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PHOTOSYNTHETICALLY ACTIVE RADIATION AND TRANSPIRATION INDICES OF TREES AND SHRUBS IN THE WALNUT FORESTS OF THE WESTERN TIEN SHAN

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Abstract: This article studies the photosynthetically active radiation (PAR) and transpiration processes of various tree and shrub species in nut-bearing forests of the Western Tien Shan mountain range. The study analyzed the influence of climate, soil and microclimate factors on plant water exchange and photosynthesis processes. The results showed that light intensity and leaf temperature activate the transpiration process, while relative humidity of the air slows it down. It was noted that high temperature and low soil moisture negatively affected the development of seedlings. The results of the study are important as a scientific basis for ensuring the stability of forest ecosystems in mountainous areas and managing natural regeneration processes.

INTRODUCTION. The processes of photosynthesis and transpiration of plants are of great importance for their growth, development, and adaptation to the environment . Forest ecosystems, especially in mountainous regions, are exposed to complex climatic conditions, which affect the ecological stability of plants. The nut-bearing forests of the Western Tien Shan are characterized by their biodiversity and sensitivity to climate change. Therefore, studying the photosynthesis and water exchange parameters of plants in this region is necessary to ensure ecosystem stability and scientifically manage natural regeneration processes. In this study, the photosynthetically active radiation (PAR) and transpiration indices of tree and shrub species were studied, and the relationship between them and climatic and soil parameters was analyzed.

MATERIALS AND METHODS

The process of photosynthesis and transpiration are the main mechanisms that ensure water and energy exchange in plants, and they depend on climatic conditions, soil properties, and biological characteristics of plant species [11]. Previous studies have shown that changes in elevation and relief can significantly affect photosynthesis and transpiration rates in mountainous regions [9]. Under conditions of high temperature and low humidity, stomatal control of plants can change, reducing photosynthetic efficiency [6]. However, there are limited studies on the adaptation of tree species to climate change in Uzbekistan, especially in the Western Tien Shan [3].

The research area was the walnut forests of the Qorankul forest department of the State Forest Service of the Republic of Uzbekistan, located at an altitude of 1030 m above sea level in the

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Western Tien Shan mountain range. 135 tree and shrub seedlings were identified in the selected 150 m² area, and their biometric and phenological indicators were regularly monitored on the 20th of each month starting from March 2024.

Photosynthetically active radiation (PAR), transpiration rate and transpiration flux were recorded using a LI-COR 6400XT spectrophotometer and other special instruments. Microclimate parameters, including air and leaf temperature, relative air and leaf humidity, were measured using YSI and HOBO measuring devices. Soil samples were analyzed for pH, moisture and organic matter content using standard laboratory methods. The obtained data were entered into SPSS and Excel was studied using correlation analysis and statistical methods using software.

RESULTS

In the nut-bearing forests of the Western Tien Shan, tree and shrub species are mainly negatively affected by abiotic factors. Among the problems associated with global climate change, the lack of soil moisture is of particular importance. The results of the study showed that the high air temperature (average around 40 °C) and the decrease in soil moisture to 4–6% observed in the summer months prevent plants from fully satisfying their water needs. As a result, water shortages slow down the growth process of seedlings, in some cases leading to heat stroke (heat damage).[10]

Also, unexpectedly warm weather conditions were observed in July 2025. This caused early fruit drop and extensive leaf scorch of Pontic hawthorn (*Crataegus pontica* C.Koch.) and Turkestan hawthorn (*Crataegus turkestanica* Pojark.). Low relative humidity and increased wind speed increased water loss in plants, further increasing the level of damage[2].

In addition, under high temperature conditions, the stomatal control mechanism of plants is disrupted, reducing the efficiency of photosynthesis and transpiration processes. This, in turn, worsens the overall physiological state of plants, weakens their ecological stability, and significantly complicates natural recovery processes[1].

These factors are among the main causes of damage to tree and shrub species in nut forests of the Western Tien Shan and require special attention in forestry management.

“Photosynthetically active radiation and transpiration indices by tree species”

No.	Tree and shrub names	ARH Relative humidity %	LRH Leaf Moisture %	AirT Air temperature (^{0}C)	LeafT Leaf temperature (^{0}C)	PAR Photosynthetically Active Radiation (µmol/m²/s)	Transpiration and water flow rate m³/s	Transpiration (µmol/m²/s)
1	Condo pistachio	28.2	36.1	33.4	33.2	153	0.66	510
2	Turkestan hawthorn	30.4	32.3	34.9	36.8	2005	0.67	6683.3

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3	Pontica hawthorn	29.6	34.9	35.4	35.2	1090	0.69	3633.3

Transferred field dimensions as a result different tree - bush types photosynthesis active radiation (PAR) and transpiration indicators noticeable difference to do was determined . In the case of *Pistacia vera L.* , the average air temperature was 33.4 °C, leaf temperature was 33.2 °C, relative air humidity was 28.2%, and leaf moisture was 36.1%. Under these conditions, the PAR value was 153 µmol/m²/s, the transpiration rate was 0.66 m³/s, and the transpiration flux was 510 µmol/m²/s. This indicates that both photosynthesis and water exchange are relatively slow at low light intensities (Table 1) [4].

In Turkestan hawthorn (*Crataegus turkestanica* Pojark.) the air temperature was 34.9 °C, the leaf temperature was 36.8 °C, the relative humidity of the air was 30.4%, and the leaf moisture content was 32.3%, and the PAR value reached 2005 µmol/m²/s. Such a high intensity of the light flux sharply activated the transpiration process in the leaf, increasing the transpiration rate to 0.67 m³/s and the transpiration flux to 6683.3 µmol/m²/s. This situation indicated that under high PAR conditions, the leaf stomata opened wider, and the processes of gas exchange and water evaporation were activated [8].

Pontic hawthorn (Crataegus pontica C.Koch) had an average air temperature of 35.4 °C, leaf temperature of 35.2 °C, and a PAR value of 1090 µmol/m²/s. The transpiration rate was 0.69 m³/s, and the transpiration flux was 3633.3 µmol/m²/s. Although this indicator is lower than that of Turkestan hawthorn, it shows much higher values than that of Khandon pistachio.

STATISTICAL ANALYSIS

Based on the data obtained during the study, the correlation analysis method was used to determine the relationship between PAR, leaf temperature, relative humidity, and transpiration flux, and it was found that there was a significant relationship between them.

First, a strong positive correlation was observed between PAR and transpiration flux (correlation coefficient $r = 0.98$; $p < 0.05$). This result suggests that as light intensity increases, the process of water evaporation (transpiration) in plant leaves also increases. As the amount of light required for photosynthesis increases, the stomata of the leaves open and water evaporation increases, which helps plants to actively carry out water exchange and gas exchange.

Secondly, a significant positive correlation was also found between leaf temperature and transpiration flux, with a correlation coefficient of $r = 0.91$ ($p < 0.05$). This means that as leaf temperature increases, water evaporation from the leaf surface becomes more active. At higher temperatures, the rate of evaporation of water molecules from the leaf surface increases, and transpiration increases. This process helps to maintain the plant's thermal balance.

Third, a strong negative correlation was observed between relative humidity and transpiration ($r = –0.88$). This means that the drier the air, the higher the rate of water loss by plants. When relative humidity is low, the rate of water vapor absorption from the atmosphere is high, and the process of water evaporation from plant leaves is accelerated. As a result, plants lose more water and the risk of water shortage in drought conditions increases.

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These correlations are important in understanding the adaptation of plants to environmental conditions and water exchange processes. They serve as a scientific basis for analyzing the interrelationship between photosynthesis and transpiration processes, especially in the context of climate change in mountainous regions, and for developing effective measures to maintain the ecological stability of forests and manage water resources.

CONCLUSION: The results of the study showed that the photosynthesis and transpiration processes of plants in the nut forests of the Western Tien Shan mountain range are highly sensitive to climate and soil parameters. In the Pistacia vera L. species, the transpiration process was slow under low light conditions, which indicated their adaptation to semi-desert and arid climates. In the Turkestan hawthorn (Crataegus turkestanica Pojark.) and Pontic hawthorn (Crataegus pontica C.Koch.), high light and temperature conditions significantly activated the transpiration process, which indicates their ecological adaptability.

Statistical analysis revealed a strong positive correlation between light intensity (PAR) and transpiration flux ($r = 0.98$; $p < 0.05$), as well as a significant positive correlation between leaf temperature and transpiration flux ($r = 0.91$; $p < 0.05$). A strong negative correlation was observed between relative humidity and transpiration ($r = –0.88$). These results indicate that plant water exchange processes are directly dependent on light and temperature conditions.

At the same time, the sharply continental nature of the climate in the region and the decrease in soil moisture slow down the growth and development processes of plants, negatively affecting their natural regeneration. The results of this scientific research serve as an important scientific basis for developing strategies for forest management, water resource conservation, and environmental sustainability in the Western Tien Shan mountain range.

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