RESULTS REGARDING THE ECOPHYSIOLOGICAL DEVELOPMENT OF SOME SWEET CHERRY CULTIVARS UNDER THE IMPACT OF CLIMATE CHANGE

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Abstract

The research of this study presents some aspects regarding the influence of ecologic conditions of agricultural year 2022 on the development and fruiting of three sweet cherry cultivars ('Van', 'Andreiaș' and 'Margonia') located at the Research Station for Fruit Growing Iasi (N-E of Romania). Phenological stages, fruit quality traits and the dynamic of pigment content of shoot leaves during growth and fructification processes were studied. Observations and determinations were performed in regards the unfolding of the phenophases: the active thermal balance (°C) and rainfall quantity (mm) on period between bud swelling (51 BBCH) to fruit ripening (89 BBCH), physical and chemical traits of the fruit (the equatorial diameter, the thickness, the length, weight and soluble dry solids SDS%) and the photosynthetic pigments content which was appeciated spectrophotometrically, by light absorption of the acetone pigment extract. All three cultivars presented productivity, fruit quality and a good adaptability to the pedoclimatic conditions in the area of Romania.

Key words: *Prunus avium* L., temperature, rainfall, phenology, pigment content

Sweet cherry (*Prunus avium* L.), an economically important and early flowering stone fruit from the temperate zone, is an important and valuable agricultural and timber crop throughout Europe (Centritto M. *et al*, 1999, Vosnjak M. *et al*, 2021). Offering the first fresh fruit of the year, with its earlier flowering, this species is more frequently exposed to temperature extremes where flowering and cherry fruit development is at risk (Wenden B., 2017).

In this sense, studies (Darbyshire *et al*, 2011; Luedeling *et al*, 2011) have shown that sweet cherry trees, a high-value crop, may be at risk in the future. Insufficient cold can result in poor bud development, sporadic and irregular bud swelling, prolonged flowering and fruit development, and uneven ripening (Allderman L.A. *et al*, 2011; Brunt C., 2012; Darbyshire R. *et al*, 2011; Kapp C.J., 2008; Kappel F. *et al*, 1997; Thomas D.S. *et al*, 2012).

In the context of global warming, a better understanding of the temperature-related limitations of sweet cherry is essential, especially in regions exposed to warmer and more variable winters, where flowering starts earlier (Vosnjak M. *et al*, 2021). Plant phenological events fluctuate from year to year and are strongly influenced by variations in environmental factors such as temperature. Long-term records of phenological data (sum of temperature degrees, chill accumulation during the winter) as well as their influence on physiological processes are valuable, because they can be used to estimate the influence of climatic variations on plant development and the calendar of life cycles (Blanke M.M, Kunz A., 2009).

The surrounding climatic environment together with the position in the tree or the phenophase it is in influences the variability of leaf photosynthesis (Flore J.A., Layne D.R., 1999). Photosynthetic pigments also play an important role in photosynthesis, light absorption and energy transfer. Low chlorophyll content it can reduce light collection affecting photosynthesis (Druta A., 2001).

The purpose of this scientific work is to analyze the development of the phenological stages, the physical characteristics of the fruits as well as the content of photosynthetic pigments in different stages of development in some sweet cherry cultivars under the impact of climatic conditions.

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MATERIAL AND METHOD

This study was carried out during 2022 using as biological material three cultivars of sweet cherry ('Van', 'Andreiaș' and 'Margonia') cultivated within Research Station for Fruit Growing (RSFG) Iași. Originating from Canada, 'Van' is an early and very productive variety with high ecological plasticity and and the ripening of the fruit is the second decade of June (Grădinariu G., 2002). The cultivars 'Andreiaș' and 'Margonia' are two new sweet cherry cultivars approved at the RSFG Iaşi.

The trees are found in experimental lots, grafted on mahaleb. The cherry tree is planted at a distance of 5 × 4 m with the crown guided as a free flattened palmette in the direction of the row of trees, without support or irrigation system. On the row of trees, the soil was prepared with the rotary tiller of the orchard, and between the rows the soil was weeded.

The phenological observations followed the development of the phenophases of the growth and fruit organs by recording the data according to the landmark stages using the BBCH scale. (Meier U. *et al*, 1994): bud swelling (51 BBCH), bud burst (53), beginning of flowering (61), end of flowering (69), fruit ripening (89). 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 (SAT), in the days when it is more than 5℃. (Wenden B. *et al*, 2016). The biometric measurements performed concerned the physical properties of the fruit (Radu *et al*, 1957): equatorial diameter of the fruit (mm), thickness (mm) and length (mm) using the Lumytools sliding tool. The fruit weight was measured using an analytical balance Radwag. The chemical analyzes consisted in determining the soluble dry solids (SDS%) using a Zeiss refractometer (Cociu V., Oprea,Ș., 1989).

The analysis of physiological parameters was performed at the physiology laboratory of Iasi University of Life Sciences.

The content of photosynthetic pigments in leaves was achieved by the spectrophotometric method described by Jităreanu C.D. *et al*, 2011. The method allows testing pigments with the UV/Vis spectrophotometer at the absorbtion 470, 647 and 663 nm. The content of different types of pigments was assessed based on the light absorption capacity of the acetonic extract (1%), analyzed by computer-aided spectrophotometer, based on Lichtenthaler`s equations (Lichtenthaler H.K., 1987; Welburn A.R., 1994):

$C_a=12.25\cdot A_{663}-2.79\cdot A_{647}$

$C_b=21.50\cdot A_{647}- 5.10\cdot A_{663}$

$C_{a+b}=7.15\cdot A_{663}- 18.71\cdot A_{647}$

$C_{x+c}=(1000\cdot A_{470}- 1.82\cdot C_a- 85.02\cdot C_b)/198$

Some of the obtained results were processed statistically. Differences between means were evaluated by using the Duncan's multiple range test at $P\leq 0.05$.

RESULTS AND DISCUSSIONS

In order to establish the adaptability of the studied cultivars to the ecological conditions in Iași-Romania, the main fructification phenophases were recorded. The amount of temperature required for fruit ripening as well as the amount of precipitation during this period was also calculated and presented in *table 1*. Thus, the earliest cultivar, in which bud swelling (51 BBCH) occurred on March 20 ('Margonia'), gathered a SAT of 1557. 4℃. With just 10 days later starting in vegetation (March 30), the 'Van' cultivar registered a temperature requirement of 810.6 ℃. Regarding the fruit ripening dates (89 BBCH), it varied from May 30 ('Van') to June 19 ('Andreiaș') and June 30 for the'Margonia' cultivar. The total amount of precipitation during the unfolding of the phenophases of the sweet cherry cultivars was 538 mm.

The phenological periods for the same cherry genotypes are variable and depending on the climatic conditions of each year (Darbyshire R. *et al*, 2012).

Table 1

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

Cultivar	51*	53*	61*	69*	89*	Σ T	Σ rainfall
	(data)	(data)	(data)	(data)	(data)	(℃)	(mm)
Van	30 III	6 IV	15 IV	26 IV	30 V	810.60	151.40
Andreiaș	26 III	5 IV	14 IV	21 IV	19 VI	1271.60	297.20
Margonia	20 III	7 IV	19 IV	3 V	30 VI	1557.40	538.00

*BBCH-Phenological growth stages (Meier *et al*, 1994): 51 (buds swelling); 53 (bud burst); 61 (beginning of flowering: about 10% of flowers open); 69 (end of flowering); 89 (fruit ripening).

Regarding the biometric measurements of the physical and chemical characteristics of the fruit, the centralized averages were statistically interpreted and presented in table 2. In the climatic

conditions of 2022, among the studied cultivars, the 'Andreiaș' cultivar stood out for its largest dimensions, with significant differences compared to the other analyzed cultivars. Although the 'Margonia' cultivar registered the smallest sizes, in terms of sugar content, it had the highest values, of 25.45%, with significant differences compared to the 'Van' (17.07%) and 'Andreiaș'(18.05%) cultivars.

Table 2

Physical and chemical characteristic of the fruit in the investigated sweet cherry cultivars (RSFG Iași - Romania, 2022, n=3)

Cultivar	Weight	Equatorial diameter	Thickness	Length	Chemical characteristics
	(g)	(mm)	(mm)	(mm)	SDS (%)
Van	7.40^{a}	24.46^{b}	20.67^{a}	20.69^{b}	17.07^{b}
Andreiaș	8.46^{a}	25.18^{a}	21.15^{a}	24.57^{a}	18.05^{b}
Margonia	5.36^{b}	24.69^{c}	18.31^{b}	20.26^{b}	25.45^{a}

*Different letters indicate the statistical difference in rows.

Photosynthetic pigments were represented by green or chlorophyll pigments (chlorophyll a and chlorophyll b) and yellow pigments or carotenoids (carotenes and xanthophylls) (Jităreanu C.D., 2007) and were extracted from sweet cherry leaves of annual branches in different phenological stages: flowering and fruit setting, fruit growth and fruit ripening and determined by the spectrophotometric method. The results obtained for the three cultivars studied were shown graphically in figure 1 ('Van'), *2* ('Andreiaș') and 3 ('Margonia').

In the 'Van' cultivar, it can be observed that the highest content in photosynthetic pigments was represented by chlorophyll pigments (C_a and C_b) and they are found in the greatest quantity in the fruit ripening phenophase. The content in yellow pigments has the lowest values in the phenophase of fruit growth but without major differences compared to ripening.

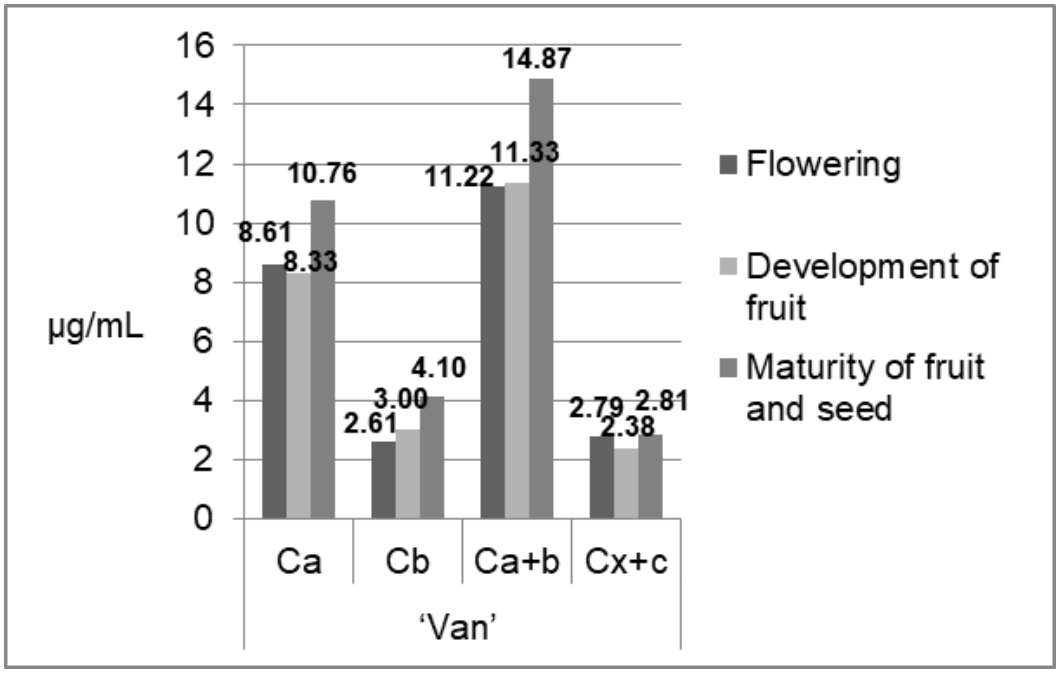

Figure 1 **The content of photosynthetic pigments (µg/mL) and their proportions in different phenological stages at 'Van' cultivar (RSFG Iași - Romania, 2022)**

At the 'Andreiaș' cultivar, the content of photosynthetic pigments was quantitatively lower compared to the 'Van', but also, in the largest quantities, it was found in the phenophase of fruit ripening. Chlorophyll a records the lowest values in the phenophase of fruit growth.

Regarding the content in carotenoid pigments, the highest values are found in the flowering and fruit setting phenophase.

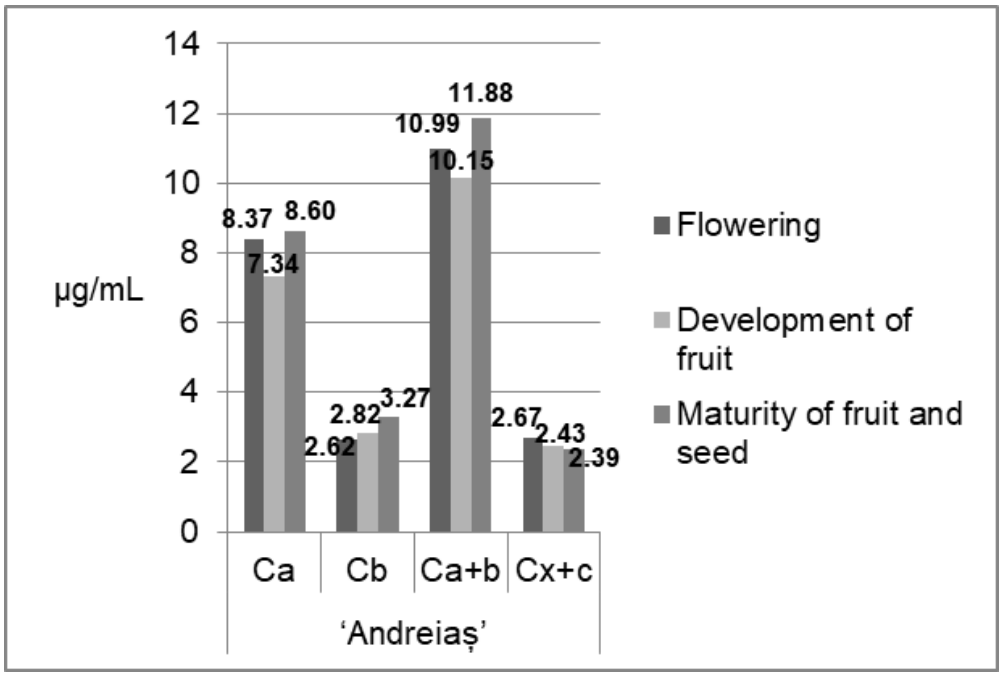

Figure 2 **The content of photosynthetic pigments (µg/mL) and their proportions in different phenological stages at 'Andreiaș' cultivar (RSFG Iași - Romania, 2022)**

The 'Margonia' cultivar was characterized by the highest content of photosynthetic pigments compared to the other two cultivars and was also found in the fruit ripening phenophase, with large differences in content compared to the previous phenophases. The content of carotenes and xanthophylls was also in higher quantities in the fruit ripening phenophase. All three sweet cherry cultivars evaluated in the study showed similar characters in terms of the content of photosynthetic pigments, having the highest content in the fruit ripening phenophase, when the biochemical and physiological processes are the most intense.

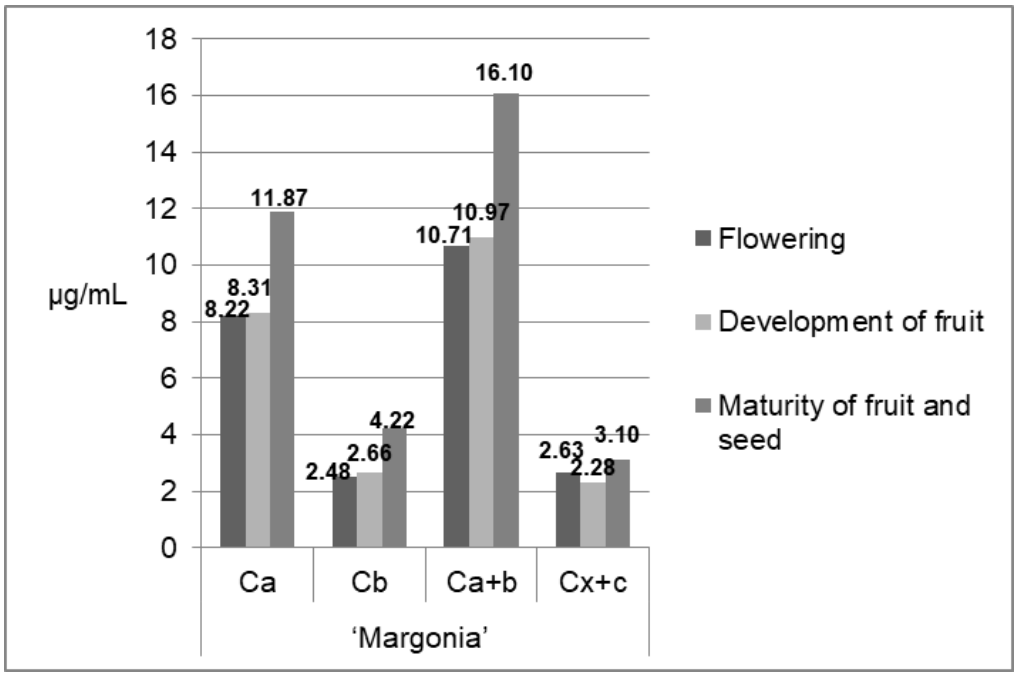

Figure 3 **The content of photosynthetic pigments (µg/mL) and their proportions in different phenological stages at 'Margonia' cultivar (RSFG Iași - Romania, 2022)**

The carotenoid pigments had minimum and maximum values in the 'Margonia' cultivar between 2.28 µg/mL during the fruit growth period and 3.1 µg/mL when the fruits ripened.

The content of chlorophyll pigments (Ca+b) varied quantitatively from a minimum of 10.15 µg/mL (at the 'Van' cultivar in the fruit growth phenophase) to a maximum of 16.10 µg/mL in the 'Margonia' cultivar in the fruit ripening phenophase.

The production was directly influenced by the intensity of photosynthesis, appreciated by the amount of photosynthetic pigments that has the ability to fix the light energy in the visible spectrum (Covașă M. *et al*, 2020).

CONCLUSION

The results presented showed that climatic factors has an influence on the development of the sweet cherry trees, influencing the unfolding of the phenophases, the size and the content in soluble dry substances of the fruits as well as the content of photosynthetic pigments in the leaves.

Observations made on the total content of chlorophyll pigments, showed that it increases in the phenophase of fruit ripening. The highest content of both chlorophyll and carotenoid pigments was recorded in the 'Margonia' cultivar.

The sweet cherry cultivars studied showed a good ecological adaptability to the conditions of NE Romania and a good correlation of the qualitative and quantitative parameters that were determined and analyzed of the fruits and leaves.

REFERENCES

Allderman L.A., Steyn W.J., Cook N.C., 2011 - *Growth regulator manipulation of apple buddormancy progressions under conditions ofinadequate winter chilling*. South African Journal of Plant and Soil 28:103–109. https://doi.org/10.1080/02571862.2011.10640020

Blanke M.M., Kunz A., 2009 - *Efects of climate change on pome fruit phenology at Klein-Altendorf*. Erwerbs-Obstbau 51:101–114 (special edition on climate change). DOI: 10.1007/s10341-009-0086-3.

Brunt C. 2012 - *Final report (CY11010) cherrycultivar selection: Chill hours and climatechange*. Horticulture Australia Ltd.

Centritto, M., Magnani F., Lee H.S.J., Jarvis P.G., 1999 - *Interactive effects of elevated [CO2] and drought on cherry (Prunus avium) seedlings II*. Photosynthetic capacity and water relations. New Phytol. 141:141–153. DOI: https://doi.org/10.1046/j.1469-8137.1999.00327.x

Cociu V., Oprea Ș., 1989 - *Metode de cercetare în ameliorarea plantelor pomicole*, Dacia, Cluj-Napoca.

Covașă M., Slabu C., Marta A.E., Jităreanu C.D., 2020 - *The action of growth regulators on the process of photosynthesis in sunflower*. Lucrări Ştiinţifice – vol. 63(1)/2020, seria Agronomie 51- 56.

Darbyshire R., Webb L., Goodwin I., and Barlow S., 2011 - *Winter chilling trends for deciduous fruittrees in Australia*. Agricultural and Forest Meteorology. 151:1074–1085. https://doi.org/10.1016/j.agrformet.2011.03.010.

Darbyshire R., Webb L., Goodwin I., Barlow E.W. R., 2012 - *Evaluation of recent trends in Australian pome fruit spring phenology*. International Journal of Biometeorology, 57 (3): 409-421. https://doi.org/10.1007/s00484-012-0567-1.

Druta A., 2001 - *Effect of long term exposure to high CO_2 concentrations on photosynthetic characteristics of Prunus avium L. plants*. Photosynthetica 39(2):289–297. https://doi.org/10.1023/A:1013757309826.

Flore J.A. and Layne D.R., 1999 - *Photoassimilate production and distribution in cherry*. HortScience 34:1015–1019.

Grădinariu G., 2002 - Pomicultură specială, Ion Ionescu de la Brad, Iași.

Jităreanu C.D., 2007 - *Fiziologia plantelor*. Ed. ''Ion Ionescu de la Brad", Iași.

Kapp C.J., 2008 - *Manipulation of the chillingrequirement of sweet cherry trees*. Master of Science in Agriculture, University of Stellenbosch.

Kappel F., Bouthillier M., Brownlee R., 1997 - *Summer pruning young 'Sweetheart' sweet cherrytrees affects yield and tree size*. HortScience36:1034–1036. https://doi.org/10.21273/HORTSCI.32.6.1034.

Lichtenthaler H.K., 1987 - *Clorophylls and carotenoids: Pigments of photosynthetic biomembranes*. Methods Wnzymol., 148, 350-382. https://doi.org/10.1016/0076-6879(87)48036-1.

Luedeling E., Girvetz E.H., Semenov M.A., Brown P.H., 2011 - *Climate Change Affects Winter Chill for Temperate Fruit and Nut Trees*. PLOS ONE 6(5): e20155. https://doi.org/10.1371/journal.pone.0020155.

Meier U., 1994 - *BBCH-Monograph. Growth stages of plants*. Federal Biological Research Centre for Agriculture and Forestry, Braunschweig.

Radu I.F., Pandele I., Enăchescu G., 1957 - *Proprietățile fizice, chimice și tehnologice ale fructelor principalelor specii pomicole cultivate în R.P.R*. București: Edit. Acad. R. P. Române, p. 256.

Thomas D.S., Hayman P., James P., 2012 - *Understanding and managing the risks andopportunities from climate change on Cherry production*. South Australian Re-search and Development Institute.

Vosnjak M., Sircelj H., Hudina M., and Usenik V., 2021 - *Response of chloroplast pigments, sugars and phenolics of sweet cherry leaves to chilling*. Scientifc Reports, 11, 7210, https://doi.org/10.1038/s41598-021-86732-y.

Welburn A.R., 1994 - *The Spectral Determination of Chloropylls a and b, as well as Total Carotenoids, Using Various Solvents with Spectrophotometers of Different Resolution*, J. Plant Physion. 144, 307-313. https://doi.org/10.1016/S0176-1617(11)81192-2.

Wenden B, Campoy J.A., Lecourt J., Ortega G.L., Blanke M., Radičević S., Schüller E., Spornberger A., Christen D., Magein H., Giovannini D., Campillo C., Malchev S., Peris

J.M., Meland M., Stehr J., Charlot G, García J.Q., 2016 - *A collection of European sweet cherry phenology data for assessing climate change*. Scientific Data, DOI: 10.1038/sdata.2016.108.

Wenden B., Campoy J.A., Jensen M. López-Ortega G., 2017 - *Climatic limiting factors: temperature. In Cherries: Botany, Production and Uses* (eds Quero-García, J. et al.) 166–188 (CABI Publishing).