RESEARCHES ON THE PROTECTION OF VINEYARDS AND ORCHARDS AGAINST SPRING FROSTS USING HEAT AND SMOKE AND USING THE RESULTING ASH AS SOIL AMENDMENT

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ABSTRACT

Orchards and vineyards can be exposed to climatic phenomena with unfavorable effects on tree growth and fruiting, such as: winter frosts, frosts and late spring frosts, hail, icing, etc. Smoke and heat are a valuable ally of fruit and vine growers, often intervening in preventing and limiting the negative effects of frosts and frosts on fruit trees and vines during the periods of budding, flowering and fruit binding. The accident is due to the freezing of water in the cellular structure of the vegetative organs (flower buds, buds, flowers, leaves). The paper presents a method of the protection for orchards and vineyards against hoar and late frosts as well as the possibility to use the resulting ash as soil amendment.

INTRODUCTION

Fruit growing and viticulture are areas of "agricultural resources" that through natural interaction (with environmental factors) and directed (with agro-technical factors) result in obtaining a variety of agricultural products - fruits - vital to human existence (Eurostat, 2018).

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. Within these limits, there is an optimal temperature at which growth continues most rapidly. These three temperature points are the cardinal temperatures for a particular plant; cardinal temperatures are known for most plant species, at least approximately. (*Matzneller et al., 2016*).

When air temperatures drop below 0 ° C, susceptible crops can be injured, with significant effects on production. Weather conditions represent the main cause for low yields and damaged crops, the impact on farmers and on local economies being high (*Atam & Arteconi, 2017; Bagdonas et al., 1978*).

In gradual frosts, the consequences are less serious as the crystallization of water is done in progressive stages, slowly, affecting the extracellular water and, subsequently, by extraction and the intracellular one. In this situation, thawing, especially when gradual and slow, leaves a chance of full or partial functional restoration of the affected parts. In sudden frosts, which occur after sudden decreases in outside temperature, there is the simultaneous crystallization of extra and intracellular water resulting in total and irreversible compromise of the affected parts (*Gu et al, 2008; European Commission, 2019*).

Frosts and hoars during plant vegetation periods represent the most unpredictable crop damaging phenomena, because they are hard to predict before they occur and is difficult to act rapidly to counteract the negative effects in a timely manner (*FAO, 2005*).

During the growing season, all green parts of the vine are sensitive to frost. Spring is a particularly delicate time for vines, as spring frosts often damage open buds and young shoots and endanger the loading of crops (*Wisniewski et al., 2008*).

In the case of fruit trees, the whole plant is more sensitive to frost and hoar in the first 2 years of vegetation, afterwards sprouts and flowering buds are susceptible to frost.

Radiation frosts occur very commonly. They are characterized by a clear sky, calm or very little wind, inversion temperature, low dew-point temperatures and air temperatures that typically fall below 0 °C during the night but are above 0 °C during the day (*Hu et al., 2018*).

The dew-point temperature is the temperature reached when the air is cooled until it reaches 100 percent relative humidity, and it is a direct measure of the water vapour content of the air.

Several passive and active methods can be used to prevent damage to vineyards and orchards caused by frosts and hoar (*Van der Gulik & Williams, 1988*).

Passive methods:

- site (some delay budbreak, others prevent the freezing of tissues, avoiding cell damage).

Active methods:

- heaters;
- wind machines;
- helicopters;
- sprinklers;
- mobile and rotating hot air blowers;
- upward vertical-flow air blowers;
- combinations of methods.

Site selection is the most important passive freeze protection. Because cold air is denser than warm air, it flows downhill and accumulates in low spots. These cold spots should be avoided when seeking a planting site. The top parts of hills are also cold and should be avoided. Usually, it is best to plant trees of vines on slopes where cold air can drain away from the crop.

Heaters offer freeze protection through direct radiation to the plants around them and by causing convective mixing of air within the inversion layer. During the time when heaters are operated, the warm air rises. As the it rises, its temperature drops until it reaches the height where the ambient air has the same temperature. Then this air spreads out and, eventually, air descends again. A circulation pattern much like that of a gravity furnace is created (Fig. 1).

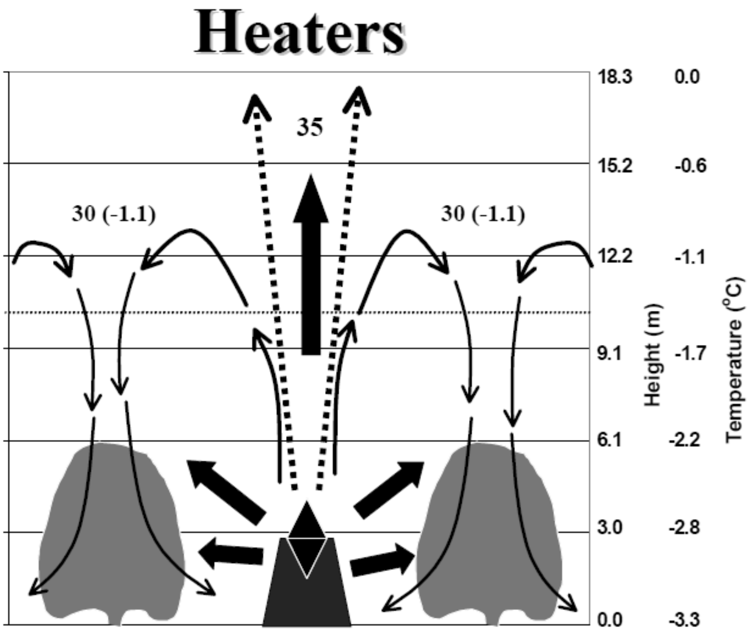

Fig.1. – Schematic diagram showing the energy effect of a smudge pot heater on temperature within an inversion (Snyder R., 2000),

If the inversion is weak, the heated air cools, but it rises too high and the circulation pattern is not produced. As a result, heaters become less efficient when there is no inversion. Making fires that are too hot will also cause heaters to be less effective due to the fact that heated air rises above the inversion ceiling and the circulation pattern cannot be created.

Smoke is a valuable ally for fruit and vine growers, often intervening in preventing and limiting the negative effects of frosts and hoars on fruit trees and vines during the fruiting, flowering and budding periods.

If heaters use biomass as burning material, a relatively high quantity of ash results.

At present, biomass ash is often treated as a waste product, and is landfilled at a cost to energy producers and to society at large. However, studies have shown that ash derived from contaminant-free biomass residues can be used as a soil liming agent and can also be a valuable source of many nutrients required by plants (e.g. calcium, magnesium, potassium and phosphorus) (Yaheliuk et al., 2020; *Stefan et al., 2015; Hannam et al., 2016*).

The paper presents a manner of protecting orchards and vineyards using smoke and heat and the subsequent testing of the resulting ash for further use as amendment in agriculture.

MATERIAL AND METHOD

The equipment used in this research is intended for the production of smoke / heat inside equipment for protection against spring frosts and frosts.

The equipment uses as main raw material biomass tablets (made from vine ropes, branches, tree leaves and vines), but due to the construction, a variety of raw materials represented by biofuels can be used. solids (firewood, briquettes, etc.). In order to obtain heat predominantly, the equipment is fed with dry tablets with a lower leaf content. If a larger amount of smoke is to be obtained, tablets with a higher content of vine leaves / fruit trees should be used which, in order to stimulate smoking, can be moistened beforehand.

The experimental model of Frost Protection Equipment is composed of the following main component parts: support frame 1, biofuel combustion assembly 2 with solid biofuel combustion furnace 3 and furnace access door 4, fan 5 for dissipating the resulting hot air after combustion, the smoke outlet 6 the outlet 7 for the hot air pushed out by the fan, the collector for resulting ash 8, the smoke pipe 9, the smoke dispersion divider 10, the pipes 11 for conducting the smoke at ground level for protection of vineyards / orchards.

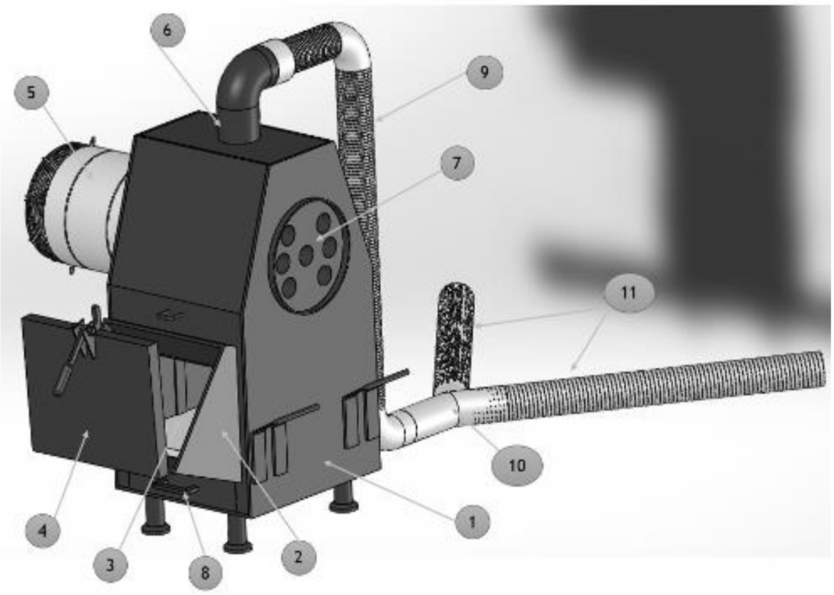

Fig.2. – Experimental model of Frost Protection Equipment

During operation, the furnace is loaded with solid biofuels in dry or wet state and the process begins by igniting them. The combustion of biofuels releases both hot air and smoke, which are taken up by a ventilation system (in the case of air) and a chimney connected to a pipe. The resulting ash is collected in a special tray located under the hearth.

The equipment uses biomass tablets as the main raw material, but, due to the construction, a multitude of raw materials represented by solid biofuels (firewood, briquettes, etc.) can be used. In order to obtain heat predominantly, the equipment is fed with dry tablets with a lower leaf content. If it is desired to obtain a larger amount of smoke, tablets with a higher content of vine leaves / fruit trees are used which, in order to stimulate smoking, can be moistened beforehand.

The following methodology was used to experiment burning the tablets using the equipment:

1. The moisture of the material to be burned in the furnace (tablets made from sawdust and mixed biomass residues) was determined and the desired moisture was reached by spraying the material with water (to determine a stronger fumigation);
2. The mass for each batch was measured using a balance;
3. The materials used as raw material were introduced into the combustion chamber;
4. The actual burning process of the tablets was performed with the help of the frost protection equipment.

RESULTS AND DISCUSSIONS

A total amount of 2.5 kg of material (introduced into the combustion chamber) was used for each sample. During the experiments, three very important parameters in the production process were monitored for each sample:

- burning time;
- energy consumption of the fan;
- the resulting amount of ash.

Table 1

Burning time

Sample 1 sawdust	Sample 2 sawdust	Sample 3 mix	Media
Time [minutes]			
30	30	30	**30**

Table 2

Ventilator electric consumption

Sample 1 sawdust	Sample 2 sawdust	Sample 3 mix	Media
Energy consumption [kWh]			
0.09	0.009	0.009	**0.009**

Table 3

Remaining ash quantity

Sample 1 sawdust	Sample 2 sawdust	Sample 3 mix	Media
Ash [g]			
208	212	237	**219**

After obtaining the ash, a series of experiments were performed on the content of its elements. The results are presented in Table 4.

Table 4

The content of elements of the ash obtained

Sample		Phosphorus	Potassium	Silicon	Chlorides
		[%]			
Sawdust	**1.**	0.074	1.678	4.02	0.037
	2.	0.073	1.702	4.14	0.032
	Average	**0.0735**	1.690	4.08	0.035
Mix	**1.**	0.081	1.465	2.721	0.052
	2.	0.086	1.432	2.658	0.054
	Average	**0.0835**	**1.448**	**2.690**	**0.053**

From table 4 it can be seen that the resulting ash has a relatively high nutritional content that can help improve soil quality in orchards and vineyards, thus making it suitable for use as soil amendment.

CONCLUSIONS

Heating is maybe the best known and one of the most effective measure of protection against frost and hoar, that can be used by the high majority of fruit and vine growers. Late frosts and hoar occur differently in the country; there are areas where the number of days in the spring months with critical temperature drops is quite numerous, with a frequency in April and exceptionally during May.

Smoke and heat can be obtained using biomass materials that available to fruit and grape vine growers, represented by residues rom pruning trees / vines and leaves that fall at the end of vegetation periods (twigs, vine strings, leaves) resulting from their own activity, having low costs, but also helping protect the environment.

The resulting ash, being obtained from natural products – biomass, can be used as soil amendment, helping improve the PH and nutritional qualities.

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