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NEW TYPE OF ANTIHAIL, ANTIRAIN AND ANTIFROST SYSTEM FOR PROTECTION OF ORCHARDS

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Abstract

The present paper presents a review regarding the use of nets and other plastic covers for the orchard protection against hail, rain and late frosts. The installation of the protection systems creates a modified microclimate that influences many orchard parameters and most of these modifications brings benefits for the farmers, as indicated by many studies made in the last decades. Two key factors that seem to be influenced in a positive manner by the plastic covers are the late frosts protection and the earlier maturation of the fruits. In the sweet cherry orchard from the Experimental field of USAMV Bucharest a roof plastic cover has been installed in order to study the evolution of the plants inside and outside the covered area. The new system which has been patented in 2020, assures protection against late frosts, hail and rain, sweet cherries being very susceptible to cracking caused by rain during the ripening season. During the study, will monitor the effectiveness of the protection as well as the impact of the system on the fruit set, the earliness of fruit production, yield quality and quantity, diseases impact and the general evolution of the cherry trees.

Key words*: fruit protection, rain cover, plastic cover, orchard protection, hail net, orchard protection.*

INTRODUCTION

Climate change is a fact that cannot be contested anymore. Its effects are being felt all around the world. We witnessed devastating storms, draughts, warm winters and cold springs, snow falls in areas where they have never been seen before, hail storms and so on.

The impact of these phenomena on agriculture is huge, because they affect all the aspects of the plants' life. If we consider the horticulture, the impact is even bigger, as the horticultural crops are generally of higher value and many of them are perennial, so one phenomenon can affect the plants for the next years.

In this context, the use of protection systems for horticultural crops is a key factor in assuring the quality and quantity of the production. For vegetable production the best way for crop protection is to use greenhouses. They are very effective in protecting the plants against late frosts and strong enough to resist hail storms. But the cost of building greenhouses is so high that, they do not represent a viable solution when we speak about fruit orchards, or even vegetables grown on field. Therefore, there is a need for a feasible, cost effective alternative that can be used to protect fruit trees and that can be used for big surfaces of land.

The present paper makes a review of the systems used worldwide to protect the fruit trees and presents also a new protection system that was developed and patented in Romania. The system combines the characteristics of the standard hail and rain protection systems with the covering and screening of greenhouses and protects the crops against late frosts, hail, rain and wind.

Review of the orchard protection systems

The orchards protection against hail by covering them with nets of various meshes and colours is one of the most effective means of protection. Besides assuring an almost perfect protection, this system brings other benefits, such as better fruit quality (Kiprianovski et al., 2016), improved yield and even improved efficiency of photosynthesis of the shaded leaves (Bosančić et al., 2021), reduction of sunburn on fruits etc.

In the last years there have been made tests with coloured, photo-selective nets. As any type of net cover will decrease the light transmission, this can adversely affect vegetative and reproductive plant growth, but

each type of colour net can improve the quality and colouration on specific cultivars (Blanke, 2009).

The anti-hail nets are used usually after blossom, till late after harvest period, when the risk of hail storm persists. Anyway, they do not protect the orchards against late frosts or rains during the harvesting period.

There are fruit species susceptible to cracking caused by rain coming in the pre-harvesting period. The most common example is the sweet cherry tree. For the protection against rain there have been proposed many solutions. All of these solutions have the same base principle which is to cover the trees with a plastic roof. One main aspect about these covers is that they can be affected and even destroyed by the wind gusts. Therefore, most of these systems can only be used during a short period of time (2-3 weeks), before and throughout the harvesting period. All the systems used against the rain proved good effects, even if the fruit cracking was not 100% avoided. According to Measham et al., (2014) "the development of apical and stem end cracks are induced by skin surface wetting, while deep cracks on the side of the fruit are induced by water moving via the vascular system". The vast majority of rain plastic shelters discharge the water in the space between the row trees, therefore there is rain water coming through the roots towards the fruit, so the second type of cracks cannot be avoided. The trees cultivated under the so called "high-tunnels" or inside greenhouses can be totally protected against cracking, but these constructions are very expensive and have other disadvantages, like low ventilation, that make them unfit for tree growers.

Using structures that permitted the plastic sheets to be used for longer periods gave the opportunity to conduct studies about the influence these covers on the various aspects of fruit cultivation. According to Lang et al., (2016), "Protective covering systems can modify many variables in the orchard production environment and ecosystem, including rain, wind, frost, and some pests and diseases, resulting in more consistent sweet cherry cropping with higher quality fruit and healthier trees in less-than-optimal growing regions."

One of the most important benefit of plastic shelters was the protection given against late spring frosts. Covering the orchard with plastic roofs "increased the temperature by approximately 1-2ºC, resulting in decreased frost damage occurring during the bloom stage" (Vávra et al., 2019, p. 503). Studies of the plastic covers on sweet cherry orchards, conducted in Germany in nineties, proved that even if they did not offer 100% protection against cracking, they "gave an efficient protection against frost during flowering in 1997" (Balmer, 1998).

Plastic covering of the canopy also proved useful for reducing the leaf diseases associated to rain water and damages caused by hail (Kjaer et al., 2016). Tests have been made to apple trees and there have been less infections and consequently less treatments. On sweet cherry orchards plastic shelters "used to cover trees from bloom throughout the growing season, can reduce some key diseases (cherry leaf spot and bacterial canker), and it may be feasible to increase certain pesticide spray intervals due to less loss of protective residues to rain or UV light breakdown" (Lang, 2014).

Because the plastic covering alters the light characteristics, it modifies the fruits maturation and colouring. Studies conducted in Vignola Region of Italy showed that the characteristics of the polyethylene used in plastic covers have different influences on the ripening date of cherry trees. Some types accelerate fruit ripening, while other induce a delay in maturation (Grandi et al., 2017). This suggested that by using different plastic covers and eventually sequential opening of the covers, some early cultivars will maturate even earlier, while the harvesting period of some late cultivars can be delayed for some days. This method can bring important benefits for farmers, as cherry prices are very high off-season.

The fruits quality grown under the plastic shelters is another key aspect that has to be considered. According to the type of covers, the influence on the quality can be different. If the system does not assure a good ventilation the fruits will have "less surface colour, reduced red juice colour and lower percent of soluble solids" (Børve and Meland, 1998) and they will "have a higher risk of infection of different

diseases" (Meland and Skjervheim, 1998). But, with shelters that assured a good ventilation, the fruits were of a very good quality, with diameter and weight higher than the ones grown in open fields (Lang, 2014).

Besides the beneficial aspects of using plastic covers for orchards there is also a big issue: pollination. Pollination using European honeybees (*Apis mellifera*) is affected negatively by plastic covers, "since these covers change the light spectral quality that honeybees use for effective navigation" (Lang, 2014). A good solution to this problem is the use of bumblebee hives (*Bombus* spp.). Bumblebees seem to be less affected by the conditions under the covers (Lang, 2014) and therefore the pollination of the flowers is good.

The effect of opening the plastic covers early in the spring on the maturation date of the fruits has been extensively studied in researches conducted all over the world. On sweet cherry trees the results have been contradictory. In some cases, the earliness of the production was spectacular: "when roof plastic covers are used during the whole season, trees bloom 6 to 13 days earlier, harvest is advanced by 12 to 19 days, and soluble solids concentration increase in comparison with uncovered controls" (Wallberg and Sagredo 2014, *apud.* Blanke and Balmer, 2005). In other cases, the results have been exactly the opposite, a "delayed ripeness from 4-7 days" (Børve and Meland, 1998), or 1 to 5 days delay (Meland and Skjervheim 1998, *apud.* Zbinden, 1988). Most probably the properties of the plastic which was used, as well as the geographical conditions of place were the studies have been made have had an impact on the results, so there is a need to replicate these studies in the Romanian conditions and with different types of plastic.

The use of plastic shelters was extended to many other species beside the sweet cherry. Raspberries grown in China, under the plastic rain shelters have a bigger height and diameter and the harvesting can be done even during rainy days, which results in a higher amount of marketable fruits and a lower percentage of lost fruits. Also, the harvesting season of primocane fruiting raspberry has been prolonged late in the autumn (Dai et al., 2020).

Kiwifruit "could be harvested 15-20 days earlier under plastic house culture than in the field without any quality deterioration" (Cho et al., 2016).

Under the rain covers the mean yield of mango fruit increased by a staggering 60.2%, while the quality of the fruits was not affected and more, the fruits decay after harvest was diminished significantly (Xu et al., 2019).

Used in apple and pear orchards, plastic shelters can reduce the incidence of the rain induced diseases, with a direct impact on the lower number of treatments. These shelters can also protect the plants against hail and sun, eliminating the burns caused by the high solar irradiance (Kjaer et al., 2016).

Apricots, peaches and nectarines grown in temperate climate are very susceptible to be affected by late frosts. In Romania, almost regularly there are several nights with freezing temperature during middle and late spring. Studies conducted at the R.S.F.G. Constanța between 2012 and 2014 showed that as much as 90% of some peach cultivars have been lost because of the frosts (Moale et al., 2016). In 1991 there has been made a study for apricot grown inside plastic houses. The results were very promising as there were obtained higher yields and earliness of 15-20 days compared to apricots grown on open fields (De Salvador et al., 1991).

MATERIALS AND METHODS

In 2020 we developed a protection system using plastic sheets linked to a structure of cement posts. The sheets covered each row of trees and the lateral sides were linked from one row to the next one with elastic strings. The resulting space between the sheets gives the air the possibility to exit the system in such a way that it does not create pressure on the structure itself. Therefore, the system can be used from early spring until late autumn, protecting the crop from late frosts, hail, rain, sunburn. If we do not want that rain water to enter inside the system, we can mount a plastic gutter that will transport the rain water outside the system (Figure 1). The system has been patented and has been already installed on about 20 hectares of different crops, like sweet cherries, raspberries, strawberries and blackberries.

As part of this study, we installed the system on 14 rows of sweet cherries orchard located

inside the USAMV Experimental field in Bucharest. The plot contains the following cultivars: 'Ferrovia', 'Lapins', 'Celeste', 'Vega', 'Skeena', 'Early Red', 'New Star', 'Kordia', 'Mora di Vignola', 'Firm Red', 'Giant Red', 'Katalin', 'Ulster', 'Sam', 'B. Burlat', 'Boambe de Cotnari', 'Hedelfinger, Germersdorf', 'Van', 'Rivan', 'Regina', 'Giorgia', 'Rubin' and 'Severin' grafted on PHLC, Colt, CAB6P, CAB11E and *Prunus mahaleb* L. The opening of the covering system has been made on March 31, 2021. We opened the system on about half of the total surface, in order to have control trees to compare.

As there are many cultivars with different canopy types and the plants are not of the same age, we identified those cultivars whose position permits to have plants both inside and outside the opened system. In this way, we can study the evolution of the covered plants by comparison with the ones that remained uncovered. The cultivars that will be studied are: 'Early Red', 'Ferrovia', 'Kordia', 'Regina', 'Rubin' and 'Severin'. In order to monitor the temperature and wind speed we installed temperature sensors inside the covered area as well aș outside. Our goal is to compare the evolution of the trees that are covered by the plastic shelter with the ones outside. The aspects that will be investigated are: effect of low night temperatures, pollination by insects, fruit development and maturation dates, fruit colouration, fruit cracking caused by rain and the general evolution of the trees.

RESULTS AND DISCUSSIONS

Several days after the system opening, the temperatures dropped significantly during the night between the 8th and 9th of April. Our sensors registered -3.8ºC outside the covered area and -2.1ºC inside. The temperature difference of about 1.5ºC is consistent with the measurements we made during the last years and with measurements made by other researchers in similar conditions (Vávra et al., 2019). In the morning of the 9th of April the whole field was covered by hoar-frost, with the exception of the sheltered area. Actually, the hoar-frost remained on the plastic sheets and did not fall on the trees (Figure 2). The 'Early Red' trees were in full blossom and we could see the effect of the hoar-frost on the flowers that have been exposed. In the following days we checked these flowers and it was clear that they have been affected (Figure 3). The covered 'Early Red' trees did not have affected flowers with the exception of some flowers which were positioned in the area were the plastic sheets were linked and they were exposed to the hoar-frost. This proved that the system can be successfully used to protect trees against hoar-frost and even against negative temperatures in spring time. On another hand, if the temperature drops significantly, the plastic covers themselves are not enough to eliminate the damages. Additional heat sources are needed, which, with the help of the covers, will increase sufficiently the temperature. In the next season we will install such heat sources and we will test how the system influences the loss of heat, as well as the fuel consumption needed to keep the positive temperature inside the covered area.

The modification of light parameters inside the covered areas gives a concern regarding the effectiveness of honeybee (*Apis mellifera*) pollination. Lang (2014) speaks about this problem and proposes as an alternative solution the use of bumblebees (*Bombus* spp.). In our research area we installed three honeybee hives situated inside the covered space and one bumblebee hive. In the first days the bees did not seem interested to visit the flowers of the sweet cherry trees, neither covered, nor situated in the open area. Most probably this was caused by the fact that there were few blossomed trees inside the experimental field and in close proximity there are some parks where there were other blossoming trees. When the majority of the trees started to blossom, the bees activity inside the experimental field increased. We could see that the honeybees preferred the trees situated outside of the covered space. There were honeybees also inside the covered space, but not in big numbers. The bumblebees however, did not seem to make differences between the inside and outside of the covered area. The pollination is ongoing during these days, so we will have the results in the coming weeks. We will further investigate also if the roof plastic covering has any effect on the fruit maturation as well as on the fruit quality and quantity.

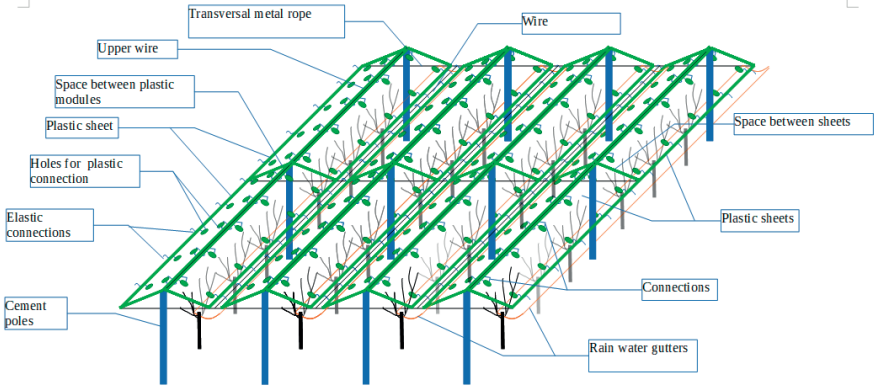

Figure 1. Roof plastic cover

Figure 2. Hoar-frost outside and inside the roof plastic cover

Figure 3. Flowers damaged by hoar-frost outside the roof plastic cover

CONCLUSIONS

The impact of climate change on fruit production is huge and cannot be underestimated anymore. The very low temperatures of winter combined with the high temperatures during late winter – early spring and with sudden drops of temperature below zero degrees in late spring are causing big problems for fruit growers in temperate areas, like Romania (Asănică et al., 2012; Asănică et al., 2014). Hail storms destroy fruit crops already on regular basis. Severe draughts alternate with heavy rains coming during the harvesting periods. There is no other solution for avoiding the damages caused by all these phenomena but to use the protected crop environments. Besides the use of greenhouses and high-tunnels, there must be found other cheaper solutions that can be afforded by the regular farmer. One such solution is the use of roof plastic covers, that can cover big areas, have a good cost-benefit ratio, can be adapted to various types of crops and provide protection against late frosts, hail and rain, besides other benefits like fruit earliness or disease protection.

All these aspects will be thoroughly studied in the next period on the specific climatic conditions of Romania. Further results of this study will be published.

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