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Exploring the Conservation and Sustainable Utilization Potential of *Parkia timoriana* (DC.) Merr: An Underutilized Multipurpose Tree Bean in North-Eastern India

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Abstract

Parkia timoriana (DC) Merr., commonly known as the Tree Bean (Family: Fabaceae), is a versatile and underutilized legume tree species with significant ecological, economic, and cultural importance in North-Eastern Indian States, Bangladesh and several South-East Asian countries. This species is primarily distributed in evergreen rain forest, moist mixed deciduous and dry evergreen forests with an altitudinal variation ranging between 0 and 600 m, but rarely reaches 1300 m in North East India and Bangladesh. Both flower and fruits of this species have high demand due to its nutritional and medicinal properties and people of North-Eastern states of India growing it in home gardens, agroforestry systems and fallow lands of shifting cultivation for their dietary supplements. However, due to the factors such as overexploitation, insect infestation, shortening of fallow period, urbanization, drier climate, lack of awareness, and discontinuity in traditional culture and knowledge, the conservation and utilization of this native underutilized edible fruit species (UEFS) has been steadily declining. Hence, this review paper comprehensively explores the conservation and sustainable utilization potential of Parkia timoriana in the North-eastern region (NER). The paper synthesizes existing literature on the botanical characteristics, distribution patterns, nutritional composition, medicinal properties, and ecological significance of Parkia timoriana in North-Eastern India through systematic review (PRISMA protocol). It examines the challenges facing the conservation of this valuable species, including habitat degradation, deforestation, and unsustainable harvesting practices. Finally, the paper identifies opportunities for collaborative efforts involving researchers, policymakers, local communities, and conservation organizations to promote the conservation and sustainable utilization of Parkia timoriana for biodiversity conservation, economic development, and human well-being in North-Eastern India.

Keywords: Tree bean, conservation, sustainable utilization, North-eastern India, biodiversity, traditional knowledge

Introduction

Parkia timoriana (DC.) Merr., commonly known as "Tree Bean," is an underutilized multipurpose leguminous tree species native to the tropical regions of Asia, including North-Eastern India. This species belongs to the Fabaceae family and holds significant ecological, economic, and cultural value in the region (Hynniewta et al., 2015). These species have been traditionally utilized by indigenous communities of the North-eastern region (NER) for various purposes, including food, medicine, timber, and fodder, reflecting its importance in local livelihoods and cultural practices (Borthakur et al., 2016). Despite its potential, the tree bean remains relatively understudied and underutilized, posing challenges to its conservation and sustainable utilization in the region (Dkhar et al., 2019). In NER, this species is normally grown in natural forests, and people are also growing it in home gardens and fallow lands of shifting cultivation for their dietary supplements (Plate 1). Both flowers and fruits of this species have high demand due to its nutritional and medicinal properties (Rathi et al., 2012). In recent years, there has been a growing interest in exploring the ecological and socio-economic significance of *Parkia timoriana* in NER. This interest is driven by the recognition of its diverse uses and the need for conservation and sustainable management of forest resources in the region (Singh et al., 2020). The unique agro climatic conditions of North-Eastern India provide an ideal habitat for the growth and proliferation of *Parkia timoriana*, making it an integral component of the region's biodiversity (Nongrum, 2019).

Plate 1. Some glimpses of *Parkia timoriana*: a) Prevalent in the Homegardens of Tura, Meghalaya; b) Ripened fruit pods and c) Selling fruit pod bunch in the local market.

Besides natural threats such as extreme climatic conditions, flood, tectonic movement and unpredictable rainfall, the North-eastern region (NER) is also overburdened due to non-judicious management of soil, water and other natural resources (Singh and Singh, 2015). The fertile cultivable lands are replaced by mining, urbanization and other human induced activities. Nowadays, land degradation is becoming a global challenge as it poses high risk on land productivity, food and livelihood security. Hence, it is an alarming sign to conserve biodiversity and maintain ecological balance of the NER. Fortunately, home gardens of NER are repositories of many multipurpose trees that are grown for food, fuel, and fodder. These trees have a remarkable potential to increase food and nutritional security for dependent and other vulnerable populations. However, factors such as habitat degradation, deforestation, insect infestation, shortening of fallow period, drier climate and unsustainable harvesting practices threaten the survival of this valuable species, emphasizing the urgency of conservation efforts (Roy et al., 2014; Hynniewta et al., 2015). By synthesizing existing research and field data in NER, the paper aims to highlight the ecological, economic, and socio-cultural importance of this species while identifying knowledge gaps and recommending strategies for its conservation and sustainable management.

Botanical Characteristics and Distribution

Parkia timoriana is commonly distributed in several South-east Asian nations, including Indonesia, Japan, Malaysia, Philippines, Thailand, and Vietnam, as well as evergreen, deciduous, and dry evergreen forests in India, Bangladesh, and other Asian countries. Its altitudinal variation ranges from 0 and 600 m, but it rarely reaches 1300 m in North East India and Bangladesh (Thangjam et al., 2019). In north eastern states such as Meghalaya, Manipur, Mizoram, Assam and Nagaland, this endemic fast-growing tree commonly grows in homegardens, agroforestry systems, forests, and shifting cultivation areas (Angami et al., 2018). The species typically grows up to 30 meters in height and is characterized by its alternate bi-pinnate leaves, which consist of 20-30 leaflets. Inflorescence is a head of flowers dangling at the peduncle up to 45 cm long and the fruits are green pods that are about 27 cm long and contain numerous seeds. The price

of a bunch of fruits in the Tura local market in Meghalaya is one hundred rupees (Plate 1.c).

Research on *Parkia timoriana* in North-eastern India has primarily focused on its botanical characteristics, distribution patterns, nutritional composition, and medicinal properties. Studies have documented the morphological features, phenology, and reproductive biology of the species, providing valuable insights into its ecological requirements and reproductive strategies (Borthakur et al., 2016). Furthermore, chemical analyses have revealed the nutritional and phytochemical composition of *Parkia timoriana* seeds, highlighting their potential as a rich source of protein, vitamins, and antioxidants (Dkhar et al., 2019). These findings underscore the nutritional significance of the tree bean and its potential contribution to food and nutritional security in the region (Nongrum, 2019).

In addition to its nutritional value, *Parkia timoriana* is recognized for its medicinal properties and therapeutic uses in traditional healthcare systems. Various parts of the tree, including the bark, leaves, and seeds, are utilized in indigenous medicine for treating a wide range of ailments, such as digestive disorders, respiratory infections, and inflammatory conditions (Hynniewta et al., 2015). Pharmacological studies have validated the efficacy of *Parkia timoriana* extracts against microbial pathogens, demonstrating its potential as a source of novel antimicrobial agents (Singh et al., 2020). These pharmacological properties highlight the importance of conserving *Parkia timoriana* as a valuable genetic resource for drug discovery and pharmaceutical development in North-Eastern India.

Systematic Review of Earlier Studies on *Parkia timoriana* in North-Eastern India

Protocol for Systematic Review

This study implements the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) protocol (Moher et al., 2009) to review the published information pertaining *Parkia timoriana* in North-Eastern India. In this analysis, we examined the literature focused on the availability, awareness, consumption, distribution, exploitation, knowledge, popularity, production and utilization of *Parkia timoriana* tree species from home gardens, forests, agro forestry systems, vacant and other marginal lands. It includes published articles, book chapters, and scientific reports on Google, Google Scholar, J-gate, Scopus and Web of Science, for all time. Finally, 33

articles were included in the synthesis after exclusion of duplicates, based on criteria and other reasons (Table 1). The information from the literature was used to prepare a comprehensive list with the names of authors, their research focus, the distribution of study area and their sources (Table 1).

Key Findings

The systematic review resulted 31 articles from Northeast India. These 31 articles that were categorized based on the research focus included nine on general reviews, six on propagation, four on genetic diversity, biotechnology and sustainable land use management, and two on plant protection and volume equations (Table 1; Figure 1). Based on the state-wise distribution (Figure 2), Manipur reported the most articles (8), followed by Assam (2), and both Nagaland with the least (1 each). Based on the reported two decadal studies, there was a notable increase in number of publications from 2019 and 2023 (Figure 3). Despite the fact that *Parkia timoriana* was present in significant numbers in Tripura, Arunachal Pradesh, and Meghalaya, no research was done apart from a few general reviews in these states. Additionally, this offers directions for future research initiatives on cultivation, conservation, and sustainable management.

Table 1. List of Earlier Studies on *Parkia timoriana* in North-Eastern India

Authors	Research Focus	Study Area
Dhyani and Chauhan, 1990	Sustainable Land use Management (Parkia-based Agroforestry)	Meghalaya
Thangjam et al., 2003	Genetic diversity	Manipur
Rocky et al., 2004	General Review	Manipur
Thangjam and Maibam, 2006	Biotechnology	Manipur
Sahoo et al., 2007	Seed Germination	Mizoram
Thangjam and Sahoo, 2012	Biotechnology	Manipur
Tomar et al., 2012	Sustainable Land use Management (Soil Health)	North-East
Firakeet al., 2013	General Review	North-East
Thingbaijam and Maibam, 2013	Genetic diversity	Manipur
Thangjam, 2014	Genetic diversity	Manipur
Lyngdoh et al., 2016	Sustainable Land use Management	North-East

	(Parkia-based Agroforestry)	
Thangjam, 2016	Biotechnology	North-East
Thangjam et al., 2017	Seed Germination	Mizoram
Angami et al., 2018	General Review	North-East
Singh et al., 2018	Plant Protection	Mizoram
Nongrum, 2019	General Review	Meghalaya
Thangjam et al., 2019a	Seed Germination	Mizoram
Thangjam et al., 2019b	Volume table preparation	North-East
Singh, 2019	Sustainable Land use Management (Eco-restoration of Jhumfallows)	Manipur
Singh and Tripathi, 2019	General Review	North-East
Borpuzari et al., 2020	Air layering	North-East
Devi et al., 2020	Sustainable Land use Management (Soil Health)	Assam
Thangjam et al., 2020	Genetic diversity	Mizoram
Singh et al., 2020	General Review	Assam
Fatima, 2021	Seed Germination	Mizoram
Ovung et al., 2021	General Review	Nagaland
Singha et al., 2021	General Review	North-East
Surendirakumar et al., 2021	Sustainable Land use Management (Soil Health)	Manipur
Kumar and Saikia, 2022	Volume table preparation	North-East
Ralte et al., 2022	Biotechnology	Mizoram
Singh, 2022	Plant Protection	North-East
Loushambam, 2023	Seed Germination	Manipur
Singh and Kumar, 2023	General Review	North-East

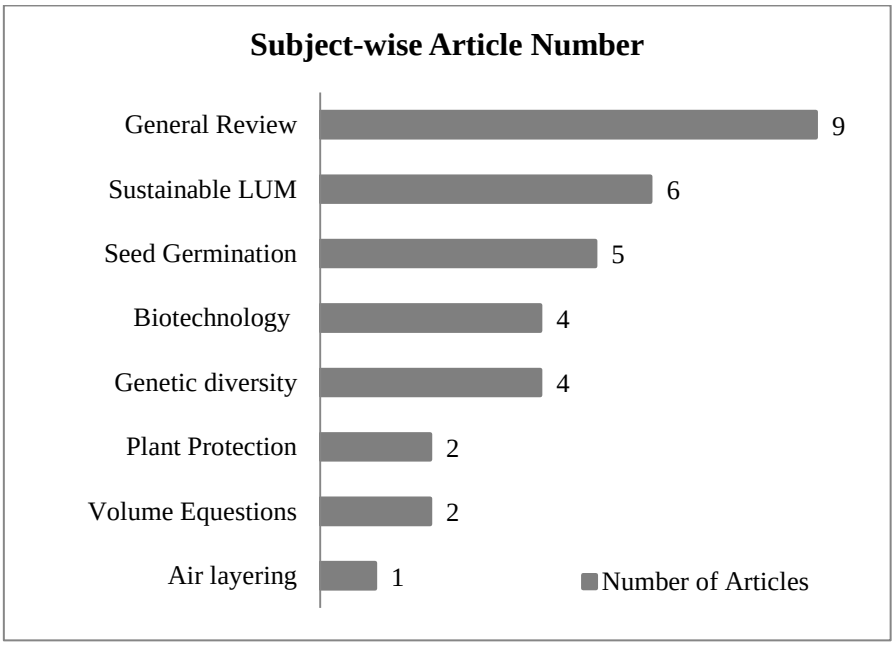

Figure 1. Subject-wise distribution of articles on *Parkia timoriana* in NER

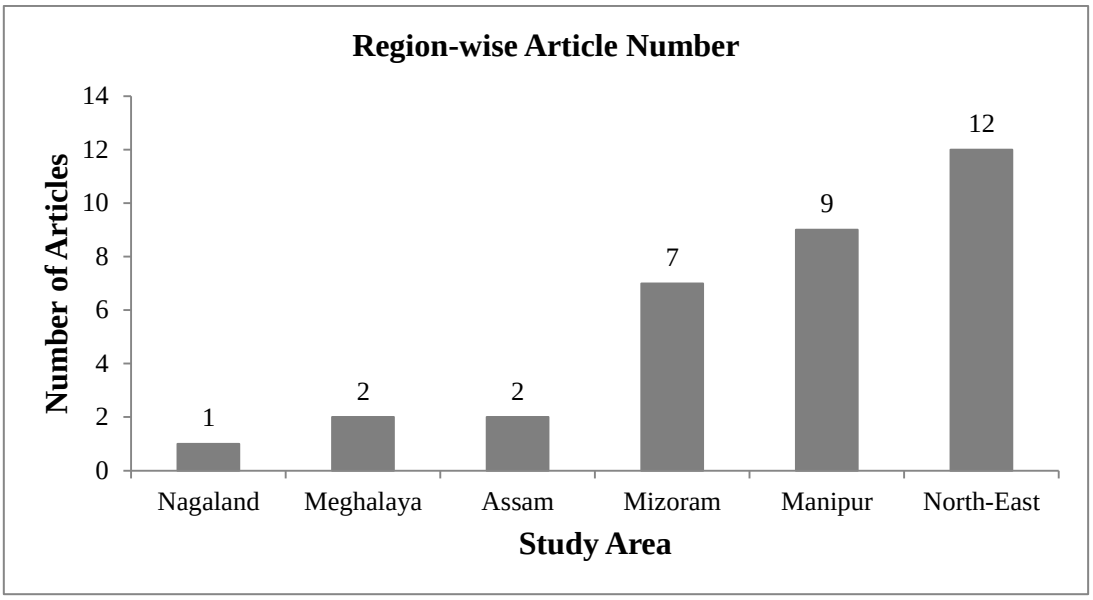

Figure 2. Region-wise distribution of articles on *Parkia timoriana* in NER

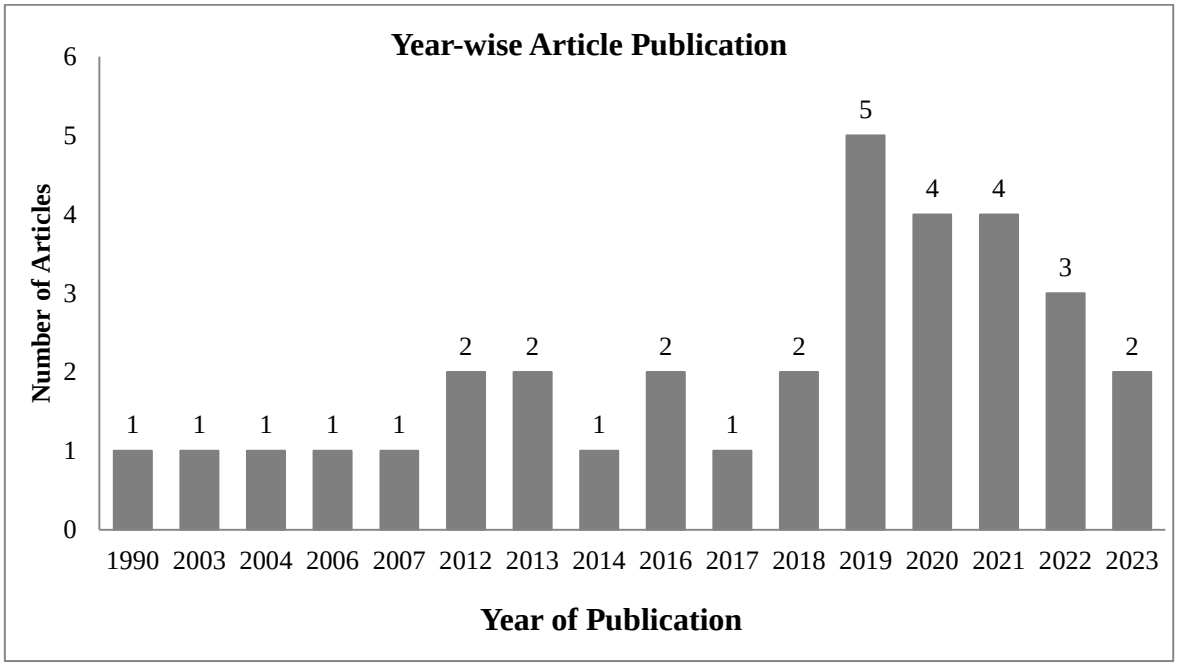

Figure 3. Year-wise distribution of articles on *Parkia timoriana* in NER

Nutritional profile of *Parkia timoriana*

The tree possesses a diverse range of nutrients and essential amino acid composition which is similar to the amino acid requirement pattern for preschool children given by World Health Organization (Angami et al., 2018; Singh and Kumar,

2023). It offers a variety of edible parts such as pods, flowers and matured seeds which are rich sources of proteins, carbohydrates, vitamins and minerals. *Parkia timoriana* is noted for its significant content of ascorbic acid (26.0 mg per 100 g), fats (20.28%), proteins (32.82%), and minerals (4.45%). However, its seed composition shows lower levels of Na (51.0), Mg (34.7), and P (160 mg per 100 g), while its calcium (97.47), potassium (2400), copper (2.3), and zinc (2.77 mg per 100 g) contents are comparable to other legumes (Salam et al., 2009; Singh and Kumar, 2023). In terms of iron and manganese, *Parkia timoriana* exhibits notable levels with 57.1 and 35.0 mg per 100 g in pods, and 34.9 and 9.4 mg per 100 g in seeds, respectively (Angami et al., 2018). In addition to this, seeds of *Parkia timoriana* are a rich source of essential amino acids (isoleucine, leucine, phenylalanine and tyrosine) and fatty acids such as oleic and linoleic acids (Mohan and Janardhanan, 1993).

Medicinal attributes and traditional uses

The plant, valued at 100 rupees per bunch of fruit or 70-120 rupees per kg in northeast India due to its extensive ethno botanical applications, is one of the costly vegetables. Its nutritional value, akin to that of an apple according to Angami et al. (2023), includes antioxidants that can prevent diseases and enhance children's learning abilities. The seeds and pods, whether fresh or dried, are employed in treating stomach and intestinal disorders, piles, diarrhea, constipation, and liver issues. The bark, when made into a paste, serves as a plaster for eczema, while both bark and leaves are utilized in creating lotions for skin ailments and ulcers. Additionally, consuming the seeds and pods, either fresh or dried, with meals is said to aid in digestive problems. Local inhabitants also utilize stored dried pods and seeds to alleviate stomach issues by soaking them in water and consuming them directly after chewing (Ovung et al., 2021). The bark decoction is utilized to address diabetes, while local individuals in Ghana have been observed using the fruit to combat leprosy and hypertension. Additionally, pods are crushed in water for facial and head cleansing purposes (Paul et al., 2016). Suvachittanont et al. (1996) noted that the strong, pungent odor emitted by *Parkia timoriana* signifies the presence of Thiazolidine-4-Carboxylic acid (TCA, Thioproline), a sulfur-containing cyclic amino acid that has demonstrated efficacy as an anticancer agent.Virtually every part of the plant is usable, from pods, seeds, flowers, and young shoots, which can be consumed raw in salads or cooked in curries, while the tree itself serves as a source of fuel wood (Sahoo et al., 2007). The pods, flowers, inflorescence,

and mature seeds are consumed in salads, curries, and chutneys, such as Singju, a Manipuri salad made from pods, and Iromba, a local delicacy prepared by combining the pods with fish curry (Salam et al., 2009; Roy et al., 2014). Immature seeds are very nutritious eaten raw or cooked with meat, green pods are used to make pickles with king chili and some communities also use leaves for making curries (Devi et al., 2020; Ovung et al., 2021).

Economical, Ecological Significance and Challenges

Parkia timoriana, a versatile tree, is renowned for its subsistence products and ability to generate cash income. During favorable seasons, tree bean cultivation has the potential to yield significant household income and it was comparable to or even surpassing income from agricultural crops (Rocky et al., 2004). The timber from Parkia trees is utilized for crafting lightweight furniture, boxes, and other appealing articles (Sharma et al., 1993). With its high tannin content (6-15%), the bark is utilized in the tannin industry, while the wood serves as a source of paper pulp (Singha et al., 2021). Additionally, it serves as a beneficial shade tree in tea gardens and as an agro forestry species in Northeast India (Dhyani and Chauhan, 1990; Alabi et al., 2005). Furthermore, the tree bean can support jhum cultivation, a prevalent land use system in hill states of the Northeast region. The integration of tree species in jhum lands aids in regulating the ecological balance, nutrient cycling, and soil erosion control, and also improving the socio-economic status of the jhum practictiones (Angami et al., 2018).

While *Parkia timoriana* has been extensively researched for its nutritional value and biological activities (Angami et al., 2018; Singh et al., 2020), its contribution to environmental management remains relatively unexplored. The tree yields abundant green manure, suitable for soil fertility enhancement. The tree bean, a swiftly maturing leguminous tree, enhances soil fertility via nitrogen fixation, fostering ecological equilibrium by enriching and enhancing soil health. It fosters advantageous bacterial communities, aiding nutrient release to improve soil vitality. Its readily decomposable leaves and components boost soil organic matter. With its substantial aboveground biomass, it significantly contributes to sequestering atmospheric greenhouse gasses, particularly carbon dioxide, aiding in regional climate change mitigation (Dhyani and

Chauhan, 1990; Angami et al., 2018). The utilization of tree foliage, particularly from indigenous agroforestry trees, for green leaf manuring is recommended in Northeast India to boost rice productivity sustainably, serving as an environmentally friendly alternative to dwindling sources of organic manures like farm yard manure (FYM) due to declining livestock populations (Tomar et al., 2012). The study found that green leaf manuring with leaves from nitrogen-fixing trees had a significant residual effect, leading to increased productivity levels over time (Tomar et al., 2012). These organic residues strategically enhance soil organic matter content; improve soil physical properties such as water infiltration rate, water-holding capacity, and erosion resistance, thereby restoring and enhancing soil quality and ultimately boosting crop yields. The seed oil exhibits insecticidal property used against aphids and the smoke produced from dried leaves effective at repelling insects (Salam et al., 2009; Singh et al., 2011). Small branches serve multiple purposes such as firewood, fodder for livestock, and materials for building shelters, while the timber from these species is prized for crafting decorative items and light furniture.

Parkia is utilized as a tool for restoring degraded jhum land and is also employed as a shade tree in tea plantations in Mizoram (Singh, 2019). Furthermore, it serves as an intercrop with banana, Areca, and other multipurpose tree species across various regions of Northeast India. Its presence leads to significant improvements in soil quality, including a 96.2% increase in soil organic carbon, a 24.0% enhancement in aggregate stability, a 33.2% rise in available soil moisture, and a reduction in soil erosion by 39.5% (Singha et al., 2021). Additionally, *Parkia timoriana* contributes to a total biomass of 2.24 Mg ha^{-1}, with a carbon sequestration potential of 0.23 Mg ha^{-1} $year^{-1}$ (Devi et al., 2020).

Since 2002, the species' population has been experiencing tree decline, leading to a reduction in income for the local community and significant expenditures on importing tree beans from Myanmar. A study reported that Manipur alone spends around 370 crore rupees annually to import Tree Bean from Myanmar (Anon, 2022). Research organizations in Northeast India have been conducting studies to pinpoint the reasons behind the decline and to devise strategies for its management. Tree bean decline has been linked to various factors, including insect pests, fungal pathogens, unavailability of water source, reduction of plant pollinated animals like bats and abiotic

stresses such as fluctuations in temperature and rainfall patterns. Among these, insect pests and diseases have emerged as the primary contributors to tree bean deterioration, with species like Asian longhorned beetles, bark-eating caterpillars, and spotted pod borers frequently identified in association with declining trees (Vanlalhmuliana et al., 2021). The *Cadra cautella* butterfly, whose hatchling uses the inside of the seed to pupate and cover it with straps, is an irritant that the seed cannot resist. Additionally, diseases such as Verticillium wilt and collar rot have been documented in declining tree bean plantations (Roy et al., 2014; Singh et al, 2018). The decline is also significantly exacerbated by inadequate management practices and neglect of post-plantation care. Some of these issues have been resolved by the active involvement of research organizations in Northeast India However further scientific and biotechnological intervention are needed for the socio-economic and ecological development of the NER.

Technological Intervention in Conservation of Tree bean

Biotechnological tools offer a promising solution for tackling the biotic and abiotic diseases plaguing the tree bean, alleviating its socio-economic challenges and production decline. Thangjam and Maibam (2006) described a protocol for somatic embryogenesis and callus formation by using MS and B5 basal media supplemented with various concentrations of 2-4-D, BAP and NAA. Explants cultured on MS medium with 2,4-D and BAP induced proliferating calli, evolving into somatic embryos in growth regulator-free MS suspension medium (Thangjam and Sahoo, 2012). Another study conducted the extraction of quality DNA by modified CTAB method (Thangjam et al., 2003). Some studies also confirmed the existence of genetic diversity which will be useful for breeding programs and selection of trees by using microsatellites, ISSR markers, RAPD markers etc. (Thangjam and Maibam, 2003; Thangjam, 2014; Phurailatpam et al., 2022). Hence, the use of biotechnological tools for the evaluation of the genetic status, mass production and genetic improvement provides a viable option. It is observed that the research is limited to genetic diversity, in vitro regeneration and genetic transformation. Therefore, further research is needed in molecular breeding, association mapping, linkage maps etc.

Research and development roadmap for *Parkia timoriana*

- Though there are multiple researches on seed germination and in-vitro regeneration, there is a lack of standard protocol for quality planting material production, field performance and agro forestry models.
- Further studies are needed for insect pest and disease management
- Multidisciplinary research for cultivation, conservation and value addition through various stakeholders.
- Financial support from the government to advance the research on its genetic improvement and development of quality planting material.
- Though there are many researchers are pointing out climate change as a culprit for disease and pest outbreak due to erratic rainfall and temperature. However, in depth research is vital to understand the root cause better.

Conclusion

Parkia timoriana, an endemic tree to northeast India, serves as a versatile multipurpose resource with significant nutritional, economic, and ecological value. Its nutrient-rich status contributes to local food security, while its medicinal properties offer remedies for various health ailments. Additionally, its pods are highly valued as a vegetable in local markets, fetching prices ranging from 800 to 1000 per kilogram and supporting rural livelihoods. The hardwood from the tree is utilized in crafts, furniture making, and the tannin industry. Ecologically, the tree aids in soil reclamation, nutrient cycling, carbon sequestration, nitrogen fixation, and erosion control. Despite its numerous benefits, the tree faces threats from insects, pests, unsustainable management practices, deforestation, and climate change. However, research efforts have primarily focused on its importance, morphology, genetic diversity, and in vitro propagation, with limited attention to understanding the reasons for its decline, conservation strategies, breeding programs, integration into agroforestry systems, access to quality planting materials, and policy development. Collaboration among stakeholders is essential to conserve and sustainably utilize this tree species, thereby enhancing food security, supporting rural livelihoods, and preserving ecological balance.

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