INFRASTRUKTURA I EKOLOGIA TERENÓW WIEJSKICH
INFRASTRUCTURE AND ECOLOGY OF RURAL AREAS

Nr II/1/2017, POLSKA AKADEMIA NAUK, Oddział w Krakowie, s. 449–456
Komisja Technicznej Infrastruktury Wsi

DOI: http://dx.medra.org/10.14597/infraeco.2017.2.1.033

COMPARISON OF THE EFFECTIVENESS OF PROTECTION AGAINST FROSTS, USING IRRIGATION AND FOGGING IN DIFFERENT TYPES OF PEACH ORCHARD

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Abstract

Spring frost in the blooming time can be a significant factor decreasing the fruit production and affects the cultivation profitability in the years with unfavourable weather conditions. In Poland, the fruit trees especially susceptible to damage are peach and apricot trees. Among the popular methods of protecting the trees against spring frost damage there are three kinds of treatment: sprinkling irrigation, fogging, smoking and using fans for mixing the layers of air. The costs of applying the particular methods differ, as well as their efficiency. The side effect of using them can be also orchard pollution. The experiment was conducted on selected peach tree cultivars, on two rootstocks. Two methods of spring frost protection were applied: sprinkling irrigation and fogging with the use of glycerin mixed with tap water in proportion 1:10. Sprinkling irrigation proved to be more effective, it protected 98% of blooms. Using the fogging device also brought a satisfying effect. The cultivars that were easily damaged by spring frost were 'Early Redhaven' and 'Cresthaven'. The greatest resistance to bloom damage was observed in the case of the 'Suncrest' and 'Saturn' trees. The yielding of the 'Inka' and 'Early Redhaven' trees protected by sprinkling irrigation was significantly better, as compared with the fogged trees. The mean fruit weight was determined mainly by the cultivar.

Key words: peach, spring frost, blossom damage, sprinkling irrigation, fogging, yield.

INTRODUCTION

Spring frost in the blooming time can be a significant factor decreasing the fruit production. In the Lower Silesia region, the fruit trees especially susceptible to damage are peach and apricot trees. Just like in the case of winter freezing, spring damage caused by low temperature heavily determines the level of yielding (Szewczuk *et al.*, 2007, Szewczuk *et al.*, 2010, Ghaemi *et al.*, 2009, Rodrigo, 2000, Kutkowska *et al.*, 2015). It, in turn, affects the cultivation profitability. Low temperatures in spring, below 0°C in April and May, are taken into consideration while choosing the place for the orchard establishment. It is necessary to avoid the frost basins while planting the trees. Local frost occurs mainly when it is sunny and the sky is bright, without clouds. At night, solar energy radiates into the higher layers of air, which causes low temperature near the ground. Nowadays, late spring frosts are more probable than in the previous years; it results from the weather changes. The frequency of late spring frosts has almost doubled in the last three decades almost doubled (Czaplicka and Dereń, 2007).

Among the popular methods of protecting the trees against spring frost damage there are three kinds of treatment: sprinkling irrigation, fogging, smoking and using fans for mixing the layers of air. The costs of applying the particular methods differ, as well as their efficiency. On small areas with valuable cultivations, like high-profile vineyards, using space heaters and mobile gas heating devices is also popular. The cost of introducing such solutions is high, and many repetitions during the night are required (Ghaemi *et al.*, 2009). It can be effective up to – 8°C, depending on the protection method and the weather conditions, especially on the speed of wind. Using organic-mineral chemical agents, e.g. Asahi SL or Help, is not a very popular method of plant protection in spring (Basak, 2011). In this case, the protection involves changing the composition of polyphenols in blooms. As a result, the resistance of flowers to low temperature is increased. It is important to use this chemical 12-24 hours before possible frost. A similar effect can be achieved by using pure glycerin before low temperature periods. Spring frost protection is necessary in selected years for early-blooming species and for the plants which fruit on one-year shoots, because in those case vegetation starts early. All of the methods are quite expensive and besides they may cause orchard pollution, e.g. smoking, fogging with diesel fuel (Ghaemi *et al.*, 2009).

MATERIAL AND METHODS

The experiment was conducted in 2016 in Samotwór, in the Experimental Station, being a part of the Department of Horticulture, Wroclaw University of Environmental and Life Sciences. The orchard is located on the south-western border of Wroclaw city. The weather conditions in the spring of 2016 are presented in Figure 1.

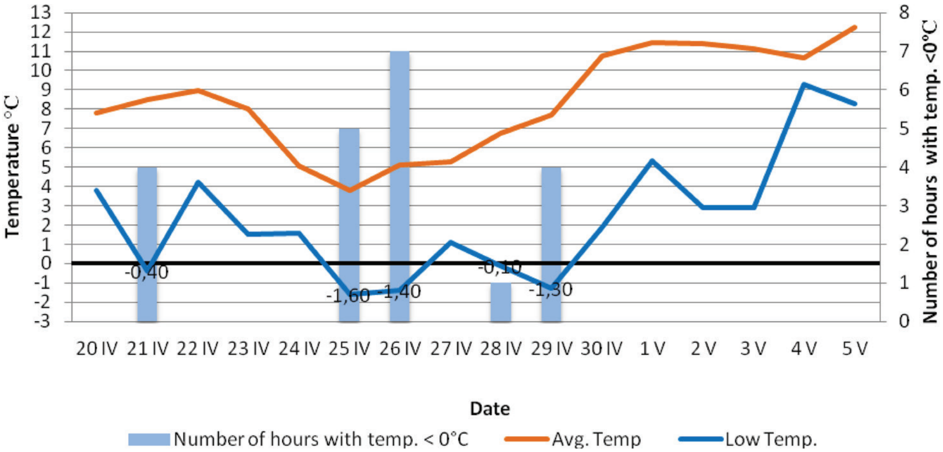

Figure 1. The average and the lowest temperature and the number of hours with temperature below 0°C in the experimental orchards from 20th April to 5th May 2016.

The experiment was conducted on selected peach tree cultivars, within the area of the experimental orchard. Sprinkling irrigation was applied on the 'Redhaven' and 'Inka' trees, grafted on the Manchurian seedling rootstock. Spacing of sprinkling irrigation system was 10 x 10 m. Water efficiency was 33 dm3·ha-1·h. The operating pressure of the installation was 2.5 bar. Sprinkling irrigation was started when temperature was going below zero till the moment when achieved + 1°C on meteorology station. Fogging with glycerin was applied using the thermic fogging device H500 SF VectorFog, on the 'Saturn', 'Redgold', 'Inka', 'Early Redhaven', 'Harnaś' and 'Suncrest' trees, grafted on the Manchurian seedling rootstock, as well as on the cultivars 'Redhaven' and 'Inka', grafted on the Pumiselect® rootstock. The control group consisted of the 'Redhaven', 'Early Redhaven', 'Saturn', 'Inka', 'Suncrest' and 'Cresthaven' trees, grafted on the Manchurian seedling rootstock. According to the information provided by the producer, the fogging device is suitable to spray on large areas, in orchards and vineyards. It can be used for chemical agents with water and oil bases. It generates drops of 10-30 microns, distributing 100 l of spray liquid per hectare in an hour. In the experiment, the mixture of glycerin and tap water was used, in proportion 1:10. During time of experiment tree were on blooming period (BBCH 60-69).

Fogging started at the same time as sprinkling irrigation, before the temperature in the experimental quarters fell below the 0 level. Temperature were checked in the meteorology automatic station produced by WeatherLink, situated in central part of orchard, on height 2.0 m above the ground. Fogging was applied twice on each tree with the device being used in every two rows. Fogging was repeated every four hours, as soon as sprinkling irrigation was paused. The protection treatment was provided on 25th April, 26th April and 29th April, at night.

On 29th Apr. 2016, after 10.00 a.m., the level of bloom damage was evaluated. From each repetition, 20 blooms were taken at the height of over 1.5 m above ground, from the middle part of canopies. In the summer, the records of yield and mean fruit weight were taken (each combination in 4 repetitions, three trees per plot). The results were statistically elaborated by an analysis of variance. The significance of the differences between the means was evaluated with the use of Duncan's multiple range t-test at $p = 0.05$. The statistical analyses were carried out separately for all kinds of experimental treatment. While comparing the cultivars, the results from the combination with sprinkling irrigation ('Inka', 'Redhaven') were left out, only the control and fogged plots were taken into consideration. The fruit harvest took place between 15th July and 20th August 2016, depending on the fruit maturity.

RESULTS AND DISCUSSION

During the blooming period in 2016 there were four critical days with the air temperature below 0°C, at the nights of 21st April, 25th April, 26th April and 29th April. The minimum temperature recorded by the meteorology station was – 1.6°C on 25th April, on other days: – 0.1, – 0.4, – 1.3 and – 1.4°C. At the nights of 25th April and 26th April, the temperature remained on the level below zero for 5 and 7 hours, from midnight until the morning. The flowers could have been injured also at the night of 29th April, when the temperature fell to – 1.3°C and remained steady for 4 hours. Bloom damage was assessed when the negative effects of frost could be observed.

In this experiment we observed a considerable influence of the protection method on the level of frost damage (Table 1). The most effective treatment was sprinkling irrigation, with 98% of blooms fully protected. This result was similar on both tested cultivars: 'Inka' and 'Redhaven' (Table 2). It confirms the reliability of this method, already mentioned by other authors (Ghaemi *et al.*, 2009). The average bloom damage on the fogged trees was 35%. This ensures a satisfying yield from peach trees. On control plots 74% of blooms were frozen.

Among the cultivars cultivated on the plots without protection, the greatest frost damage of blooms was noticed on 'Cresthaven', followed by 'Early Redhaven' and 'Inka'. The 'Suncrest' trees (and similarly 'Saturn') presented the least number of destroyed blooms. On the fogged plots, the highest percentage of damaged blooms was on the 'Early Redhaven' and 'Harnaś' trees and the lowest

– on the ‘Saturn’ and ‘Suncrest’ trees. The ‘Inka’ cultivar showed a high level of damage when the trees were grafted on the Manchurian seedling rootstock (47%), whereas on the Pumiselect® rootstock the percentage of dead flowers was low – 10%. Moreover, a high percentage of damage on this rootstock was observed on the ‘Early Redhaven’ trees (37%). In terms of the rootstock used, no significant differences in the number of damaged blooms were noticed. However, we observed a tendency to a greater spring frost flower damage in the case of the trees grafted on the Manchurian seedling. It means that the rootstock affects the level of bloom damage, as it was shown in Tsipouridis and Thomidis’s experiment (2005). Still, the results of our experiment do not overlap with the observations of other authors examining the resistance of peach tree cultivars to winter frost (Szewczuk *et al.*, 2007, Szewczuk *et al.*, 2010).

Table 1. The percentage of bloom damage, the yield and the mean fruit weight in the experimental combinations in 2016.

Treatment			Percentage of bloom damage	Yield (kg · tree^{-1})	Mean fruit weight (g)
System of protection	**Cultivar**	**Rootstock**			
Control (no protection)	‘Cresthaven’	Manchurian Seedling	67% ef	0,48 a	200 bc
	‘Early Redhaven’	Manchurian Seedling	72% fg	1,09 a	205 bc
	‘Inka’	Manchurian Seedling	85% g	4,04 a	234 bc
	‘Redhaven’	Manchurian Seedling	40% c	4,64 a	173 b
	‘Saturn’	Manchurian Seedling	48% de	0,48 a	66 a
	‘Suncrest’	Manchurian Seedling	43% d	0,92 a	179 b
Fogging	‘Early Redhaven’	Manchurian Seedling	66% e	9,16 c	198 bc
	‘Harnaś’	Manchurian Seedling	42% d	0,96 ab	177 b
	‘Inka’	Manchurian Seedling	41% c	13,89 d	289 c
	‘Inka’	Pumiselect®	10% ab	0,00 a	-
	‘Redgold’	Manchurian Seedling	37% c	3,01 a	228 bc
	‘Redhaven’	Pumiselect®	37% c	0,36 a	360 d
	‘Saturn’	Manchurian Seedling	17% b	1,24 a	96 a
	‘Suncrest’	Manchurian Seedling	20% b	3,00 a	239 bc
Sprinkling	‘Inka’	Manchurian Seedling	2% a	37,07 e	173 b
	‘Redhaven’	Manchurian Seedling	2% a	14,56 d	160 ab

The yield from the tested trees was not so high in 2016 (Tab. 1). The cultivation without any protection gave less than 5 kg from a tree. In the case of the ‘Suncrest’, ‘Saturn’, ‘Redhaven’ and ‘Redgold’ cultivars in the fogging combination, the level of yielding was similarly low. There was no yield from the 'Inka' trees, grafted on the Pumiselect® rootstock. The yielding of the 'Inka' and 'Early Redhaven' trees protected by sprinkling irrigation was significantly better, as compared with the fogged trees. The crop amounted to 37.07 kg per tree from the sprinkled 'Inka' and 14.56 kg from the 'Redhaven' trees (from the fogged plots – 13.89 kg and 9.16 kg, respectively). The crops were bigger than those received by Mrowicki and Morgaś (2015). Szewczuk and Gudarowska (2007) obtained a higher yield from the 'Inka' trees than from 'Redhaven', as compared to the total yield from 8 years. The low level of yield from the trees injured by winter frost was shown by Szymajda *et al.* (2013). Different levels of fruiting, depending on the year, were observed also by Podsiadło *et al.* (2005).

The yielding levels achieved in the experimental quarters in 2016 were not satisfying. The numbers of kilograms from a tree were lower than those described in other papers (Szewczuk and Gudarowska, 2007, Podsiadło *et al.*, 2005). Such a situation might have been caused by the storms and hailing that occurred in July 2015 and destroyed many trees. Hailstones injured one-year shoots of the peach trees, which resulted in small fruit falling off in June 2016. Probably, heavy hail damage and plant stress made it impossible to obtain high yield in the following season, that is in the experimental year.

Table 2. The percentage of bloom damage depending on the cultivar, rootstock and protection method

Cultivar	**Percentage of bloom damage**	**System of protection against frost**	**Percentage of bloom damage**
Mean for cultivars		**Mean for protection system**	
'Cresthaven'	67% a	Control	71% c
'Early Redhaven'	70% a	Fogging	34% b
'Inka'	45% a	Sprinkling irrigation	2% a
'Redgold'	37% a	**Rootstock**	**Percentage of bloom damage**
'Redhaven'	40% a		
'Saturn'	35% a	**Mean for rootstock**	
'Suncrest'	29% a	Manchurian seedling	23% a
'Harnaś'	42% a	Pumiselect®	37% a

The mean fruit weight was determined mainly by the cultivar. There was no influence of the protection method and the level of yielding on the fruit size. The only exception was 'Inka', grafted on the Manchurian seedling. From the fogged plots we received 289-gram peaches, while the fruit from the sprinkled plots weighed 173 g, with the yield higher by 170%. The fruit from the combination with sprinkling irrigation had a typical weight for this cultivar (Szewczuk and Gudarowska, 2007). The fruit of the 'Redhaven" cultivar had a bigger size than those obtained by Mrowicki and Morgaś (2015). The experiment confirmed the well-known tendency to increase the fruit size and to decrease the yielding at the same time.

CONCLUSIONS

1. The most effective method of the protection against spring frost was sprinkling irrigation. Using the fogging device with a glycerin mixture also brought a satisfying effect.
2. The lowest percentage of frost damage was observed in the combination of the 'Redhaven' trees, grafted on the Manchurian seedling in spring 2016. The number of destroyed blooms was similar to that in the combination with fogging, with the trees grafted on the Pumiselect® rootstock.
3. The 'Early Redhaven' and 'Crestvahen' cultivars showed the greatest susceptibility to spring frost damage. The 'Suncrest' and 'Saturn' trees were the most resistant to bloom damage.
4. Satisfying levels of yielding after spring frost were received from the plots with sprinkling irrigation, as well as from the 'Early Redhaven' and 'Inka' trees, grafted on the Manchurian seedling and protected by fogging.

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Received: 15.02.2017
Accepted: 04.05.2017