E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2025; SP-8(1): 95-99
Received: 29-10-2024
Accepted: 02-12-2024

Rahul HK
College of Forestry, Ponnampet, Karnataka, India

Vasudev L
College of Horticulture, Hiriyur, Karnataka, India

Ramakrishna Hegde
College of Forestry, Ponnampet, Karnataka, India

Suresh D Ekbote
ZAHRS – Hiriyur, Karnataka, India

Parashraurам Chandrvamshi
College of Horticulture, Hiriyur, Karnataka, India

Corresponding Author:
Vasudev L
College of Horticulture, Hiriyur, Karnataka, India

Enhancing germination of *Swietenia macrophylla* King. with Beejamrutha an organic formulation

Rahul HK, Vasudev L, Ramakrishna Hegde, Suresh D Ekbote and Parashraurам Chandrvamshi

DOI: https://doi.org/10.33545/2618060X.2025.v8.i1Sb.2333

Abstract

Aims: This study aimed to evaluate the impact of Beejamrutha treatment on the germination of *Swietenia macrophylla* seedlings.
Study Design: The study followed a comparative analysis using paired t - test of treated and control seed groups to assess germination success.
Place and Duration of Study: The research was conducted in 2024 at the forest nursery of the College of Forestry, Ponnampet, Karnataka, India.
Methodology: Seeds were sourced from mature *S. macrophylla* trees and classified based on physical characteristics, with metrics including color, volume and density. Beejamrutha, a traditional organic formulation, was prepared by fermenting cow dung and urine with soil and lime. Seeds were pretreated with Beejamrutha for 12 hours, while control seeds were soaked in water for one hour. Germination rates, mean daily germination, and other parameters were monitored over the germination period.
Results: Beejamrutha treatment notably enhanced germination rate (From 49.4% to 55.93%), decreased germination initiation time by three days, and improved mean daily germination by 50% over the control. Brown seeds exhibited lower density and larger dimensions than white seeds, influencing their germination patterns and response to Beejamrutha. Furthermore, Beejamrutha treatment doubled the germination value, indicating significant improvements in seed vigor and early growth.
Conclusion: Beejamrutha treatment substantially benefits *S. macrophylla* seed germination and seed vigor, highlighting its potential as a sustainable alternative for improving nursery practices in forestry.

Keywords: *Swietenia macrophylla*, Beejamrutha, germination rate, mean daily germination and organic formulations

1. Introduction

The increasing reliance on chemical fertilizers and pesticides in modern nursery practices has certainly boosted seedling vigor; however, it has also raised significant environmental concerns, including soil degradation, pollution of water resources, and a reduction in food quality (Kannaiyan, 2000) [14]. These unsustainable practices have led to a global call for eco-friendly alternatives, fostering interest in organic farming as a viable solution to mitigate the adverse impacts of chemical inputs. Organic farming emphasizes the use of natural inputs and sustainable techniques to restore soil fertility, enhance biodiversity, and produce safe, nutritious crops. In response, organic bio-fertilizers, such as *Beejamrutha* (A traditional seed treatment bio-fertilizer in India), have gained prominence. *Beejamrutha* (meaning "seed elixir") is specifically formulated for seed treatment and has shown potential in enhancing germination, protecting seedlings from pathogens, and promoting early plant vigor (Palekar, 2006) [1]. Studies have confirmed that *Beejamrutha* contains beneficial microorganisms, including nitrogen fixers and phosphorus solubilizers, which contribute to improved seedling growth and resilience against diseases (Devakumar *et al.*, 2008; Srinivas *et al.*, 2010) [6, 23].

Swietenia macrophylla, or big-leaf mahogany, is a tropical hardwood species highly valued for its durable, fine-grained wood, which is extensively used in furniture making, cabinetry, and construction (Lamb, 1966; Mayhew and Newton, 1998) [16, 17]. Native to Central and South America, this species is widely cultivated in tropical regions for its economic importance and

Contribution to reforestation programs. However, the propagation of *S. macrophylla* in nurseries faces challenges due to slow and inconsistent germination rates, often caused by factors such as seed dormancy and suboptimal environmental conditions (Lamb, 1966) [16]. Given the ecological and economic significance of *S. macrophylla*, improving germination protocols is essential to ensure successful seedling establishment and support sustainable reforestation efforts. Recent studies suggest that organic seed treatments could play a critical role in enhancing the germination and vigor of *S. macrophylla* seedlings. Organic amendments such as cattle urine, vermiwash, and neem seed extract, rich in plant growth regulators and essential nutrients, have demonstrated effectiveness in breaking seed dormancy, promoting faster germination, and encouraging healthy root and shoot development (Dominguez, 2004; Gutierrez-Miceli *et al.*, 2007) [7, 10]. These organic formulations improve soil structure, enhance water retention, and enrich the rhizosphere with beneficial microorganisms, creating an optimal environment for seedling growth. Furthermore, the use of organic treatments aligns with sustainable forestry practices, promoting pest and disease resistance through natural defence mechanisms (Peyvast *et al.*, 2009) [21].

Seed attributes, particularly seed size and density, are widely recognized as determinants of seed vigor- a key factor influencing seedling growth and field establishment under varying environmental conditions (Bewley *et al.*, 2013; Baskin and Baskin, 2014) [3, 2]. Seed vigor is often linked to the reserve nutrient content within the seed, which supports critical early growth stages, enabling the young seedling to establish roots and develop essential structures for survival (Fenner and Thompson, 2005) [9]. Larger and denser seeds generally contain more substantial nutrient reserves, providing seedlings with a robust start, higher stress tolerance, and an enhanced growth trajectory (Moles and Westoby, 2004) [18]. Conversely, smaller or less dense seeds, which contain limited nutrient reserves, may yield weaker seedlings prone to environmental stress and competition (Donohue *et al.*, 2010) [8]. In the context of *S. macrophylla*, understanding the influence of seed size, density, and other attributes on germination success is crucial to optimizing nursery practices and enhancing seedling survival, especially in degraded or nutrient-poor soils (de Oliveira *et al.*, 2015) [5].

Given the importance of seed vigor in forestry and crop science, evaluating seed attributes has become a focal point in research aimed at species conservation and improved cultivation practices (Navarro *et al.*, 2006) [19]. For tropical hardwoods like *S. macrophylla*, maximizing seedling performance necessitates a careful selection of seeds based on their physical attributes, which can act as reliable predictors of germination rates and overall growth success. Seed attributes may also influence the seed's capacity to withstand storage and handling, factors that are crucial for large-scale planting initiatives (Khurana and Singh, 2001) [15]. Consequently, studies focused on seed attributes provide valuable insights for enhancing germination protocols and supporting sustainable cultivation of *S. macrophylla*. In light of these considerations, this research investigated the seed attributes of *Swietenia macrophylla*, particularly seed size and density, and evaluates the effects of *Beejamrutha* treatment on germination outcomes. By identifying optimal seed characteristics and assessing the potential of organic treatments, this study aims to enhance germination rates and support the successful establishment of *S. macrophylla* seedlings under both nursery and field conditions, contributing to sustainable forestry practices and the conservation of this valuable hardwood species.

2. Materials and Methods

The seeds of *Swietenia macrophylla* were collected from mature to medium sized trees and stored at the Seed Development Unit, Nagavala nursery at Mysuru, Karnataka, India. All seeds were collected during the peak harvest season to minimize variability due to environmental conditions. The experiment was carried out in the nursery of College of Forestry, Ponnampet, located in the Hilly zone (zone 9), Kodagu district of Karnataka. Ponnampet is situated at 12° 08′ 48″ N, 75° 56′ 31″ E and at an altitude of 867 m above MSL.

Seed Attribute Analysis

Standardized procedures assessed the key seed parameters such as color, shape, dimensions, volume, density, and moisture content. Seed color and shape were visually assessed and categorized under controlled lighting. Dimensions, including length, width, and thickness, were measured using digital calipers with 0.01 mm precision, based on methodologies adapted from Otalakosk *et al.* (2020) [20]. Seed volume was determined by the water displacement method, where seeds were submerged in a graduated cylinder, and the displaced water volume recorded. Seed weight was carried out on 1000 pure seed weight of the sample. These weights are based on 8 replicates of 100 seeds (ISTA, 1993). Seed density was calculated by dividing seed mass (measured with an analytical balance to 0.001 g accuracy) by volume. Moisture content was evaluated using the oven-dry method, with seeds dried at 105 °C for 24 hours to determine fresh and dry weights. The moisture content percentage was calculated according to ISTA (2024) standards.

Seed germination under Beejamrutha

Beejamrutha was prepared by combining 500 g of fresh cow dung with 500 ml of cow urine in a large container. To this mixture, 10 g of lime was added and the entire mixture was stirred thoroughly to ensure that all ingredients were well combined. A handful of soil, preferably from fertile land, was added to introduce beneficial microorganisms, followed by adding 1 L of water. The mixture was stirred until a uniform consistency was achieved. The container was then covered with a breathable cloth to allow for air circulation while protecting it from contamination and the mixture was left to ferment for 24 hours. After the fermentation process, Beejamrutha was used for pretreatment.

A total of 3000 seeds were subjected to seed germination experiment, where 1500 seeds were treated with Beejamrutha for twelve hours (B) and 1500 seeds were soaked in water for one hour as control (C). The seeds were sown in sand bed and the observations were collected up to the completion of germination.

3. Results and Discussion

Seed Attributes

The data depicted in Table 1 provides comparative seed attributes for winged (Brown) and dewinged (White) seeds, where brown seeds exhibited larger dimensions, with a seed length of 87.75±16.51 mm, width of 18.30±2.58 mm, and thickness of 5.50±1.10 mm. In contrast, white seeds showed smaller dimensions, with a length of 19.30±1.18 mm, width of 8.94±1.02 mm, and thickness of 2.77±0.51 mm.

Moisture content was relatively similar between the two, with brown seeds at 6.74 per cent and white seeds at 5.83 per cent (Fig. 1). Brown seeds, however, are lighter, with a 100 seed weight of 52.66 g compared to 32.15 g for white seeds. Brown seeds occupied a significantly larger volume (Per 100 seeds), measuring 123.07 cm³, compared to just 25.02 cm³ for white seeds. This difference in volume contributed to the lower density of brown seeds (0.28 g/cm³) in contrast to the higher density of white seeds (1.28 g/cm³). These differences in size, volume, and density between brown and white seeds highlighted distinct morphological and physical characteristics, which could influence their handling, storage, and potential germination responses.

Table 1: Seed attributes of *Swietenia macrophylla*

Seed color	Brown	White
Seed shape	Winged seeds	Winged seeds
Seed length (mm)	87.75±16.51	19.30±1.18
Seed width (mm)	18.30±2.58	8.94±1.02
Thickness (mm)	5.50±1.10	2.77±0.51
Moisture content (%)	6.74	5.83
100 seed weight (g)	52.66	32.15
100 seed volume (cm³)	123.07	25.02
Seed density (g/cm³)	0.28	1.28

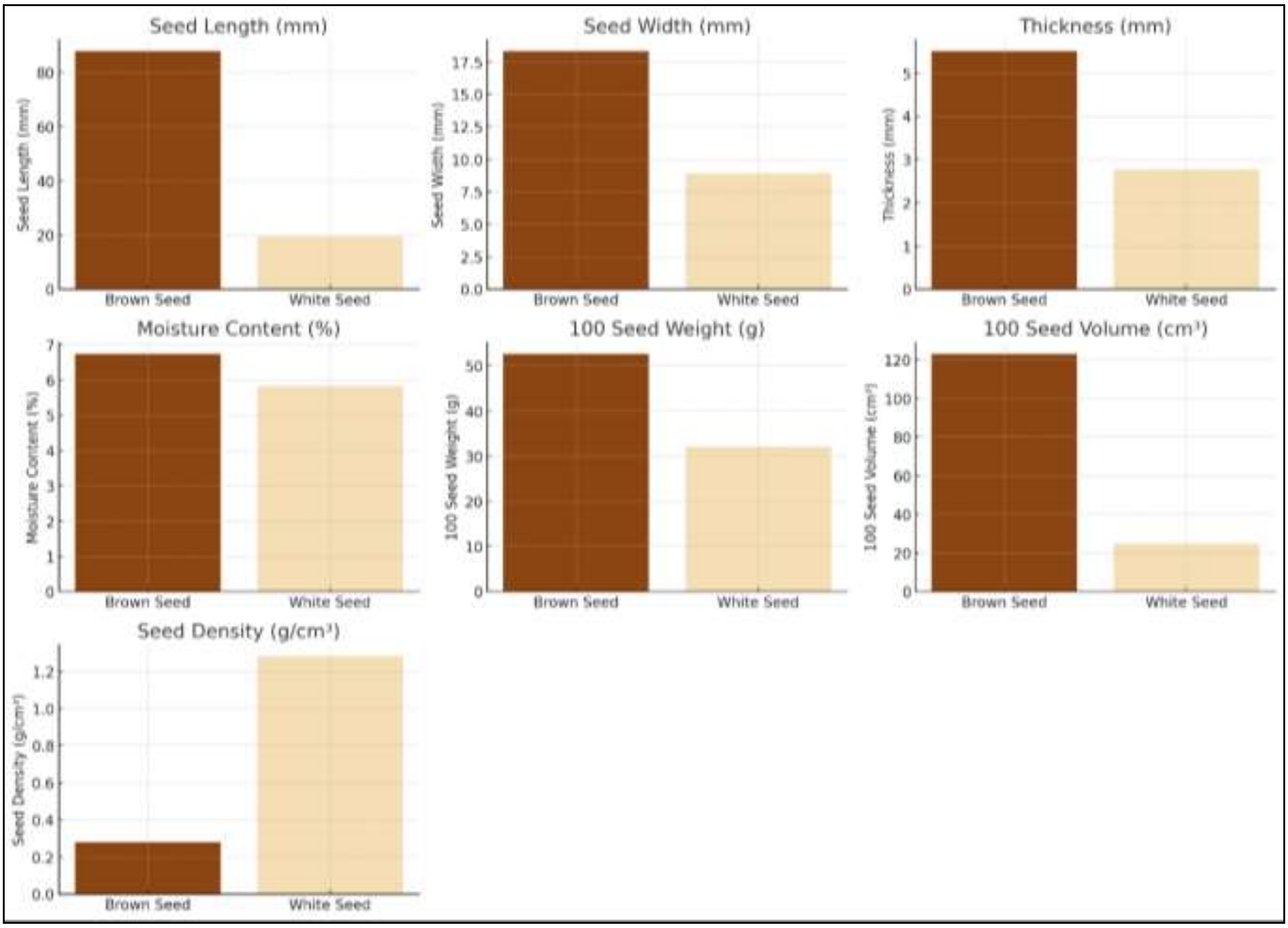

Fig 1: Comparison of seed attributes between brown and white seeds

Seed germination under Beejamrutha

Seed germination and seedling growth are critical for effective plant production, with pre-sowing treatments playing a significant role in these processes. As Salimath *et al.* (2023) [22] emphasize, while genetic factors influence seed germination, environmental conditions such as pre-treatments are crucial. Table 2 reflects the impact of Beejamrutha on seed germination parameters, showing notable improvements compared to the control. Beejamrutha enhanced the germination percentage from 49.4 per cent in the control to 55.93 per cent, yielding a positive response index of 0.13. This increase indicates a beneficial effect of Beejamrutha on the overall germination rate. Hemalatha and Chaudhari (2021) [11] similarly observed that cow dung slurry, a key component of Beejamrutha, provides essential nutrients and promotes beneficial microbial activity, which can enhance germination.

The time to initiate germination decreased from 25 days in the control to 22 days with Beejamrutha, corresponding to a negative response index of -0.12. This reduction suggests that Beejamrutha accelerates the onset of germination, likely by improving seed coat permeability and facilitating water absorption and gas exchange (Chavan *et al*., 2019) [4]. The mean daily germination (MDG) increased from 0.6 in the control to 0.9 with Beejamrutha, reflecting a positive response index of 0.50 (Fig. 2). This indicates that Beejamrutha promotes faster and more consistent germination on a daily basis. The peak germination value improved from 0.89 to 1.21 with Beejamrutha, showing a positive response index of 0.36. This suggests that Beejamrutha enhances the maximum germination rate achieved. Similarly, the germination value nearly doubled from 0.53 to 1.08, resulting in a highly positive response index of 1.04, which underscores Beejamrutha's effectiveness in improving overall seed vigour. Although the germination energy was higher with Beejamrutha (Positive response index of 0.33), indicating a prolonged germination period, the overall performance improvement is evident. This aligns with findings by Sutheesh *et al*. (2016) [24], who noted that cow dung slurry is a cost-effective pretreatment option. Overall, Beejamrutha demonstrates significant advantages in enhancing seed germination.

Table 2: Germination parameters under Control and Beejamrutha

Sl. No.	Germination parameters	Control (Without beejamrutha)	Beejamrutha	Response index	t - value	p-value
1.	Germination (%)	49.40	55.93	0.13	2.503	0.014*
2.	Days taken to initiate germination	25	22	- 0.12	1.434	0.0003**
3.	Mean daily germination (MDG)	0.6	0.9	0.50	3.804	-
4.	Peak value	0.89	1.21	0.36	-	-
5.	Germination value	0.53	1.08	1.04	-	-
6.	Germination energy	23.33	15.53	0.33	-	-

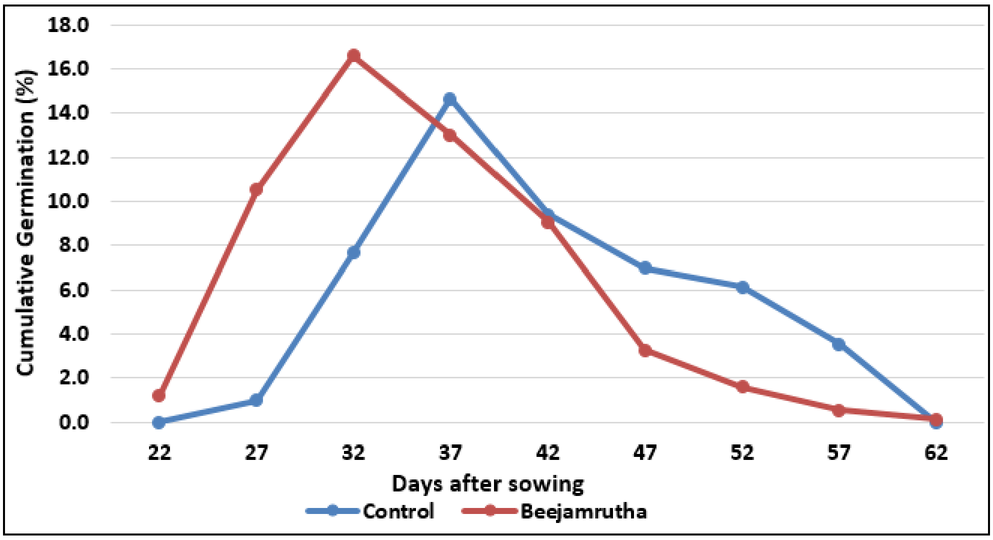

Fig 2: Cumulative germination per cent of *S. macrophylla* seeds

4. Conclusion

Distinct physical attributes of brown seeds, such as larger size and lower density, influenced their handling and germination response compared to white seeds. Additionally, Beejamrutha significantly improved germination percentage, vigour, and reduced germination time, showcasing its potential as a sustainable pre-sowing treatment.

5. Acknowledgements

The authors wish to convey their deepest gratitude to all individuals and the institution who played a crucial role in the successful completion of this original research manuscript.

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