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Technologies Usable for Anti-freeze Protection of Vineyards and Orchards

One frequent cause of subzero ground temperatures during the growing season is the influx of cold arctic air from higher latitudes. Temperature drops can arrive day or night, and they can also be caused by radiation inversion. The foundation of this phenomenon lies in quick cooling in ground-level atmospheric layers due to the quickly cooling soil surface, unlike in higher layers. This phenomenon occurs the most in valleys, where heavy cool air from surrounding slopes piles up under lighter and warmer layers. Temperature drops are fairly short in duration, and they manifest the most strongly in the second half of the night, or at daybreak. Anti-freeze protection methods can be classified into passive and active methods. The basic principle behind passive methods is prevention. From the standpoint of grapevine and fruit tree cultivation, the most effective preventive protection method lies in choosing a suitable location, or choosing late-shooting varieties. These measures can only be put in place in full during new planting. For fruiting plants, it is appropriate to increase the bushes' and trees' resistance to active stress factors by ensuring their optimal nourishment and good health. The active methods are based on taking direct actions to affect the plants in the period when temperatures drop below freezing. The basic idea is to increase the temperature in the bush and tree zone using technologies that raise the temperature in the ground layer by mixing atmospheric substances, by spraying water, or via direct air heating.

Protection via Airflow

Wind rotors come in the form of stationary equipment that is structurally reminiscent of wind generators. This equipment comprises a tubular steel stand about 6–10 m high. Its mast ends in a combustion engine (gas is most often used as the fuel) or an electric engine that drives a two- or three-blade rotor. The cold air layers near the ground are pushed upward by the rotor and mixed with the warmer upper layers.

Mobile ventilators are made up of a support frame with a single-axle undercarriage fitted with a hitch used for anchoring it to a tractor's towing mechanism. These ventilators can be equipped with deflectors of various shapes that direct warmer air sucked in from above into the area of the vegetation. The machine's working mechanism is a ventilator propeller affixed to a stand or to a hydraulically controlled collapsible arm. The arm's elevation can be as much a 8 m. The ventilator's five-blade propeller is housed inside a cylindrical cover, and it is driven by a diesel engine. This equipment is effective on an area of 4–6 ha at temperatures down to -2°C and on an area of 1–2 ha at a temperature of -5°C.

Meanwhile, powerful mounted or towed **tractor ventilators** are a new option on the market. For an effective anti-freeze response based around this kind of ventilator, it is necessary to first choose a suitable location among the plants (the lowest point), where it is then deployed.

Helicopters can provide an effect similar to that of wind rotors; with these, aerodynamic pressure on the support rotor is generated, producing airflow, during which atmospheric substances are mixed as the helicopters fly over vegetation at low elevations. In light of their operating expenses, helicopters tend to be used rather rarely, in the most critical period, i.e. the morning hours.

Protection via Water

One frequent method for anti-freeze protection is **spraying** above-ground portions of bushes and trees with water using sprayers or micro-sprayers placed above ground level on a support structure. Drop size is a major factor in determining the effectiveness of this measure. The uninterrupted ice cover that forms on the surface of bushes and trees helps to protect them from low temperatures. Meanwhile, high water consumption is among the main disadvantages of this technology. For the commonly used systems, it amounts to 10–40 $m^3.ha^{-1}$ per hour. When temperatures drop to the range of 0 to -4 °C, it is enough to disperse the water in batches of 1–2 $mm.m^{-2}.h^{-1}$. When it has dropped below -4 °C, the batches need to be nearly doubled. The plants need to be sprayed nonstop throughout the below-freezing temperatures to prevent the risk of major damage.

Protection via Direct Heating of the Air

Direct air heating systems represent another – quite expensive – anti-freeze protection option. In the conditions of the Czech Republic, it is possible to encounter the burning of clipped lumber, or sometimes fossil fuels, either between planting rows or along the circumference of plantations. However, this system is high-risk, as it can set and spread fires. Candles are also used, as are steel buckets filled with a flammable gel or paraffin. 400–600 sources are needed here for each hectare of cultivated land. Depending on their size, they need to burn for 8–12 hours. They raise the air temperature by 5–6 °C overall. Their main disadvantages include the labour involved in spacing out a large number of heat sources between rows and in lighting them, and the high cost of purchasing them.

Mobile **devices with airflow heating** are tractor-towed machines in which the work is performed by a powerful radial ventilator driven by the tractor's power take-off shaft that sucks in cold air from the space behind the towed device. The air is heated to a temperature of 70–90 °C using propane burners, and it is then blown onto the target vegetation using blowing channels along the sides. New designs of these machines also use the option of burning bales of cut wood materials or bales of straw. The flowing heated air affects the area of up to 40–60 m on both sides of the device. This equipment's stated effectiveness is roughly 6–10 ha at temperatures of up to −6 °C.

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