

World-wide Frost Problems and Frost Protection

By R.L. Snyder, University of California, Davis, California, USA

Throughout the world there are huge economic losses to frost damage each year. In fact, in the USA, there are more economic losses to frost damage than any other natural hazard including earthquakes, floods, droughts, hurricanes and tornados. Most countries with temperate climates experience frost damage to crops and even tropical countries can have frost damage at high elevations. Considerable effort has been expended by researchers and government agencies to better forecast freezing conditions and to find low-cost protection methods.

Whether or not there is frost damage at a particular minimum temperature depends on many factors including the plant species, crop variety, cold-temperature hardening, cultural practices including pruning, fertility and irrigation, weather conditions and the presence of ice-nucleation active (INA) bacteria. It is nearly impossible to exactly predict the level of damage to a specific cultivar from sub-zero temperatures at a particular location; however, one can develop a frost-risk map that provides information on locations that are more prone to freezing temperature. Then the probability and risk of a damaging temperature can be used to estimate expected cultivar-specific economic losses by zone. The main advantage of such an analysis is that it provides growers with the means to make cost-effective economic decisions.

All countries with frost problems practice passive protection, which includes biological and ecological techniques carried out before a frost night that reduce potential damage. The methods include site selection, good cultural practices, soil water management and INA bacteria control. In general, most passive frost protection methods are cost effective.

Active protection methods are temporary and energy and/or labour intensive, so they are generally practiced in more temperate climates where frost problems tend to be more serious. Active methods, which require effort on the day preceding or during the night of the frost event, include temporary covers, heaters, sprinklers, wind machines, helicopters, that are used to prevent or replace natural energy losses. The cost effectiveness of active protection depends on the value of the crop and cost of the method. For example, liquid fuel heaters are commonly used for protection in Mexico, where the government subsidizes fuel oil, whereas liquid fuel heaters are not widely used in the USA, where fuel costs and air pollution standards discourage usage. Solid fuel heaters are used in some countries (mainly in South America). Surface irrigation is commonly used for frost protection where low-cost water is readily available. Sprinklers are also widely used throughout the world. Some systems are set up for both summertime irrigation and frost protection, which improves cost effectiveness. In other instances, dual systems including one for irrigation and another for frost protection are used. Over-plant impact sprinklers are used on crops that are less prone to branch breakage. Under-plant impact sprinklers and now micro-sprinklers are commonly used for crops that are damaged by the weight of ice loading. Recently, targeted sprinklers are beginning to be more popular in regions with limited water supply. Wind machines are widely used (mainly on citrus orchards and grape vineyards); however, electric wind machines are now considered marginally cost effective to purchase and use in California.

On a world-wide scale, there have been few advances in frost protection during recent decades. In many cases, using an active protection method is marginally cost-effective and perhaps development of a well designed frost protection insurance policy might be a better approach. However, frost risk maps and good information on probability and risk are needed to develop a fair and equitable insurance policy and to determine if active methods are justifiable.