

Germination Characteristics of *Styphnolobium japonicum* (L.) Schott Seeds and Their Ecological Significance in Urban Greening

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Abstract

This article examines the growing emphasis placed in Uzbekistan on the cultivation of ornamental tree species that provide environmental benefits and can also serve as productive sources of raw materials in residential areas, recreational zones, and the grounds of enterprises and organizations. Particular attention is given to the Japanese pagoda tree, *Styphnolobium japonicum* (L.) Schott. The paper presents its botanical characteristics and distribution, seed storage longevity, and laboratory germination performance, and discusses its significance for urban greening on the basis of contemporary scientific literature.

Keywords

Japanese Pagoda Tree, *Styphnolobium japonicum* (L.) Schott, Urban Greening, Landscaping, Navoi, Ornamental Tree, Promising Tree Species, Seed Germination, Drought Resistance, Urban Green Infrastructure, Microclimate

1. Introduction

In recent years, particular attention has been paid in Uzbekistan to urban greening and landscaping. The range of ornamental trees adapted to local soil and climatic conditions is being expanded, and promising species and forms are being introduced. Research is being conducted to establish green spaces in urban environments and to increase the diversity of biologically resilient tree species used for landscaping. Ornamental trees play an essential role in improving the appearance and environmental quality of settlements, especially towns and cities. In addition to their aesthetic function, trees provide important ecosystem services by creating

shade through interception of solar radiation, moderating wind speed, trapping dust particles on leaf surfaces, and contributing to the reduction of certain gaseous pollutants [1] [2]. In arid regions, their ability to tolerate high temperatures, water scarcity, and urban stress becomes an equally important selection criterion. At a time when large-scale construction and landscaping are taking place throughout the country, green spaces and landscape design should be developed around new facilities in parallel with construction. This requires the production of ornamental tree seedlings capable of adapting to local conditions. Plants selected for landscaping should be well adapted to urban conditions and relatively resistant to adverse influences [3]. Appropriate selection of tree species is therefore crucial in urban landscaping, while unfavorable local soil and climatic conditions must also be considered [4]. One of the principal objectives of greening is to create a healthy, aesthetically complete natural environment for people. Identifying ornamental plants for newly developed areas, selecting and preserving highly decorative trees and shrubs, propagating them, and studying their bioecological characteristics are matters of both scientific and practical importance [1] [2]. The Japanese pagoda tree, *Styphnolobium japonicum* (L.) Schott (syn. *Sophora japonica* L.), is one such multifunctional tree species. According to Kew Science, its native range is associated with central and southern China, whereas it has been introduced into Japan, Uzbekistan, and many other regions [5]. It is widely planted as an ornamental tree in cities around the world and is valued for its broad crown, whitish-cream flowers in the second half of summer, relatively long growing season, tolerance to heat and drought, and resistance to urban pollution [6] [7]. The presence of Japanese pagoda trees in Navoi provides practical evidence that the species can grow under local conditions. However, the climate of Navoi Region is not uniform: substantial differences in temperature, precipitation, and water availability occur between the irrigated and urbanized southern zones and the northwestern desert areas. For this reason, a scientifically sound approach is not to recommend the species uniformly throughout the entire region, but rather to develop differentiated recommendations according to agroclimatic and irrigation conditions [8] [9]. Navoi is one of Uzbekistan's youngest major industrial centers. Creating an environment that meets high ecological, climatic, and aesthetic standards, preserving existing green areas, and expanding them are pressing tasks. In recent years, the construction of new roads and residential areas has altered natural landscapes in and around Navoi. This further increases the need to study the composition of the city's dendroflora, identify promising ornamental species, and analyze their bioecological characteristics. In view of Navoi's distinctive climatic conditions, soil properties, and level of anthropogenic pressure, assessing the ecological adaptability and morphobiological characteristics of trees and shrubs growing in the city and selecting promising species for urban landscape design are of considerable scientific and practical importance.

2. Materials and Methods

The Japanese pagoda tree (*Styphnolobium japonicum* (L.) Schott)—one of the or-

amental tree species used for landscaping in the city of Navoi—was selected as the subject of the study. Seeds were collected from ornamental *Styphnolobium japonicum* trees growing in Navoi during late October and November of 2024 and 2025 and were stored at room temperature (20°C - 25°C) under ambient relative humidity conditions. Seed germination under laboratory conditions was determined using Petri dishes or a moist substrate; the experiment employed various temperature regimes—specifically 15°C, 20°C, 25°C, and 30°C—and the number of germinated seeds was recorded (**Figure 1**).



Figure 1. Process of determining the laboratory germination capacity of Japanese pagoda tree (*Styphnolobium japonicum* (L.) Schott) seeds.



Figure 2. Mature, healthy, mechanically undamaged seeds.



Figure 3. Mass of 100 seeds.

For the experiment, mature, healthy, and mechanically undamaged one- and two-year-old seeds were selected (Figure 2). The mass of 100 seeds was 16.18 g (Figure 3). Prior to sowing, two different soaking methods were employed: soaking in purified/distilled water (Figure 4) and treatment with hot water at 80 °C for 10 minutes (Figure 5).



Figure 4. Seeds soaked in distilled water.



Figure 5. Seeds soaked in hot water at 80 °C for 10 min.

For seeds stored for one year, the highest germination rate was 88% at 25 °C, whereas for seeds stored for two years, this figure was 76%. At 15 °C, germination rates were 72% and 60% respectively; at 20 °C, they were 80% and 68%; and at 30 °C, they were 64% and 56%. Seed germination was expressed using the formula:

$$G = (n/N) \times 100$$

where n is the number of germinated seeds, and N is the total number of seeds used in the experiment.

Germination was calculated as a percentage representing the ratio of seeds that germinated within 10 days to the total number of seeds tested. Comparisons regarding temperature and storage duration were made descriptively. The statistical significance of the differences was not assessed due to the absence of independent experimental replicates.

3. Results and Discussion

The study examined the role of the Japanese pagoda tree, *Styphnolobium japonicum* (L.) Schott, in improving the visual quality of Navoi, maintaining ecological balance, and contributing to atmospheric purification, as well as the laboratory germination of its seeds. Japanese pagoda tree is a deciduous member of the Fabaceae and can reach 15 - 25 m in height under favorable conditions. It has a broad crown and odd-pinnate leaves, usually consisting of 7 - 17 leaflets. The flowers are whitish-yellow to cream-colored and are borne in large panicles. The fruit is a several-seeded pod with a distinctly constricted, segmented appearance [5] [10].

Division: Angiospermae (flowering plants)

Order: Fabales

Family: Fabaceae

Genus: *Styphnolobium* Schott

Species: *Styphnolobium japonicum* (L.) Schott

Synonym: *Sophora japonica* L.

In many members of the Fabaceae, a thick seed coat with low water permeability causes physical dormancy. This characteristic has also been reported for seeds of the Japanese pagoda tree. Choi, Tak, and Kim investigated the effects of scarification, hot-water treatment, and other pre-sowing treatments on seed germination and showed that the hard seed coat is one of the factors limiting germination [11]. Therefore, improving seedling production technology requires consideration not only of temperature, but also of seed-coat water permeability and appropriate pre-sowing treatments (Table 1).

Table 1. Laboratory germination of 1-year-old and 2-year-old *Styphnolobium japonicum* (L.) Schott seeds.

Storage period	Temperature (°C)	Number of seeds tested	Number of germinated seeds (in 10 days)	Germination %
1 year	15°C	25	18	72%
1 year	20°C	25	20	80%
1 year	25°C	25	22	88%
1 year	30°C	25	16	64%
2 years	15°C	25	15	60%
2 years	20°C	25	17	68%
2 years	25°C	25	19	76%
2 years	30°C	25	14	56%

Among the temperatures tested during the ten-day observation period, the highest germination rate for both seed batches was recorded at 25°C: 88% for seeds stored for one year and 76% for those stored for two years. The lowest rates were observed at 30°C, amounting to 64% and 56%, respectively. The germination rate of seeds stored for one year exceeded that of seeds stored for two years by 12

percentage points at 15°C, 20°C, and 25°C, and by 8 percentage points at 30°C.

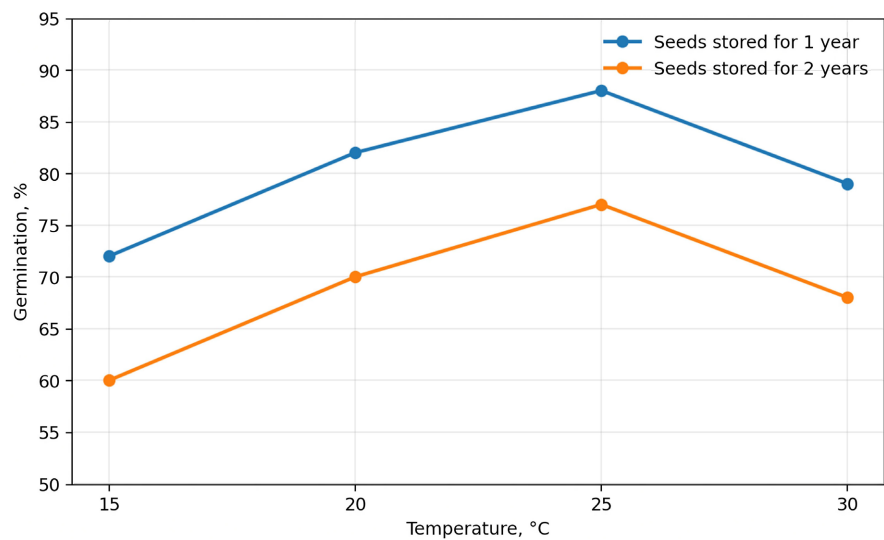


Figure 6. Seed germination as affected by storage duration and temperature.

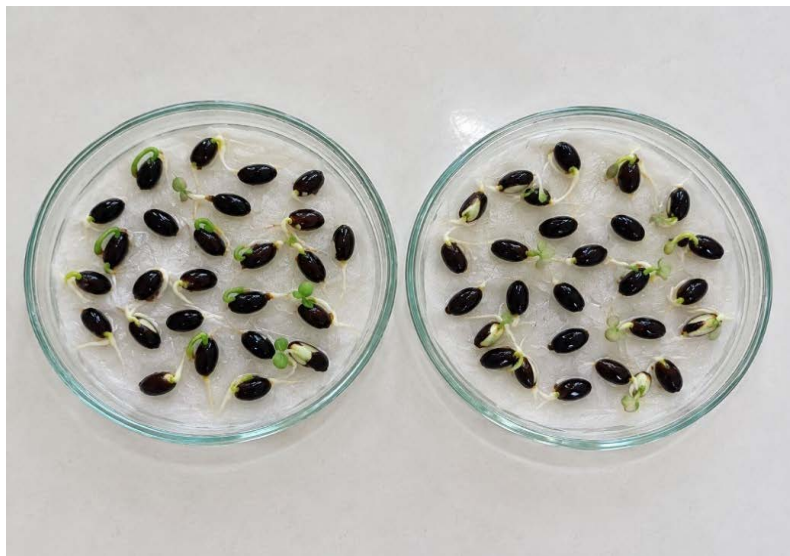


Figure 7. One-year-old and two-year-old seeds germinated at 25°C after 10 days.

The results showed that in **Figure 6** and **Figure 7**, within the tested temperature range, 25°C provided the most favorable conditions for germination of Japanese pagoda tree seeds. Germination proceeded more slowly at 15°C, while a decline was observed at 30°C compared with 25°C. This pattern is consistent with general physiological principles concerning the effects of temperature on enzymatic activity and respiration in seeds. The decrease in germination with longer storage may be associated with physiological ageing of the seeds, changes in membrane and enzyme systems, and altered permeability of the seed coat.

Among the temperatures tested, the highest germination rate was observed at 25°C, reaching 88% for seeds stored for one year and 76% for seeds stored for two

years. Higher germination rates were recorded across all temperatures for the seeds stored for one year.

The literature indicates that the hard seed coat of Japanese pagoda tree can restrict germination and that scarification may increase germination in some seed lots [11]. In the present experiment, however, germination of 76% - 88% was obtained at 25°C even without scarification. This difference may be related to seed maturity, collection and storage conditions, seed-coat permeability, and characteristics of the local seed source. Future experiments should therefore investigate mechanical scarification, storage moisture, and seed-coat water permeability in combination. The present study provides initial practical data on the laboratory germination of seed material formed under Navoi conditions. The results suggest that nurseries should avoid prolonged seed storage where possible, use fresh seed or lots stored for no more than one year, and test germination at temperatures around 25°C. In the longer term, producing planting material from locally sourced seed may provide a practical basis for increasing the supply of planting stock adapted to regional conditions, renewing street and park trees, and making use of the ecological potential of this species in arid urban greening.

4. Ecological Significance of Japanese Pagoda Tree in Urban Greening

The value of Japanese pagoda tree in urban greening is determined by the combination of its ornamental, microclimate-regulating, and sanitary-hygienic properties. Its broad, dense crown provides effective shade during summer, its compound pinnate leaves retain a green appearance for a relatively long growing period, and its fragrant whitish-cream flowers create an ornamental effect in the second half of summer after the main flowering period of many other tree species has ended. Sources from Kew, the Missouri Botanical Garden, NC State Extension, and the Royal Horticultural Society note that the species is widely used as an urban, street, and park tree and that mature trees show tolerance to heat, drought, air pollution, and a range of urban conditions [5]-[7].

The role of this species in moderating the urban microclimate is important for practical landscaping. In field measurements conducted by Kántor, Kovács, and Takács beneath a mature *Sophora japonica* tree in Szeged, mean air temperature was 0.5°C lower, mean radiant temperature was 22.1°C lower, and physiological equivalent temperature (PET) was 9.3°C lower than at an exposed sunny location [12]. These results indicate that the tree's principal cooling effect is not limited to reducing air temperature; it also blocks direct solar radiation and thereby lowers the heat load experienced by the human body. In cities such as Navoi, where summer solar radiation is high, shade trees of this type may improve thermal comfort along pedestrian routes, boulevards, public squares, and recreational areas, although site-specific field assessments under local microclimatic conditions are still required.

Recent studies on dust and atmospheric pollutants also support the ecological

services provided by Japanese pagoda tree. In a study conducted under arid conditions in Aksu, *Styphnolobium japonicum* was identified as one of the species with a high capacity for dust retention and wind attenuation; under the conditions of that study, dust retention reached $656.50 \text{ g}\cdot\text{m}^{-2}$, and a wind-reduction effect was observed over distances exceeding 60 m [13]. In a species-specific air-purification index developed for cities in northern China, *S. japonicum* was included among recommended urban greening species based on a combined set of indicators related to PM_{2.5}, PM₁₀, O₃, and NO₂ [14]. In an experiment published in 2025, Japanese pagoda tree was rated highest among four tree species for NO₂ purification per unit leaf area under different environmental conditions [15]. At the same time, the ecological benefits of urban trees should be assessed not only in terms of species characteristics but also in relation to planting design. Observations in a street canyon in Shenyang involving *Sophora japonica* and *Ulmus pumila* showed that trees helped reduce coarse particulate matter (PM₄, PM₁₀, and TSP), whereas during some periods the concentrations of fine PM₁ and PM_{2.5} were higher at tree-covered sites. The authors attributed this to reduced airflow caused by the canopy [16]. Thus, excessively dense planting should be avoided in narrow streets bordered by tall buildings, and tree spacing, crown height, and prevailing ventilation direction should be taken into account. Such an approach can help maximize the positive effect of urban greening on air quality.

5. Conclusions

Styphnolobium japonicum (L.) Schott is a multifunctional tree species combining ornamental, microclimate-regulating, and sanitary-hygienic functions. Its broad crown and late-summer flowering enhance the decorative quality of streets, boulevards, and parks, while its tolerance of heat, drought, and urban pollution makes it a promising species for greening arid cities. Field studies indicate that shade from mature *Styphnolobium japonicum* can substantially reduce human thermal load, while other investigations demonstrate its potential for dust retention and NO₂ removal [12]-[15]. However, because a dense canopy can reduce air exchange in narrow street canyons, planting schemes should be adapted to the local environmental context [16]. Urban trees require sufficient growing space. Depending on species and growth characteristics, approximately 4 - 50 m² of land may be required for optimal development. Only under suitable conditions can trees effectively perform such functions as absorbing carbon dioxide and releasing oxygen, trapping dust, humidifying the air, producing phytoncides, and providing aesthetic benefits [17]. Within the tested range of 15°C - 30°C, the highest seed germination was observed at 25°C: 88% for seeds stored for one year and 76% for seeds stored for two years. The highest germination rate in the trial was observed at 25°C; a lower germination rate was recorded for the seed batch stored for two years. For Navoi and other hot, arid regions, future studies should comprehensively evaluate scarification, substrate and irrigation regimes, field emergence, salinity and drought tolerance, shading efficiency, dust retention, and air-quality-

related indicators.

At the same time, the conclusions of this study are limited by the use of laboratory conditions, seed material from a single area, and a restricted range of storage durations. Field emergence, seedling survival, drought and salinity tolerance, irrigation requirements, long-term responses to urban dust and gaseous pollutants, and the effects of different planting schemes on microclimate and air exchange should be evaluated in separate experiments. In particular, field measurements under Navoi conditions are needed to determine water use by Japanese pagoda tree, crown shading, dust accumulation on leaf surfaces, and its effectiveness in reducing summer heat stress; these represent important directions for future research.

Author Contributions

Aziza Hikmatullo Tursuntosheva conducted the seed germination experiments, collected and analyzed the experimental data, and prepared the manuscript. Anarjan Abdugarimovna Matkarimova supervised the research and provided scientific guidance and critical review of the manuscript. Both authors reviewed and approved the final manuscript.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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