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Effect of late spring frost event on nutrition aspects of a sour cherry orchard in East Hungary

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Summary: Similarly to 2007, 2011 was also critical year for fruit growers in Eastern-Hungary. Serious frost damage was observed at late blooming period (6 May (T=$^-$1.6°C)) in this region, which caused approximately 60-65% of fruit loss.

The aim of this study is to investigate the effects of a spring frost event on nutrient uptake and status of the trees of a sour cherry plantation at Újfehértó.

The symptoms of frost were observed visually. This visual observation was confirmed by SPAD readings. The frost affected the macro- and micronutrient contents of leaves.

It was found that the frost affected the nutrient uptake negatively, but the effect of it was not significantly sometimes. It can be stated that the nutrient demand of trees can be supplied only under even worse conditions.

Key words: *Prunus cerasus* L ., climatic anomalies, frost event, nutrient uptake, fruit quality

Introduction

Climatic anomalies are significant hazards to many horticultural and viticultural regions all over the word. As the VAHAVA report stated the average of global temperature is rising and that the distribution of precipitation in time and space is undergoing a dramatic change in Hungary as well. The frequency of frost events and their damage is continuously increasing.

Despite of this the Hungarian growers have a very little information about the effects of climatic change (*Nagyné* et al., 2010, 2011).

It is very hard task to estimate the fruit failure which follows from climatic extremes. But everybody agrees that the rate of it is growing continuously year by year. For example, in Hungary, in 2007 the estimated fruit failure caused 100 billion HUF (4 billion EURO) deficiencies for the fruit growing sector (*Soltész* et al., 2008). Effects of extreme climatic conditions (frost in May, drought in summer) pointed out that the fruit failure reached 100%. So, the frequency of unexpected climatic events and their growing rate are resulting more and more problems for fruit growers all over world. Nowadays, we have to live together with these problems and have to correct the tested fruit growing technologies to these events as influential factors.

Among climatic anomalies, the frost is a prevalent hazard that can be responsible for yield losses and serious damage to orchard trees. The resistance to frost damage may be associated with the nutritional status of plant (*Childers,* 1954; *Faust,* 1989; *Nagy* et al., 2010).

In temperate climates, damage on deciduous fruit trees occurs in buds, flowers and developing fruits after the completion of dormancy and these losses due to frost in the spring are usually greater than losses due to low winter temperatures (*Bramlage,* 1993; *Rodrigo,* 2000).

An understanding and ability to minimise the risk of fruit loss or damage is fundamental to managing a profitable enterprise. Damage not only puts at risk the current season's crop, but also because of the perennial nature of fruits and grapevines, can influence the productivity of fruits and vines for several seasons in the future.

Earlier, when developing a fruit orchard, three factors should be taken into consideration: "Location, *Location*, **Location**". Nowadays this approach is not enough to realize qualified fruit growing, because climatic anomalies occur there where their appearance were not characteristic earlier.

Change of climatic conditions cause new tasks for today's fruit growers and scientists as well. Urgent task of the near future is to correct and adjust the tested technologies of fruit growing according to these climatic events as modifier factors. It is especially true for nutritional aspects of fruit growing technology which respond sensitively for changing of environmental conditions.

The aim of this study is to explore the effects of a serious frost event at the beginning of May on nutrient uptake of trees and fruit quality in an Eastern Hungarian sour cherry plantation and find the adequate response for it.

Materials and methods

Similarly to 2007, 2011 was also critical year for fruit growers in Eastern-Hungary. Serious frost damage was observed at late blooming period (6 May (T=⁻1.6°C)) in this region, which caused approximately 60-65% of fruit loss.

At the Research Station of Újfehértó, a large part of tart cherry plantations was affected by frost damage. But around the central building frost event was not observed due to the "house effect" and the special microclimate followed from the micro-relief. This situation gave possibility to study the effect of frost on nutrient uptake and fruit quality.

Our investigation was started in early spring in 2011, in a tart cherry orchard (*Prunus cerasus* L .) of the Research Station of Újfehértó (GYKSZNK Kft.), Újfehértó, in Eastern Hungary. The orchard was located on sandy soil. It was established in the spring of 2000, at a spacing of 7.0 x 5.0 m.

For plant analysis the following tart cherry cultivars were selected: 'Kántorjánosi 3' and 'Újfehértó fürtös'. From these cultivars frost affected and not affected samples were also collected for plant analysis to study the effects of frost event on nutrient uptake of trees.

Healthy, fully developed leaves were collected from the mid-third portion of current season extension shoots. Leaf samples were collected 100 days after full bloom, from 50 uniform trees. Leaf samples were dried in a well-ventilated drying oven for 6 hrs at 70 °C and then the whole sampled material was finely grounded and homogenized. Nitrogen content of plant samples was determined from homogenized samples directly using the dry combustion method according to Nagy, (2000), using an Elementar Vario EL analyser (Elementar Analysensysteme GmbH, Hanau, Germany).

Leaf phosphorus was quantified by colorimetrically with phospomolybdovanadate method (reference), using a spectrophotometer (Metertech VIS SP-850 Plus; Metertech Inc., Taipei, Taiwan). The potassium content of leaves was quantified by flame atom emission spectrophotometry method using an Unicam SP90B Series 2 Atomic Absorption/Emission Spectrophotometer (PYE Unicam, England). Leaf Ca, Mg and microelements were measured by atomic absorption method (Varian AA 20 atomic absorption spectrophotometer, Mulgarve, Australia).

The mean of five readings from the portable chlorophyll meter (SPAD 502+, Minolta, Japan) was obtained for each leaf (20 developed leaves).

Results and discussion

Describe of frost event

At dawn of 6 May serious frost event was observed in a large part of fruit plantations of Research Station of Újfehértó. The minimum temperature (observed at 2 m) of air is decreased below -1.6 ºC *(Fig. 1)*. Due to the frost the higher parts of fruit growing area were suffered frost damage observed by visually *(Photo 1–4)*.

The registered degree of frost was approximately 65-65%. The visual symptoms of frost damage were observed up to 2 m from the surface. The main part of fruit set was dropped under 2 m of trees. Above this level the fruit sets were healthy, not injured or frozen.

Around the central building, frost event was not observed due to the "house effect" and the special microclimate followed from the micro-relief.

Samples from damaged and not damaged orchard part make possibility to compare these leaves and fruit samples to investigate the effects of frost.

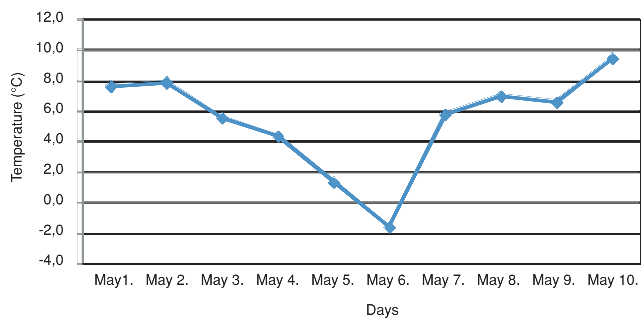

Figure 1. Minimum temperature degree at 2m (Újfehértó, V.1.2011. – V.10.2011.)

Table 1. Data of air temperature (V.1.2011. – V.10. 2011.)
Meteorological data of Research Station at Újfehértó

	Air temperature at 2 m, °C			Air temperature at 5 cm, °C
Date	minimum	mean	maximum	minimum
1 May	7.7	13.2	18.7	4.4
2 May	7.9	12.4	17.3	6.9
3 May	5.6	14.4	21.2	4.5
4 May	4.4	8.4	13.5	4.4
5 May	1.4	8.6	13.8	-1.1
6 May	-1.6	9.6	16.4	-3.3
7 May	5.8	9.4	13.9	5.4
8 May	7.0	11.2	16.3	5.3
9 May	6.6	15.3	21.4	5.7
10 May	9.5	18.6	25.3	6.2

Photo 1 and 2. Damaged cv. 'Kántorjánosi 3' (left) and damaged cv. 'Újfehértói fürtös' (right) (Újfehértó, June 2011.)

Air temperature data at the time of the frost event were presented in Table 1. From the data of Table 1 it was evident that at dawn of 6 May significantly and suddenly decreased the air temperature. The low humidity content of air (mean vapour content of air was 47%) and the low motion of air (1,94 m/s) strengthened the degree of frost.

Results of leaf analysis

In the course of our study the leaf samples of damaged trees were signed by D and the leaf samples of don't damaged trees were the control samples.

Results of leaf analysis are showed in Table 2–6.

Photo 3. Fruit sets of damaged cv.'Újfehértói fürtös' (May 2011.Újfehértó)

Photo 4. Fruit sets of not damaged cv.'Újfehértói fürtös' (May 2011. Újfehértó)

Results of Chlorophyll analysis

Table 2. Relative chlorophyll contents (SPAD) of investigated leaves

Cultivars	Relative chlorophyll content (SPAD)
Kántorjánosi control	50.9b
Kántorjánosi D	46.8a
Újfehértói fürtös control	52.5b
Újfehértói fürtös D	49.1a

In each column, means followed by the same letter are not significantly different (P<0.05).

From the data of *Table 2,* it was evident that the value of the relative chlorophyll content was depended on cultivar and the frost damage also. Frost injury decreased the relative chlorophyll content of leaves significantly. The leaves of healthy trees were seemed greener and healthier than the leaves of damaged trees at the field observations. This visual observation was confirmed by SPAD readings. Our results were explained by the negative effect of frost event on leaf chloroplastis.

Results of leaf macronutrients

Results of leaf macronutrients analysis were presented in *Table 3 and 4.*

Leaf N was low at 'Újfehértói fürtös' and optimal at 'Kántorjánosi 3'. It was found that leaf N was not affected by cultivars. Leaf N content was not affected by the frost significantly but its had a decreasing effect on leaf N.

Results pointed out that leaf P content was low. Leaf P was independent on cultivar and frost event. Leaf K was also low. Cultivars affected leaf K content but the frost did not cause significant effect on it.

Table 3 Effect of frost on leaf N, P and K content

Cultivars	N%	Nutrient Supply	P%	Nutrient Supply	K%	Nutrient Supply
Kántorjánosi control	2.24a	**S**	0.17a	**L**	1.12a	**L**
Kántorjánosi D	2.20a	**S**	0.16a	**L**	1.14a	**L**
Újfehértói fürtös control	2.17a	**L**	0.16a	**L**	0.94a	**L**
Újfehértói fürtös D	2.11a	**L**	0.14a	**L**	0.99a	**L**

Legend: L-low, S-sufficient
In each c Column, means followed by the same letter are not significantly different (P<0.05).
Nutrient contents were expressed in percentage of dry matter

Ca and Mg content of studied leaf samples were low. Adverse climatic condition slightly increased the Ca content in leaves but decreased leaf Mg. The effect of frost was not significant.

Table 4 Effect of frost on leaf Ca and Mg content

Cultivars	Ca%	Nutrient Supply	Mg%	Nutrient Supply
Kántorjánosi control	1.61a	**L**	0.57a	**L**
Kántorjánosi D	1.64a	**L**	0.54a	**L**
Újfehértói fürtös control	1.42a	**L**	0.55a	**L**
Újfehértói fürtös D	1.48a	**L**	0.54a	**L**

Legend: L-low, S-sufficient
In each clumn, means followed by the same letter are not significantly different (P<0.05).
Nutrient contents were expressed in percentage of dry matter

Results of leaf micronutrients

Results of leaf micronutrients analysis were presented in *Table 5 and 6.*

Table 5 Effect of frost on leaf Mn, Zn and Cu content

Cultivars	Mn mg/kg	Nutrient Supply	Zn mg/kg	Nutrient Supply	Cu mg/kg	Nutrient Supply
Kántorjánosi control	47.93a	**S**	15.92b	**L**	6.78a	**L**
Kántorjánosi D	4.55a	**S**	11.82a	**L**	6.14a	**L**
Újfehértói fürtös control	51.83a	**S**	12.73b	**L**	5.87a	**L**
Újfehértói fürtös D	52.37a	**S**	10.51a	**L**	6.38a	**L**

Legend: L-low, S-sufficient
In each column, means followed by the same letter are not significantly different (P<0.05).

It was found that the Mn content of all examined leaf samples was in the optimal nutrient supply category. These values were in the upper range of optimal zone. Leaf Mn was affected by cultivars but the frost event had no significant effect on it *(Table 5)*.

Leaf Zn content was low at all leaf samples. It may be explained by the soil pH, the clay content of soil and the low available Zn content of soil. Available soil Zn was decreased by the drought as well. Moreover, it was found that the frost event decreased the leaf Zn content also significantly.

From the data of Table 5 it was evident that the leaf Cu content was in the low nutrient supply category in all samples. In contrary to those obtained leaf Zn, leaf Cu was not affected by the frost significantly. It may be explained by the systematic foliar Cu treatment (plant protection treatments).

Leaf Fe and B contents were presented in *Table 6.*

Table 6 Effect of frost on leaf Fe and B content

Cultivars	Fe mg/kg	Nutrient Supply	B mg/kg	Nutrient Supply
Kántorjánosi control	88.82b	**L**	37.47b	**L**
Kántorjánosi D	78.08a	**L**	24.27a	**L**
Újfehértói fürtös control	84.32b	**L**	38.11b	**L**
Újfehértói fürtös D	65.74a	**L**	23.21ab	**L**

Legend: L-low, S-sufficient
In each clumn, means followed by the same letter are not significantly different (P<0.05).

It was found that the leaf Fe contents were in low nutrient supply category. It can be explained by the low Fe supply capacity of the soil. We found that the frost event significantly decreased the leaf Fe. This result is in harmony with the visual observations and the results of SPAD readings. We found that the damaged leaves are colourless, their colour is paler green than the healthy leaves.

Results of leaf analysis pointed out that the boron content of leaves was low in the control and the damaged samples as well. The low boron supplying can be explained by the low soil boron content and the unfavourable climatic conditions. Beside frost event, extremely drought period was observed between March and July.

Moreover, the frost event significantly decreased the leaf B content.

CONCLUSIONS

At the beginning of May strong frost event affected the plantations. The low humidity content of air and the low motion of air strengthened the degree of frost.

The symptoms of frost were observed visually. This visual observation was confirmed by SPAD readings. The frost affected the macro- and micronutrient contents of leaves.

Reviewing the effects and nutrient disorders caused by climatic anomalies, the following statements can be taken:

Nutrient demand of trees can be supplied only under even worse conditions.

The most effective weapon against damage of climatic anomalies is preventative action.

Proper choice of cultivars, species and cultivation should provide further possibilities to avoid and moderate the effects of climatic anomalies.

Fruit growing technologies especially nutrition should be corrected and adjusted to the climatic events as modifier factors.

Urgent task of the near future is to correct and adjust the tested technologies of fruit growing according to these climatic events as modifier factors.

Optimal nutrient supply of trees decreases the sensitivity for unexpected climatic events. To solve these problems supplementary, foliar fertilization is recommended, which adjusted to phonological phases of trees.

Acknowledgements

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