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RESEARCH ARTICLE

A HUNGARIAN INNOVATION SAVES THE PRODUCE OF FRUIT PRODUCERS AND WINEMAKERS

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ABSTRACT

Fruit growers and winemakers are suffering from year to year from frost, especially from spring frost, which usually hits almost all of their produce. There was no effective protection against the temperature of -3 to -25 °C during winter or springtime and the producer can only take note of the damage. The currently known solutions can be quite efficient during preferable circumstances, but they barely satisfied the producers' expectations in practice. These solutions such as antifrost irrigation, using paraffin torches or buying propane gas driven antifrost machines can solve meet challenges, but the efficiency of these is rather limited and their cost is terribly high and usually cannot be paid by the producers. So, I draw the attention here to a new Hungarian innovation, a new antifrost machine, the Fog-Dragon and its smaller brother, the Fog-Mushroom. The machine burns the lit fuel in its combustion chamber and spreads the resulting hot smoke and steam in the plantation. Hot air prevents frost damage whilst the smoke will not allow the heat to escape from the ground. The water vapor increases the gravimetric density of the smoky hot air further, therefore it spreads through the plantations covering the area in mist. A single Fog-Dragon provides protection for 10 ha of land against frost damage. Wide range of fuel options which for example can be made of hay, straw or corn bale, wood chips, vine-branch bale or logs of wood. During operation the machine has to be moved with smoot motion with 40-60 meter turns returning to the given point of the plantation according to the weather condition and the temperature. For the operation the machine has to be towed by a minimum 45 horsepower tractor. The manufacturer has already developed three version of the machine depending on its width: the 211 cm large machine, the Big-Dragon for the protection of large orchards, the 176 cm large Small-Dragon for the protection of smaller orchards and large vineyards and the 150 cm large Mini-Dragon for the protection of smaller vineyards. The smaller brother, the Fog-Mushroom is locally installed during operation and thus provides spring-time frost protection for smaller gardens, vineyards, strawberry fields, sapling field. The system operates with split firewood or similar biomass. One machine protects 2800-3000 m2. Both electric and petrol-powered models are available. The electric powered model starts automatically as the temperature drops below a certain point. Dry fuel such as smaller logs or pellet is required for operation. I can firmly suggest to growers and winemakers allover the World and machine traders as well to be confident to turn to the Fog-Dragon and Fog-Mushroom for having a good antifrost assistance, try and regularly use the machines. They will have a reliable tool to save their produce and revenue from the negative effects of frost.

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INTRODUCTION

The life of fruit growers and winemakers often faces serious challenges. The largest of these is the frost that almost every year fades - especially the spring frost. There was no effective protection against the temperature of -3 to -25 °C during winter-time and the producer can only take note of the damage. The night frost has wreaked havoc in the European fruit and vegetable sector last year. Several billions of euros in the balance of a pan and a number of ineffective attempts and methods in the other. A lot of growers were talking about a situation that they have never had experienced before. The total damage in Italy was huge, it concerned millions of euros. A lot was damaged in the fruit cultivation and open ground cultivation by rain and hail. According to damage reports coming in from South Tirol that varied from 30 to 40 %, but the Emilia Romagna has been hit hard. An area of 450 hectares of vineyards has been considerably damaged there. There was also talk of 3 million tomato plants that have frozen to death.[i] Other affected products are asparagus, soft fruit, stone fruit and strawberries.

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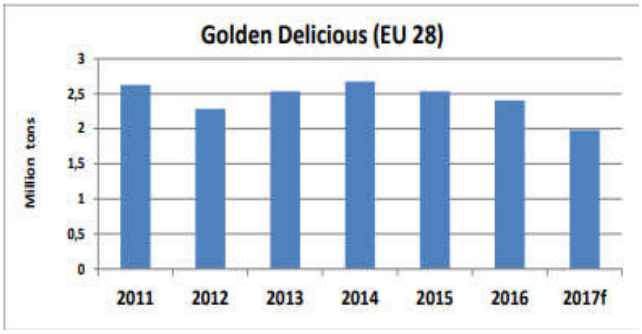


European Pome Fruit Crop Forecast, A Summary from the WAPA Report: 08.2017

The dark brown center of this apple flower indicates it was killed by a freeze; See in „Assessing frost and freeze damage to flowers and buds of fruit trees" by the Michigan State University

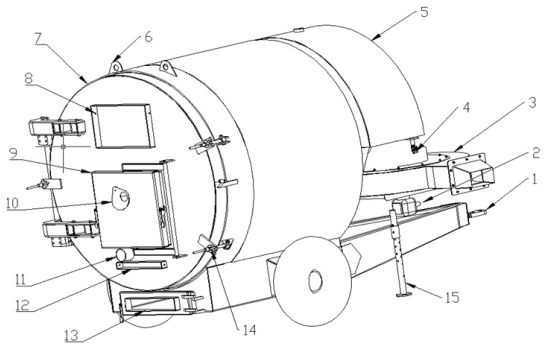
IMPORTANCE OF RELATIVE HUMIDITY

°C	-5,0	-4,5	-4,0	-3,5	-3,0	-2,5	-2,0	-1,5	-1,0	-0,5	0,0	1,0	2,0	3,0	4,0
RP %															
100	-5,0	-4,5	-4,0	-3,5	-3,0	-2,5	-2,0	-1,5	-1,0	-0,5	**0,0**	1,0	2,0	3,0	4,0
95	-5,2	-4,7	-4,2	-3,7	-3,2	-2,7	-2,3	-1,8	-1,3	-0,8	**-0,3**	0,7	1,7	2,7	3,7
90	-5,4	-4,9	-4,5	-4,0	-3,5	-3,0	-2,5	-2,0	-1,5	-1,0	**-0,6**	0,4	1,4	2,4	3,3
85	-5,7	-5,2	-4,7	-4,2	-3,7	-3,2	-2,8	-2,3	-1,8	-1,3	**-0,8**	0,1	1,1	2,0	3,0
80	-5,9	-5,4	-4,9	-4,4	-4,0	-3,5	-3,0	-2,5	-2,1	-1,6	**-1,1**	-0,2	0,8	1,7	2,7
70	-6,3	-5,8	5-,4	-4,9	-4,5	-4,0	-3,5	-3,1	-2,6	-2,2	**-1,7**	-0,8	0,1	1,1	2,0
60	-6,7	-6,3	-5,9	-5,4	-4,9	-4,5	-4,1	-3,6	-3,2	-2,7	**-2,3**	-1,4	-0,5	0,4	1,3
50	-7,2	-6,8	-6,3	-5,9	-5,5	-5,0	-4,6	-4,2	-3,7	-3,3	**-2,9**	-2	-1,1	-0,3	0,6

Source: www.agrofrost.eu

Source: Wallpaper Up, www.wallpaperup.com

The first version of the Fog-Dragon in the factory's court at Albertirsa Source: Agroinform monthly journal, www.agroinform.hu



Drawing from the Dolina Ltd.

Burning in the combustion chamber observing through the spy hole; Source: Dolina Ltd.

Look, how easy is to refill the combustion chamber. Just open the round bale door. Source: https://www.agrocentrum.hu /index.php/holegfuvok-futok-paratlanitok/kodsarkany-foggdragon-detail

See the fog-Dragon in three different sizes Source: Dolina Ltd

The Fog-Mushroom Source: Agrárágazat monthly journal, www.agraragazat.hu

Non-protected culture

Protected culture

Photos by Geza Rozgonyi, fruit grower from Tiszadada, Hungary; April 2017

Photo from the journal Vosgues Matin, 19 January 2018

Photo from the journal Badische Zeitung, 23 March 2018

However, many more fruit and vegetables has been hit. Various techniques and machines have been deployed to fight the frost, including helicopters, but they have been seen ineffective. When it comes to kiwis in the region Lazio more than 60 percent of the harvest was affected. There are around 700 growers and 3,000 hectares of apple orchards in Austria. The apples were already in bloom when the cold weather hit,

so this means that the blossom barely survived. Temperatures up to -6 ºC caused heavy frost damage in Austrian production areas in the early hours of the 21st of April 2017. The areas of Steiermark, Kärnten, Südburgenland and some places in Niederösterreich, Oberösterreich, Tirol and Vorarlberg were particularly damaged. Mainly fruit tress were heavily damaged by the frost. In total over 12,000 hectares have been affected. The total damage was well over 60 million euros.[ii] It was very cold in Belgium, down to minus 6. Various machines and products were used to keep the orchards warm, but this was for naught among many growers, as it only became a few degrees warmer and so the temperature was still below freezing. In Belgium they don't have enough water around to irrigate. The largest fruit region in Zuid-Limburg was heavily damaged. The results reckoned a damage of 80 percent of the apple trees. The farmers bond asked growers, who confirmed that 78 percent of the apples, 82 percent of the cherries and 63 percent of the pears have been hit.

In France a lot of fruit varieties were affected by the frost. When it comes to cherries the area from Avignon up has been greatly affected. There are also reports of damage at Lyon towards the east.[iii] Table grapes in the region of Ventoux are largely damaged. In the middle and north of France there were reports of top fruit damage. There are mixed confirmed coming from the Loire Valley, which is huge. Everyone were talking of more than 60 percent loss. The prices immediately rose sharply. The previous chart clearly indicates the production trends of the golden delicious apple in this decade. The hardest frost has hit the European production in early 2012 and 2017. Several billions of euros loss and high fruit producer and consumer prices mean the consequence. Therefore, the protection against (ground) frost is in the focus.
Nearly all traditional protection methods can be useful, but for example smoking, auto-swing or absorbed heat from straw bales, oily cloths or paraffin torches cannot be mechanized. Moreover, they are not efficient in all circumstances and a lot of them have to be used up, so their purchase is terribly expensive. Antifreeze irrigation and spraying can protect plants from frost but a huge quantity would need to many growers and cannot be realized everywhere. As for machines, there are some, which emits heat constantly, but the challenge of the escape of that heat is not resolved at all. Some of these machines costs an arm and a leg.[iv] They are equipped with propane gas which purchase is difficult and expensive. A new solution was needed which could somehow hold the heated air down, near the plants and trees. The relative humidity of the ambient air is the key.[v]

The Importance of Relative Humidity: Our starting point here is the so called greenhouse effect. The Earth's atmosphere for sunlight is largely 'transparent', so the heat produced by our Sun directly warms up the atmosphere and the surface of the Earth. Atmosphere and surface release this amount of heat in the form of electromagnetic radiation longer than visible light, so-called infrared light. However, some atmospheric gases such as water vapor (H2O) and carbon dioxide (CO2) effectively absorb it and radiate part of it to the Earth to keep the planet warm. This process is called 'greenhouse effect'. This natural process is largely influenced by the amount of greenhouse gases in the atmosphere. The most important of these gas is water vapor (clouds), which corresponds to 36 to 70 percent of the heat being re-radiated. During cloudless, open sky nights, the amount of heat absorbed and radiated back to the ground is significantly less than that of cloudy periods. It is important to know that it is practically impossible to regenerate the radiated heat in the plantation, so it is a good idea to prevent or slow down the high natural radiant heat loss.
How can we slow the heat loss down? Increasing the relative humidity. In fact, it is low, more frost will appear at the same temperature. For example, having a relative humidity of 50 percent and 0 ºC of temperature, we would have frost damage by - 2,9 degrees. Check the next table which clearly shows how much degrees we examine actually in the air depending on the humidity. As for fruit orchards or vineyards the danger of freezing increases under a relative humidity of 85 percent. That is why vaporized water in the air is very important. In the nature, the vaporized water appears in the form of fog. Consequently, if we would like to hold the warm layer down, we need to produce fog somehow in order to increase the humidity in the air. And that is the key in the functioning of the anti-frost machine, the Fog-Dragon and his smaller brother, the Fog-Mushroom.

The fog-dragon is the solution: Dolina Ltd. is a stately company, since the owner, Laszlo Farkas has built the iron smith empire in the footsteps of his father. Forty years ago, the company has been founded in Albertirsa as a small cooperative, at the end of 1991. Initially, they mainly engaged in the manufacture and repair of construction machinery and machine parts, and since 1995 their activity has been expanded with the production of industrial and agricultural chains. In 2003, a hot-dip galvanizing plant was built. With the establishment of the plant, it was possible to increase the number of employees and to increase the sales revenue. The production of wood-based biomass boilers was started in 2008. Fully automated boilers require minimal human intervention, which can be easily handled by anyone with PLC control.[vi] Laszlo Farkas, however, cultivates one hectare of vineyards and fruit plantations.

All of these had been hit by spring frost in 2016 and he suffered almost a hundred percent damages despite all conventional protection such as spraying and antifrost irrigation. For example, he had smoked strawberries, frost-proof irrigation, but nothing helped. He was informed about a propane-gas powered machine that had spilled the hot air heated by the gas in the plantations. However, this seemed a very expensive fun, costing around 1 thousand euros per hectare, because the machine was pretty expensive as it costed 18 thousand euros. Since the company had already produced wood-fired boilers, Laszlo Farkas thought that he would exploit the only disadvantage of such boilers, namely that they could be terribly smoked and use this disadvantage up in frost protection.[vii] So the idea was to install a biomass boiler on a tractor-towable structure. Drive the fan using the cardan shaft to blow away the smoke and warm air up between the plantations. Hot air is protected against freezing, while smoke and the added vaporized water do not it allow to 'escape' above the ground. This mixed agent: hot air, plus flue gas (smoke), plus vaporized water also prevent the plantation from lightening up by an emitted spark next to increasing the relative humidity of the ambient air.[viii]
The Fog-Dragon was born. Let me recall here, that as the water injected, the humidity of the air has increased, which is very important for frost protection, because low relative humidity increases the risk of frost. The sprayed water also increases the volume weight of the exhausted, smoky hot air and consequently spreads over a plantation or a vineyard, like a fog-blanket. Bela Glattfelder, President of the Hungarian

National Biomass Federation, has informed that the Fog-Dragon has surpassed all the defenses so far, because the spring in 2017, there was no frost in those plantations where the machine was 'deployed'.[ix] How can we describe the functioning of the Fog-Dragon? This antifrost machine has been developed to protect vine and fruit plantations against ground frost. The machine extends the resulting heat and smoke in the plantation by igniting the fuel placed in the combustion chamber inside the machine. The towing tractor drives the fan from its PTO (cardan) shaft. The fan passes the air for combustion through the ashtray door and cools the air between the combustion chamber and the double side wall of the round bale door. The cooling air is mixed with the flue gas and the additional cooling air added thereto in the first conical part of the machine and thus a uniform temperature gaseous material is dispersed. The water from the water tank of 300 liters above the mixing cone is being dispersed into the outgoing hot air, thereby increases the density of exhausted air and flue gas to help keeping this air layer near the soil surface.[x] Just to shortly repeat the process:

- The fan blows the hot flue gas – it mixes it with the cold air and cools the motor side
- It produces heat of combustion: about 60-65 degrees near the outlet flap
- Exhausts at two-sides about 30 m
- It heats and mixes the air by this movement
- The blown heat sprays water in air and increases the density of air
- The extended steam, smoke and hot air provides protection.

Application of the Fog-Dragon:

- When the temperature falls below 0.5 °C or
- Relative humidity is less than 85 percent
- Take 60-meter rounds by the machine in the orchard or vineyard
- You have to be back at 12-14 minutes (considering the 60 meter rounds)
- Fast refilling - 10 minutes maximum, many times more(functional appliances, combustion equipment)
- It's the coldest before dawn
- Lawn level should be low (more power, less cooling).[xi]

The machine burns the fuel in the combustion chamber and burns the resulting heat, smoke and water into the plantation. Examples of applicable fuels include:

- Hay, straw and maize bale,
- Vineyards bale,
- Wood chips,
- Logs,
- Extracted logs.

This clearly shows that the machine fully fits in the concept of circular economy, because fruit producers or winemakers can easily use many superfluous plantation by-products (logs, trimmings, hay, straw or maize) in fueling the machine.

Effects of the machine:

- It moves the air, thus facilitates the mixing of top warmer and bottom cold air layers.
- It produces heat from combustion of fuel, which increases the ambient air temperature.
- Spreads the resulting smoke and vapor into the plantation, which retain a substantial part of the heat emitted from the ground.xii

The Fog-Dragon is much more effective than traditional protection modes (eg. oily cloth, paraffin torch, antifreeze irrigation) and cheaper and also more efficient than competing machines that emit only heat that flies away quickly, on the contrary, the Fog-Dragon emits fog that stays below the ground for a long time. Applicants can go ahead in lines between the lines with 45 – 60 meter turns depending on the temperature and return to the starting point in the plantation. Operation could be ensured with a minimum of 45 horse power tractor with PTO (cardan shaft) drive. After two or three minutes of ignition the hot air, the smoke and the water vapor are coming, and a normal not too dense round bale burns for 5-6 hours. The high-performance equipment is capable of solving protection on 8 to 10 hectares. The manufacturer has already developed three version of the machine depending on its width: the 211 cm large machine, the Big-Dragon for the protection of large orchards, the 176 cm large Small-Dragon for the protection of smaller orchards and large vineyards and the 150 cm large Mini-Dragon for the protection of smaller vineyards.[xiii] The smaller brother of the Fog-Dragon is the Fog-Mushroom which is an effective tool for protecting smaller plantations and gardens. The Fog-Mushroom is settled and ensures the protection of fruit trees in smaller gardens, vineyards, strawberry and Fragaria Vesca plantations, as well as saplings against spring frost by igniting split firewood (or equivalent solid biomass). The area protected by one machine could be around 2800-3000 m2. The manufacturer outlines it in electric or gasoline powered versions. The electric powered machine is activated automatically by the external temperature. Dry and solid fuel (mainly smaller wood logs or pellets) is required for the operation. The machine operates the same way as the Fog-Dragon. It blows the heated air, the smoke and the vaporized water in 360 degrees away. A 100 liter water tank is put on the machine.[xiv]

Testimonies of the machine: I have already indicated that the President of the Hungarian Biomass Federation officially announced that the plantation of those growers who had been using the Fog-Dragon had been approximately 100 percent protected from frost in 2017 and this year. One good example is a fruit grower in Tiszadada, Szabolcs-Szatmár-Bereg county in Hungary, who could totally save 8 hectares of his apricot orchard from frost of -4 ºC, exactly on that area where he had previously used his Dragon. The photos here illustrates well the difference between the flowers in a saved area and that hit by frost.[xv] The machine has been also tried in other countries in Europe: in Romania, in Serbia but also in France and Germany. Let me outline two experiences here from these two latter countries:

"I had to use my new Dragon already in March (2018) *to save my apricot orchard against frost. I noted a frost damage between 5 and 15 % depending on the variety, which is a good result after my attempts other modes of protection."*

(Julien Grandieu, Fruits de Pays Verger Grandieu, arborist, Grignoncourt, Vosges, France)[xvi]

"The Fog-Dragon is pulled by a tractor through the rows of fruit trees. Meanwhile, materials such as straw or wood are

burned inside. In principle, it works like a wood furnace: at the bottom, I charge and recharge the chamber. In addition to the normal oven, cold air is provided so that I can control the temperature. We drove continuously at 80 degrees. In addition, vaporized water is added to the unit, which plunges the hot air. This hot air blows fog smoke into the cold air on the floor. I had a good result comparing to what we could do with candles before. But from the candles we would need 200 to 300 pieces per hectare, a Dragon can cover about 8-10 hectares. A candle now costs between 10 and 12 euros. The Dragon is almost half what I spent before."

(Joel Siegel, Obstgut Siegel KG, Arborist, Schallstadt-Mengen, Baden, Germany)[xvii]

These new antifrost machines have a larger and larger demand form allover Europe. So far the manufacturer has sold more than 100 Fog-Dragons in Hungary, Serbia, Croatia, Romania, Slovakia, France, Germany and Norway. The machines are exposed at many agricultural fairs in Europe: in Budapest (Hungary), in Stuttgart (Germany) and in Angers (France).

Summary

It was outlined in a detailed manner how huge damages are caused by the frost to fruit growers and winemakers, mainly during the spring in each year. The currently known solutions can be quite efficient during preferable circumstances, but mainly not. These solutions such as antifrost irrigation, using paraffin torches or buying propane gas driven antifrost machines, but the efficiency of these is rather limited. A new Hungarian innovation, the Fog-Dragon and its smaller brother, the Fog-Mushroom are biomass boilers against frost. The Dragon is towed and emits fog: heat about 65 - 90 degrees, flue gas and vaporized water, which remains below the ground (agent lightened) and thus protects the plants and trees against frost. A machine can cover up to 10 hectares. Available in three sizes (2.11 - 1.76 - 1.5 m width), the Fog-Dragon can be used in any size or type of plantation (orchards, vineyards, etc.). The Mushroom is settled and ensures the protection of fruit trees in smaller gardens, vineyards, strawberry and Fragaria Vesca plantations, as well as saplings against spring frost by igniting split firewood (or equivalent solid biomass). The area protected by one machine could be around 2800-3000 m2. The manufacturer outlines it in electric or gasoline powered versions. I can firmly suggest to growers and winemakers allover the World and machine traders as well to be confident to turn to the Fog-dragon and Fog-Mushroom for having a good antifrost assistance, try and regularly use the machines. They will have a reliable tool to save their produce and revenue from the negative effects of frost. For further information about the machines and the manufacturer, please turn to G. Patzay, promoter of the Fog-Dragon and the Fog-Mushroom in Europe and in the World.
Phone number: +36308696715

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[xii] See the monthy journal of Agrárágazat.hu; link: https://agraragazat.hu/hir/fagymentes-ultetveny-igy-lehetseges

[xiii] See the article from Agrárágazat.hu, outlined above

[xiv] See the article from Agrárágazat.hu, outlined above

[xv] Own words by Geza Rozgonyi, a fruit grower from Tiszadada, Hungary

[xvi] See some article in a regional journal Vosgues Matin (France), links: https://www.vosgesmatin.fr/edition-de-la-plaine/2018/01/18/vergers-de-grandieu-pour-presentation-d-une-machine-anti-gelee-a-grignoncourt
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