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INNOVATIVE METHODS FOR SPECIFIC APPLICATIONS AGAINST LATE SPRING FROST AFFECTING FRUIT TREES

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Abstract: The paper presents one of the important objectives approached by the IND–AGRO–POL Cluster Association on providing technical advice to the fruit–growing farmers by addressing innovative methods for specific applications against fruit trees late spring frosts. The paper presents briefly and easily understandable the current state of knowledge regarding the protection against frosts of fruit tree plantations, offering practical advice for optimal planning according to the working conditions of the Romanian fruit tree farms that lead to reducing the consequences and combating the frosts by reducing the radiative cooling, destructing the thermal inversion layer from the soil, homogenizing the air temperature in the microclimatic layer and consequently, maintaining the air temperature on the soil surface above 0°C.
Keywords: innovative methods, late frosts, fruit trees

1. INTRODUCTION

In Romania, which is located in the temperate climate zone of the northern hemisphere, multiple external climatic influences overlap (oceanic, Scandinavian–Baltic, continental–excessive, Black Sea and sub–Mediterranean), so a large variety of climate risks can occur, due to the physical characteristics of the air masses in advection [1]. An important place, in the group of weather–climatic phenomena unfavourable to agriculture, is occupied by spring frosts [2].

Every year, press releases are presented by the representatives of the Ministry of Agriculture and Rural Development (MADR) mentioning a decrease in the temperature of the air layer from the soil surface below 0°C, during the warm period of the year (the vegetation period of the crops), which negatively affects the development of plants and sometimes terminates the vegetation cycle prematurely, or even leads to plant death [16].

For example, the National Meteorological Administration of Romania issued a climatic characterization for the first calendar month of spring of 2020, specifying the following: "March 2020 is generally characterized by a particularly changing weather, the cold and humid days alternating with the warm and sunny ones. This alternation occurs due to changes in air circulation over South–eastern Europe and also due to the retraction of the back part of the East–European anticyclone toward east, which favours warmer and more humid air (coming from the Mediterranean Basin or from the Atlantic) entering the area of our country. As a consequence of these changes in the distribution of baric centres on the European continent, the average monthly temperature shows a clear increase compared to February. Exceptions are some restricted areas from the intramontane depressions, located in the east of Transylvania, where the temperature averages are kept low, reaching –1°C" [14].

A major user of this agrometeorological information, which comes from the National Meteorological Administration, can be the agricultural/fruit–growing farmer, because he can prevent and reduce the risk generated by the frosts of agricultural crops/fruit trees during the flowering period [3].

ANNALS of Faculty Engineering Hunedoara – International Journal of Engineering
ISSN 1584 - 2665 (printed version); ISSN 2601 - 2332 (online); ISSN-L 1584 - 2665
Universitatea Politehnica Timişoara

In the literature it is mentioned that the probability of frost injury of, for example, apricot flowers and fruits, constitutes on average 10 – 90%, because it needs a certain air temperature, the optimum values being between 14 and 35°C, the maximum limit being the highest of all species, simultaneously with a large amplitude of the optimal range (21°C). The flowers, in the white bud phenophase, bear the temperature drop to –4.4°C (10% loss) or to –10°C (90% loss), and when open they resist to temperatures of –2.7°C up to at –5.5°C, while recently fertilized ovaries are destroyed at 0° to –2.8°C [5].

Protecting fruit trees from late spring frosts is a concern of the IND–AGRO–POL Cluster Association and therefore one of the objectives addressed in the project "Strategic RDI agenda of the IND–AGRO–POL innovation cluster" is to provide technical consultancy to fruit–growing farmer, which do not want the low temperatures to lead to the loss of the crop, perhaps even of the investment, by approaching innovative methods to mitigate and combat the negative consequences of frosts [12].

2. MATERIALS AND METHODS

The following databases were used for the preparation of this paper:

- the climate data base from agro–meteorological products of the National Meteorological Administration that were exploited to take adequate measures of fruit–growing management in order to prevent and reduce the negative influences of unfavourable weather conditions on the fruit tree crops during the flowering period [13];
- reading sheets of articles in the literature (consulting the scientific databases), studying the websites of the frost protection equipment manufacturers, which use methods of applying substances before and during the frost event to prevent the killing of the buds, methods of preventing the loss of thermal energy, or methods of supplying additional thermal energy to live buds [15].

3. RESULTS

For the elaboration of the present work, a series of technologies for the prevention of frosts in the orchard were processed and analysed, which are applied in operation and it was concluded that the application of these measures is differentiated, in relation to the meteorological and local conditions (relief and micro–relief, varieties of plants, technical conditions), as well as depending on the material costs available.

In an orchard, the occurrence of the late spring frost phenomenon automatically leads to the compromise of the buds of the more sensitive species, which pass the obligatory rest faster, such as apricot, peach, almond trees [4].

Under these circumstances, Agrofrost, which is the biggest producer of frost protection machines in the world, proposes the implementation of measures to prevent, as much as possible, the losses caused by temperature variations. Thus, Agrofrost offers four frost protection products (Frostbusters, FrostGuards, Wind machines and Frost Alarms), which are presented in Table 1 [6].

Table 1. Agrofrost's four frost protection products

FROSTBUSTER	FROSTGUARD	WIND MACHINES	FROST ALARM
			

— **FROSTBUSTER** (Figure 1) is a trailed machine, which works on the principle of reducing the energy that water extracts from the flower when it freezes, consisting of a gas burner that heats the air up to 80–100°C. The heated air is blown between the trees through 2 outlets (1 at the left and 1 at the right) by a fan operated from the tractor's power take–off. It is, in fact, a mini–trailer that walks on the tree row returning to the same place every eight minutes, protecting a

Figure 1. Model FROSTBUSTER 501 produced by AGROFROST [7]

total area of maximum 8–10 hectares. FROSTBUSTER has a patented burner with temperature controller and ionization sensor, making it the safest burner used in agriculture. At the same time, it has the possibility of starting the burner automatically, depending on the fan speed: if a certain speed level (fan rotation) is exceeded, the burner will start automatically. When the speed drops below this level, the burner will stop.

— **FROSTGUARD** (Figure 2) is the stationary variant by which the air is blown out through an outlet at ground level; because of this it protects a surface of the orchard, in oval form, with dimensions from 60×80 m to 100×110 m, against any type of frost, even against the one determined by the wind. FROSTGUARD is a revolutionary system of protection against frost. It has a powerful fan, powered by a propane engine and a burner, which also works on propane gas. The machine rotates and a rotation takes about 9 minutes. Once started, FrostGuard works autonomously. FROSTGUARD is equipped with an electric alarm that alerts if the temperature is too high or low. It is available in 3 different versions: Revolution R20, Revolution R25 and Revolution R30.

Revolution R20 Revolution R25 Revolution R30

Figure 2. FROSTGUARD types produced by AGROFROST [8].

The working principle – Phase Changes or Phase Transitions – is shown in Figure 3. Because we pass with a hot air stream, every 8 minutes, part of the ice evaporates (called sublimation) and the remaining ice gets energy from the passing air. The higher the humidity, the more energy is transferred. After a few minutes, the air cools down again, the relative humidity increases and some new rime will be formed. This liberates again energy and gives again energy to the flowers. This allows us to create an optimal protection with only a fraction of the energy input that is needed by other systems.

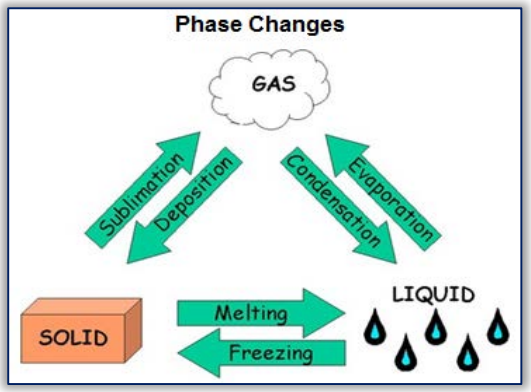

Figure 3. FROSTBUSTER working principle [9]

— **WIND MACHINE** produced by AGROFROST (Figure 4) is completely independent in terms of energy being powered by a heat engine. The tower can be set up and laid down by an electrical jack. Available with gearbox for tractor PTO. At the same time, monitoring the functional parameters greatly reduces the specific energy consumption. The fan of the frost prevention system is placed at the top of a tower with a height of 10.6 m, aspirating the air from the warmer area resulting from the thermal inversion and directing it to the colder areas around the trees and the associated land. In this way, the temperature increase is determined, which is the higher as the thermal inversion is more intense (equal to the temperature difference between the 1.5 m and 15 m air layers respectively). The maximum efficiency of the ventilation system for the prevention of frost is at approx. 20 m from tower, decreasing gradually toward the edges until it is cancelled. For automation WIND MACHINE is equipped with an Auto Start electronic control and command

Figure 4. WIND MACHINE tower set up for orchards

system for automatically stopping and starting the engine using a temperature sensor. This option stops the engine when the air temperature rises to a favourable level, thus saving fuel. To simplify installation and maintenance, and especially to make it safer, this tower can be equipped with the ability to put up and down the tower by means of an electrical jack [10].

The propeller is made of special resins that give it a low weight and maximum mechanical strength. At the same time, this eliminates the vibration of the assembly and prevents the danger of ice forming on the propeller. The CHINOOK–type propeller, which is designed as a combination of the tractive propellers and propulsive propellers used in Dornier aircrafts, has improved aerodynamics due to the sector's 80° angle coverage, which allows it to operate not only on the horizontal plane, but also on the vertical plane, getting higher in the atmosphere and drawing down much warmer air (Figure 5).

The mobile model (Figure 6) has additional advantages – it is not a fixed installation: it can be used anywhere, it can be used several times in different cultures in the same year, quick to install and easy to transport.

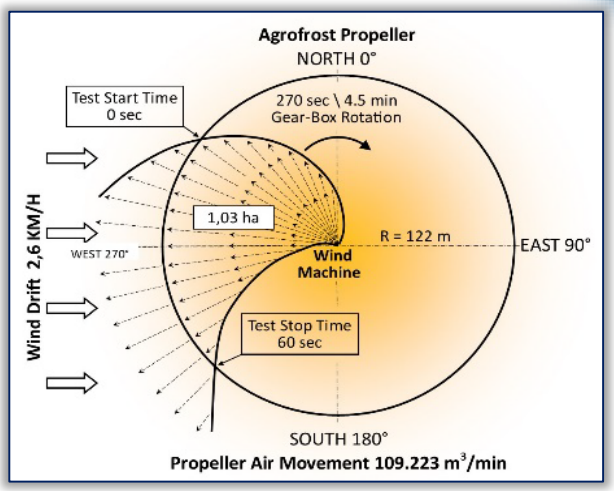

Figure 5. Aerodynamics of CHINOOK propeller from the WIND MACHINE ventilation system

Figure 6. The mobile model of the ventilation tower for orchards WIND MACHINE

— **FROST ALARM** (Figure 7) uses a sensor to determine the temperature and humidity ratio, a SIM card for sending SMS data, has the possibility to transmit messages to 4 mobile phone numbers and to send SMS alarm messages indicating the temperature values and the battery charge level. FROST ALARM is located in the orchard, in the place with the lowest temperature point, and the sensors have an accuracy of 0.1°C [11].

Figure 7. FROST ALARM produced by AGROFROST

4. CONCLUSIONS

— Late spring frosts, frequently have a mixed character (advective–radiative), occur under relatively high average daily temperatures, the phenomenon being determined by the invasion of cold air and its cooling by radiation, on clear nights;

— All the methods for combating the frosts and mitigating the consequences proposed for the protection of fruit trees have a great efficiency being suitable for the working conditions in the Romanian orchards.

Acknowledgement

This event was supported by a grant of the Romanian Ministry of Research and Innovation, CCCDI – UEFISCDI, project number PN–III–P2_2.1–CLS–2017–0009/ 2 CLS/ 2018, within PNCDI III.

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ANNALS of Faculty Engineering Hunedoara – International Journal of Engineering
ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN–L 1584 – 2665