the point where vine damage begins.

Overhead sprinkler systems are designed to apply .11 inches of water per hour, which requires 55 gallons per minute per acre. At this rate full protection of vineyards to temperatures in the mid-20's has been achieved.

Overhead sprinkler systems are expensive and require a substantial water supply. They do not require extensive labor to operate, they are clean and quiet in operation, do not use large amounts of fossil fuels and can be used for irrigation, pest and disease control, heat suppression, vineyard establishment and spring and fall frost protection.

Wind machines depend on mixing warm air from above the vineyard with the colder air at ground level for effectiveness. A wind machine alone can raise the temperature in the vineyard by 25% of the difference between the air temperature at 4' and 40'. If there is a difference of four degrees you can get a 1° temperature rise. If there is little difference between the temperature in the vineyard and above, wind machines are ineffective unless used with heaters. Ten HP per acre is recommended for effective frost control.

Orchard heaters are rare used alone, but almost always used in conjunction with wind machines. A common density is ten per acre and most growers prefer to place the heaters around the border of the vineyard. Modern orchard heaters will meet air pollution standards in California when properly operated. While even spacing of heaters throughout a vineyard is more efficient than border placement, one man on a tractor with a flame thrower can light a row of heaters in a few minutes, eliminating the need for a labor crew in the middle of the night. Heaters burn up to a gallon of diesel oil per hour. Current and future cost and availability of oil makes continued use of heaters questionable.

One completely new approach to frost protection has been developed by Dr. Steven Lindow at UC Berkeley. His work is based on the theory that certain bacteria are responsible for initiating the formation of ice crystals in plant tissue. Without a plentiful supply of these bacteria, ice formation occurs at temperatures several degrees lower than when they are present. Laboratory evaluations using a cold chamber indicate that there is in fact a difference between tissue treated with a bacteriacide and untreated tissue in response to cold temperatures. Based on Dr. Lindow's work, in 1996 the first commercial biological frost control agent, Blight-ban A506, was used in pears in California. However, research in grapes has yet to be carried out in California.

Recording the Temperature

All frost protection work in the field is based on air temperatures recorded by a sheltered thermometer four feet from the ground. This standardization is necessary because thermometers exposed in different ways record different temperatures. A thermometer directly exposed to the sky will record a temperature lower than one shielded from the sky, and one located closer to the ground will reflect the colder temperatures at ground level.

Good instrumentation allows good management of a frost protection system, while poor instrumentation may lead to unnecessary expenditures of energy and money.

Growers in areas where cold temperature injury is likely to occur could profit by the operation of a recording thermograph. This instrument traces a continuous temperature line on a seven day chart and records extreme temperatures as well as durations.

Frost alarm systems are utilized to alert growers when to start sprinklers.

References

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