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The Impact of the Paulowniaceae Family Species Introduction on Biodiversity and the Structure of Local Ecosystems

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Keywords

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Abstract

This research examines the potential for the introduction of Paulownia tomentosa into the climatic conditions of the Turkistan city. The ecological, economic, and ornamental characteristics of the P. tomentosa were analyzed, and its ability to grow in fertile soils was highlighted. The experiment employed a method of vegetative propagation using root cuttings, with particular attention given to the main ecological factors influencing plant development (temperature, humidity, and substrate type). The results demonstrated that rooting and initial growth of paulownia were most effective in peat-based substrate under moderate temperature and humidity conditions. According to the research results, the most favorable conditions for rooting and initial growth of Paulownia tomentosa include the use of peat as a substrate, moderate temperatures (20–25 °C), and optimal humidity levels. Although high humidity promotes rapid plant growth, it also increases the risk of diseases such as wilting and rot. The use of soil-based substrates, particularly under high humidity conditions, showed lower effectiveness. It was also determined that suboptimal (lower) temperatures significantly slow down plant development. Additionally, morphological differences were observed depending on the temperature regime: under normal temperatures, a greater number of smaller leaves was noted, while under lower temperatures, the number of leaves decreased, but their size increased. These findings can serve as a scientific basis for the large-scale cultivation of paulownia in the Turkistan region.

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1. INTRODUCTION

Paulownia is a fast-growing deciduous tree native to the countries of Southeast Asia. Depending on soil and climatic conditions, the height of paulownia can reach 15–20 meters, and in some cases up to 25 meters, with a trunk diameter ranging from 0.6 to 1 meter. The Paulowniaceae family (formerly classified under Scrophulariaceae) comprises nine species and several naturally occurring hybrids developed in China. The most significant species of this family include P. kawakamii, P. catalpifolia, P. australis, P. fortunei, P. albiphloea, P. elongata, P. fargesii, and P. tomentosa. Paulownia species have been documented growing both in natural and cultivated conditions across various regions of the world, including China, Japan, Southeast Asia, Europe, North and Central America, and Australia. These species demonstrate high adaptability to a wide range of edaphic and climatic factors and are capable of thriving even in marginal or challenging growing environments (Jakubowski, 2022).

The successful experience of cultivating paulownia plantations in Europe and the United States demonstrates the viability of this practice not only for the rapid production of timber, but also for addressing critical environmental issues, such as the conservation of natural resources and exerting a positive influence on the global ecosystem.

Paulownia flowers before leaf emergence, typically in April and May. Its flowers are white, purple, or occasionally blue in color. The fruit is an ovoid, pointed capsule measuring between 30 and 45 mm in length. Fruit ripening occurs between September and October, during which the capsules turn brown and may remain on the tree throughout the winter. Each capsule can contain up to 2,000 seeds, and a mature tree may produce up to 20 million seeds annually. The seeds are small, flat, winged, and weigh approximately 0.17 mg. During the winter and spring months, as the capsules split open, the seeds are easily dispersed by the wind (Yadav, Tiwari, Patel and Joshee, 2013).

Species of the genus Paulownia possess bark that can be gray, brown, or nearly black. While smooth in young trees, the bark becomes progressively scaly with age, developing vertical fissures and areas of cork tissue. Leaves are generally sparse, and the crown tends to form an umbrella-like structure. With the exception of older branches, most plant parts are covered in mucilaginous glandular hairs, dense multicellular trichomes, and dendritic or stellate hairs. In mature trees, the leaves are smaller, entire, and have smooth or undulating margins. The inflorescences typically consist of two to five flowers, which may be pedicellate or nearly sessile. They develop in the axils of miniature or reduced leaves during the summer and autumn seasons. At the apical tip, there is a fleshy, bell-shaped calyx with five unevenly divided lobes. The calyx lobes are triangular, with the upper median lobe slightly larger and commonly exhibiting dense dentation. In some species, trichomes are shed during flowering.

The corolla is large, ranging in color from purple to white, bilabiate in structure, with two elongated lobes on the upper lip and three on the lower. The bell-shaped corolla tube is typically inclined forward by approximately 5 mm from the base, after which it gradually or abruptly expands. Near the inflorescence, the upper lip is slightly compressed downward, giving the floral arrangement a flattened appearance. The inner surface of the corolla often contains purple spots or streaks and yellowish wrinkled patches. The stamens are didynamous, measuring about half the length of the corolla. The pistil is of equal or slightly greater length. The ovary is bilocular. The fruits are loculicidal capsules, ovoid or ellipsoid in shape. The pericarp varies from thin to thick and may become woody. Its internal surface may be either smooth or rough. The placentas are oily, wrinkled, and morphologically diverse. The seeds are numerous, ellipsoid, extremely small, membranous, and winged with longitudinal striations. The seed coat consists of two layers: an inner layer of thick-walled brown cells and an outer transparent layer that forms wing-like extensions. The seed contains endosperm (Molčanová, Bobal, Bobalová, Vukics and Humpa, 2022).

Paulownia wood is highly resistant to decay and mechanical damage, retains dimensional stability, and demonstrates notable fire resistance, making it a sought-after material in the global timber industry. Due to its light weight, resistance to rotting, lack of warping or cracking, and knot-free structure, it is frequently used in the manufacturing of components for aircraft, gliders, vehicles, and ships, both in China and internationally. As it is approximately 40% lighter than conventional wood, its use in packaging boxes allows for significantly increased shipping volumes. Additionally, paulownia holds substantial potential as a raw material for pulp and paper production (Franz, 2007).

Medicinal preparations derived from the leaves, fruits, and wood of Paulownia exhibit therapeutic effects in the treatment of bronchitis, particularly by suppressing cough and reducing phlegm production. These plant parts are used in the formulation of tablets and injectable medications. The fruits contain organic acids, fatty oils, flavanones, and alkaloids. Aqueous extracts from the leaves and fruits, when applied daily to the scalp, are reported to promote healthy hair growth and, according to traditional use, to restore hair pigmentation, turning gray hair dark. Additionally, the application of leaves and wood is associated with the reduction of edema in swollen lower limbs. Pharmacological studies have demonstrated that fruit extracts alleviate symptoms of cough and asthma and possess antihypertensive properties (Waas, Verbruggen and Wright, 2010).

One of the distinctive features of Paulownia is its large, fibrous leaves. During the first two years of growth, the leaves release substantial amounts of oxygen through photosynthesis. They act as natural filters, effectively reducing airborne dust and noise. The accelerated metabolism associated with its rapid growth makes Paulownia an efficient "oxygen factory." Its fast growth rate, large leaf size, ornamental crown, six-week flowering period, and overall resilience render Paulownia highly suitable for landscaping parks and public spaces, establishing green belts around urban areas, and planting along roads and highways. The large, pubescent leaves play a significant role in purifying the air from dust and smoke. Owing to their size and surface area, a single Paulownia tree is capable of absorbing up to 22 kg of CO_2 and releasing up to 6 kg of oxygen per day (Zhu, Chao, Lu and Xiong, 1986).

Paulownia wood is highly durable and virtually resistant to insects and pests. It ignites at a temperature of approximately 400 °C, indicating a high level of thermal resistance. Upon combustion, Paulownia wood releases around 23 MJ/kg of energy, which is 5 units higher than that of oak (18 MJ/kg), making it a promising source of bioenergy. In livestock farming, the green biomass of Paulownia can be utilized either as a forage supplement or as a standalone fodder crop (Khivrich, Gumentik, and Katelevskiy). Additionally, Paulownia is suitable for establishing windbreak belts to protect agricultural lands from wind erosion.

Paulownia exhibits significant drought and heat tolerance. Under cultivation, consistent irrigation is required only during the initial two years of growth, with water consumption of approximately 30–40 liters per seedling, applied once or twice per week. After the development of a mature root system (from the third year onward), additional irrigation becomes unnecessary. The most vigorous growth occurs during the early developmental stages, whereas from the age of five, growth rates slow to about 20–30 cm per year, with trunk diameter increasing by 0.5–1 cm annually. According to The Plant List database, the genus Paulownia comprises seven species; however, the most practically valuable are hybrid cultivars characterized by straight trunks and compact crowns, including Shan Tong, Paulownia In Vitro 112, P. tomentosa, and Paulownia Pao Tong Z07. In recent years, new hybrids (Hybrid 9501 and 9502) have been developed in the United States, featuring enhanced frost and cold resistance, making them suitable for successful cultivation in the northern regions of the United States, Canada, and the United Kingdom (Aloi, Pane, Miele, Motta, Pane and Nicotera, 2021).

Three key requirements are essential for the successful growth of *Paulownia*:

- well-drained soil, which limits its adaptability to clay-rich substrates;
- minimum temperature not falling below –20 °C;

– an annual precipitation of at least 500 mm, with the majority of water availability concentrated in the warm season.

Growth is significantly inhibited when the total salt concentration in the soil reaches 1% (He, Vaidya, Perry, Parajuli and Joshee, 2016).

Energy Efficiency:

Biofuel: The high cellulose content of Paulownia wood makes it a suitable raw material for biofuel production. Its rapid growth rate offers a sustainable and efficient biomass source.

Thermal energy: Paulownia wood can also be utilized as a fuel for heat generation, which is particularly beneficial in regions reliant on wood-based heating systems.

Environmental Benefits:

Carbon fixing: Due to its accelerated growth, Paulownia actively captures atmospheric CO_2, contributing to the reduction of greenhouse gas concentrations and mitigating climate change.

Reduced deforestation pressure: Cultivating Paulownia as a wood resource alleviates pressure on natural forests, thereby reducing the need for deforestation.

Paulownia exhibits a high rate of transpiration, extensive leaf coverage, and a well-developed root system, which makes the availability of adequate moisture a critical factor for its optimal growth (Woods, 2008).

Paulownia produces distinct branches and sparsely distributed leaves that allow for efficient light penetration. The species exhibits intensive natural pruning. However, even minimal shading can adversely affect tree morphology or result in complete dieback. Experimental studies conducted on seedlings indicate that approximately 70% shade can lead to plant mortality (Joshee, 2012).

Paulownia demonstrates strong adaptability to a wide range of temperatures. Its northern distribution limit generally aligns with the January isotherm of –5 °C (Mezenina & Shestak, 2023).

Paulownia tomentosa is a species native to China, growing in both plains and mountainous regions. It is used for the production of various items, including aircraft parts, toys, tools, plywood, furniture, medicinal preparations, and musical instruments. Furthermore, certain varieties of Paulownia tomentosa are valuable as fertilizers and fodder plants. Its ecological benefits are partly due to its ability to grow in soils with low nutrient content, which is facilitated by its deep root system (Corredoira, Ballester, and Vieitez, 2008).

The acclimatization of Paulownia tomentosa is being carried out in Almaty city and in several districts of the Almaty region, such as Zhambyl (Uzynagash village), Ile (Zhetygen village), Enbekshikazakh (Teskensu, Karaturik villages), Talgar, and other areas. Primarily, hybrid varieties of Paulownia are cultivated for commercial purposes, allowing the plant to adapt to local ecological conditions through the process of introduction. In addition, planting of hybrid Paulownia can be carried out in the Turkestan region, in the Tulkibas district, and in the village of Mashat. A deputy of the regional maslikhat organized the import of 10,000 seedlings from China for landscaping purposes, which were successfully planted. In the Jetyssai district, a 1-hectare seed plantation of Paulownia is being cultivated. At the initiative of the head of the Jetyssai district, over 40,000 seedlings have been planted along regional, provincial, and national roads, as well as in cities, towns, and rural districts, with nearly 1,000 of these being Paulownia seedlings. In

Kyzylorda region, Paulownia seedlings have been planted in the filter fields of the biological wastewater treatment plants as part of an experimental project (Tyshchenko and Yakuba, 2014).

M.Ya. Lovkova, A.M. Rabinovich et al. have noted a correlation between the accumulation of certain groups of physiologically active compounds in plants and the concentration of microelements within them. Among plants, there are both concentrators and superconcentrators of specific microelements. In some cases, a plant is capable of accumulating only a single microelement in a supraphysiological dose, whereas certain species can accumulate several microelements simultaneously. This ability of plants is widely studied in relation to their medicinal properties. Paulownia tomentosa accumulates varying amounts of microelements at different stages of the vegetative growth period (Wang and Shogren, 1992).

Thus, species of the Paulowniaceae family are notable not only for their external morphology but also for their ecological advantages, ornamental value, and broad applicability in industry, medicine, and other fields. Furthermore, studies of its dry wood have demonstrated that this plant is capable of accumulating a substantial amount of heavy metals in its timber over the course of its life cycle.

Successful plant introduction requires a preliminary assessment of the climatic conditions of the target region. Accordingly, in order to select the most resilient and efficient species from the Paulowniaceae family suitable for the climate of Turkestan city, it is essential to conduct a comprehensive study of the local climatic characteristics. The initial step in this research was to examine the growth potential of Paulownia and assess its adaptability to the climatic conditions of Turkestan. To this end, the following tasks must be carried out:

- Study the developmental biology of Paulownia and its environmental requirements;
- Analyze the soil and climatic conditions of Turkestan to evaluate their suitability for Paulownia cultivation;
- Identify the main advantages and disadvantages of Paulownia cultivation technology;
- Gather data on the ecological significance of Paulownia as a natural purifier.

2. MATERIAL AND METHOD

Based on the results of the literature review, Paulownia tomentosa was selected as the most promising species for the climatic conditions of Turkestan and used as the primary object of study. To determine the climatic characteristics of the region, including maximum and minimum temperature values, data from the Hydrometeorological Center were utilized. Figure 2 below illustrates the average annual maximum and minimum temperatures recorded in Turkestan (Figure 1).

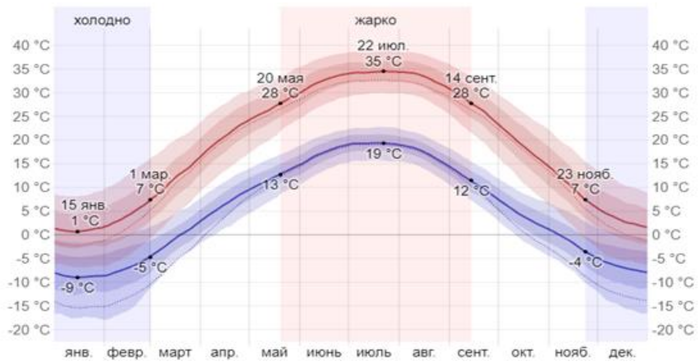


Figure 1. *Average maximum and minimum temperatures in Turkestan (according to data from the Hydrometeorological Center)*

According to the data obtained, the average minimum temperature in Turkestan during winter is –19 °C, while the average maximum temperature in summer reaches 35–36 °C. It has also been noted that Paulownia tomentosa Steud. is tolerant to frost conditions as low as –23 to –18 °C.

The method of propagating Paulownia through root cuttings has been extensively described by the researcher Drvodelić. According to him, this technique has been the most widely used method of vegetative propagation of Paulownia in China for over half a century. Root cuttings approximately 15 cm in length are collected outdoors from beds covered with sand. The sand serves to retain excess moisture that filters through the soil. These beds are typically covered with nylon material to maintain elevated temperature and humidity levels. Once the root system begins to develop, the cuttings are removed from the sand and transplanted into nurseries.

Propagation of Paulownia by root cuttings involves four main stages:

1. Collection and treatment of root cuttings.

Young root cuttings are collected during the plant's dormancy period, from December to March, provided that the soil is neither frozen nor covered with snow. Cuttings should be taken from young trees aged no more than 1–2 years. For efficiency, the root systems of these trees are extracted using an excavator. Once collected, the root cuttings are cleaned of soil and treated with fungicide. The optimal size for cuttings is 1.5–3.0 cm in diameter and approximately 10 cm in length. From a single one-year-old mother plant, 20–30 root cuttings can be obtained, and this number doubles for two-year-old plants.

In three-year-old hybrids that were studied, the root system extended to a maximum depth of about 50 cm on both sides. Surface root formation is influenced by shallow watering. Polarity is an important consideration during root cutting propagation, as mistakes in planting orientation may occur. After collection, the cuttings should be kept in a dry, well-ventilated area for 5–10 days prior to planting to promote better rooting.

Even the thicker parts of the root system that are unsuitable for standard cuttings can still be used to produce seedlings. However, these seedlings are not employed for high-quality industrial timber or nearby forest plantation biomass, as they are cost-prohibitive. Instead, they are mainly used for individual planting in gardens and parks, along streets and avenues to filter exhaust gases, for creating windbreaks in agriculture, establishing new tree lines, or mitigating the spread of invasive species.

If planted correctly, root cuttings from one-year-old plants can achieve a 100% success rate in establishment.

2. Planting cuttings in containers filled with substrate.

The root cuttings should be planted in containers made from suitable materials and filled with substrate. The proximal end of the root (closer to the stem) should be placed upward, at the surface of the substrate. The proximal end is cut at a 90° angle, while the distal end (farther from the stem) is cut at a 45° angle, meaning the lower part of the cutting should be angled downward.

Cuttings are manually placed so that they lie flat at the same level as the substrate surface. Typically, square PVC containers with a height of 12–15 cm and a volume of 1.0–1.5 liters are used. Perforated PVC bags of the same volume may also be used as a more cost-effective alternative, though they are less efficient compared to solid PVC containers.

Standard substrates with good air–water balance are used to promote rooting

3. Rooting of Root Cuttings

For successful rooting, consistently moist substrate and an ambient temperature of at least 20 °C are required. Rooting takes place in warm, enclosed environments. Due to the presence of intrinsic nutrients, root segments begin to develop adventitious roots from buds aligned parallel to the shoot axis and from meristematic cells.

For optimal shoot development, the cuttings should be provided with either artificial white light (in the range of 4500–6500 K) or sufficient natural daylight during long-day conditions.

The extent of callus formation (scar tissue) on the root cuttings depends on the species or hybrid form, as well as the external rooting conditions. According to experimental observations, the rooting success rate reaches approximately 97%.

4. **Germination of New Plants**

Cuttings that have developed 1–3 shoots and reached a height of 10 cm can be transplanted to a new location in late spring, when there is a risk of flowering. During planting, excess shoots can be removed, leaving only one, though it is also possible to leave all of them, as the seedlings are transplanted after the completion of their first vegetative cycle, which results in their being pruned (at the root collar area).

The seedlings are planted in soil that has been pre-prepared in the nursery (including tilling, plowing, and disking) into furrows designed for drip irrigation, which are then covered with 120 cm wide black plastic film. The planting is done in such a way that the seedlings are placed through triangular-shaped openings in the film (forming an "X" pattern), with 60–80 cm spacing between plants in the row and 50–60 cm between rows. This method was tested during the experiment, and all necessary stages were applied during the planting of root cuttings.

3. RESULTS AND DISCUSSION

The experiment consisted of several stages:

1. Preparatory stage (September 2023).

During the preparatory stage, the objectives and tasks of the experiment were defined:

To study the growth and development of Paulownia tomentosa from root cuttings under experimental conditions.

To determine the optimal conditions for rooting and growth; measure the growth rate; assess the impact of various factors (light, humidity, temperature, substrate type). Since introduction requires adaptation to the climate and natural conditions of the new region, it is considered effective to examine the response of the research subject to the influence of different factors.

The next step in the preparatory phase involved the collection and preparation of cuttings. Root cuttings were extracted from the root system of 1–2-year-old Paulownia tomentosa trees grown from seeds in the Botanical Garden of IKTU, as shown in "Figure 3." The upper part of the trees was pruned, and root cuttings were harvested from the root system. The length of the root cuttings ranged from 6 to 8 cm. After extraction, the cuttings were cleaned of soil and prepared. Their length was adjusted according to the length of the planting containers. The upper part of the cuttings was cut at a 90° angle, and the lower part was cut at a 45° angle in preparation for planting. The harvested root portions were replanted in the soil, and new shoots began to emerge from them.

Figure 2. *Root cutting process of Paulownia tomentosa*

Two types of substrates were used for the experiment: peat and soil. Peat provided good aeration and moisture retention, while the soil had a dense structure and supplied nutrients. To accelerate root formation, the cuttings were treated with the phytohormone Kornevin and planted in prepared substrates at a depth of 5-7 cm. The cuttings, which were trimmed at a 90° angle, were left 1-2 cm above the surface of the substrate. Planting was carried out in a greenhouse.

Main Phase (September 2023 – May 2024) During the main phase, care and monitoring activities were organized. The study was divided into 5 groups based on different conditions:

Group 1: peat, normal humidity, normal temperature;
Group 2: peat, high humidity, lower temperature;
Group 3: peat, high humidity, normal temperature;
Group 4: soil, normal humidity, normal temperature;
Group 5: soil, high humidity, lower temperature.

Watering of the planted cuttings was carried out twice a week for the high humidity groups and once a week for the groups with normal humidity. The plants were placed in areas with good lighting to ensure adequate sunlight exposure. The greenhouse temperature was maintained at 20-

25°C (normal temperature) and 15-20°C (slightly lower temperature). Weekly measurements of growth (seedling height), leaf count, and stem diameter were taken.

RESULTS: Rooting and Initial Growth (October – November 2023) Two weeks after planting, the first seedlings appeared (see "Figure 3"). The fastest rooting was observed in the group with peat, normal humidity, and normal temperature (Group 1). Rooting and seedling emergence showed different results across the groups. Accordingly: Group 1 – 95%, Group 2 – 80%, Group 3 – 85%, Group 4 – 75%, and the lowest rooting rate was observed in Group 5, at 70%. These values were calculated by dividing the number of rooted and emerged cuttings in each group by the total number of cuttings in the group and multiplying the result by 100.

a) б)

Figure 3. *a, b – The beginning of seedling emergence from rooted cuttings*

The poorest results were observed in the group with soil substrate, high humidity, and lower temperature, where rooting was slow or completely absent, and signs of rotting were observed in some cuttings. In our case, due to the high humidity, moss formation was observed on the surface of the substrate.

Moss growth on the substrate restricted airflow, leading to the rotting of the cuttings. Typically, if not addressed promptly, this can lead to the initiation of fungal diseases.

Growth and Development (December 2023 – February 2024)

In December, active seedling growth was observed in the peat-based groups. The soil-based groups showed slower growth, especially under high humidity.

Effect of Factors (March – May 2024)

The highest seedling height and leaf count were recorded in Group 1. The peat and high humidity group showed good growth results, but excessive humidity caused some cuttings to rot, and seedlings began to wilt and die. The soil substrate groups continued to show slow growth and relatively smaller stem diameters. Plants exposed to lower temperatures exhibited very slow growth, regardless of substrate type or humidity levels. The average seedling height, leaf count, and stem diameter results for each group can be seen in the following table, "Table 1."

Table 1. *Average results based on the latest data of the study groups*

Groups	Average height of shoots (cm)	Average number of leaves	Average stem diameter (mm)
1	41	10	8.5
2	31	8	6
3	36	7	6.5
4	28	7	5
5	22	5	4

The experiment results show a significant impact of different conditions on the growth of Paulownia rooting cuttings.

The most successful group in terms of plant height was Group 1 (average height 41 cm), which was grown in peat under normal humidity and temperature. Group 2, grown under high humidity and low temperature, showed an average height of 31 cm. This decrease in height could be attributed to the fact that high humidity and low temperature slow down metabolic processes in plants and increase the risk of diseases, which is also supported by the observation of moss formation on the cutting substrate.

Effect of Substrate on Seedling Growth:

A comparison of Groups 1 and 4, grown in peat and soil under normal humidity and temperature, showed that cuttings grown in peat reached a greater height (41 cm versus 28 cm). Peat provides good aeration of the root system, which promotes active root growth and, as a result, increases the overall biomass of the plant.

Leaf Count and Stem Diameter:

The average number of leaves also varied depending on the growing conditions. Group 1 showed the highest number of leaves (10), which can be explained by optimal conditions for photosynthesis and transpiration. At the same time, Groups 4 and 5, grown in soil, showed fewer leaves (7 and 5, respectively), which could be due to the poor aeration and drainage of the soil compared to peat.

Figure 4. *Appearance of Group 1 Paulownia tomentosa seedlings in May*

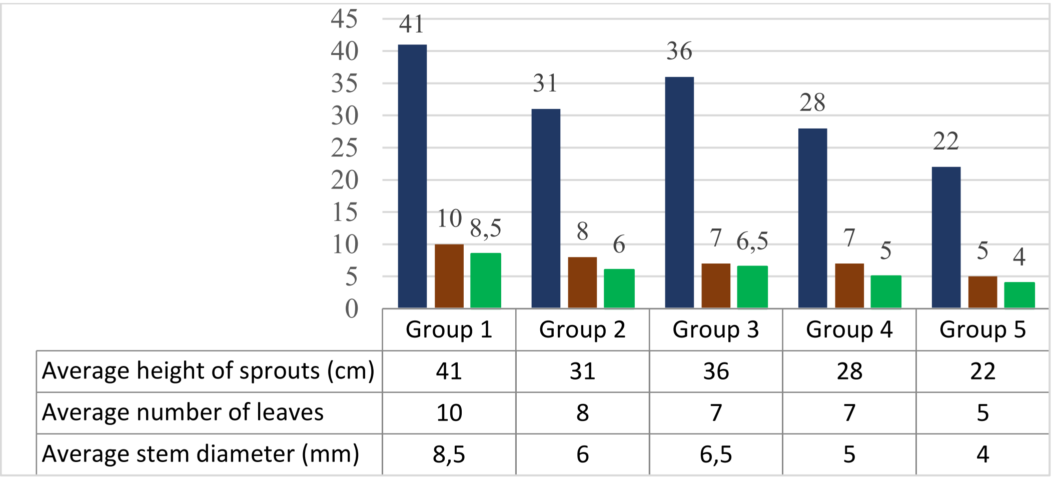
Based on the results and data obtained in the final phase of the experiment, a statistical analysis was performed.

Using specific formulas, the standard deviation and standard error were calculated. The results of the analysis can be seen in the following table, "Table 2"

***Table 2** – Results of the statistical analysis*

Groups	AHS (cm)	SD	SEM	ANL	SD	SEM	ADS (mm)	SD	SEM
1	41	1.61	0.38	10	1.49	0.35	8.5	1.58	0.37
2	31	2.18	0.54	8	1.35	0.34	6	1.51	0.38
3	36	3.06	0.74	7	1.38	0.33	6.5	1.52	0.37
4	28	1.34	0.34	7	1.35	0.34	5	1.50	0.38
5	22	1.36	0.36	5	1.24	0.33	4	1.50	0.40

The stem diameter was maximal in Group 1 (8.5 mm), which further confirms the suitability of these growing conditions for Paulownia. The following figure shows the appearance of the seedlings in Group 1 in May (Figure 5). Groups grown under high humidity and low temperature showed a decrease in stem diameter, likely due to unfavorable conditions for strong wood structure development.



- average height of shoots (cm)

- average number of leaves

***Figure 5.** Graphical representation of the average results based on the latest data of the study groups*

AHS-average height of shoots
ANL-the average number of leaves
ADS-the average diameter of the stem
SD - the standard deviation
SEM - a standard error

To calculate SD (standard deviation) and SEM (standard error of the mean), standard formulas are used. For example, the formula for calculating SD (standard deviation) is:

$$SD = \sqrt{\frac{\sum(x-\mu)^2}{N}}$$

Where, x - the rate of each escape

μ- the average value

N - total number of shoots

SEM is calculated using the formula: $$SEM = \frac{SD}{\sqrt{N}}$$

4. CONCLUSION

Based on the results of the experiment, the following conclusions can be drawn:

- The optimal conditions for rooting and growth of Paulownia tomentosa from root cuttings include the use of peat as a substrate, moderate humidity, and a temperature range of 20–25 °C;
- High humidity promotes rapid growth but may also lead to the development of various diseases, wilting, and rot;
- Soil as a substrate, particularly under conditions of high humidity, provides less favorable conditions for rooting and growth.

Temperatures below the optimal range slow down plant growth regardless of the substrate type and moisture level. Additionally, it was observed that under optimal temperature conditions, the number of leaves is higher, but their size is smaller, whereas at lower temperatures, the number of leaves is reduced but they tend to be larger.

Thus, the experiment suggests that maintaining an optimal temperature is the key factor for successful plant cultivation.

AUTHOR CONTRIBUTIONS

Author Contributions: S.N.N. Conceptualization, Data curation, Formal analysis, Investigation. S.N.N. and B.G.A. Conceptualization, Formal analysis, Investigation, Writing – review & editing. S.N.N. and B.G.A., N.A.T. Writing – original draft. S.N.N. and B.G.A.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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