# RESEARCH ON THE ECO-PHYSIOLOGICAL EVOLUTION OF SOME SWEET CHERRY CULTIVARS UNDER THE INFLUENCE OF CLIMATE CHANGES

## CERCETĂRI PRIVIND EVOLUȚIA ECO-FIZIOLOGICĂ A UNOR SOIURI DE CIREȘ SUB INFLUENȚA SCHIMBĂRILOR CLIMATICE

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***Abstract.***
*Knowing the vegetation course of the sweet cherry cultivars is a major desideratum and a basic condition in the zoning of a fruit crop in order to capitalize on the biological production potential. The research of this study was carried out during the years 2022 and 2023 and aimed at the development of the phenological stages, the quantification of the sum of the temperature degrees and the total amount of precipitation, the stomatal conductance at the leaf level as well as the evaluation of the fruit quality and the productivity of three cultivars of sweet cherry trees ('Van', 'Andreiaș' and 'Margonia') from the Research Station for Fruit Growing Iași, located in the N -E area of Romania. The climatic conditions of the studied years (2022-2023) confirm the global context of climate change, the average annual temperature having values of 11.4°C, with a positive deviation of +1.7°C more than the multi-annual average (2000-2020) and total precipitation totaled 440 mm, with a deficit of -77.5 mm from the reference value, thus influencing the phenological patterns, physiological processes and productivity of the sweet cherry crop.*
**Key words:** stomatal conductance, phenophases, productivity, *Prunus avium* L., temperature

***Rezumat.***
*Cunoașterea parcursului de vegetație al soiurilor de cireș reprezintă un deziderat major și o condiție de bază în zonarea soiurilor în vederea valorificării potențialului biologic de producție. Cercetările din cadrul acestui studiu s-au desfășurat pe parcursul anilor 2022 și 2023 și au vizat desfășurarea stadiilor fenologice, cuantificarea sumei gradelor de temperatură și a cantității totale de precipitații, conductanța stomatală la nivel foliar precum și evaluarea calității fructelor și a productivității a trei soiuri de cireș ('Van', 'Andreiaș' și 'Margonia') din cadrul Stațiunii de Cercetare - Dezvoltare pentru Pomicultură din Iași. Condițiile climatice ale anilor studiați (2022-2023) confirmă contextul global al schimbărilor climatice, temperatura medie anuală având valori de 11,4 °*

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*C, cu o abatere pozitivă de +1,7 ° C mai mult decât media multianuală (2000-2020) iar precipitațiile totale au însumat 440 mm având un deficit de -77,5 mm față de media multianuală influențând astfel modelele fenologice, procesele fiziologice și productivitatea culturii de cireș.*

**Cuvinte cheie:** conductanță stomatală, fenofaze, productivitate, *Prunus avium* L., temperatură.

## INTRODUCTION

Physiological and biochemical agro-productive performance, growth and competitive capacity of fruit trees are increasingly affected by the effects of global climate changes, very different at the regional level, which mainly cause considerable changes in the water regime [Kreuzwieser and Gessler, 2010]. Sweet cherry (*Prunus avium* L.) has become one of the most valued and economically prolific fruit crops around the world which is mainly grown in areas with about 550 mm of annual precipitation but in the last decade, these areas have experienced a dramatic reduction in the water regime, which has led to some adaptation changes for sweet cherry trees.

In the current context of global warming, a better understanding of the limitations of sweet cherry's optimal climatic conditions is essential, especially when warmer and more variable winters occur and flowering occurs earlier [Vosnjak *et al*., 2021].

Tree phenological events fluctuate from year to year and are strongly influenced by variations in environmental factors, so long-term records of phenological data (sum of temperature degrees, winter cold accumulation) as well as their influence on physiological processes but also of fruit production and quality are valuable, because they can be used to estimate the influence of climatic variations on plant development and the calendar of vegetation cycles [Blanke and Kunz, 2009].

The aim of the present study was to evaluate the unfolding of the phenological stages, the quantification of the sum of the temperature degrees and the total amount of precipitation, the stomatal conductance at leaf level during the growing season as well as the fruit quality and the productivity of three varieties of cherry under the impact of the conditions climatic.

## MATERIAL AND METHOD

This study was conducted in the period 2022-2023 in the experimental field of Research Station for Fruit Growing (RSFG), located in North-Eastern Romania using as research material three cultivars of sweet cherry (‘Van’, ‘Andreiaș’ and ‘Margonia’) grafted on *Prunus mahaleb* L. seedlings as rootstock and planted at a distance of 5×4 m and training as open vase shape/ open center, without irrigation system.

The local weather conditions and other climatic features were obtained from the meteorological AgroExpert system, located in the experimental field. The average annual temperature of the studied years (2022 and 2023) was 11.3 °C, and the total precipitation was 430.3 mm with a deviation of 87.5 mm from the multiannual values.

In order to obtain results regarding the influence of climate change on sweet cherry genotypes, the observation and statistical processing of data were used as research methods.

Phenological observations followed the development of phenophases of growth and flowering by recording data according to milestones BBCH scale [Meier, 2001]: buds swelling (51 BBCH), bud burst (53 BBCH), full flowering (65 BBCH), fruit growth, 50% (75 BBCH) and fruit ripening (89 BBCH). The determining factor for phenology stages is the heat and the rainfall quantity, so that, for starting certain phenophases is necessary the cumulative sum of active temperatures (Σt°a), in the days when it is more than 5 °C [Wenden *et al.*, 2016].

$\Sigma t°a = \Sigma T\ atd - BL$, in which:

ΣT atd - sum of average temperature of days between two subsequent phenological stages;

BL - the biological limit of fruit tree species.

In order to estimate the transpiration process and the rate of gas exchange through the stomata of the leaves, measurements of the stomatal conductance were carried out with a portable foliar porometer (Model SC-1, Decagon Devices Inc., Pullman, WA) using the method described by Pietragalla and Pask [2012] of determining the flow of water vapor from the surface of the leaf in atmosphere in local conditions. Ten readings were taken for each replicate, on three phenological stages.

Fruit production and quality were assessed by weighing with a Radwag electronic scale (0.01g sensitivity) and measuring diameters with a digital caliper. Soluble dry solids (SDS) content was measured using a digital refractometer (Hanna Instruments HI96804) and expressed in °Brix. Measurements were taken in triplicate annually and analyzed using Duncan's multiple comparison test, with significant differences at $p < 0.05$. The Pearson correlation coefficient (r) was calculated to evaluate relationships between water regime parameters and fruit production and quality.

## RESULTS AND DISCUSSIONS

To assess the adaptability of sweet cherry cultivars in North-East Romania, key phenophases of vegetation and fruiting were recorded, along with temperature and precipitation data (Table 1). In 2023, vegetation began 16–21 days earlier than in 2022, increasing the risk of late frosts due to February temperature increases, known as winter "windows" [Wenden et al., 2016]. Flowering occurred in mid to late April, depending on the cultivar. The heat sum for fruit ripening ranged from 810.6°C (‘Van’, 2022) to 1628.8°C (‘Margonia’, 2023). Precipitation deficits during fruit growth negatively affected fruit quality and next year's productivity [Burzo et al., 1999].

*Table 1*

**The development of the main phenophases and required the sum of active temperatures (SAT) and total rainfall (RSFG Iași - Romania, 2022-2023)**

| Cultivar | Year | Phenological stage (data) | | | | | Σ t°a | Σ rainfall |
|---|---|---|---|---|---|---|---|---|
| | | 51 BBCH | 53 BBCH | 65 BBCH | 75 BBCH | 89 BBCH | (℃) | (mm) |
| Van | 2022 | 30.03 | 06.04 | 19.04 | 19.05 | 30.05 | **810.6** | **150.6** |
| | 2023 | 09.03 | 18.03 | 16.04 | 15.05 | 01.06 | **893.5** | **45.8** |
| Andreiaș | 2022 | 26.03 | 05.04 | 17.04 | 20.05 | 15.06 | **1271.6** | **227.0** |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **2023** | 11.03 | 23.03 | 18.04 | 18.05 | 20.06 | **1263.7** | **53.8** |
| **Margonia** | **2022** | 20.03 | 06.04 | 25.04 | 26.05 | 30.06 | **1557.4** | **248.0** |
| | **2023** | 07.03 | 20.03 | 22.04 | 28.05 | 26.06 | **1623.8** | **53.8** |

*BBCH-Phenological growth stages (Meier, 2001): 51 (buds swelling); 53 (bud burst); 65 (full flowering); 75 (fruit growth, 50%); 89 (fruit ripening).

Stomatal conductance measures gas exchange during transpiration and stomatal responses to environmental factors like soil water, light, humidity, temperature, and $CO_2$ concentration [Damour et al., 2010]. In 2022-2023, under North-East Romania's conditions, average stomatal conductance ranged from 7.78 m²s/mol at stage 65BBCH to 7.04 m²s/mol at stage 75BBCH, peaking at 10.40 m²s/mol at stage 89BBCH. Seasonal variations were influenced by leaf humidity, with minimum values during fruit growth (75BBCH). Statistically significant differences occurred between cultivars and monitoring years. Seasonal changes and stomatal responses to drought in sweet cherry are linked to fruit development and ripening [Yoon & Richter, 1990]. A fact also highlighted in this case, where all cultivars registered a visible increase in sap flow during the ripening period (89BBCH).

Also, a small decrease in stomatal conductance may reveal a protective mechanism against water and heat stress, allowing plant water conservation and improving plant water use efficiency.

*Table 2*

**Stomatal conductance at foliar level in the main phenological stages in the studied sweet cherry cultivars (RSFG Iasi, Romania 2022-2023)**

| Cultivar | Year | 65BBCH | 75BBCH | 89BBCH |
|---|---|---|---|---|
| | | (m²s/mol) | | |
| **Van** | **2022** | 8.65 [a] | 7.09 [ab] | 10.88 [bc] |
| | **2023** | 7.81 [ab] | 6.85 [ab] | 8.20 [d] |
| **Andreiaș** | **2022** | 8.35 [a] | 7.17 [ab] | 11.43 [b] |
| | **2023** | 7.28 [bc] | 6.60 [b] | 9.14 [d] |
| **Margonia** | **2022** | 7.88 [ab] | 7.67 [a] | 12.52 [a] |
| | **2023** | 6.70 [c] | 6.83 [b] | 10.25 [c] |
| **Average** | | **7.78** | **7.04** | **10.40** |
| **STDEV** | | **0.71** | **0.37** | **1.56** |
| **COVAR** | | **9.10** | **5.28** | **15.03** |
| **Min.** | | **6.70** | **6.60** | **8.20** |
| **Max** | | **8.65** | **7.67** | **12.52** |

*****-Different letters after the number correspond with statistically significant differences for *p* 5% - Duncan test, n=3.

**- BBCH-Phenological growth stages (Meier, 2001): 65 (full fowering); 75 (fruit growth); 89 (fruit ripening);

An analysis of the productivity of the trees, on average per tree (kg) was presented in Table 3. Thus, among the analyzed cultivars, the highest amount of fruits was recorded at 'Andreiaș' cultivar in the two years of the study, exceeding 30 kg /tree in the year 2023.

Drought conditions in the years of the study influenced the growth and productivity of the studied cultivars differently, in 2022, registering a lower productivity.

The weight and the dimensions of the fruits in diameter (width, thickness and length) are very important properties, being the parameters that give the commercial appearance. Sweet cherry cultivars with large fruits (both in size and weight) are increasingly valuable, but these parameters are strongly influenced by climatic conditions and the cropping system applied [Sirbu *et al*., 2018], and may vary from year to year even by 4 g [Hayaloglu and Demir, 2016].

The weight of the fruits of sweet cherry fruits during the studied period varied between 7.95 g ('Margonia', year 2022) and 10.52 g ('Andreiaș', year 2023). Soluble sugar content varied annually, on average over the course of the study, with average values between 18.5°Brix and 22.5°Brix. Depending on the cultivar, the SDS content of the fruit during maturity, according to numerous studies [Girard and Kopp, 1998; Guarino *et al*., 2010], can have minimum values of 13.2°Brix and can reach maximum values of 25.5°Brix.

*Table 3*

**Production and characteristic of the fruits in the studied sweet cherry cultivars (RSFG Iasi, Romania 2022-2023)**

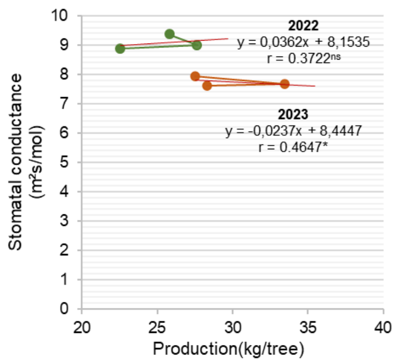
| Cultivar | Year | Production (kg/tree) | Weight (g) | Diameter (mm) | SDS (°Brix) |
|---|---|---|---|---|---|
| **Van** | **2022** | 22.53 $^{c}$ | 8.40 $^{b}$ | 18.62 $^{b}$ | 20.4 $^{b}$ |
| | **2023** | 28.30 $^{b}$ | 9.02 $^{b}$ | 19.58 $^{b}$ | 22.53 $^{a}$ |
| **Andreiaș** | **2022** | 27.67 $^{b}$ | 9.28 $^{b}$ | 22.63 $^{a}$ | 20.4 $^{b}$ |
| | **2023** | 33.43 $^{a}$ | 10.52 $^{a}$ | 22.57 $^{a}$ | 21.93 $^{a}$ |
| **Margonia** | **2022** | 25.83 $^{bc}$ | 7.95 $^{c}$ | 17.8 $^{c}$ | 18.5 $^{c}$ |
| | **2023** | 27.51 $^{b}$ | 8.64 $^{b}$ | 18.00 $^{bc}$ | 20.23 $^{b}$ |
| **Average** | | **27.55** | **8.97** | **19.87** | **20.67** |
| **STDEV** | | **3.56** | **0.89** | **2.21** | **1.42** |
| **COVAR** | | **12.92** | **9.94** | **11.10** | **6.88** |
| **Min.** | | **22.53** | **7.95** | **17.80** | **18.50** |
| **Max** | | **33.43** | **10.52** | **22.63** | **22.53** |

*****-Different letters after the number correspond with statistically significant differences for *p* 5% - Duncan test, n=3.

In order to determine the dependence relationship between the physiological indicator of stomatal conductance and the quantity and quality of the production of the three sweet cherry cultivars, the correlation coefficient (r) was calculated in the two years of the study, represented graphically.

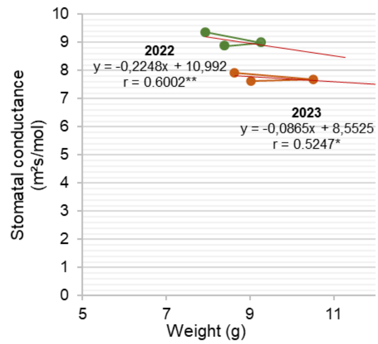
The obtained results highlight a correlation of stomatal conductance with fruit production per tree insignificant in the year 2022 and significant (r=0.4647) in the year 2023 (Figure 1.). In relation to the average fruit weight, a significant correlation coefficient (r= 0.4475) was obtained in 2023 and distinctly significant in 2022 (r= 0.6498) (Figure 2.), close values also found in the correlation with fruit diameter (Figure 3.).

A highly significant correlation was recorded between the stomatal conductance at leaf level and the content of soluble dry substances (Figure 4.), a coefficient r=0.9761 was obtained in 2022 and in 2023, r=0.9958. This type of correlation shows that if one variable increases in its values, the other variable decreases in its values by an exact linear rule [Ratner, 2009].



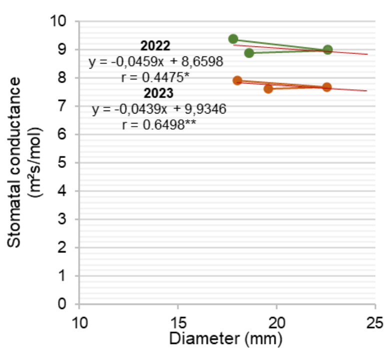

ns- insignificant correlation; *- significant correlation

**Fig. 1.** Correlation between leaf stomatal conductance and fruit production



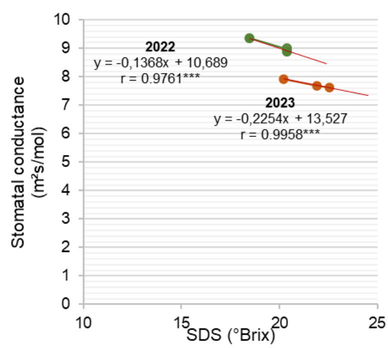

*- significant correlation; **-distinctly significant correlation

**Fig. 2.** Correlation between leaf stomatal conductance and fruit weight




*- significant correlation; **-distinctly significant correlation

**Fig. 3.** Correlation between leaf stomatal conductance and fruit diameter.




***-highly significant correlation

**Fig. 4.** Correlation between leaf stomatal conductance and fruit soluble dry substances

## CONCLUSIONS

The presented results confirm the fact that climatic factors influence the development of the sweet cherry in the development of the phenophases but also the characteristics of the fruits as well as the water regime at the leaf level.

Values of sweet cherry trees water status indicators fluctuate and increase depending on environmental conditions, tree architecture, soil and varietal variability.

The studied cultivars showed a good ecological adaptability to the conditions in N-E Romania and a significant correlation of the qualitative and quantitative parameters at leaf and fruit level.

Following the study of the dynamics of the water regime, general patterns of water exchange in cherry leaves were established in the climatic conditions of N-E Romania without an irrigation system. From a physiological point of view, the results show a high efficiency of leaf water use, especially at times and in environments with high evapotranspiration requirements.

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