BIO Web of Conferences **194**, 01068 (2025) https://doi.org/10.1051/bioconf/202519401068
BFT-2025

Determination of the transpiration intensity of *Sambucus Nigra* L. leaves in different habitats during various phases

Zaruhi Vardanyan[1], *Lilia* Bayramyan[1], *Gayane* Sahakyan[1], *Hasmik* Mkhitaryan[1], and *Aleksandr* Lebedev[21]

[1]Vanadzor State University, 36, Tigran Mets Ave., 2021 Vanadzor, Republic of Armenia
[2]Russian State Agrarian University – Moscow Timiryazev Agricultural Academy, 49, Timiryazevskaya st., 127434 Moscow, Russia

Abstract. One of the key indicators characterizing a plant's water regime is the intensity of transpiration, the magnitude of which provides insight into water expenditure under different ecological conditions. The aim of this study is to examine the transpiration intensity and water retention capacity of *Sambucus nigra* L. leaves growing in the Vanadzor area under different ecological conditions. The research of *Sambucus nigra* L. in the Lori region was conducted both through route surveys and stationary observations at altitudes ranging from 900 to 1500 meters above sea level. The study sites were selected in locations where the main populations of the species are found. The transpiration intensity of the *Sambucus nigra* L. plant varies depending on environmental conditions. During the flowering stage, the transpiration intensity is higher than during to the fruiting stage. The impact of ecological conditions on the intensity of transpiration as well as the relative transpiration is significant. There is an inverse proportional relationship between soil moisture content and the plant's water retention capacity: the higher the soil moisture, the lower the plant's ability to retain water and vice versa.

1 Introduction

The Lori region is distinguished by its rich and diverse vegetation. The climate here is temperate, with average annual temperatures ranging between 15-23°C in summer and -4.8°C in winter. Lori is situated at an altitude of 1326-1600 meters above sea level. Ecological conditions significantly influence plant growth, development, and various physiological processes. A plant's water regime is highly responsive to changes in environmental conditions and impacts vital biological processes occurring within the plant organism. The physiological state of a plant is often reflected in the water regime, which is closely linked to metabolic and morphological changes driven by ecological influences [1, 2].

One of the key indicators characterizing a plant's water regime is the intensity of transpiration, the magnitude of which provides insight into water expenditure under different

1 Corresponding author: alebedev@rgau-msha.ru

ecological conditions. Transpiration is considered an upper terminal driving force that plays a critical biological role in the absorption and displacement of water within the plant.

To evaluate the water regime characteristics of plants growing in various habitats, it is necessary to determine both the intensity of transpiration and the water-retention capacity of leaves. The water necessary for plant growth and development is absorbed from the soil through a branched root system. The availability of water in the soil is crucial for the plant's ability to retain moisture in its tissues, which in turn depends on the composition and properties of soil [3, 4].

Studies on the water regime of plants such as *Rosa canina* L., *Rubus caesius* L., *Salix alba* L., and *Hippophae rhamnoides* L. in the Lori and Tavush regions of Armenia have shown that habitat-specific climatic conditions influence the levels of water deficiency and the amounts of free and bound water in plant tissues.

By studying the intensity of transpiration in the stems and leaves of Sambucus nigra L. during different stages of growth and development, it has been observed that the highest intensity during the budding phase occurred in plants growing in forest edge habitats, while the lowest was recorded in plants located in the concave areas of slopes.

The aim of this study is to examine the transpiration intensity and water retention capacity of *Sambucus nigra* L. leaves growing in the Vanadzor area under different ecological conditions.

2 Materials and methods

In the vegetation of the Lori region, Sambucus nigra L., commonly known as black elderberry, occupies a unique place due to its ecological and phytocenotic characteristics. The Armenian local names for black elderberry include borkich, tantrveni, ktkkeni, shambuk and porkich. The species belongs to the *Adoxaceae* (formerly *Caprifoliaceae*) family. *S. nigra* L. is distributed across the Caucasus, Western Europe, North Africa, and Crimea. Another form, *S. nigra* f. Laciniata (L.) Zabel, which is valued as an ornamental plant for gardens, can be found in lower and mid-mountain regions. In the Lori region, this form is found as a rare specimen on the grounds of the Armenia Sanatorium in Vanadzor.

Foreign researches have conducted studies on the medicinal properties of *Sambucus nigra*, identifying its antioxidant, antibacterial, and antiallergic effects [5–7]. The properties of extracts and beverages derived from its generative organs have also been studied [8]. During the COVID-19 pandemic, scientists abroad investigated the antioxidant and immunomodulatory effects of elderberry extracts. A 30-day usage of the extract showed a reduction in symptoms among patients [9–12].

Similar research has also been initiated in Armenia, though it is still at an early stage. Since 2015, studies have been conducted in Lori region regarding the distribution of life forms and bioecological characteristics of black elderberry. Research is also underway on the antibacterial activity of juices and tinctures derived from its flowers and fruits, as well as on the plant's biometrical parameters.

The subject of the study includes individuals of the *Sambucus nigra* L., which belong to the *Caprifoliaceae* family and are deciduous shrubs or small trees. They are typically found in forests, gardens, and clearings. The genus *Sambucu*s includes about 40 species distributed across temperate and subtropical zones of both hemispheres (excluding central and southern Africa). In Armenia, *Sambucus nigra* is found in the northern regions and Zangezur, particularly in forest zones and dense undergrowth. It is a shade-tolerant and moisture-loving plant [13, 14]. In the Lori region, it is found in forest areas near Vanadzor, Stepanavan, and the surrounding forests of the villages of Vahagni and Yeghhegnut. The studied individuals were located within the same general area but occupied different ecological niches and were thus exposed to varying microclimatic conditions.

The process of transpiration is influenced by several factors, including light, temperature, soil moisture, and others.

The research of *Sambucus nigra* L. in the Lori region was conducted both through route surveys and stationary observations at altitudes ranging from 900 to 1500 meters above sea level. The study sites were selected in locations where the main populations of the species are found.

The studies were carried out in 2024 in three distinct habitats around Vanadzor city in the Lori region:

- experimental site 1 – surrounding area of the "Armenia" Sanatorium in Vanadzor;
- experimental site 2 – green space around the Memorial Monument in Vanadzor;
- experimental site 3 – forest-edge area of the Khndzorut district in Vanadzor.

Field and laboratory studies were conducted using standard methods. For this purpose, 12-15 typical individuals were selected from different parts of each area, on which experiments were conducted. After gathering and fixing required plant material, it was immediately transported to the laboratory. Experiments were performed in 7-8 repetitions.

The intensity of transpiration was determined using the rapid weighing method according to L. A. Ivanov. The essence of the method lies in repeatedly weighing plant leaves at short intervals – e.g., every 5 or 15 minutes – recording the weights, and then allowing water to evaporate naturally. Then weighing are conducted again, and the difference between the initial and final weights is used to calculate the intensity of transpiration. This method allows to compare the obtained data.

3 Results and discussion

The studies sites were located at altitudes ranging from 900 to 1500 meters above sea level. As a result of the research, it was found that the species grows and develops well in moist soils, especially in areas with fewer tall plants. Light intensity has a significantly positive impact on the plant's development, and thus the species is typically found in relatively well-lit areas.

The microclimatic conditions of the growth habitats have influenced the morphological characteristics of *Sambucus nigra* L.

To compare the intensity of leaf transpiration during the flowering and fruiting phases of *Sambucus nigra*, experiments were conducted in the second half of April and in the last ten days of September.

Table 1 presents the data on the intensity of transpiration in the leaves of *Sambucus nigra* plants growing under different microclimatic conditions during the flowering phase.

From Table 1, it can be seen that during the flowering phase, the transpiration intensity is highest in the plants from Experimental Site 3 – 108.4 g/(m^2*h). This value exceeds the transpiration intensity of the leaves from plants at Experimental Site 1 by a factor of 1.01, and those at Experimental Site 2 by a factor of 1.02. The deviation from the standard is ±1.35. Based on the obtained data, the standard error of the mean was also determined, which amounted to 0.78. The differences in transpiration intensity indicators across different vegetation phases are associated with the plants ability to regulate their water balance. Tissue studies of *Sambucus nigra* L. leaves show the water deficiency is related to the altitude of the growth site above sea level. 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 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 water deficiency in the leaves is also affected by the average amount of annual precipitation of the habitat.

Table 1. Transpiration intensity of Sambucus nigra plants (g/(m^2*h)) during the flowering phase depending on the microecological conditions of the growth site (April 2024).

Location	Mass of 15cm^2 paper (mg)	Leaf mass from paper (mg)	Freshly cut leaf mass (mg)	Leaf mass after 5 min (mg)	Leaf mass after 15 min (mg)	Transpiration intensity (g/(m^2*h))	Relative transpiration
Experimental Site 1	249	24±0.4	159±0.3	156±0.2	153±0.5	107,2±0.2	0,73±0.3
Experimental Site 2	249	18±0.2	154±0.6	151±0.7	148±0.3	105,7±0.4	0,69±0.7
Experimental Site 3	249	25±0.5	160±0.4	158±0.7	151±0.2	108,4±0.6	0,81±0.5

This is accompanied by several morphological characteristics, among which pubescence plays an important role. Many authors attribute a protective function to pubescence, aimed at preventing excessive water loss during the transpiration process. In the early stages of vegetation, when the cells of the trichomes are in an active physiological state, pubescence not only protects the plant from excessive water loss but also contributes to vital processes by increasing the volume of transpired water. In addition, trichomes possess high osmotic pressure, which allows the leaves to exhibit a stronger capacity for cuticular transpiration compared to other epidermal cells.

Table 2 presents the results of experiments conducted during the fruiting stage of the plant.

From Table 2, it can be seen that the transpiration intensity is the highest in the leaves of plants from the second experimental site, with a value of 124.1 g/(m^2*hour). This value exceeds the transpiration intensity of the leaves from the first test side by 1.12 times and from the third experimental site by 1.29 times. The deviation from the standard is ± 13.84. Based on the obtained data, the average arithmetic error has also been calculated, which is 8.

The above analysis allows us to conclude that, during the fruiting phase, the third experimental site (forest-edge area of Khndzorut neighbourhood), where the lowest soil moisture was recorded, had more pronounced leaf hairiness. This likely contributed to a higher transpiration intensity in Sambucus nigra plants. Conversely, this effect was comparatively weaker in the plants growing at the second experimental site.

In the flowering phase, the trichomes lose their role in water vaporization. Therefore, the transpiration intensity during this phase was more dependent on the water supply of the soil. Despite the lower values recorded during the flowering phase, the transpiration intensity was still higher in the plants from the second experimental site, and lower in those from the third experimental site. This is closely related to the ecological conditions of the respective growth areas.

Table 2. Transpiration intensity (g/(m^2*hour)) of *Sambucus nigra* L. during the fruiting stage depending on the micro-ecological conditions of the growing site (September 2024).

Location	Paper mass with an area of 15cm2 (mg)	Leaf mass from paper (mg)	Freshly cut leaf mass (mg)	Leaf mass after 5 minutes (mg)	Leaf mass after 15 minutes (mg)	Transpiration intensity (g/(m^2*hour)) during fruiting	Relative transpiration
Experimental Site 1	249	36±0.4	164±0.2	162±0.2	158±0.6	110.7±0.5	0,72±0.6
Experimental Site 2	249	49±0.5	275±0.4	272±0.7	266±0.4	124.1±0.2	0,82±0.5
Experimental Site 3	249	42±0.3	186±0.6	184±0.3	180±0.2	96±0.3	0,62±0.7

As shown in Table 2, the highest transpiration intensity and relative transpiration intensity were recorded in plants from the second experimental site, with a value of 124.1 g/(m^2*hour). These findings indicate that the different ecological conditions at each site influenced transpiration intensity in distinct ways.

As is well-known, several factors affect transpiration, which helps explain the observed data. The second experimental site, located at a higher altitude, experienced higher temperatures and relatively more sunlight, contributing to the intense transpiration process. Light is a key factor in regulating transpiration, as green cells absorb not only infrared but also visible light from the sun, which is necessary for photosynthesis. However, only about 1-2% of the absorbed light is used for photosynthesis, with the rest being converted into heat and used for water vaporization.

Studies showed that the first experimental site, near the "Armenia" sanatorium, was more humid and shaded, which contributed to the lower transpiration intensity observed there (110.7 g/(m^2*hour)). High air humidity negatively affects transpiration because the lower the relative humidity of the air, the lower its water potential, which accelerates transpiration. As the air humidity increases, transpiration decreases, and at very high humidity, only guttation occurs. High air the normal transpiration process, affecting the upward transport of nutrients, plant temperature regulation, and the movement of stomata.

This analysis highlights the importance of various ecological and climatic factors on plant transpiration and emphasizes how soil moisture, light intensity, and air humidity contribute to the overall transpiration process.

The lowest transpiration intensity was observed in the leaves of Sambucus nigra plants at the third experimental site, with a value of 96 g/(m^2*hour). This is associated with the shaded nature of the site and the relatively dry soil. It is well-known that soil moisture is a critical factor influencing transpiration intensity. The less water there is in the soil, the less water is available to the cells, and consequently, the plant reduces transpiration by closing the stomata.

The amount of water vaporized by the plant depends on the size of its leaf area. The larger the leaf area, the more water the plant loses. However, through the process of evolution, plants have developed adaptations to reduce water vaporization. Reducing the leaf surface area by 2-3 times can significantly decrease transpiration. The plants under study have shown corresponding high and low transpiration intensities, reflecting these adaptive strategies. Therefore, based on our experimental data, the soil moisture content and the transpiration intensity of the plants during the flowering phase were directly correlated.

It was also determined by us the intensity of free water evaporation, i.e., the evaporation intensity of water from an open area, was also determined by us according to using the formula proposed by L.I. Ivanov. During the experiment, room-temperature water was poured into a Petri dish, and its surface area, weight, and time were recorded.

Then, it was left for 30 minutes, after which a second weighing was performed. The obtained results are presented in Table 3.

Table 3. Intensity of free (from the dish surface) water evaporation.

Object	Weighing time		Weight in grams		Evaporated water (g)	Area (cm²)
	1st	2nd	1st	2nd		
Dish with water	249	36±0.4	164±0.2	162±0.2	158±0.6	110.7±0.5

The averages values of transpiration intensity during the flowering and fruiting stages were compared with the evaporation rate of water from the dish surface (Figure 1).

From Figure 1, it is clearly seen that the intensity of water evaporation from a free surface exceeds the transpiration intensity from the leaf surface of the *Sambucus nigra* plant during the flowering stage by 1.37 times, and during the fruiting stage by 1.41 times.

To assess the water regime of *Sambucus nigra* plants growing in different habitats, the water retention capacity of the leaves was also determined. This reflects the ability of plants growing in various environments to regulate water exchange.

The leaf water retention capacity was measured using the Arland method. Leaves were collected from plants in three selected plots. The petioles were lightly coated with Vaseline, and the leaves were weighed. Then, the leaves from different areas were weighed again after 1, 2, 3, 5, and 24 hours, and the weights were recorded. The amount of water lost was determined based on the decrease in leaf weight.

These data were expressed as percentages relative to the initial leaf weight, giving an idea of the water content of leaves from different sites (Figure 2).

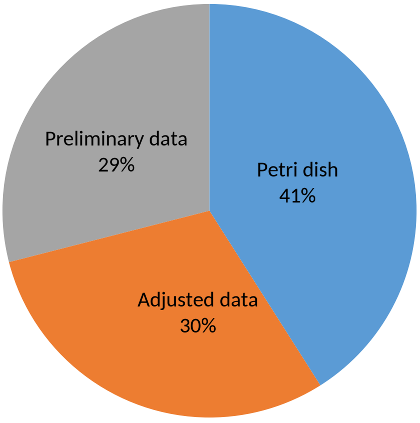

Fig. 1. Comparison of Transpiration Intensity from Basin and Leaf Surface.

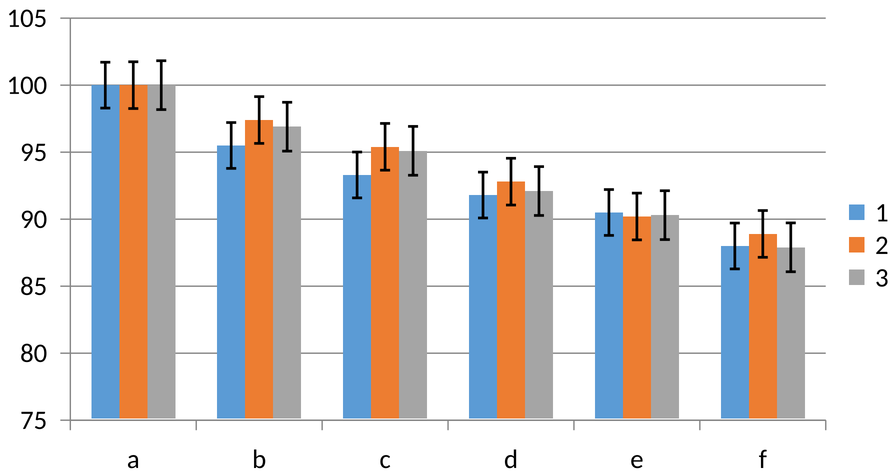

Fig. 2. Water Content Indicators of Black Mulberry Plant Leaves Growing in Different Sites: a – initial (baseline), b – after 1 hour, c – after 2 hours, d – after 3 hours, e – after 5 hours, f – after 24 hours.

It is evident that depending on the habitat, the water retention capacity of *Sambucus nigra* plants changes significantly. Due to the influence of environmental conditions at the growth sites, the differences in the plants water retention capacity are expressed in the fact that the lowest water retention is observed in the plants from the 3th experimental plot, while the highest is in those from the 2nd plot.

This suggests that there is an inverse proportional relationship between soil moisture content and the plant's water retention capacity: the higher the soil moisture, the lower the plant's ability to retain water and vice versa.

4 Conclusions

The transpiration intensity of the *Sambucus nigra* L. plant varies depending on environmental conditions. During the flowering stage, the transpiration intensity is higher than during to the fruiting stage.

The impact of ecological conditions on the intensity of transpiration as well as the relative transpiration is significant.

There is an inverse proportional relationship between soil moisture content and the plant's water retention capacity: the higher the soil moisture, the lower the plant's ability to retain water and vice versa.

References

1. P. Petrík, A. Petek-Petrik, M. Mukarram, B. Schuldt, L.J. Lamarque, Leaf physiological and morphological constraints of water-use efficiency in C3 plants. AoB Plants. **5(4)**, plad047 (2023). https://doi.org/10.1093/aobpla/plad047
2. G. Ievinsh, Water Content of Plant Tissues: So Simple That Almost Forgotten? Plants. **12(6)**, 1238 (2023). https://doi.org/10.3390/plants12061238
3. W. Huang, Y. Zhong, C. Zhang, M. Ren, Y. Du, X. Song, Leaf Traits and Water-Use Characteristics of Impatiens hainanensis, a Limestone-Endemic Plant under Different

Altitudes in Dry and Foggy Seasons. Water. **14(2)**, 139. https://doi.org/10.3390/w14020139

4. M. Vaz Monteiro, T. Blanuša, A. Verhoef, P. Hadley, R.W.F. Cameron, Relative importance of transpiration rate and leaf morphological traits for the regulation of leaf temperature. Australian Journal of Botany. **64(1)**, 32-44 (2016). https://doi.org/10.1071/BT15198
5. I. Nikolova, T. Paunova-Krasteva, Z. Petrova, P. Grozdanov, N. Nikolova, G. Tsonev, A. Triantafyllidis, S. Andreev, M. Trepechova, V. Milkova, N. Vilhelmova-Ilieva, Bulgarian Medicinal Extracts as Natural Inhibitors with Antiviral and Antibacterial Activity. Plants. **11(13),** 1666 (2022). https://doi.org/10.3390/plants11131666
6. N. Srinivas Goud, P. Gobind, Antioxidant, Antimicrobial Activity, and Total Phenol and Flavonoids Analysis of Sambucus nigra (Elderberry). International Journal of Current Pharmaceutical Research. **12(1)**, 35-37 (2020). https://doi.org/10.22159/ijcpr.2020v12i1.36829
7. M. Banach, B. Khaidakov, D. Korewo, M. Węsierska, W. Cyplik, J. Kujawa, L.M. Ahrné, W. Kujawski, The Chemical and Cytotoxic Properties of Sambucus nigra Extracts – A Natural Food Colorant. Sustainability. **13(22)**, 12702 (2021). https://doi.org/10.3390/su132212702
8. D. Seymenska, D. Teneva, I. Nikolova, N. Benbassat, P. Denev, In Vivo Anti-Inflammatory and Antinociceptive Activities of Black Elder (Sambucus nigra L.) Fruit and Flower Extracts. Pharmaceuticals (Basel). **17(4)**, 409 (2024). https://doi.org/10.3390/ph17040409
9. M. Cioch, P. Satora, M. Skotniczny, D. Semik-Szczurak, T. Tarko, Characterisation of Antimicrobial Properties of Extracts of Selected Medicinal Plants. Polish Journal of Microbiology. **66(4)**, 463-472 (2017). https://doi.org/10.5604/01.3001.0010.7002
10. K. Młynarczyk, D. Walkowiak-Tomczak, P.G. Łysiak, Bioactive Properties of Sambucus nigra L. as a Functional Ingredient for Food and Pharmaceutical Industry. Journal of Functional Foods. **40**, 377-390 (2018). https://doi.org/10.1016/j.jff.2017.11.025
11. S. Wieland, V. Piechotta, T. Feinberg, E. Ludeman, B. Hutton, S. Kanji, D. Seely, C. Garritty, Elderberry for Prevention and Treatment of Viral Respiratory Illnesses: A Systematic Review. BMC Complementary Medicine and Therapies. **21(1)**, 112 (2021). https://doi.org/10.1186/s12906-021-03283-5
12. G. Torabian, P. Valtchev, Q. Adil, F. Dehghani, Anti-influenza activity of elderberry (Sambucus nigra). Journal of Functional Foods. **54,** 353-360. https://doi.org/10.1016/j.jff.2019.01.031