

Seed Germination, Viability, Imbibition and Storage Behaviour of *Radermachera xylocarpa* (Roxb.) K. Schum.: A Research-Based Study

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Abstract

Radermachera xylocarpa (Roxb.) K. Schum. (family Bignoniaceae) is a large, ecologically significant deciduous tree native to the dry and moist deciduous forests of India. Due to habitat degradation, overexploitation, and poor natural regeneration, the species is considered rare and vulnerable in several regions. Efficient seed-based propagation is essential for ex-situ conservation, nursery production, and forest restoration. This study synthesizes research findings on seed morphometrics, imbibition kinetics, viability testing via tetrazolium (TZ) staining, germination performance across different substrates and pre-treatments, and short-term desiccation and storage behaviour. Results show that *R. xylocarpa* produces large, thin, winged, membranous seeds with high seed coat permeability, leading to rapid triphasic water imbibition. Optimization of the 2,3,5-triphenyltetrazolium chloride (TZ) test revealed that a 0.5% concentration with a 24-hour staining period yields accurate viability detection (up to 91.00%), whereas higher concentrations or prolonged staining cause overstaining. Seed germination tests demonstrated that cocopeat substrate provides the highest germination capacity (62%) and superior seedling vigour compared to filter paper (23%), sand, or MS basal medium. Pre-soaking in exogenous gibberellic acid (GA3) was ineffective in improving germination over distilled water controls. Seeds exhibited orthodox storage behaviour, tolerating desiccation down to approximately 5.59% moisture content and maintaining high viability ($68.15 \pm 2.73\%$) after three months of low-temperature storage. These findings provide clear physiological guidelines for nursery propagation, seed testing, and long-term conservation of *R. xylocarpa*.

Keywords: *Radermachera Xylocarpa*; Seed Germination; Seed Viability; Tetrazolium Test; Imbibition Dynamics; Seed Storage; Orthodox Seed; Forest Restoration.

1. Introduction

Radermachera xylocarpa (Roxb.) K. Schum. (syn. *Stereospermum xylocarpum*), commonly known as the Padri tree or Bitter Padri, is a magnificent deciduous tree species belonging to the family Bignoniaceae. Native to the Western Ghats, Central India, and parts of the Deccan Peninsula, the tree yields valuable timber and possesses medicinal properties. Traditionally, leaf juices and fruit decoctions are utilized in ethnomedicine for treating metabolic disorders such as diabetes.

Despite its ecological and economic value, *R. xylocarpa* faces threats of population decline due to habitat fragmentation, timber exploitation, and limited natural regeneration in forest ecosystems. Natural seed dispersal occurs via large, woody, falcately curved capsules that split open to release wind-dispersed, rectangular, winged seeds. However, field emergence is frequently restricted by seed decay, seasonal drought, and unoptimized soil conditions.

To support nursery production and conservation planning, detailed insights into the seed functional traits, imbibition kinetics, viability evaluation, substrate performance, and storage physiology are necessary. This paper synthesizes

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empirical data on *R. xylocarpa* seed biology to establish standardized protocols for nursery managers and restoration practitioners.

2. Materials and Methods

2.1. Seed Collection and Morphometrics

Mature, dry woody capsules of *R. xylocarpa* were collected prior to dehiscence from natural forest stands. Seeds were extracted, air-dried, and screened for mechanical damage or insect infestation. Seed weight (100-seed mass), length, width, and coat characteristics were measured to establish morphometric traits.

2.2. Imbibition Kinetics

Seed water absorption kinetics were evaluated by soaking dry seeds of known initial mass in distilled water at ambient laboratory temperature ($25 \pm 2^\circ\text{C}$). Seed fresh weight was recorded periodically over a 48-hour period after blot-drying excess surface water to determine percentage mass increase:

$$\text{Water uptake \%} = (\text{Wt} - \text{Wo}) / \text{Wo} \times 100$$

where Wo is the initial dry weight and Wt is the fresh weight at time t .

2.3. Tetrazolium (TZ) Viability Optimization

Seed viability was evaluated using 2,3,5-triphenyltetrazolium chloride staining. Seeds were pre-hydrated and exposed to various TZ solution concentrations (0.1%, 0.5%, and 1.0%) for different incubation periods (6 h, 12 h, and 24 h) at 30°C in the dark to determine optimal staining parameters for embryo evaluation.

2.4. Germination Experiments and Substrate Comparison

Germination tests were performed using distinct substrate environments:

- **Cocopeat** (sterilized in root trainers)
- **Cocopeat + Sand (1:1 v/v)**
- **Filter Paper** (moistened in Petri dishes)
- **MS Basal Medium** (aseptic culture)
- **Nursery Sand Beds**

Seeds were soaked overnight in distilled water (control) or exogenous growth regulators GA3 ($5\mu\text{M}$), GA3 ($10\mu\text{M}$) prior to incubation at $25 \pm 2^\circ\text{C}$ at 12-hour photoperiod. Germination (radicle emergence $\geq 2\text{mm}$) was recorded weekly for 3 to 4 weeks. Seedling growth metrics (shoot length, root length, fresh weight, and dry weight) were measured 20 days post-emergence.

2.5. Storage Physiology

Seeds were subjected to controlled desiccation to lower moisture content from an initial level (12.93%) down to 5.59% using silica gel. Desiccated seeds were sealed in airtight containers and stored at low temperatures (-20°C) for three months, after which germination capacity and viability were re-assessed.

3. Results and Discussion

3.1. Seed Morphometrics and Imbibition Kinetics

Seeds of *R. xylocarpa* are broad, flat, rectangular, and surrounded by a thin, transparent, membranous wing. The thin seed coat offers minimal physical resistance to water movement.

Imbibition dynamics exhibited a rapid triphasic hydration pattern. Water uptake occurred rapidly during the first hour, reaching a fresh weight increase of 221.20%, and plateaued at approximately 480.69% by 30 hours. This high permeability indicates that *R. xylocarpa* seeds lack physical dormancy (coat-imposed impermeability).

3.2. Tetrazolium Viability Testing

Because *R. xylocarpa* seeds possess highly permeable testas, standard TZ concentrations and long incubation durations can cause chemical over staining, obscuring tissue differentiation.

The optimum staining condition was achieved at **0.5% TZ concentration for 24 hours at 30°C**, yielding clear pink/red embryo staining and a maximum reported viability of 91.00%. High-concentration treatments (1.0%) resulted in dark, over stained tissue that confounded viability interpretation.

3.3. Germination Dynamics across Substrates

Substrate composition significantly affected germination percentage and seedling vigour. Cocopeat proved to be the optimal substrate, achieving 62% total germination. MS basal medium sustained 46\% germination, while filter paper resulted in low germination (23%) due to rapid drying and poor moisture retention around the broad winged seed.

Table 1: Seed germination performance of *Radermachera xylocarpa* across different substrates (overnight water pre-soak)

Substrate / Medium	Germination (%)	Seedling Establishment Response
Cocopeat	62.00	Healthy seedling development; high survival post-transfer
MS Basal Medium	46.00	Good germination; poor survival during ex-vitro transfer
Cocopeat : Sand (1:1)	30.00	Moderate emergence; reduced growth compared to pure cocopeat
Filter Paper	23.00	Desiccation-sensitive; incomplete radicle elongation

Although MS medium supported initial germination, seedlings transferred from *in vitro* flasks to soil conditions suffered high mortality. In contrast, seedlings grown in root trainers with cocopeat established robust root-shoot systems and successfully acclimatized to field conditions.

3.4. Response to Pre-sowing Growth Regulator (GA3)

Exogenous application of gibberellic acid (GA3 (5µM), GA3 (10µM)) did not enhance germination rates compared to distilled water controls. Control seeds (overnight water soaking) showed higher final germination percentages and superior total seedling length and biomass. This confirms that physiological dormancy is absent or negligible in freshly harvested mature seeds of *R. xylocarpa*.

Table 2: Effect of pre-sowing treatments on seedling growth parameters of *R. xylocarpa* in cocopeat (20 days post-emergence)

Treatment	Germination (%)	Seedling Length (cm)	Fresh Weight (g)	Dry Weight (g)
Control (Water Soak)	62.00	Superior	Higher	Higher
GA3 (5µM)	<62.00	Reduced	Lower	Lower
GA3 (10µM)	<62.00	Reduced	Lower	Lower

Source: Trivedi et al. (2016)

3.5. Storage Physiology and Desiccation Tolerance

Desiccation trials confirmed that *R. xylocarpa* seeds tolerate moisture reduction down to 5.59\% without loss of cell membrane integrity.

Table 3: Seed moisture, viability, and germination responses during short-term storage

Storage Condition / Stage	Seed Moisture Content (%)	Viability / Germination (%)	Storage Category
Freshly Harvested	12.93 ± 0.45	91.00 (TZ Viability)	Baseline
Desiccated	5.59 ± 0.22\$	64.17 ± 2.57	Desiccation Tolerant
Stored (3 Months at -20°C)	5.59 ± 0.22\$	68.15 ± 2.73\$	Orthodox

Seeds maintained stable germination capacity (68.15%) after three months of sub-zero storage (-20°C). These characteristics demonstrate **orthodox seed storage behaviour**, indicating that long-term ex-situ seed banking is a viable conservation strategy for this species.

4. Nursery and Conservation Implications

- **Nursery Substrate Selection:** Pure cocopeat in root trainers is recommended over conventional sand beds or plain filter paper for mass propagation. Cocopeat maintains high aeration and moisture around the flat, winged seeds.
- **Simple Pre-sowing Protocols:** Chemical scarification or hormonal stimulation (GA₃ is unnecessary. A simple overnight (12–24 h) soak in clean ambient water is sufficient to maximize germination.
- **Ex-situ Conservation:** Because seeds tolerate desiccation to $\sim 5\%$ moisture content and survive sub-zero temperatures (-20°C), medium and long-term seed banking can be established for wild populations in regional gene banks.

5. Conclusion

Radermachera xylocarpa produces non-dormant, highly permeable orthodox seeds that rapidly absorb water upon hydration. Seed viability can be evaluated using a 0.5% tetrazolium solution for 24 hours. Nursery germination is optimized using cocopeat substrate following a 12–24 hour water soak, achieving up to 62% germination without requiring hormone treatment. Furthermore, the species' desiccation and low-temperature tolerance enables ex-situ seed storage for forest conservation and ecosystem restoration programs.

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