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OPTIMIZING NURSERY-RAISING TECHNIQUES FOR BORPAT (*AILANTHUS GRANDIS* PRAIN) TO ENHANCE ERI SILK PRODUCTION IN NORTHEAST INDIA

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ABSTRACT

The eri silkworm (*Samia ricini*), a polyphagous and multivoltine species is integral to the production of eri silk, a unique silk variety known for its wool-like texture and thermal qualities. It feeds on various host plants, with castor (*Ricinus communis*) being the primary host. However, the perennial borpat (*Ailanthus grandis*) with its year-round leaf availability offers a viable alternative to the seasonal and economically challenging castor. This study explores the nursery-raising techniques for borpat to ensure effective seedling production, addressing the limitations posed by erratic flowering, tall mature trees, and low seed viability. Optimal soil conditions for borpat, including deep, moist, and well-drained loamy soils, are emphasized. The preparation of nursery beds involves meticulous ploughing, levelling, and the use of soil, well-decomposed farmyard manure (FYM), and sand in a specific ratio. Seed collection and treatment are discussed, highlighting the importance of strategic timing and fungicide treatment to combat seed-borne diseases. Seed sowing at a proper depth and spacing is critical for successful germination, and the use of mulch and regular watering is recommended to maintain soil moisture. Weeding is essential during the early stages of seedling development to reduce competition for nutrients. After 3–4 months, seedlings are transferred to polytubes with a soil-sand-FYM mixture to support root growth and nutrient availability. Finally, field transplantation of 6–8 months old seedlings, measuring 2–2.5 feet in height, ensures higher survival rates and better growth performance. This research underscores the need for suitable nursery-raising techniques to enhance the mass propagation of borpat, ensuring a sustainable supply of host plants for eri silkworms contributing to the socio-economic development of rural, hilly, and tribal communities involved in ericulture in North-east India.

***Keywords* :** Borpat, Nursery raising, Perennial host, Eri silk, Ericulture

Introduction

The eri silkworm (*Samia ricini*), is a polyphagous and multivoltine species, that belongs to the family Saturniidae. It is capable of producing 5–6 crops per year depending on the availability of host plant foliage. In tropical Asia, 19 eri silk moths (genus: *Samia*) species have been recorded. Among these, three species *Samia ricini, Samia canningi*, and *Samia fulva* are found exclusively in India (Peigler and Naumann, 2003). The silk produced by *Samia ricini* is known as eri silk, also referred to as 'Endi silk' or 'Erandi silk'. Eri silk cannot be reeled like other silks because it is made from eri cocoons that are open at one end. Eri silk is unique from other silks in that it has the softness and sheen of silk but lacks the lustre. It also has the texture and look of wool. It is a good substitute for wool because of its reputation for toughness and special thermal qualities (Suryanarayana, 2005). In 2022-23, eri silk accounted for 82.3% of the total non-mulberry (Vanya or wild) raw silk production in India, amounting to 7,349 MT out of 8,928 MT (Anonymous, 2023). Eri silkworms are commonly reared in the northeastern states of India. Ericulture can supplement income to many rural, hilly, and tribal communities in

Northeast India. Farmers in several other states, including Uttar Pradesh, Bihar, Jharkhand, Gujarat, West Bengal, Orissa, Madhya Pradesh, Andhra Pradesh, Tamil Nadu, Maharashtra, Karnataka, and Sikkim, have recently taken up ericulture (Patidar *et al*., 2022). The eri silkworm feeds on various host plants including castor (*Ricinus communis*), kesseru (*Heteropanax fragrans*), borpat (*Ailanthus grandis*), borkesseru (*Ailanthus excelsa*), tapioca (*Manihot esculenta*), and payam (*Evodia flaxinifolia*). A total of 31 food plants have been reported for rearing eri silkworms (Singh *et al.,* 2024). Among these, castor is the primary host plant. However, castor requires re-cultivation every six months due to its annual growth nature, presenting significant seasonal and economic challenges. In contrast, borpat (*Ailanthus grandis*), a perennial plant, offers a more reliable alternative because of its year-round leaf availability. The borpat tree produces large amounts of leaves throughout the year and is preferred by eri silkworms after castor leaves shown in Fig. 1 (Ahmed *et al*., 2015).

Fig. 1: Eri silkworms rearing on borpat leaves at farmer's level
(Photo courtesy: Dr. S.A. Ahmed).

The borpat, also known as the "tree of heaven," is a member of the Simaroubaceae family and falls under the Sapindales order. Cytological studies of Meiosis-I have revealed different chromosome counts for this species. Mehra and Khosla (1969) reported 2n=62 whereas, Singhal *et al*. (1985) reported a chromosome count of 2n=64, this discrepancy is likely due to aneuploidy at the diploid level.

The borpat tree features compound, alternate leaves that are 15–20 cm long. It is recognized for its rapid growth and is commonly found in tropical moist and deciduous forests at altitudes of up to 1200 meters (Fig. 2). In India, it is predominantly found in the states of West Bengal, Arunachal Pradesh, Assam, Meghalaya, and Sikkim. In West Bengal, borpat is found in the Buxa, Kalimpong, and Tista Valley areas (Ghosh and Mallick, 2014). In Assam, its presence is noted in Lakhimpur-Borpathar, Sibsagar-Merapani, Cachar-Lambabak, Barak, Rongagora, Digboi, Jeypore, Khasi Hills, and Jaintia Hills, specifically in Nongkla and the Garo Hills (Kanjilal *et al*., 1934). In Arunachal Pradesh, the borpat is found in the forest areas of Pasighat, Sagalee, and Hapoli (Fig. 3).

Fig. 2: Naturally growing borpat tree (tree of heaven) at Medo in Arunachal Pradesh.

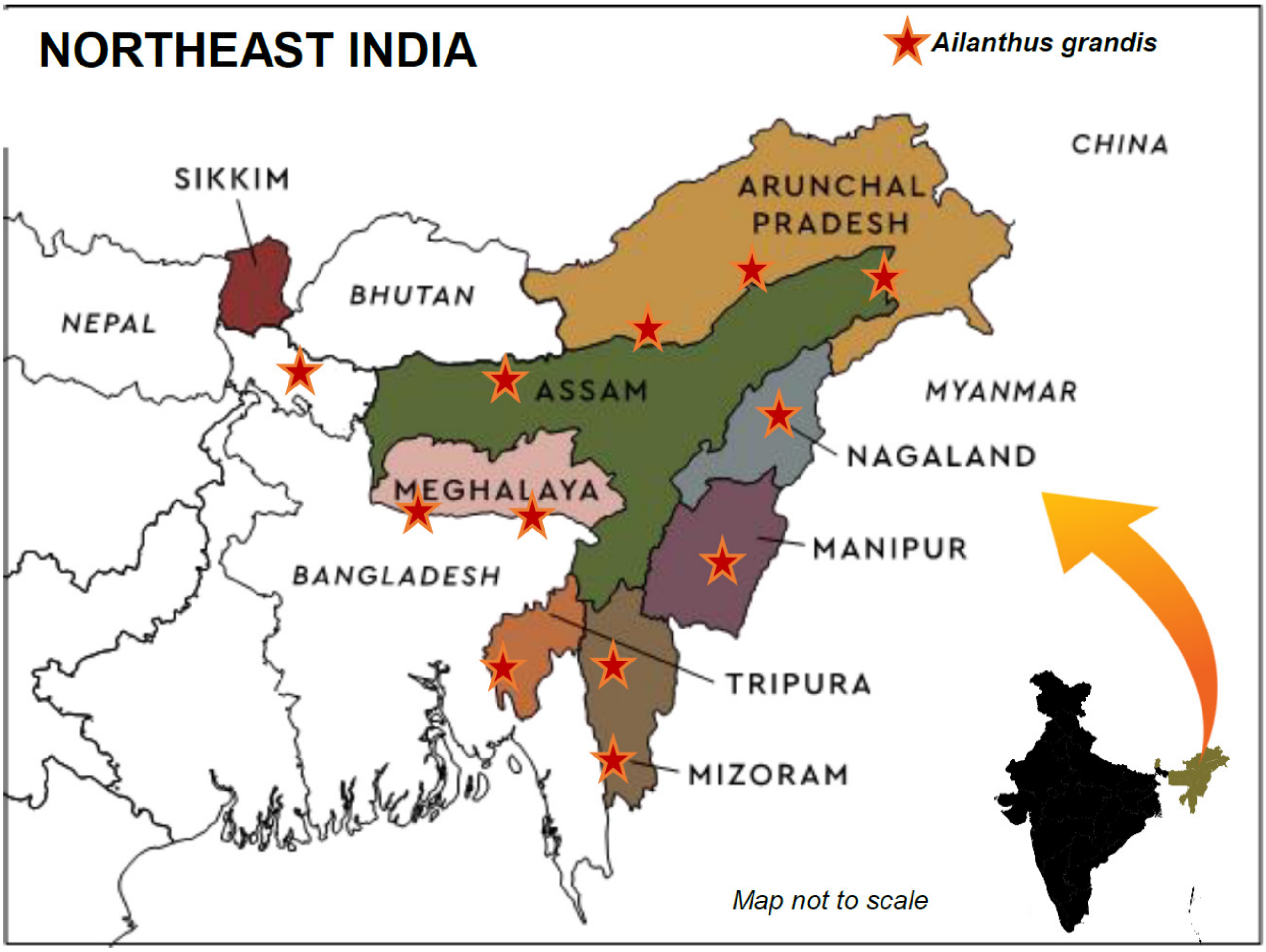

Fig. 3: Distribution map of borpat, *Ailanthus grandis* P. in north-eastern states of India

The popularization of borpat as one of the superior host plants for eri silkworms has recently begun but is currently constrained by the limited availability of seedlings for eri farmers. Under the Transfer of Technology programs aimed at promoting borpat, approximately 5,000 seedlings were distributed between 2020 and 2023 by CSB-CMER&TI, Lahdoigarh, Jorhat, Assam. Major limitations in the cultivation and utilization of borpat for ericulture include the unavailability of seeds for mass multiplication and the lack of effective vegetative propagation methods (Patidar *et al.*, 2022). In addition, erratic flowering and fruiting patterns, long seed dormancy, and low seed viability also poses limitations in its multiplication (Guhathakurta and Ghosh, 1972). There are some significant challenges associated with mass propagation using seeds as below:

- **Erratic Flowering and Fruiting:** Borpat trees have an irregular flowering and fruiting pattern, which can result in unpredictable seed output.
- **Tall Mature Trees:** Borpat trees typically reach their flowering age at around 25-30 years and can grow to be very tall, often reaching heights of 30 to 40 meters. This immense height makes it challenging to access healthy borpat seeds for propagation.
- **Seed Dispersal:** The seeds of borpat are winged and lightweight, easily carried by the wind to distant locations. This natural dispersal mechanism makes it difficult to collect a significant number/quantity of seeds from forest areas.
- **Limited Viability:** Borpat seeds have a short viability period, typically losing their ability to germinate within 5–6 months after harvesting.

Considering the above facts, it is imperative to develop suitable nursery-raising techniques for borpat to ensure effective and sufficient seedling production from the available seeds. Nursery-raising techniques and their management practices developed at CSB-CMER&TI, Lahdoigarh, Jorhat, Assam have been discussed in this paper and summarized in Table 1.

Table 1: Salient features of borpat nursery techniques:

Particulars	**Borpat (*Ailanthus grandis*)**
Fruiting Season	March-April
Sowing of Seeds	May-June
Soil Media Mixture	2:1:1 (Soil: FYM: Sand)
Fresh Seeds/kg (no.)	1800–2000
Seed viability	5–6 months
Germination period	25–55 days
Germination (%)	75–80 %
Bed size & Height	10 m × 1 m & 15 cm
Seed sowing pattern	Row to row: 10–15 cm Seed to seed: 4–5 cm
No. of seeds per Bed (10 × 1 m)	1800–2000
Space between beds	30 cm
Depth of sowing seed	2–3 cm
Seeds requirement/Acre of nursery	280–300 kg
Seedling transplantation (from bed to prefilled polybags)	After 3–4 months
Seedling transplantation (from polybags to field)	After 6–8 months seedlings attain a height of 60–75 cm
Plantation seasons	May-June & September-October
Spacing	3 × 3 m (450 plants/acre)

Nursery raising techniques for borpat:

Soil Requirements

The studies on soil requirements and plant ecology provide valuable insights into the optimal conditions for borpat cultivation. Guhathakurta and Ghosh (1972) highlighted the plant's preference for deep, moist, and well-drained loamy soils. Their study on the natural habitat of borpat noted a strong correlation between the plant's distribution and regions characterized by high rainfall and humidity. This suggests that soil moisture levels are crucial for the health and growth of borpat. The plant naturally grows up to 1200 meters above mean sea level (MSL) in the foothills of the northeast Indian Himalayan range, encompassing regions such as West Bengal, Arunachal Pradesh, Assam, Meghalaya, and Sikkim.

Further supporting these findings, Das *et al.* (2015) indicated that borpat exhibits higher growth rates and better health in soils that maintain consistent moisture levels without waterlogging. Their research underscored the importance of soil texture and composition in creating a conducive environment for root development and nutrient uptake. This emphasizes the need for careful soil management to optimize borpat cultivation, ensuring that the soil is both well-drained and retains adequate moisture to support the plant's growth requirements.

Preparation of Beds

Preparing nursery beds is a critical step in the raising of nursery, as it ensures seedlings' healthy growth and development. Properly prepared beds enhance the seedlings' resilience against environmental stresses and diseases, promoting better establishment and growth in the field. To optimize the conditions for seedling growth, meticulous preparation of nursery beds is essential. The beds should be ploughed and leveled carefully, measuring 10 meters by 1 meter and elevated to a height of 15 cm. A 30 cm gap between beds is crucial to facilitate cultural operations, such as efficient weeding and proper drainage. The soil composition for the nursery beds should consist of a mixture of soil, well-decomposed farmyard manure (FYM), and sand in a ratio of 2:1:1. This specific blend has been shown to improve seedling vigour and survival rates, as demonstrated in a study by Sharma and Singh (2019). The addition of organic matter, particularly FYM, enhances soil microbial activity, leading to better nutrient availability and uptake by the seedlings (Kumar *et al.*, 2020).

Seedlings are particularly vulnerable to environmental stresses such as excessive rainfall and direct sunlight, which can cause physical damage and stress. To mitigate these risks, it is recommended to cover the beds with a 50% shade agro-net or a thatched shed. This protective measure helps shield the seedlings from harsh weather conditions, promoting healthier and more resilient growth (Patel *et al.*, 2018).

Seed Collection and Treatment

Borpat, known for its erratic flowering and fruiting habits, presents unique seed collection and treatment challenges. Understanding these aspects is crucial for effective propagation and cultivation. The flowering of borpat occurs from October to January, with fruit ripening from March to April. The fruits are winged samaras, and the seeds are light brown with a thin membranous testa and oily cotyledons (Fig. 4a and 4b). Borpat exhibits a significant variation in fruiting from year to year and tree to tree within the same plantation. A study by Roy and Basu (2018) focused on the variability of borpat flowering and fruiting patterns and highlighted the need for strategic monitoring and timing in seed collection to manage erratic fruiting habits effectively. This study also emphasized the role of environmental factors in influencing reproductive behaviour, which can inform better management practices for seed collection. Although borpat seeds generally do not require treatment before sowing, it is advisable to treat seeds with fungicides like Mancozeb @ 3.0 g/kg of seed to prevent seed-borne fungal diseases. A study by Singh *et al.* (2017) demonstrated that treating seeds with fungicides like Mancozeb significantly reduced the incidence of seed-borne fungal diseases, leading to higher germination rates and healthier seedlings. This study underscores the importance of fungicide treatment, especially for seeds with oily cotyledons, which are more prone to fungal infections.

Seed Sowing

Seed sowing is a crucial step in the raising of borpat nursery, ensuring optimal germination and healthy seedling development. Seeds should be sown at a depth of 2–3 cm, allowing them to access moisture while being adequately covered to protect them from pests and environmental stressors. The spacing of rows should be 10–15 cm, with 4–5 cm between individual seeds. Alternatively, seeds can be broadcast evenly across the bed for uniform germination. Approximately 15 square meters of nursery space is required per kilogram of borpat seeds, equivalent to around 2000 seeds. This allocation ensures that the seeds have enough space to germinate and grow without overcrowding; otherwise low space can lead to competition for resources and increased susceptibility to diseases. A study by Patel *et al.* (2019) demonstrated that optimal seed depth and spacing significantly improved germination rates and seedling vigour in borpat. The study found that seeds sown at a depth of 2-3 cm with adequate spacing experienced better air circulation and nutrient availability, leading to healthier seedlings. To maintain soil moisture, it is advisable to cover the seed beds with a thin layer of straw or banana leaves. This mulching helps in retaining soil moisture, provides shade to the seeds, and protects them from direct sunlight and heavy rain. Regular watering is essential, especially during dry periods, to ensure consistent moisture levels in the soil. The frequency and amount of watering should be adjusted based on weather conditions to prevent both drought stress and waterlogging. A study by Sharma and Singh (2018) highlighted the benefits of mulching in maintaining soil moisture and protecting seeds during the initial stages of germination. The use of straw or banana leaves as mulch was found to enhance moisture retention and create a conducive microenvironment for seedling emergence. Once germination begins, the mulch should be removed to facilitate further growth; which allows the seedlings to receive adequate sunlight and reduces the risk of fungal infections that can thrive in damp conditions under the mulch.

Weeding

Weeding is a critical aspect of the raising of borpat nursery, particularly during the early stages of seedling development. Due to specific germination characteristics, effective weeding practices in nursery beds are essential to ensure healthy growth and optimal establishment of seedlings. Borpat seeds typically germinate between 25 to 55 days after sowing, exhibiting epigeal germination (Fig. 4c and 4d). Due to the larger size (~2 cm) of its cotyledons, seedling emergence can be hindered by the web of weed roots. Regular weeding every 7–10 days is crucial until the seedlings reach a 20–25 cm height to minimize competition for nutrients and space. In addition, it improves the growth and survival rates of seedlings (Das *et al.*, 2017).

(a) (b) (c) (d)

Fig. 4: (a) Mature borpat seeds with wings (b) Borpat seeds without wings (c) Germinated seed (d) Epigeal germination in borpat seedlings, [cotyledons (seed leaves) emerge above the soil surface during the early stages of seedling development].

Transfer of Young Seedlings into Polytubes

Transferring young seedlings into polytubes and eventually to the field are critical stages in the cultivation of borpat. These processes ensure that seedlings develop strong root systems and acclimate to the conditions necessary for optimal growth. After 3–4 months of growth in nursery beds, seedlings are ready for transfer into polybags (polytubes). At this stage, seedlings are sufficiently developed to handle the transplantation shock without significant stress. Carefully lifting each seedling from the seed beds is crucial to minimize root damage. Using tools like a small trowel can help gently loosen the soil around the roots, allowing for easier removal. Ensuring minimal root disturbance is crucial for maintaining the seedlings' health and vigour. Polytubes should be filled with a mixture of soil, sand, and well-decomposed farmyard manure (FYM) in a ratio of 2:1:1. This mixture provides a balanced medium that supports root growth, drainage, and nutrient availability. Soil provides essential nutrients and a stable medium for root anchorage. Sand enhances drainage and aeration, preventing waterlogging. Farmyard Manure (FYM) adds organic matter, improving soil fertility and microbial activity. Place each seedling into an individual polytube, ensuring that it is planted at a consistent depth to promote uniform growth. Proper spacing between polytubes is necessary to prevent overcrowding and ensure that each seedling receives adequate light, air, and nutrients. Immediately after transplanting into the polytubes, water the seedlings thoroughly to help settle the soil around the roots and reduce transplant shock. Regular monitoring is essential to check for signs of stress or disease and to ensure that the seedlings are adapting well to their new environment.

Field Establishment

Borpat seedlings aged between 6-8 months and measuring 2–2.5 feet in height are ideal for field transplantation (Fig. 5). This age and height combination ensures that the seedlings are robust enough to withstand the transition from the controlled environment of the nursery to the more variable conditions of the field (Fig. 6). Studies by Patel *et al.* (2020) indicates that seedlings transplanted at 6–8 months with a height of 2–2.5 feet have a significantly higher survival rate and better growth performance in the field. This is because they have developed a strong root system and are less susceptible to environmental stresses than younger, smaller seedlings.

Fig. 5: Borpat seedlings in nursery bed and polybags.

Fig. 6: Systematic plantation of Borpat in the field for ericulture.

Conclusion

The cultivation of borpat (*Ailanthus grandis*) as a host plant for the eri silkworm presents significant opportunities for sustainable silk production and rural economic development, especially in Northeast India. Effective nursery-raising techniques, including soil preparation, seed collection and treatment, proper sowing, and diligent post-sowing care, are essential for the successful propagation of borpat. Research has underscored the importance of deep, moist, well-drained loamy soils, meticulous bed preparation, and the use of organic matter to enhance seedling growth. Ensuring consistent moisture levels through mulching and regular watering, combined with strategic weeding practices, significantly improves seedling vigour and survival rates. Transplanting young seedlings into polytubes after 3–4 months and ensuring they reach an optimal age and height before field transplantation are critical steps in the cultivation process. Seedlings aged 6–8 months and measuring 2–2.5 feet in height exhibit higher survival rates and better growth performance in the field. Despite challenges such as erratic flowering, limited seed availability, and the need for effective vegetative propagation methods, the potential of borpat as a reliable host plant for eri silkworms remains promising. Continued research and development of propagation techniques will be crucial in overcoming these obstacles and ensuring the widespread adoption of borpat cultivation. By addressing these challenges and implementing the recommended practices, borpat cultivation can be effectively promoted, enhancing the sustainability and profitability of eri silk production, and providing a valuable source of income for rural and tribal communities.

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