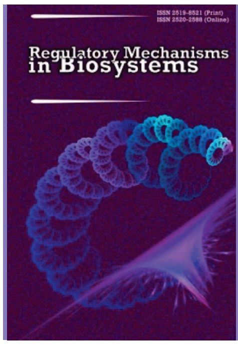

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Eco-physiological characteristics of *Corylus colurna* and *Taxus baccata* in Armenia under *in situ* and *ex situ* conditions

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Thanks to the special state policy in Armenia, people's interest in nature has increased. People try to get acquainted with the world of plants not only in nature, but also in botanical gardens. It is very important to include rare and beautiful species of local flora in botanical gardens. This process sometimes requires acclimatization of the targeted species, for example in case of *Corylus colurna* L. and *Taxus baccata* L. Our study highlights for the first time the results of an eco-physiological study (water content, intensity of transpiration and photosynthetic productivity) of two rare woody plant species *C. colurna* and *T. baccata*, growing in the wild in Armenia. We investigated the patterns of physiological behavior of the plants under different climatic conditions. Being highly valuable ornamental and rare species, *ex situ* conservation tools are applied to them in the appropriate structures of the country, among them the mesophyll forest, lower forest and semidesert zones. Obviously, we can conclude that for all indicators our most arid conditions are in the semidesert zone, at the same time often the conditions of the mesophyll forest zone are more favorable than those of the natural localities. The results of this research also show that acclimatization can help these species to be successfully preserved even in places where they grow very poorly under natural conditions or even disappear. According to the results of the studies carried out, it can be concluded that the two studied species at present can be grown in the semidesert zone as well.

Keywords: rare plants; total water content; photosynthetic productivity; intensity of transpiration; plastids; relict.

Introduction

The Caucasus Ecoregion covering an area of 586,800 km^2, is one of the world's Biodiversity Hotspots – the richest and at the same time the most threatened reservoirs of plant and animal life on earth. This area encompasses Armenia, Azerbaijan, Georgia, the North Caucasian region of the Russian Federation, Northeastern Turkey, and Northwestern Iran (Myers et al., 2000; Zazanashvili et al., 2020). This region is known not only for its rich biological diversity, but also for cultural heritage, making it a unique area of global importance (Zazanashvili & Mallon, 2009; Beridze & Gering, 2021). In this study, we explore the diverse ecosystems of Armenia, whose rich climate, relief, and soil diversity have all played a significant role in shaping its unique and rich biodiversity. It occupies a very small territory (less than 30,000 km^2) in the South Caucasus, but it has an extremely rich landscape and biological diversity. About 3,800 species of vascular plants (approximately half of the Caucasus flora) are registered in Armenia, 147 of them are local endemics (The Fifth..., 2014). This rich biodiversity is attributed to diversity of natural ecosystems. Due to the huge variety of climates (from dry subtropics to cold alpine) and soil conditions, all the main Caucasian ecosystems (besides humid subtropics) are represented in Armenia – deserts and semi-deserts, steppes, meadow-steppes, forests and open woodlands, sub-alpine and alpine vegetation as well as an intrazonal ecosystem (The Fifth... 2014).

According to Takhtajan (1978), Armenia is located on the border of the Boreal and Ancient Mediterranean subkingdoms of the Holarctic kingdom, in the zone of intense influence of the Caucasian, Anatolian and Atropatene centers of flora development. At the same time, the territory of the republic is divided into two unequal parts, which belong to Caucasian and Armeno-Iranian provinces (Tamanyan & Fayvush, 2009).

Such vast floristic richness coupled with a diverse range of natural conditions, the distribution of territory over various phyto-geographical regions and a very small area have led to the fact that a large number of plant species have a very narrow distribution area. As a consequence, some of them are exceedingly rare in Armenia and listed in the Red Data Book of Plants of Armenia (Tamanyan et al., 2010), such as *Corylus colurna* and *Taxus baccata*.

Conservation of the country's biodiversity is one of the most important tasks defined by the UN Convention on Biodiversity Conservation. The immediate requirements for the conservation of ecosystems and individual species under *in situ* and *ex situ* conditions for the near future are defined in the 2010 Aichi biodiversity targets, in particular in targets 5 and 12 (The Fifth... 2014).

In order to preserve individual plant species and ecosystems in general under *in situ* conditions in Armenia, specially protected natural areas (national parks, reserves, sanctuaries, natural monuments) are established. To conserve plant species outside their natural habitat, the semidesert belt (Yerevan Botanical Garden) with its two branches in mesophyll forest and high mountainous belts (Vanadzor and Sevan) plays a significant role. To conserve certain plant species effectively in artificial conditions, it is essential not only to assess the natural conditions of their growth and compare them with the conditions of botanical gardens and arboretums, but also to identify their ecological and physiological characteristics and assess the adaptive potential, which allows them or not to successfully adapt to new growing conditions. This research focuses on studying the main physiological parameters (water content, intensity of transpiration and photosynthetic productivity) of two rare woody plant species included in the Red Data Book of Armenia (Tamanyan et al., 2010): *Corylus colurna* (Turkish hazel) and *Taxus baccata* (common yew).

Common yew and Turkish hazel are two remarkable species naturally growing in Armenia and are considered to be the glacial relict species (Enescu et al., 2016; Lobiuc et al., 2016). Unfortunately, the yew is endangered due to its overexploitation in many countries (Lobiuc et al., 2016).

As already mentioned, the research was carried out in situ in the lower forest belt (in the surroundings of Ijevan city in the natural habitats of the two discussed species) and ex situ in the semidesert and mesophyll forest belts (Yerevan and Vanadzor botanical gardens).

The natural ecosystems where we conducted our investigations are located in lower forest belt (Tavush Marz) in NE Armenia at the altitude 755 m a.s.l. Here we have a moderately warm climate classified as Cfa (Mild temperature – Fully humid – Hot summer) by the Köppen climate classification. The average temperature of the year is 8.5 °C, in January –2.4 °C, while in August 19.6 °C. The annual precipitation is 721 mm.

The semidesert belt (Yerevan Botanical Garden) considered in the scope of this research is located in the north-eastern suburbs of Yerevan, occupying almost 80 hectares of semi-desert terrain at an altitude of 1200–1250 m (Chubaryan & Harutyunyan, 1967). In this location we have a hot humid continental climate classified as Dfa (Snow – Fully humid – Hot summer) by the Köppen climate classification. The region experiences cold winters, with an average January temperature of approximately –4 –6 °C. The average July temperature ranges from 22–26 °C, and the maximum temperature is around 40 °C. The mean annual temperature of Yerevan stands at 10.2 °C. The average annual precipitation level is 300–400 mm.

The mesophyll forest belt (Vanadzor Botanical Garden) situated at 1400–1450 m altitude (40°47'38" N 44°29'13" E), is located south of Vanadzor city in a mild climate region with a temperate forest type (Chubaryan, 1969). In this location we have cold temperate climate classified as Dfb (Snow – Fully humid – Warm summer) by the Köppen climate classification. The area experiences cold winters, with a mean annual temperature 4.4 °C. January is the coldest month with an average temperature of –7.8 °C. The hottest month is August with an average of 15.4 °C. The mean annual temperature of Vanadzor registers at 4.4 °C. The annual precipitation level is around 1,138 mm.

Material and methods

Corylus colurna L. (Betulaceae) is included in the Red Data Book of Plants of Armenia in the category "endangered species" (EN) (Tamanyan et al., 2010). In Armenia, it is found in nature only in the Ijevan floristic region. In the vicinity of Ijevan, a specialized reserve "Hazel Nut" has been established, where this species is very abundantly represented in the ecosystem G1.A7311 – Oak-hornbeam-hazel forest (Fayvush & Aleksanyan, 2016). Elsewhere, this species is usually found as individual trees in oak-hornbeam (*Quercus macranthera* F. et M. ex Hohen. – *Carpinus betulus* L.) forests in Armenia (Fayvush & Aleksanyan, 2016). It grows in the lower to middle mountain belts at an altitude of 650–1500 m a.s.l. (Batsatsashvilli et al., 2017). It prefers to grow on shallow, low-nutrient, and dry lime soils, but it can also be found in areas with both lime and silicate rock. In its native region it typically experiences an average annual temperature of 5–13 °C and annual precipitation of 570–800 mm (Seho et al., 2019). Besides Armenia, it grows in the Balkans, Asia Minor, Iran, the Himalayas, the Caucasus – in Dagestan, Western and Eastern Transcaucasia, in Talysh (Batsatsashvilli et al., 2017).

Taxus baccata L. (Taxaceae) is included in the Red Data Book of Plants of Armenia in the category "vulnerable species" (VU) (Tamanyan et al., 2010). In Armenia, it is found in the Ijevan and Zangezur floristic regions in the lower and middle mountain belts at an altitude of 700–1500 m a.s.l., in forests and along river banks. Sometimes the species forms isolated yew groves (ecosystem G3.97B), more often it occurs solely in beech forests (ecosystem G4.91) (Fayvush & Aleksanyan, 2016). Yew is adaptable to various soil types with good drainage, including humus and base-rich soils, as well as dry rendzina and sandy soils with adequate moisture. While yews have varying tolerances to frost and cold, can handle moderate drought and temporary flooding, they are vulnerable to long-term poor drainage (Benham et al., 2016). Besides Armenia, it grows in Europe, the Mediterranean, Asia Minor, North Africa, in most regions of the Caucasus (Tamanyan et al., 2010).

The main indicators of eco-physiological adaptability of plants have been studied using well-known and highly recommended methods (Agakhanyants, 1981; Mezhunts & Navasardyan, 2010; Akopian et al., 2023; Ghukasyan et al., 2023; Hayrapetyan et al., 2023). Investigations were conducted in the following directions:

– aridity index calculation for all locations,

– measurement of the pecularities of the water content, intensity of transpiration,

– study of photosynthetic productivity and the content of plastid pigments (chlorophyll *a* and *b*).

For the whole research, the measurements were carried out between 1100–1300 during the period of intensive plant growth (March–November).

Calculation of the aridity index was done using the Marton method (Agakhanyants, 1981). The research was carried out in 2021–2022, in the temperate forest belt in the vicinity of Ijevan city and in semidesert (Yerevan Botanical Garden) and mesophyll forest belts (Vanadzor Botanical Garden).

The water deficit was determined based on the principle of leaf water saturation. One gram of the leaf circles was weighed and then placed in a Petri dish filled with distilled water. After 2 hours, the circles were removed, dried with filter paper and weighed again. To ensure that the leaves were fully saturated with water, they were placed back in the Petri dish for an additional 30 minutes, then removed again, dried and weighed. This process was continued until the weight of the sample no longer changed and the leaves were considered to be fully saturated. The last weighing data was used as the final result. After that, these life circles were dried in a thermostat at 105 °C for 5 hours, weighed, and then dried again up to stable weight.

To determine the total water content of leaves, fresh samples (circles of 20 leaves) were weighed and then dried in a Binder BF-56 thermostat at 105 °C. After 4–6 hours they were taken out and weighed. Then the samples were put back into the thermostat and weighed again after 2 hours. This process was continued until the absolute dry weight of the test sample was recorded.

The content of free water in the leaves was determined by using the following experiment: 30% solution of sucrose was prepared and checked with a refractometer (HI96801). 1.5 mL of 30% sucrose was poured into the pre-weighed weighing bottle, the lid tightly closed and the content weighed again. Twenty leaves were cut from the four sides of the middle part of the tree, the circles removed with a bunch cutter, poured into the weighing bottle with the tip of a metal needle, without sticking to the sucrose solution, and the weighing bottle reweighed with its entire content. Subtracting the weight of weighing bottle and sucrose from this result (the result of the second weighing) gave the weight of the leaf circles. The plates remained in the solution for 2 hours, during which the free water of the leaf tissue passed into the sucrose solution and lowered its density. The solution was stirred with a glass rod, then 1–2 drops were transferred into the refractometer chamber, and the density after the experiment was recorded.

Subtracting the amount of free water from the amount of total water l give the bound water content of the leaf.

The intensity of transpiration of the leaves was determined by rapid weighing with analytical balance ABS 220-4N. The leaf material was cut with scissors and quickly weighed with an analytical balance, after 5 minutes the weighing wass repeated.

The content of photosynthetic pigments (chlorophylls *a* and *b*, and carotenoids) was determined by a modified method based on the use of an organic solvent of dimethyl sulfoxide, which allows one to obtain stable extracts necessary for performing extralaboratory studies (Mezhunts & Navasardyan, 2010). For the determination of plastid pigments, we took 100–500 mg weight of a fresh leaf sample, placed it in 25 mL graduated and ground-necked test vials, added 7–10 mL of dimethyl sulfoxide (DMSO), closed each vial with a cork, wrapped it with a black cloth and placed it in a wooden box. In order to dissolve pigments in the laboratory, we put the test vials with the samples in a water bath (WB7 2) at a temperature of 65 °C until the leaf tissues were completely discolored and the extract was obtained. The measurement was carried out on a spectrophotometer (UV-6300PC Double Beam Spectrophotometer, China, 2020), and the quantitative accounting of chlorophylls *a* and *b* and carotenoids was carried out according to the following formulas:

$$\text{chlorophyll } a = 12.7E_{663} – 2.69E_{645};$$
$$\text{chlorophyll } b = 22.9E_{645} – 4.68E_{663};$$
$$\text{sum of carotenoids} = 4.695E_{440.5} – 0.268\ (a + b),$$

where the E is the spectrophotometer reading.

The photosynthetic productivity was also measured during this research by the method of leaf halves, the essence of which is the determination of the increase in the weight of the plant mass in per unit area as a result of photosynthesis in a certain time. For this purpose, leaves were selected from the 4 sides of the middle part of the trees, the number of which had to be not be less than 20. Half of the leaves were cut along the length of the main vein and placed in a bowl filled with water for 0.5 hours to saturate the tissue with water. Then, 100 cycles of leaves were removed, divided into equal number of groups and dried in a thermostat for 4–6 hours at 105 ºC. This determined the initial dry weight per unit leaf area (mg/dm^2). The other half of the leaf with the petiole remained on the plant for several hours (4–5 h), after which the dry weight of their surface (mg/dm^2) was determined as described above. The amount of dry material accumulated during photosynthesis was determined by the difference between the dry weight of the last and the first determinations, which, dividing by the time between the determinations, expressed the photosynthetic productivity in mg/dm^2, hour.

To determine the leaf surface area, the leaves were laid out on paper and their contours are outlined, cut out and weighed. A square of 100 cm^2 was cut out of the same paper and weighed.

Results

When discussing the aridity index, it should be noted that the lower the index value, the higher the aridity of the territory. Studying the aridity index for the vegetatively active months (March–November) and calculating their arithmetic mean (Table 1), it becomes clear that the highest degree of aridity (aridity index 1.0) is noted for the Yerevan Botanical Garden which is located in the driest semi-desert conditions. Then it is followed by Ijevan (natural ecosystem) (1.8), located in the lower forest belt, and the most mesophilic conditions are noted in the Vanadzor Botanical Garden (2.4), located in the middle forest belt.

Table 1
Aridity index for the studied areas in the period 2021–2022

Months	Semidesert belt			**Lower forest belt**			Mesophyll forest belt		
	temperature, ^{0}C	precipitation, mm	aridity index	temperature, ^{0}C	precipitation, mm	aridity index	temperature, ^{0}C	precipitation, mm	aridity index
March	8.7	26.6	1.4	7.5	40.6	2.3	4.9	43.1	2.8
April	13.5	18.2	0.7	11.0	42.2	1.9	8.6	41.3	2.2
May	18.1	51.2	1.8	16.2	90.2	3.4	13.6	103.3	4.4
June	23.0	27.7	0.8	20.6	78.4	2.5	17.2	96.8	3.5
July	27.5	14.2	0.3	23.5	55.8	1.6	19.9	61.4	2.0
August	27.4	6.0	0.1	23.5	22.5	0.6	20.0	32.3	1.1
September	22.5	9.5	0.3	18.5	28.1	0.9	15.5	40.9	1.6
October	14.0	30.4	1.3	12.9	33.7	1.4	10.4	40.9	2.0
November	6.7	41.8	2.5	6.7	27.3	1.6	3.6	32.6	2.3
Mean	17.9	25.0	1.0	15.6	46.5	1.8	12.6	54.7	2.4

While assessing the success of adaptation of a particular plant species to the new habitat conditions, the water content and the intensity of transpiration are extremely important. Table 2 shows these data for two studied species growing in nature in lower forest and in the semidesert and mesophyll forest belts. As can be seen, almost all indicators of the water content and transpiration intensity are the lowest in the semidesert (Yerevan Botanical Garden), and the highest in the mesophyll forest belt (Vanadzor Botanical Garden).

Table 2
The water indicators and the intensity of transpiration of the studied plant (average for the period 2021–2022, n = 6; mean ± standard deviation)

Plant species	Research location	Total water content, %	Free water, %	Bound water, %	Free to bound water ratio	Water deficit, %	Intensity of transpiration, mg CO_2 dm^2/hour
Taxus baccata L.	semidesert belt	63.10 ± 0.82^a	42.20 ± 0.79^a	20.91 ± 0.08^a	2.013 ± 0.037^a	3.79 ± 0.74^a	193.5 ± 1.0^a
	lower forest belt	79.45 ± 1.12^b	52.80 ± 0.99^b	26.65 ± 0.16^b	1.977 ± 0.029^a	4.72 ± 0.84^a	353.0 ± 1.1^b
	mesophyll forest belt	80.60 ± 0.75^b	55.59 ± 0.80^c	25.01 ± 0.09^c	2.217 ± 0.037^b	6.52 ± 0.63^c	358.2 ± 1.1^c
Corylus colurna L.	semidesert belt	61.42 ± 0.64^a	40.62 ± 0.59^a	20.80 ± 0.25^a	1.948 ± 0.036^a	35.11 ± 0.67^a	240.0 ± 1.2^a
	lower forest belt	80.02 ± 0.83^b	53.28 ± 0.54^b	26.74 ± 0.30^b	1.985 ± 0.005^a	37.43 ± 0.98^b	444.8 ± 0.7^b
	mesophyll forest belt	83.63 ± 0.82^c	57.35 ± 0.77^c	26.28 ± 0.31^b	2.177 ± 0.038^b	38.62 ± 1.11^b	461.5 ± 0.7^c

Note: different letters for the three research locations for each plant species indicate samplings which reliably ($P < 0.05$) differ from one another according to the results of the Tukey test.

Table 3 shows data on the content of chlorophyll and the photosynthetic productivity of the studied species under different growing conditions. As we can see from the data, the highest amount of chlorophyll (*a* + *b*) for both species is observed in natural conditions in Ijevan, and the lowest in the most arid conditions of the semidesert belt. But at the same time, the highest photosynthetic productivity is noted for the most mesophilic conditions of the mesophyll forest belt. Obviously, as in terms of the water content, the most arid conditions of the semidesert belt for the two studied species of woody plants are extreme for photosynthesis.

Table 3
Chlorophyll content and photosynthetic productivity of studied species (average values for the period 2021–2022, n = 6; mean ± standard deviation)

Plant species	Research location	Chlorophyll content, mg/dm^2				Photosynthetic productivity, mg/dm^2 per hour
		a	*b*	*a+b*	*a/b*	
Taxus baccata L.	semidesert belt	3.22 ± 0.18^a	1.15 ± 0.08^a	4.37 ± 0.26^a	2.79 ± 0.06^a	5.41 ± 0.38^a
	lower forest belt	4.62 ± 0.46^b	1.83 ± 0.36^b	6.43 ± 0.09^b	2.66 ± 0.80^a	8.63 ± 0.28^b
	mesophyll forest belt	4.12 ± 0.81^{ab}	1.72 ± 0.55^{ab}	5.85 ± 1.36^{ab}	2.48 ± 0.36^a	10.41 ± 0.74^c
Corylus colurna L.	semidesert belt	4.12 ± 0.30^a	1.15 ± 0.08^a	5.26 ± 0.38^a	3.39 ± 0.36^a	6.71 ± 0.47^a
	lower forest belt	5.22 ± 0.39^b	1.63 ± 0.28^b	6.84 ± 0.11^b	3.32 ± 0.81^a	10.25 ± 0.17^b
	mesophyll forest belt	4.91 ± 0.46^{ab}	1.71 ± 0.30^b	6.63 ± 0.75^b	2.90 ± 0.24^a	11.92 ± 0.72^c

Note: see Table 2.

Discussion

The minimum aridity index for all three investigated points was recorded in August (driest and hottest month) The maximum value of the index in the mesophyll forest and lower forest belts was observed in May, which corresponds to the wettest month, while the temperature is average. In contrast, the highest aridity index in the semidesert belt was in November, which was the driest month and the humidity was average. In other words, for the lower forest and mesophyll forest belts, the most crucial climatic factor is humidity, and for semidesert belt, it is temperature (Fig. 1). This allows us to conclude that the most vulnerable conditions for these plants in all 3 points are in August, so it is recommended to water these plants more intensively in August in all the discussed territories.

The observed plants feel their best in May in lower forest and mesophyll forest belts. At the same time, although the aridity index in the semidesert belt in November is high, this is mainly due to high precipitation. However, it should be taken into account that it is quite cold in November for this species, so it is desirable to plant these species in places where they will be protected from the wind as much as possible.

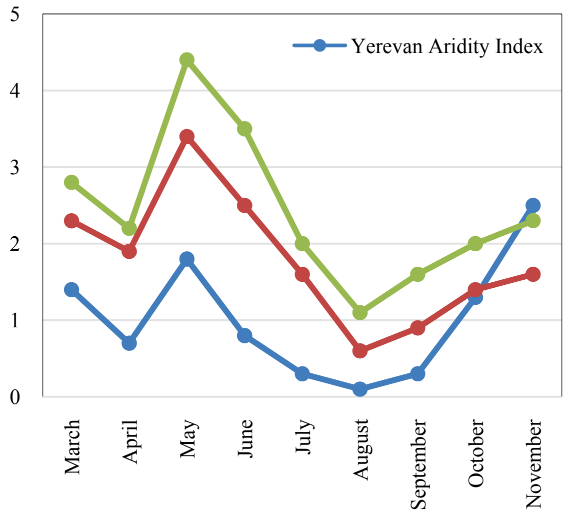

Fig. 1. The variation of aridity index throughout the year in semidesert, mesophyll forest and lower forest belts

The obtained data shows that in terms of total and free water content, the mesophyll forest belt has more suitable conditions than even in the natural habitat. In the case of bound water, the index in the natural habitat is slightly higher than in the mesophyll forest belt. It should also be noted that water deficiency, water-holding capacity and transpiration intensity are also increasing, which are caused by changes in edaphic, weather conditions, external (light intensity, insufficient atmospheric vapor pressure, heat) and internal (number of stomata, leaf diffusion resistance) conditions under the complex influence. This is also due to the fact that all species are mesophilic and are better adapted to the relatively mesophilic climatic conditions of the Caucasus region, and the semidesert belt is located on the borders of the arid Armenian-Iranian province of the Old Mediterranean region (Takhtajan, 1978). All indicators are closely related to each other and their harmonious presence in given ecological conditions ensures the homeostasis and dynamic life of plants. In case of water deficit, semidesert belt values are just a little different from Ijevan's ones. Comparing the transpiration rate in natural habitat and in the semidesert belt, we can conclude that the life activity of these plants in the semidesert belt occurs about 1.8 times less than in the natural habitat. This means that without enough water the plant will shorten its life cycle. Therefore, in order to ensure the existence of these species in the semidesert belt, it is necessary to pay attention to the water content, though it is not only a question of irrigation, but also of ensuring sufficient humidity of the air. The latter can be done by using fountains or water dispersing systems around the trees.

It is clear that the natural conditions of the lower forest belt are optimal for both these species in terms of the chlorophyll content, and in the mesophyll forest belt are even excessive. The obtained data show that the reason for having the highest intensity of photosynthesis in mesophyll forest belt is due to the fact that here we have mesophilic conditions while in the lower forest conditions are temperate. It follows from this that these plants can be used to create groves in the mesophyll forest belt. Moreover, yew can be used as a natural green fence to separate some parts of a garden from each other or, simply, to create alleys. In both species, the intensity of photosynthesis in Yerevan Botanical Garden is about 1.5 times less than in the natural habitat. This is a very important indicator, because if the issue of regulating the water content can be solved in help of technical saturation, then the increase in the amount of chlorophyll as well as the activity of photosynthesis, requires a more versatile approach. It should be remembered that the green color of the leaves is not enough, it may be due to the presence of carotenoids and not the presence of chlorophyll. Such changes, which are more characteristic of the natural abscission, often occur in plants under insufficient conditions. The altitude of the habitat and, accordingly, the increase in light intensity leads to a decrease in the total chlorophyll content, this is natural and is explained by the ratio of chlorophyll *a* and *b* forms to light, as a result of which the total chlorophyll content, *a/b* ratio, decreases with altitude. This can be attributed to a biological feature, it is the plant's response to high light intensity, being a shade-loving species, it accumulates more chlorophyll under low light and less under high light intensity. Changes in the content of green pigments were inversely correlated with the functional activity of plants (Jia, 2023). The results of our experiment also indicate that there was a decrease in chlorophyll and an increase in the intensity of photosynthesis and assimilation indicators in the lower forest and mesophyll forest belts. And the semidesert belt occupies an intermediate place. Overall, it should also be taken into account that according to forecasts of climate change, a significant increase in average temperatures and a decrease in precipitation are expected in Armenia, that is, the aridity of the territory will increase, which will undoubtedly affect the vulnerability of many plant species, primarily mesophyllic in nature (Fayvush & Aleksanyan, 2016; Fayvush et al., 2020). In other words, from time to time all these indicators should be studied again and the changes in acclimatization approach should be adapted accordingly.

Conclusion

We investigated the patterns of physiological behavior of plants under different climatic conditions. Obviously, we can conclude that for all indicators the most arid conditions prevail in the semidesert belt, at the same time often the conditions of the mesophyll forest belt are more favorable than those of the natural localities in the lower forest belt. Considering the need to conserve these species in ex situ conditions and predicted climate changes, the conditions of the mesophyll forest belt should be considered optimal for cultivation, conservation, reproduction and for the creation of plantations, which will even become better than the natural conditions in the vicinity of the lower forest belt over time.

Most likely, this is due to the fact that both studied species in their natural areas are closely related to the more mesophyllic Circumboreal floristic province and the conditions of the mesophyll forest and lower forest belts are optimal for them, while the semidesert belt is located in the Ancient Mediterranean subkingdom, and here the studied plants are already in extreme conditions.

In conclusion, according to the results of the studies carried out, it can be concluded that the two studied species at present can be grown in the semidesert belt as well. However, in terms of eco-physiological indicators, the conditions of the semidesert belt for these species of woody plants are extreme and are not very suitable for their real preservation in ex situ conditions. Here they should be grown exclusively for demonstration purposes with additional irrigation, possibly in the currently planned "park of relics" in the Caucasian flora of the semidesert belt, where there are the most technically equipped conditions for irrigation and care. The conditions of the mesophyll forest belt are optimal, even better for creating a collection of these species and their real preservation in ex situ conditions exercising minimal care. And given the forecast climate change and the likely aridization of the climate in lower forest belt, it is likely that mesophyll forest belt conditions will become optimal for these species and it will become possible to introduce them into nature for widespread creation of artificial plantations.

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