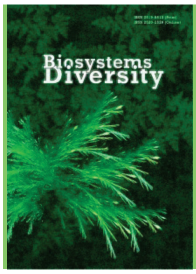

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Dependence of some physiological indicators of generative and vegetative organs of *Sambucus nigra* on habitat conditions

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We carried out studies on water deficiency of *Sambucus nigra* L. (black elderberry) plant leaves extract and fruit juice, relative turgidity, sucrose content in fruits, chlorophyll content in the leaves, as well as gas exchange rates in the leaves, in particular, the changes in the concentrations of oxygen released during photosynthesis by leaves and carbon dioxide released during leaf respiration depending on habitat conditions (altitude of the habitat, position of slopes, average annual precipitation). Taking into account the difference in climatic conditions and the generality of some indicators, Vanadzor (1326–1600 m above sea level) and Stepanavan (1400–1830 m above sea level) regions of Lori Province, "Dilijan" National Park, Lake Parz, and the forest areas adjacent to the city of Dilijan (1240–1612 m above sea level) in Tavush Province in Armenia were chosen as the research sites. The test samples were taken from eight different test sites in Lori and Tavush provinces. Tavush Province is more humid than Lori Province. The highest rate of water deficiency in the leaves of the studied plants was recorded in *S. nigra* f. *laciniata* (L.) Zabel., and the lowest in *S. nigra* in Vanadzor forest. It can be assumed that the index of water deficiency in the leaves may depend on the position of the slopes of the test sites and the value of the filtration coefficient of the soil types. On the north-facing slope at the height of 1341 m above sea level and on the south-facing slope at the height of 1830 m above sea level, the values of water deficiency of the leaves are almost the same. Such data allows us to assume that the degree of water deficiency in the leaves is also affected by the filtration coefficient of habitat soil types. In two points that have north-facing positions, the water deficiency of leaves at the height of 1341 m above sea level is 2.14 times more than at the height of 1328 m above sea level. At 1328 m above sea level the filtration coefficient is small and the plant absorbs a lot of water. Based on the data we received we obtained rankings of plants according to the different criteria of the experimental plants: water deficiency in leaves tissues, relative turgidity, the sum of chlorophylls in the leaves, the sucrose content in the fruits, percentage of oxygen released as a result of photosynthesis, percentage of carbon dioxide released as a result of respiration. We found a certain dependence between the indicators of the water regime and the height above sea level of the researched habitats. We also found out that the water regime is influenced by certain microclimatic conditions such as the position of the slopes, whether they are north or south facing, as well as the average annual precipitation. Knowing the physiological processes taking place in the vegetative and generative organs of the *S. nigra* plant is important from the point of view of evaluating the intensity of growth and development of the generative organs. We consider that the results of the study will be applicable in the process of plant selection based on the indicators of the physiological processes taking place in the plant organism.

Keywords: water deficiency; water regime; chlorophyll content; optical density; height above sea level; leaf; fruit; black elderberry.

Introduction

Sambucus nigra L. or black elderberry belongs to the Caprifoliaceae family. *Sambucus nigra* is widespread in the Caucasus, Western Europe, North Africa, Crimea. In the territory of the Republic of Armenia, it occurs in the northern regions and in the south in Zangezur, in forest zones, and especially in thickets (Manasyan et al., 2003). Armenian common names of the plant are Borkich, Tantrveni, Kttkeni, Shambuk, Porkich. It is a shade-loving and moisture-loving plant, a deciduous shrub or more rarely a small tree growing to 10 m (Atkinson & Atkinson, 2002). There is also a variety of *S. nigra* with dissected leaves (*S. nigra* f. *laciniata* (L.) Zabel or cut-leaved elder), which is widespread in Armenia, mainly in the lower and middle mountain zones. It is a garden plant and is grown as an ornamental shrub or small tree (Torosyan, 1983; Harutyunyan & Harutyunyan, 1986; Vardanyan, 2005). From the review of the available relevant literature, it can be seen that in some countries there is quite a lot of research aimed at studying the properties of the juice obtained especially from the generative organs of *S. nigra* (Cioch et al., 2017), as well as at studying the herbaceous life form species (*Sambucus ebulus* L.) of *S. nigra*, antioxidant, antibacterial activity of the plant (Rodino et al., 2015; Yahudin & Karomatov, 2016; Goud & Prasad, 2020). Similar studies are also found in Armenia (Vardanyan & Hovhannisyan, 2017). There are researches devoted to the study of water regime of plant organs, especially to the water needs of the plant during the first years of its growth (Rolbiecki et al., 2018), the content of chlorophyll in leaves, and the bioecological features of the plant (Vardanyan et al., 2022).

Research has been carried out on carbohydrates, organic acids, pigments of the anthocyanin group in the fruits of the black elderberry (Veberic et al., 2009). Some studies are also carried out on the general characteristics of genotypes of wild and cultivated *S. nigra* individuals (Horčinová Sedláčková et al., 2019). Besides, some authors in their studies paid attention to the relationship between altitude and metabolite biosynthesis. It is proved that altitude influences the biosynthesis of many secondary metabolites (Senica et al., 2016). In some countries, the cultivation of black elderberry is underway (Mratinić & Fotirić, 2007). We also carried out cultivation work. We moved several individuals of the *S. nigra* plant growing in the wild to a personal plot and performed physiological studies of the individuals growing in the home area. However, there are almost no research articles that study the dependence of the physiological processes of vegetative and generative organs of the plant on the height of the plant's habitat above sea level, on the position of the slope, and on the average annual precipitation. Therefore, we set a goal to study water deficiency in leaves and fruits, relative turgidity, sucrose content in fruits, changes in the concentration of oxygen released during photosynthesis by leaves and carbon dioxide released during leaf respiration and chlorophyll content in leaves depending on the elevation of the habitat of *S. nigra* plant growing in Lori and Tavush Provinces of the Republic of Armenia.

Material and methods

We carried out studies of water deficiency in plant leaves and fruits, relative turgidity, sucrose content in fruits, chlorophyll content in leaves, changes in the concentrations of oxygen released during photosynthesis by leaves and carbon dioxide released during leaf respiration depending on the habitat conditions (altitude above sea level, position of slopes, average annual precipitation). Taking into account the difference in climatic conditions and the generality of some indicators, Vanadzor (1326–1600 m above sea level) and Stepanavan (1400–1830 m above sea level) regions of Lori Province, "Dilijan" National Park, Lake Parz and the adjacent forest areas (1240–1612 m above sea level) of the city Dilijan in Tavush Province were chosen as research sites (Baghdasaryan et al., 1971; Manasyan et al., 2003).

We took into account the position of the slopes of the test sites, whether they are north-facing or south-facing. The test sites in Stepanavan are south-facing, in Vanadzor they are north-facing and in Dilijan they are both north-facing and south-facing. Average annual precipitation was also taken into account. According to the data in the relevant literature, the average annual precipitation in Vanadzor area is 586 mm, in Stepanavan it is 683, and in Dilijan it is 593 mm (Mkrtchyan & Hayrapetyan, 2008).

The plants of *S. nigra* found in the forest coexistence of Lori and Tavush Provinces were selected as objects of research. The test samples were taken from eight different test sites: from personal plots in Vanadzor and Stepanavan, from the adjacent forests of Vanadzor and Stepanavan, Lori Province, as well as from the territory of the "Dilijan" National Park. Samples of variety *S. nigra* f. *laciniata* (L.) Zabel found in the territory of "Armenia" recreation complex in Vanadzor were also taken.

We determined water deficiency, relative turgidity in the leaves and fruits, sucrose content in fresh fruits and the changes in the concentrations of oxygen released during photosynthesis and carbon dioxide released during respiration of the leaves of the researched plants. The experiments were carried out using the methods accepted in plant physiology. We determined water deficiency and relative turgidity of plant leaf tissues according to the method of water deficiency determination (Yedoyan & Vardanyan, 2006). For the experiments we used a thermostat Biobase (Biobase Constant Temperature Incubator (BJPX-HII, China, 2017). The experiments were set up in 7 replicates.

We determined water deficiency in the leaves by the following method. For this purpose, the sample of fresh leaves was saturated with water, for which it was immersed in a Petri dish filled with water for two hours. Then we dried the leaf sample with filter paper and weighed it, after which we immersed it again in a Petri dish filled with water for 30 minutes, took it out, dried it with a filter paper and weighed it. If the weight was constant, we were sure that the cells were completely saturated with water. The next step was to dry the leaf sample in a thermostat at 105 °C until constant weight was recorded.

We used the following formulae to determine water deficiency and relative turgidity (%):

$$\text{water deficiency} = \frac{(\text{weight of water saturating the tissue}) - (\text{initial weight of water})}{(\text{weight of water saturating the tissue})} \cdot 100,$$

$$\text{relative turgidity} = \frac{\text{tissue wet weight} - \text{tissue dry weight}}{\text{turgescent tissue weight} - \text{tissue dry weight}} \cdot 100.$$

We determined the sucrose content in the fruit juice extract using a refractometer Milwaukee MA871 (Digital Brix Refractometer Milwaukee MA871, Romania, 2015), having previously determined the cell juice density. We carried out the experiments using the refractometric method. Determination of the optical density of chlorophyll in the leaves of the plants of the studied habitats was carried out using an AE-30F digital photoelectric colorimeter at wavelengths of 530 and 660 nm (photoelectric colorimeter AE-30F, Erdma Inc., Japan, 2005). We previously prepared an alcoholic solution of chlorophyll from leaf tissues.

The value of the optical density was used to determine the content of chlorophylls *a* and *b*, the total amounts of chlorophylls *a+b* in the extract of the leaves of the test samples using the following formulae (Vorobyov et al., 2013):

$$\text{Chl } a = 12.7\, E_{660} - 2.69\, E_{530}$$

$$\text{Chl } b = 22.9\, E_{530} - 4.68\, E_{660}$$

We studied the changes in the concentrations of oxygen released during photosynthesis and carbon dioxide released during respiration of the leaves of *S. nigra* plant samples collected from different habitats. The studies were carried out using the LabQuest 2 device (LabQuest 2, Vernier LQ2-LE, China, 2015). The experiments were repeated seven times for each variant. The data in the tables are presented as x ± SD (mean value ± standard deviation). ANOVA were calculated with the Bonferroni correction. For comparison of characteristics on the eight test plots, we used the Tukey test. Differences were considered significant at $P < 0.05$.

Results

The highest rate of water deficiency in the leaves of the studied plants was 27.27 ± 0.23% and was recorded in variety *S. nigra* f. *laciniata* (sample plot 2), and the lowest rate was 12.76 ± 0.01% in *S. nigra* from sample plot 8 (Table 1).

Table 1
Comparison of water deficiency and relative turgidity of *S. nigra* plant samples depending on habitat (x ± SD, n = 7)

Test site	Height ASL, m	Slope position	Water deficiency, %	Relative turgidity, %
1. *S. nigra* (sample plot 1)	1326	north	16.61 ± 0.43^{c}	83.39 ± 0.43^{e}
2. *S. nigra* f. *laciniata* (sample plot 2)	1341	north	27.26 ± 0.23^{g}	72.74 ± 0.23^{a}
3. *S. nigra* (sample plot 3)	1425	north	13.79 ± 0.05^{b}	86.21 ± 0.05^{f}
4. *S. nigra* (sample plot 4)	1830	south	26.47 ± 0.31^{f}	73.46 ± 0.31^{b}
5. *S. nigra* (sample plot 5)	1357	south	17.69 ± 0.13^{d}	82.31 ± 0.13^{d}
6. *S. nigra* (sample plot 6)	1612	south	20.84 ± 0.03^{e}	79.16 ± 0.03^{c}
7. *S. nigra* (sample plot 7)	1240	north	17.68 ± 0.02^{d}	82.32 ± 0.02^{d}
8. *S. nigra* (sample plot 8)	1328	north	12.76 ± 0.01^{a}	87.24 ± 0.01^{g}

Note: different letters near the figures for the characteristics (within one column) indicate that there is a significant difference at $P < 0.05$ according to the Tukey test.

The reason for the almost identical results of the samples on the slopes of different positions is probably the difference in the average amount of annual precipitation, as the rate of water evaporation from the south-facing soil surface is higher than from the north-facing soil surface. Therefore, it can be assumed that the amount of water deficiency in the leaves is also affected by the average amount of annual precipitation of the habitat. Water deficiency in the leaves of plants growing on one of the test sites at the height of 1341 m above sea level is 2.14 times higher than water deficiency in the leaves of plants growing on another test site at the same height. Water deficiency of the plants on the south-facing slopes in Dilijan exceeds water deficiency of the plants on the north-facing slopes. This circumstance can also be explained by the fact that water evaporation from the soil surface is more intensive on the south-facing slopes. The arithmetic mean index of water deficiency in the leaf tissues of the studied plants was 19.14 ± 5.08%, and the index for relative turgidity was 80.85 ± 5.09%.

With the increase in altitude of the experimental sites above sea level, the total amount of chlorophylls Chl *a* + Chl *b* decreases at the height from 1240 to 1425 m, and then rises sharply at the height of 1612 m above sea level. The increase in the total amount of chlorophylls may be due to the south-facing position of the experimental site and the high amount of precipitation. It is interesting that in the leaves of the plants growing on the south-facing test site at the height of 1830 m above sea level the total amount of chlorophylls Chl *a* + Chl *b* decreases. In this case, it can be assumed that the reason is that the test site is part of the sub-forest (Table 2). The arithmetic mean index of chlorophyll a in the leaf tissues of the tested plants was 7.731 ± 0.602 mg/g. The mean index of chlorophyll b was 9.696 ± 2.131 mg/g and the mean index of chlorophyll *a* + *b* was 17.426 ± 2.329 mg/g.

It can be seen that water deficiency in the fruits of the plants taken from the Vanadzor forest area is the highest, and in the test samples growing in Dilijan it is the lowest. The reason for this may be that the average amount of annual precipitation in Dilijan exceeds the average amount of annual precipitation in Vanadzor. Water deficiency of the fruits in the test samples of *S. nigra* taken from sample plot 3 exceeds water deficiency of the fruits of *S. nigra* plants taken from sample plot 1 by 1.46 times. It exceeds water deficiency of the fruits of *S. nigra* f. *laciniata* samples (sample plot 2) by 1.11 times. Water deficiency of the fruits in the test samples taken from sample plot 3 is 2.35, 4.31, 6.25, 5.25 and 5.06 times higher than in the test samples taken from sample plots 4, 5, 6, 7, and 8 respectively (Table 3). The arithmetic mean value of fruit water deficiency of the tested plants was 19.56 ± 15.81%, and the arithmetic mean value of relative turgidity was 80.43 ± 12.82%.

Table 2
The optical density of chlorophyll *a* and *b* (mg/g) content in the leaves of *S. nigra* under different habitat conditions (x ± SD, n = 7)

Test site	Chlorophyll *a*	Chlorophyll *b*	Chlorophylls *a* + *b*
1	8.030 ± 0.004^{e}	9.309 ± 0.004^{d}	17.339 ± 0.007^{d}
2	8.485 ± 0.068^{f}	8.418 ± 0.001^{c}	16.903 ± 0.067^{c}
3	8.544 ± 0.017^{f}	11.012 ± 0.015^{f}	19.556 ± 0.016^{g}
4	7.538 ± 0.057^{c}	6.271 ± 0.001^{a}	13.808 ± 0.057^{a}
5	6.586 ± 0.064^{a}	7.807 ± 0.003^{b}	14.393 ± 0.063^{b}
6	7.710 ± 0.003^{d}	13.416 ± 0.004^{h}	21.125 ± 0.005^{h}
7	7.344 ± 0.004^{b}	11.424 ± 0.005^{g}	18.768 ± 0.006^{f}
8	7.609 ± 0.005^{c}	9.903 ± 0.002^{e}	17.512 ± 0.005^{e}

Note: see Table 1.

Table 3
Comparison of water deficiency (%) and relative turgidity (%) of fruit samples of *S. nigra* depending on habitats of test samples (x ± SD, n = 7)

Test site	Water deficiency	Relative turgidity
1	30.57 ± 0.51^{g}	69.43 ± 0.51^{b}
2	27.53 ± 0.30^{f}	72.47 ± 0.30^{c}
3	44.63 ± 0.13^{h}	55.37 ± 0.13^{a}
4	18.99 ± 0.24^{e}	81.01 ± 0.24^{d}
5	10.35 ± 0.01^{d}	89.65 ± 0.01^{e}
6	7.14 ± 0.02^{a}	92.86 ± 0.02^{h}
7	8.52 ± 0.08^{b}	91.50 ± 0.08^{g}
8	8.81 ± 0.02^{c}	91.19 ± 0.02^{f}

Note: see Table 1.

The amount of sucrose in the fruits of plants growing on the test sites of the north-facing slopes increases on average by 1.15 times along with the increase in height of the test sites above sea level (Table 4). In the fruits of plants growing on the test sites of the south-facing slopes the amount of sucrose decreases by 1.87 times along with the decrease in height of the test sites above sea level. However, some deviations are observed. For example, along with the increase in height of the north-facing slopes from 1328 to 1341 m above sea level the amount of sucrose in the fruits of the plants decreases 1.20 times, while at a height from 1341 to 1425 m above sea level this index increases. The amount of sucrose in the fruits of the plants on the south-facing slopes decreases along with the increase in height above sea level. The arithmetic mean value of sucrose content in the pulp of the fruits of the studied plants is 6.289 ± 1.306%.

Table 4
Refractive index and sucrose content in fresh fruits of *S. nigra* taken from different habitats

Test site	Refractive index	Sucrose content, %
1	1.445 ± 0.005^{e}	6.400 ± 0.141^{d}
2	1.391 ± 0.001^{c}	5.197 ± 0.146^{b}
3	1.443 ± 0.002^{de}	6.786 ± 0.204^{e}
4	1.475 ± 0.002^{f}	7.514 ± 0.157^{f}
5	1.347 ± 0.004^{b}	5.814 ± 0.168^{c}
6	1.338 ± 0.002^{a}	4.039 ± 0.058^{a}
7	1.438 ± 0.002^{d}	6.051 ± 0.084^{c}
8	1.555 ± 0.002^{g}	8.514 ± 0.135^{g}

Note: see Table 1.

We studied the changes in concentrations of oxygen released during photosynthesis and carbon dioxide released during respiration of the leaves of *S. nigra* plant samples collected from different habitats using the LabQuest 2 device (Table 5). At the 200th s of the experiment, the amount of oxygen released by the plants of sample plot 5 was the highest, and the amount released by the leaves of plants of sample plot 6 was the lowest. The amount of carbon dioxide released by the plants of sample plot 5 was again the highest and the amount released by the leaves of plants of sample plot 7 was the lowest.

Table 5
Amount (%) of oxygen and carbon dioxide released by leaves of test samples taken from different habitats

Test site	200th s		400th s		600th s	
	O_2	CO_2	O_2	CO_2	O_2	CO_2
1	13.72 ± 0.04^{d}	39.82 ± 0.25^{e}	13.88 ± 0.07^{bc}	48.15 ± 0.21^{d}	13.92 ± 0.11^{b}	57.37 ± 0.62^{f}
2	13.49 ± 0.06^{b}	53.38 ± 0.57^{f}	13.62 ± 0.04^{a}	54.71 ± 0.39^{e}	13.70 ± 0.09^{a}	55.21 ± 0.58^{e}
3	14.07 ± 0.07^{g}	37.92 ± 0.33^{d}	14.12 ± 0.12^{d}	43.12 ± 0.31^{c}	14.13 ± 0.18^{b}	49.01 ± 0.61^{d}
4	13.81 ± 0.04^{e}	32.40 ± 0.29^{c}	13.81 ± 0.09^{b}	36.73 ± 0.22^{b}	13.81 ± 0.12^{ab}	39.88 ± 0.43^{b}
5	14.10 ± 0.11^{g}	56.20 ± 0.67^{g}	14.09 ± 0.08^{d}	65.26 ± 0.41^{f}	14.08 ± 0.22^{b}	74.84 ± 0.59^{g}
6	13.21 ± 0.05^{a}	27.35 ± 0.21^{b}	13.71 ± 0.06^{ab}	36.69 ± 0.38^{b}	13.86 ± 0.09^{ab}	44.67 ± 0.41^{c}
7	13.75 ± 0.07^{de}	18.59 ± 0.19^{a}	14.03 ± 0.09^{cd}	25.74 ± 0.19^{a}	14.12 ± 0.13^{b}	33.14 ± 0.38^{a}
8	13.61 ± 0.05^{c}	40.03 ± 0.36^{e}	13.93 ± 0.06^{c}	72.80 ± 0.52^{g}	14.04 ± 0.12^{b}	104.02 ± 0.58^{h}

Note: see Table 1.

At the 400th s, the amount of oxygen was the highest in the plants of sample plot 3 and in the leaves of plants of sample plot 2 it was the lowest. The amount of carbon dioxide released was the highest in the plants of sample plot 8 and in the plants of sample plot 7 it was the lowest.

At the 600th s, the oxygen content was the highest in the plants from sample plot 3 and it was the lowest in plants from sample plot 2. The amount of carbon dioxide was higher than normal in the plants of sample plot 8, and it was lower than normal in the plants of sample plot 7. At the 600th s, the amount of carbon dioxide released during respiration in the plants of sample plot 8 exceeded the amount obtained in the plants of sample plot 7 by 3.14 times.

The arithmetic mean value of the oxygen content released by the leaves of the tested plant samples at the 200th s of the experiment was 13.72 ± 0.28%, at the 400th s it was 13.90 ± 0.17%, at the 600th s it was 13.96 ± 0.15%. The mean value of carbon dioxide was 38.21 ± 11.81%, 47.90 ± 14.85% and 57.27 ± 21.44% at the 200th, 400th and 600th s, respectively.

Discussion

In this work we studied several physiological parameters of leaves and fruits of the plant *S. nigra*. The plants were selected from eight different test sites, which differed from each other in habitat conditions. We examined water deficit and relative turgidity of leaves and fruits, and these parameters varied with altitude. Other researchers are also engaged in the study of water regime of the plants (Gritsan et al., 2019; Jagosz et al., 2019) and influence of water deficiency or pests (Holoborodko et al., 2021, 2022a, 2022b; Shupranova et al., 2021) on the physiological condition of the plants. The water circulation of elderberry plants principally depends on the conditions of the atmosphere (Tőkei et al., 2005). *Sambucus nigra* is not a drought-tolerant species (Byers, 2005; Byers et al., 2012). Elderberry is barely sensitive to the water content in the soil (Tőkei et al., 2005).

Our study of the content of sucrose in the fruits showed that with increase in altitude above sea level, the amount of sucrose increases in the plants growing on the north-facing slopes, and decreases in the plants growing on the south-facing slopes. A comparison of the amount of sucrose was made in the fruits of plants collected from eight different experimental sites. The lowest amount of sucrose in the fruits of the experimental sites studied by us was found in the fruits of the plants of sample plot 6, and the highest in sample plot 8, which mainly depends on the ecological conditions of the habitat. In the conducted studies, the amount of sucrose in the fruits changed depending on the habitat conditions, in which the annual rainfall is of great importance, which was also confirmed in the works of other authors (Mikulic-Petkovsek et al., 2016). According to various studies, among carbohydrates the amount of glucose and fructose in the fruits of *S. nigra* is higher (Gentscheva et al., 2022), and the amount of sucrose is less. Some researchers found that the amount of carbohydrates in leaves and petals decreases in the following sequence: glucose > fructose > sucrose. A similar picture is observed in fruits (Ferreira et al., 2020). Sucrose content in fruits is quite low in all varieties of *S. nigra* (Młynarczyk et al., 2018; Kan, 2019).

The study of the amount of chlorophyll in the populations of the black elderberry plant showed that the amount of chlorophyll *a* in four sample plots was almost equal in each. The lowest value was obtained for plants growing in sample plot 3. This is because these plants grow in the subforest in a shady area. That is why the amount of chlorophyll *b* is higher in these samples and it exceeds the amount of chlorophyll *a* (Vardanyan et al., 2016). The concentration of carbon dioxide in the leaves and fruits of the black elderberry plant was studied, paying attention to its effect on the intensity of photosynthesis and the content of chlorophyll (Creydt et al., 2019). We studied the changes in the concentrations of oxygen and carbon dioxide released in the leaves depending on the habitat conditions.

In general, the leaves of the black elderberry plant in the freshly cut state continue to carry out photosynthesis, albeit at a lower intensity. The concentration of carbon dioxide increased from the 200th s to the 600th s in all investigated populations, on average 1.88 times, that is, the intensity of respiration increased, and the concentration of carbon dioxide released in the leaves of plants of the populations of sample plot 8 at the 600th s increased 2.59 times. Of the two processes of gas exchange in the leaves, respiration was more intense. This is natural as gas exchange processes in the leaves become difficult. The amount of oxygen released increased because a small fraction of the released carbon dioxide was immediately used during photosynthesis. From the results of our studies, we found out that variations in the amounts of oxygen and carbon dioxide released depend very little on habitat conditions. Thus, the concentration of carbon dioxide gas at 1830 m above sea level increased 1.23 times at the 600th s compared to the index at the 200th s. At 1240 m above sea level, which is the lowest point, the value changed 1.72 times. That is, if the height above sea level is low, the rate of increase in breathing intensity is higher. This can be due to the abundance of moisture, since the oversaturation of moisture increases the intensity of respiration.

Conclusion

The index of water deficiency in the leaves may depend on the altitude and the average amount of annual precipitation. As a result, on the north-facing slope at the height of 1341 m above sea level and on the south-facing slope at the height of 1830 m above sea level, the values of water deficiency in the leaves are almost the same. The reason is the difference in the annual average amount of precipitation because the rate of water evaporation from the soil surface on the south-facing slope is higher than on the north-facing slope. Therefore, it can be assumed that the amount of water deficiency in the leaves is also affected by the average amount of annual precipitation of the habitat.

Along with the increase of altitude of the experimental sites above sea level, the total amount of chlorophylls Chl *a* + Chl *b* decreases at the height from 1240 to 1425 m and then rises sharply at the height of 1612 m above sea level reaching up to 21.124. The increase in the total amount of chlorophylls may be due to the south-facing position of the experimental site and the high amount of precipitation.

It is interesting that in the leaves of the plants growing on the south-facing test site at the height of 1830 m above sea level the total amount of chlorophylls Chl *a* + Chl *b* decreases. In this case, it can be assumed that the reason is that the test site is part of the sub-forest.

Water deficiency in the fruits of the plant taken from the Vanadzor forest area is the highest, and in the test samples growing in Dilijan it is the lowest. The reason for this may be that the average amount of annual precipitation in Dilijan exceeds the average amount of annual precipitation in Vanadzor.

The amount of sucrose in the fruits of plants growing on the test sites of the north-facing slopes increases on average 1.15 times along with the increase in height of the test sites above sea level. In the fruits of plants growing on the test sites of the south-facing slopes the amount of sucrose decreases 1.87 times along with the decrease in height of the test sites above sea level. However, some deviations are observed, which are due to the amount of precipitation in different habitats.

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The authors declare that there is no competing interest.

References

Atkinson, M. D., & Atkinson, E. (2002). *Sambucus nigra* L. Journal of Ecology, 90(5), 895–923.

Baghdasaryan, A. B. (1971). Haykakan SSH fizikakan ashkharhagrutyun [Physical geography of the Armenian SSR]. Akademija Nauk Armianskoy SSR, Yerevan (in Armenian).

Byers, P. (2005). Elderberry research and production in Missouri. New York Berry News, 4(11), 1–4.

Byers, P., Thomas, A., & Gold, M. (2012). Growing and marketing elderberries in Missouri. In: Agroforestry in Action. University of Missouri Center for Agroforestry, Missouri. Pp. 1–12.

Cioch, M., Satora, P., Skotniczny, M., Semik-Szczurak, D., & Tarko, T. (2017). Characterisation of antimicrobial properties of extracts of selected medicinal plants. Polish Journal of Microbiology, 66(4), 463–472.

Creydt, M., Vuralhan-Eckert, J., Fromm, J., & Fischer, M. (2019). Effects of elevated CO_2 concentration on leaves and berries of black elder (*Sambucus nigra*) using UHPLC-ESI-QTOF-MS/MS and gas exchange measurements. Journal of Plant Physiology, 234–235, 71–79.

Ferreira, S. S., Silva, A. M., & Nunes, F. M. (2020). *Sambucus nigra* L. fruits and flowers: Chemical composition and related bioactivities. Food Reviews International, 38, 1237–1265.

Gentscheva, G., Milkova-Tomova, I., Nikolova, K., Buhalova, D., Andonova, V., Gugleva, V., Petkova, N., Yotkovska, I., & Ivanova, N. (2022). Antioxidant activity and chemical characteristics of *Sambucus nigra* L. blossom from different regions in Bulgaria. Horticulturae, 8(4), 309.

Goud, S. N., & Prasad, G. (2020). Antioxidant, antimicrobial activity and total phenol and flavonoids analysis of *Sambucus nigra* (elderberry). International Journal of Current Pharmaceutical Research, 12(1), 35–37.

Gritsan, Y. I., Kunakh, O. M., Dubinina, J. J., Kotsun, V. I., & Tkalich, Y. I. (2019). The catena aspect of the landscape diversity of the "Dnipro-Orilsky" Natural Reserve. Journal of Geology Geography and Geoecology, 28(3), 417–431.

Harutyunyan, L. V., & Harutyunyan, A. L. (1986). Hayastani dendrofloran [Dendroflora of Armenia]. Luys, Yerevan. Vol. 2. Pp. 267–269 (in Armenian).

Holoborodko, K. K., Seliutina, O. V., Ivanko, I. A., Alexeyeva, A. A., Shulman, M. V., & Pakhomov, O. Y. (2021). Effect of *Cameraria ohridella* feeding on *Aesculus hippocastanum* photosynthesis. Regulatory Mechanisms in Biosystems, 12(2), 346–352.

Holoborodko, K. K., Sytnyk, S. A., Lovynska, V. M., Ivanko, I. A., Loza, I. M., & Brygadyrenko, V. V. (2022a). Impact of invasive species *Parectopa robiniella* (Gracillariidae) on fluorescence parameters of *Robinia pseudoacacia* in the conditions of the steppe zone of Ukraine. Regulatory Mechanisms in Biosystems, 13(3), 324–330.

Holoborodko, K., Seliutina, O., Alexeyeva, A., Brygadyrenko, V., Ivanko, I., Shulman, M., Pakhomov, O., Loza, I., Sytnyk, S., Lovynska, V., Grytsan, Y., & Bandura, L. (2022b). The impact of *Cameraria ohridella* (Lepidoptera, Gracillariidae) on the state of *Aesculus hippocastanum* photosynthetic apparatus in the urban environment. International Journal of Plant Biogy, 13, 223–234.

Horčinová Sedláčková, V., Grygorieva, O., Vergun, O., Vinogradova, Y., & Brindza, J., (2019). Comparison of selected characteristics of cultivars and wild-growing genotypes of *Sambucus nigra* in Slovakia. Biosystems Diversity, 27(1), 56–61.

Jagosz, L. B., Rolbiecki, S., Figas, A., Ptach, W., Rolbiecki, R., Stachowski, P., Kasperska-Wołowicz, W., Grybauskiene, V., Klimek, A., & Dobosz, K. (2019). Water needs of *Sambucus nigra* L. grown in the reclaimed areas in Poland. Folia Horticulturae, 31(2), 269–276.

Kan, T., (2019). Some biochemical characteristics of fruit samples of *Sambucus nigra* genotypes from Northeastern Turkey. Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 47(3), 553–557.

Manasyan, M. G., Grigoryan, A. T., & Yeghyan, G. B. (2003). Loru marz, bnutyun, bnakchutyun, tntesutyun [Lori Province, nature, population, economy]. Yerevan State University Publishing House, Yerevan (in Armenian).

Mikulic-Petkovsek, M., Ivancic, A., Schmitzer, V., Veberic, R., & Stampar, F. (2016). Comparison of major taste compounds and antioxidative properties of fruits and flowers of different *Sambucus* species and interspecific hybrids. Food Chemistry, 200, 134–140.

Mkrtchyan, R. S., & Hayrapetyan, F. P. (2008). Hayastani bnutyan oratsuyts [Nature calendar of Armenia]. Yerevan State University Publishing House, Yerevan (in Armenian).

Młynarczyk, K., Walkowiak-Tomczak, D., & Łysiak, P. G. (2018). Bioactive properties of *Sambucus nigra* L. as a functional ingredient for food and pharmaceutical industry. Journal of Functional Foods, 40, 377–390.

Mratinić, E., & Fotirić, M. (2007). Selection of black elderberry (*Sambucus nigra* L.) and evaluation of its fruits usability as biologically valuable food. Genetika, 39(3), 305–314.

Rodino, S., Butu, A., Butu, M., & Cornea, P. C. (2015). Comparative studies on antibacterial activity of licorice, elderberry and dandelion. Digest Journal of Nanomaterials and Biostructures, 10(3), 947–955.

Rolbiecki, S., Rolbiecki, R., Jagosz, B., Ptach, W., & Figas, A. (2018). Water needs of elderberry (*Sambucus nigra* L.) in first three years of growing in different regions of Poland. In: 17th International Scientific Conference "Engineering for Rural Development". Latvia. Pp. 733–737.

Senica, M., Stampar, F., Veberic, R., & Mikulic-Petkovsek, M. (2016). The higher the better? Differences in phenolics and cyanogenic glycosides in *Sambucus nigra* leaves, flowers and berries from different altitudes. Journal of the Science of Food and Agriculture, 97(8), 2623–2632.

Shupranova, L. V., Holoborodko, K. K., Guslistiy, A. O., Shulman, M. V., & Pakhomov, O. E. (2021). Peroxidase activity and isoenzyme composition in *Robinia pseudoacacia* L. leaves under the influence of *Parectopa robiniella* Clemens, 1863. Agrology, 4(4), 174–179.

Tőkei, L., Dunkel, Z., & Jung, A. (2005). A new method for determining water uptake in elderberry plantation. Physics and Chemistry of the Earth, 30(1–3), 245–248.

Torosyan, A. A. (1983). Hayastani deghabuyser [Medical plants of Armenia]. Akademija Nauk Armianskoy SSR, Yerevan (in Armenian).

Vardanyan, Z. H. (2005). Tsaragitutyun [Dendrology]. Akademija Nauk Armianskoy SSR, Yerevan (in Armenian).

Vardanyan, Z. S., & Hovhannisyan, A. I. (2017). *Sambucus nigra* L. tesaki jrayin rezhimi arandznahatkutyunner Gugarqi taratsashrjanum [Features of water regime of *Sambucus nigra* L. in Gugark region]. Scientific Proceedings of Vanadzor State University, B, 57–64 (in Armenian).

Vardanyan, Z. S., Bairamyan, L. Y., Sahakyan, G. R., & Mkhitaryan, H. K. (2022). Biometricheskie pokazateli organov rasteniya *Sambucus nigra* L. v zavisimosti ot usloviy proizrastaniya [Biometric indicators of the organs of *Sambucus nigra* L. depending on growth conditions]. Sciences of Europe, 91(1), 7–11 (in Russian).

Vardanyan, Z. S., Hovhannisyan, A. I., & Mirzoyan, Y. S. (2016). Qlorofili parunakutyan voroshum *Sambucus nigra* L. ev *Rumex acetosa* L. tesakneri terevnerum [Determination of chlorophyll content in leaves of *Sambucus nigra* L. and *Rumex acetosa* L.]. Scientific Proceedings of Vanadzor State University, B, 97–104 (in Armenian).

Veberic, R., Jakopic, J., Stampar, F., & Schmitzer, V. (2009). European elderberry (*Sambucus nigra* L.) rich in sugars, organic acids, anthocyanins and selected polyphenols. Food Chemistry, 114(2), 511–515.

Vorobyov, V. N., Nevmerzhitskaya, Y. Y., Khusnetdinova, L. Z., & Yakushenkova, T. P. (2013). Praktikum po fiziologii rastenij [Workshop on plant physiology]. Kazan' University, Kazan' (in Russian).

Yahudin, R. R., & Karomatov, I. J. (2016). Lekarstvenniye travy buzina chernaya, buzina travyanistaya [Medicinal plants *Sambucus nigra* L., *Sambucus ebulus* L.]. Biology and Integrative Medicine, 4, 36–44 (in Russian).

Yedoyan, R. H., & Vardanyan, Z. S. (2006). Buyseri fiziologiayi laborator ashkhatanqneri dzernark [Manual of laboratory works of plant physiology]. Yerevan State University Publishing House, Yerevan (in Armenian).