CONSIDERATIONS ON THE PROTECTION OF VINEYARDS AND ORCHARDS AGAINST HOAR AND FROST

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ABSTRACT

No matter how favourable the light and humidity conditions may be, plant growth stops when the air and leaf temperature drops below a certain minimum or exceeds a certain maximum value. When air temperatures drop below 0 °C, susceptible crops can be injured, with significant effects on production. Hoar and late frosts occur differently, there are areas where the number of days in the spring months with critical temperature drops are quite numerous, with a frequency in April and exceptionally during May. The negative effect is all the greater as it is recorded after a warm period which can cause an advance of the period of formation of flower buds and the appearance of flowers. The paper presents a series of considerations on the protection of orchards and vineyards against hoar and late frosts.

INTRODUCTION

When air temperatures drop below 0 °C, susceptible crops can be injured, with significant effects on production. Each year, there are several economic losses due to damage caused by weather conditions. After that, the impact on affected farmers and the local economy is often devastating. Consequently, a simplified, widely available source of information is needed to help farmers address this serious problem.

Technically, the word “frost” refers to the formation of ice crystals on surfaces, either by dew freezing or by a phase change from vapor to ice (*Bettencourt, 1980; Mota, 1981*).

However, the word is widely used by the public to describe a meteorological event when crops and other plant have frost damage. Growers often use the terms 'frost' and 'hoar' interchangeably, the vague definition being 'an air temperature lower than 0 °C.

Examples of definitions of frost in the literature include:

• the appearance of a temperature less than or equal to 0 °C measured in a shelter “with Stevenson screen” at a height between 1.25 and 2.0 m;

• the appearance of an air temperature lower than 0 °C, without defining the type and height of the shelter (*Hewett, 1971*);

• when the surface temperature drops below 0 °C; and the existence of a low air temperature that causes damage or death to plants, without reference to ice formation.

Late frosts and hoars occur differently in the country, there are areas where the number of days in the spring months with critical temperature drops are quite numerous, with a frequency in April and exceptionally during May (Zinoni et al., 2002).

By frost is meant the lowering of the temperature of the air layer near the ground below 0ºC in the warm period of the year (the vegetation period of the crops).

Frosts are caused by the penetration of cold air, whose temperature is below -1ºC and does not exceed this limit even during the day. Frosts form on clear, quiet nights. The intensity and duration of these frosts depend on the exposure of the slope, the condition of the soil surface, the humidity in the soil and the air.

MATERIAL AND METHOD

The frosts and hoars during the spring months, which are recorded in the early hours of the morning, can be predicted one day before, in the evening, having enough time to take measures to protect the trees / vines. The forecast criteria consist in following the temperature and the clarity of the sky; the two climatic phenomena are registered in the situations when there are:

• clear sky and calm weather with the sudden drop in atmospheric temperature below 10 ^{o}C;

• the decrease of the atmospheric temperature around 9 pm, between 4 - 5^{o}C, clear sky and the lack of air currents in the atmosphere;

• decrease of the temperature at ground level between 1.5 - 2^{o}C, clear sky and with a calm atmosphere.

Late spring frosts and hoars can cause significant damage by compromising the fruit, during flowering and even in the first days after shaking the petals, when the fruit is small. The danger is greater when it catches different species of trees / grape vines in full bloom, especially almonds, apricots, peaches, cherries, sour cherries and even some varieties of plum and apple with early flowering.

Damage to crops due to frost results not from the cold temperature, but mainly from the extracellular formation of ice (not inside the cells) in plant tissue, which removes water and dehydrates the cells and causes cell damage. After cold periods, the plants tend to harden against freezing. A combination of these factors and other factors determines the temperature at which ice forms in plant tissue and when they deteriorate. The amount of frost damage increases as the temperature decreases, and the temperature corresponding to a specific level of damage is called "critical damage temperature".

Some direct and indirect preventive measures can be taken against these climatic accidents, such as: avoiding the establishment of fruit plantations on lands where late frosts and frosts frequently appear; cultivation of late flowering varieties; application of preventive measures to delay vegetation (spraying trees with lime, gathering snow at the base of the trunk to keep the soil cooler and wetter), etc. The categories of protection methods are presented in Table 1.

Table 1

Categories and subcategories of frost protection methods

Category	Subcategory	Protection method
Passive	Biological (prevention or resistance)	Induction of frost resistance without changing plant genetics
		Seed treatment with chemicals
		Plant selection and genetic improvement
		Species selection for the time of phenological development
		Selection of planting dates for annual crops after which the probability of frost decreases in the spring
		Growth regulators and other chemicals
	Ecological	Selection of place for culture
		Changing the landscape and the microclimate
		Nutritional control
		Soil management
		Covering the crop (weeds) and mulching

Active	Covers and radiation	Organic materials coatings without supports
		Covers with holders
	Water	Sprinklers over the plant
		Sprinklers under the plant
		Micro-sprinklers
		Surface irrigation
		Artificial mist
	Heaters	Liquid fuels
		Solid fuels
		Propane
	Wind machines	Horizontal
		Vertical
		Helicopters
	Combinations	Fans and heaters
		Fans and water

Protection by heating the air

Where possible, fine spray irrigation can be used, which can raise the air temperature to the crown by 2-4 ^{o}C. The installation must work until the fine ice sheet that forms on the trees melts.

Heaters provide additional heat to help replace energy loss. Generally, heaters raise the temperature of metal objects (for example, cell heaters) or operate as open fires. If enough heat is added to the volume of the crop so that all energy losses are replaced, the temperature will not drop to harmful levels. Proper design and management is required. By designing a system that uses more and smaller heaters that are properly managed, efficiency can be improved to the point where the crop is protected from major frost conditions. However, when there is little or no reversal and there is a gust of wind, the heaters may not provide adequate protection.

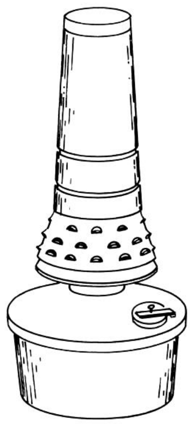

Fig.1. – Cone type heater (Van der Gulik and Williams, 1988)

Most of the energy in the heaters is released in the form of hot gases and heated air, which mainly heats the ambient air by convection. The radiant energy from the heaters travels directly to the nearby plants that are in the direct line of the heating installations. However, depending on the density and structure of the crop canopy, only a small percentage

of the radiant energy from the heaters is intercepted.

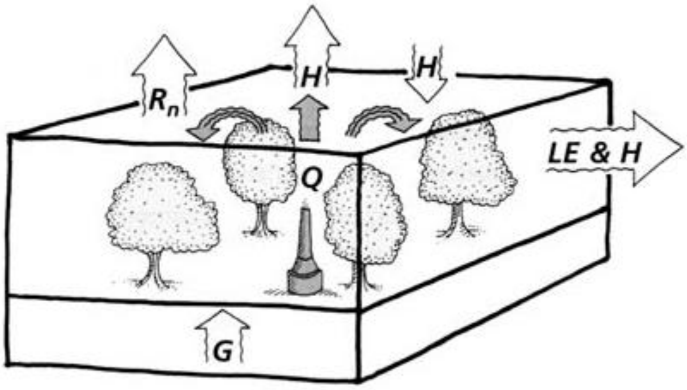

Fig.2. – Representation of energy flows in an orchard (Van der Gulik and Williams, 1988)
R_n – net radiation; ***H*** - significant vertical and horizontal heat flow; ***G*** - conductive heat flow from the ground; ***LE*** – latent heat; ***Q*** – energy added by heating

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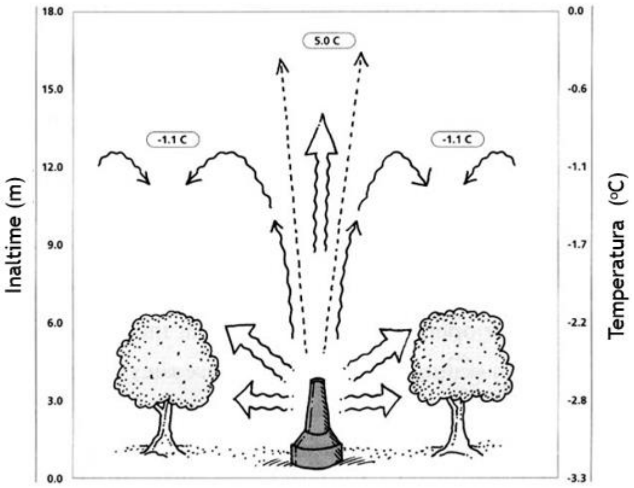

Fig.3. – The effect of heaters on fruit / vine crops, (Van der Gulik and Williams, 1988)

The most effective method available to all fruit growers is fumigation. It is based on burning materials that produce a lot of smoke, burn slowly and without flame, maintaining a warmer layer of air in the immediate vicinity of the tree crown. Fumigation has an effect at temperatures of -2 - 4^{o}C and is obtained by burning reclaimed manure, leaves or wet straw, to which are added residues from the distillation of oil or used tires, which are placed in the form of piles (80-100 pcs/ha). The cells are covered with a thin layer of earth that has the role of stifling burning.

RESULTS AND DISCUSSIONS

The fumigation method is based on the principle of reducing the effect of night radiation with the help of a smoke shield, of limited duration, generated by a fumigant substance. The smoke curtain prevents the soil and trees from cooling, reducing the effect of night radiation. It is recommended to use substances that produce persistent smoke around the trees. The aerosols produced must be white in colour, as they have a higher power of reflection and thus prevent the production of night radiation.

The screens of artificial smoke clouds are formed by burning multiple fires per hectare, made of fumigant material (wet straw, wood chips, cut branches, sawdust), to which oil residues can be added. Special vessels / burners may be used in which a mixture of multiple biofuels is placed. Smoke piles made from household waste are the most economical, being effective especially in the case of short-term and moderate intensity frosts.

Figure 4. Bale smokers and smudge smokers [10, 11]

In general, a large number of small heaters is the most efficient; Large heaters establish convection currents that break the warm ceiling and attract cold air. For frost protection, the heaters are placed in "sight" of the plants or trees, but for advective frost, the heavier concentration is placed along the rising edge. Common fuels for heaters include oil, coal, briquettes and wood. The oil and briquettes are the most effective because they ignite quickly and can be extinguished easily.

CONCLUSIONS

Heating is probably the best known and most effective measure of protection against frost. It is most effective on nights with a strong temperature reversal, a condition in which the air temperature rises significantly from the ground 12 up to 15 meters). The depth of air to be heated is therefore rather small, and the area over which a given increase in temperature can occur increases linearly with the power of inversion. In the absence of a temperature reversal, the heaters are protected by heat radiation to the plants and the soil surface and by emitting a layer of moist smoke that reduces the net loss of soil.

Given the climatic conditions in Romania, but also the economic climate and the financial availability for investing in methods of protection against frosts, the most appropriate method is the method of using smoke and heat as protective agents.

Smoke and heat can be obtained using materials available to fruit growers and grape vine growers, namely plant residues (twigs, vine strings, leaves) resulting from their own activity, resulting in low costs, but also an ecological protection technology.

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