Online ISSN 2456-6489

Review Article

Indian Journal of Agroforestry
Vol. 27, No. 2, April–June 2025

Status and Development of Tree Breeding and Improvement of Species Amenable for Industrial Agroforestry

K T Parthiban[1*]

[1]*Forest College and Research Institute, Tamil Nadu Agricultural University, Mettupalayam 641 301, Tamil Nadu*

* Corresponding author. E-mail: ktparthi2001@gmail.com

https://doi.org/10.48165/ija.2025.27.02.09

ARTICLE INFO
Received: 02.08.2024
Accepted: 02.06.2025

Keywords:
Agroforestry
Prioritized species
Breeding plan
WBIs
Tree Breeding

ABSTRACT

India is a robust producer and consumer of wood and wood products. The growing population, urbanization, industrialization, changes in housing and education policies, etc. have accelerated the wood demand at an alarming rate. The legal and policy guidelines have restricted the availability of wood from natural forest which ushered in a total mismatch between the demand and supply. Considering this into account, the Government of India through its National Forest Policy (1988) and National Agroforestry Policy (2014) have directed all stakeholders to promote industrial agroforestry. However, industrial agroforestry has witnessed wide range of challenges and constraints and among them, the availability of improved genetic resources through tree improvement programme is most significant. Against this backdrop, TNAU has prioritized species amenable for industrial agroforestry and developed genetic stocks through systematic tree breeding protocol and approach. Over a decade of tree improvement programme resulted in development and release of 11 High Yielding Short Rotation (HYSR) clones through State Variety Release Committee (SVRC) and over 15 different varieties under pre-release stage which witnessed the adoption by wide range of Wood-based Industries (WBIs) due to their wood quality, productivity and early harvest. The current manuscript elaborates the challenges, species prioritized, breeding plan and approach and development of HYSR varieties amenable for multifunctional industrial utility in association with wide range of Wood-based industries.

INTRODUCTION

Forest in general and trees in particular played a vital role in meeting the domestic and industrial requirement of both wood and non-wood products. In the process of growth and development, population explosion, industrialisation, urbanisation and the increase in demand for wood and wood products have exploited the resources available in the natural forest. It was estimated that the country has a loss over 1.5 million hectares annually which resulted in rapid decline of forest cover. This besides the productivity of India's forest is estimated at 0.7 m3/ha/annum coupled with reduced growing stock volume which have also become a major threat to the production of Indian Forest. The Forest Conservation Act (1980) and the Supreme Court Directives (1996) have almost stopped the felling operation in natural forest and declined the availability of wood and wood products from the natural forest. Considering these developments and the legal restriction, the Government of India as early in 1988 through its National Forest Policy has directed all wood-based industries to source their own raw materialresources. The increase in demand for wood and wood products, decreased supply from the natural forest coupled with legal restrictions has ushered in a total mismatch between the wood demand and supply. This necessitated and underscored the need for development of organised plantations through the industry-based agroforestry. Several initiatives and strategies were developed to promote forestry and agroforestry plantation

but, the achievements in plantation development programme are dismally modest due the existence of various challenges and constraints. Among various challenges, the existence of low productivity from the unimproved genetic resources is very significant which detracted the attraction of industrial agroforestry developmental activities.

Against this backdrop, Forest College and Research Institute of Tamil Nadu Agricultural University has conceived and implemented Systematic Tree Breeding and Improvement Programme in a wide range of tree species amenable for Industrial Agroforestry through a value chain approach. This manuscript reviews the challenges, need for systematic breeding programme, species prioritized, breeding plan and approach, varietal development process, development of improved variety and clones coupled with its deployment in Industrial Agroforestry Programme. The content and input provided in this manuscript will act as a readymade

reference for tree breeders, scientists, professional foresters and industries involved in tree breeding research.

Existing Challenges and Constraints

The promotion of agroforestry specifically industry-based agroforestry has exhibited wide range of challenges and constraints from the entire Production to Consumption System. Among the various challenges and constraints that existed in the agroforestry system the following are the most significant challenges which detract the attraction of agroforestry promotion and development (Parthiban *et al.,* 2016).

i. Availability of Unimproved Genetic Resources

Barring few exceptions, most plantation programmes established in the country deploys seed sources from unimproved genetic resources resulted in uncertain productivity and erratic wood quality. This resulted in uncertain and poor yield which act as a major barrier.

ii. Low productivity from the existing plantations

It has been estimated and also reported that the plantations established through unknown and unimproved genetic resources has exhibited a lowest productivity level of <10m3/ha/annum. This low productivity is a major challenge for the commercial viability of agroforestry systems.

iii. Absence of Quality Planting Material (QPM)

The absence of improved genetic resources directly correlates with non-availability of quality planting materials. Most seedlings produced and deployed in operational plantation programme are from uncertified open nurseries without any genetic evaluation. These unimproved seed sources-based seedlings exhibited wide range of success and failures and limit the agroforestry developmental activities

iv. Absence of New and Alternate Genetic Resources

Most industries use only one or two prioritized species amenable for the respective industrial utilization. Again, these species are predominantly exotic in nature and witnessed specific adaptability and acceptability. India is housed with wide range of indigenous species which are fast growing and accredited with excellent wood properties amenable for multifarious industrial utility. The inventory and utilization of these species is a major challenge for want of suitable and organized tree improvement programme.

v. Varying wood quality

The existing plantations established through unimproved genetic resources exhibited wide range of wood quality in terms of physical, chemical, mechanical, anatomical and other thermo-chemical properties. This besides, the form, structure, bark content, brittleness, incidence of post-harvest pest and disease, etc. also play a significant role in varying wood quality and pronounced as a significant barrier.

Long rotation

Another major challenge that limits and detracts the attraction of industrial agroforestry development in the country is the long rotation nature of tree component. Till the recent past, most plantations are long rotation and the growers have to wait for several years to reap the benefits from agroforestry. Since, most farm holdings in the country are of small size, the farmers depend predominantly on regular income from the agricultural activities. The translational towards agroforestry is highly recalcitrant which is a most significant challenge.

The above flagged issues are the major challenges and constraints that exists in the operational industrial agroforestry development programme which underscored the need for deployment of improved genetic resources through systematic tree breeding and improvement programme.

Need for organized Tree Breeding and Improvement

India is one of the robust producers and consumers of wood and wood products. Today, the country's de-

mand for wood and non-wood products is increasing at an alarming rate. It is estimated that the country would need over 700 million m3 to meet the raw material requirement of the organized sectors of wood-based industries (>152 million m3), unorganized sectors of industries (>150 million m3) and for energy requirement of domestic and industrial purpose (400 million m3) (FAO, 2009; Parthiban *et al.,* 2021).

Several strategies are developed and implemented by government sectors, wood-based industries and other public and private players towards agroforestry promotional development but the achievement in this front is dismally modest. This is primarily due to non-availability of improved genetic resources and the associated quality seedling production, low productivity, long rotation and absence of alternate genetic resources. Hence, organized tree breeding and improvement received potential attention and attraction towards resolving the issues flagged above.

Among 28 states and eight Union Territories in the country, the potential of state of Tamil Nadu towards industry-based agroforestry is very significant due to the existence of wide range of wood-based industries like timber, ply and panel, pulp and paper, match splints, packing case, energy and other NTFP industries. It has been estimated that the state of Tamil Nadu needs over 70 lakh tonnes of raw material requirement to meet the organized sector of industries like timber (>30 lakh tonnes/annum), pulp & paper (17.5 lakh tonnes/annum), ply and panel (>10 lakh tonnes/annum), match splints (5 lakh tonnes/annum) and packing cases (>2.5 lakh tonnes/annum). This, besides the state would need over 100 lakh tonnes for biomass utility to cater to the raw material requirement of biomass power plants, co- generation plants, co-firing and other industrial energy utility (Parthiban *et al.,* 2022)

Besides the existing demand, the state also attracting new wood-based industries like particle board, MDF, biofuel industries, furniture park, etc., which may require another 10 lakh tonnes per annum from the year 2025 onwards. Such a massive wood requirement for the state cannot be met from the existing forest due to legal restrictions and agroforests with varying wood productivity. All these developments have extended a greater scope and need for organized tree improvement programme in wide range of species to develop improved genetic resources, High Yielding Short Rotation (HYSR) clones and other speciality varieties.

Tree improvement programme incorporated with the deployment of clonal technology is very essential to develop short duration varieties and ensure the availability of QPM. Above all, inventorization, characterization and evaluation of indigenous species amenable for industrial utility, increased productivity and short harvesting period extend a greater scope for organized tree improvement programme. Accordingly, a systematic and organized tree improvement programme has been conceived and implemented in Tamil Nadu which resulted in successful varietal development and the entire process is discussed below

Prioritized species amenable for agroforestry in Tamil Nadu

As indicated earlier, the state of Tamil Nadu is housed with wide range of wood, non-wood and other value addition industries and extends a greater scope of promotion of agroforestry both for industrial and commercial importance. The state of Tamil Nadu has seven agro-climatic zones and represents wide range of agro ecosystem amenable for cultivation of diversified agroforestry species. Above all, the people in the state of Tamil Nadu traditionally incorporates tree components in the farm settings through agroforestry, farm forestry, bund planting, sporadic planting, wind breaks, etc. Considering the demand that exists in the state coupled with assessing the existing land use and capability system followed by discussions and consultations with farmers and members of Consortium of Industrial Agroforestry, 30 tree species were identified and prioritized for incorporation in agroforestry promotion and developmental activities. The species prioritized and incorporated are furnished below.

Breeding plan and approach

FCRI, TNAU has developed a systematic and

organized breeding programme and implemented during the last three decades. However, after 2004 the breeding programme has been revisited and moderated deploying the current needs and technological advancements. The traditional tree breeding approaches like provenances seed sources and progeny evaluation has been the backbone of forest genetic resources assessment and formed as a base population for development of advanced clones and hybrids (Mitra, 2000). Though, 30 species have been identified for incorporation in the state of Tamil Nadu; based on demand from the stakeholders and the increased attention towards agroforestry, over 15 different tree species have been intensively deployed in organized and systematic tree breeding improvement programme. The general plan and tree breeding approach followed for most industry-based tree species are depicted in the figure 1.

Table 1

Category	Prioritized species	Category	Prioritized species	
Timber Species	Teak	Plywood species	Eucalyptus	
	Khaya		Melia	
	Sissoo		Kadam	
	Mahogany		Toona	
	Gmelina		Acrocarpus	
	Thespesia populnea		Silver oak	
			Khaya	
High value Species	Sandal wood		Chukrasia	
	Red sanders			
Pulpwood species	Eucalyptus	TBOs species	Neem	
	Casuarina		Pungam	
	Subabul		Punnai	
			Jatropha	
			Mahua	
			Simarouba	
Matchwood species	Ailanthus	Other species	Bamboo	
			Acacia sp.	
			Terminalia sp.	
Floss species	Silk Cotton			

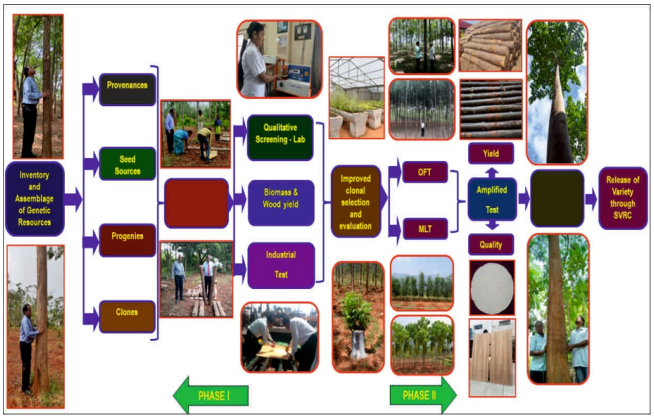


Figure 1: . Tree improvement plan and approach for species amenable for Industrial Agroforestry

Development of Improved Genetic Resources

The organized and systematic tree breeding programmes carried out over two decades have resulted in development of wide range of genetic resources amenable for industrial agroforestry with improvement in productivity and wood quality. The genetic resources were deployed and evaluated for the full rotation or harvesting period and based on the productivity and acceptable wood quality (industry specific/product specific). These clones are released through the State Variety Release Committee (SVRC) for adoption by farmers and other stakeholders. The clones so far released through the SVRC are presented in Table 1 along with yield and quality parameters.

Similarly, wide range of improved genetic resources amenable for multifunctional industrial utility are developed and are currently at pre-release stage. These clones are also demonstrated and deployed in various out-grower schemes. The major clones and improved genetic resources under pre-release stage are furnished in table 2 along with yield and quality parameters. The developed genetic resources predominantly in the form of clones are deployed in organized and consortium mode industrial agroforestry promotional programme (Figure 2).

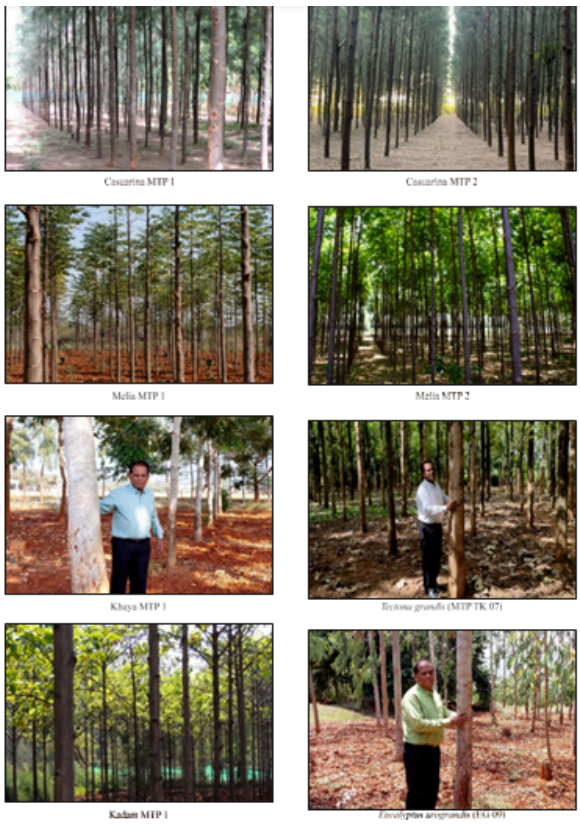


Figure 2: HYSR clones amenable for Industrial Agroforestry

Table 2: List of HYSR clones released as varieties through SVRC

S.No.	Species	Clones	Productivity (MT/ha)	Rotation (Years)	Industries	Wood quality	
1	Casuarina	*Casuarina equisetifolia* MTP CA1	100	3	Pulp and paper industries	Pulp yield over 48 %	
		Casuarina MTP 2	150	3		Amenable for pulp and pole industries	
		Casuarina MTP 3	150	3		High holocellulose (75.80%) and wood density (724.07 Kg/m3)	
2	Eucalyptus	Eucalyptus MTP 1	150	5	Pulp and paper industries	Pulp yield of over 48 %	
3	*Melia dubia*	Malai Vembu MTP 1	250	6	Ply and panel industries	Veneer recovery is over 58%.	
		Malai Vembu MTP 2	100 (pulpwood)	2 (pulpwood)	Pulp and paper &	Pulp yield is over 50%	
			200 (Plywood)	5 (Plywood)	Ply and panel industries	Veneer recovery > 64%	
		Malai Vembu MTP 3	80	8	Ply and panel industries	Face veneer recovery is more than 12%	
4	*Neolamarckia cadamba*	Kadam MTP 1	135 (pulpwood) 175 (Plywood)	3 (pulpwood) 5(Plywood)	Pulp and paper & Ply and panel industries	The pulp yield of this variety is more than 44% and the recovery is more than 20%	
						Leaves are excellent fodder – Protein (16-22%)	
5	*Khaya senegalensis*	Khaya MTP 1	150	6	Timber, Plyandpanelindustries	Density > 800 kg/m	
						SHAPE * MERGEFORMAT	
						Holocellulose – 66.41% & Lignin – 28.60%	
						Calorific value – 4777 Kcal/kg	
6	*Pterocarpus santalinus*	Red sanders MTP 1	Heartwood yield – 100 kg/ tree	15-18	Timber industries	Density - >860 kg/m	
						Wood is heavy and strong with wavy grain	
7	*Ceiba pentandra*	Silk Cotton MTP 1	900 – 1500 pods/ tree	Yield starts from 4-6 years upto 40 years	Floss based industries	Pods - Medium sized densely packed with floss	
						Pod weight: 50-60 g & Pod length: 19-20 cm	
						Floss weight: 12-16 g	

Industries supported Tree Breeding Programme

Most of the tree breeding and improvement programme are extensively supported by wide range of industries like timber, ply and panel, pulp and paper, match splints, energy and NTFPs either directly or through the consortium. A suitable MoA was executed between TNAU and wood-based industries for a systematic development of industry specific varieties and the associated expansion activities through contract tree farming. This has extended continued research and development mechanism leading to development of

improved genetic resources and the associated High Yielding Short Rotation clones accredited with improved wood quality (Parthiban *et al.*, 2019)

Deployment in operational industry based Out- grower's scheme

TNAU has conceived a value chain model on industrial agroforestry in 2005 and implemented in Tamil Nadu very systematically from 2008 onwards in association with wide range of wood-based industries to resolve various challenges and constraints that exist in operational agroforestry developmental activities. The major innovations are technological, organizational and marketing interventions through a consortium approach (Parthiban *et al.*, 2021). An institutional mechanism called Consortium of Industrial Agroforestry has been established to link the entire production to consumption processes through technological supported mechanism. The improved genetic resources and the associated clones developed are linked through industry based out-grower's schemes towards establishment of genetically improved industrial agroforestry plantations. The last ten years of technology leveraged agroforestry development has witnessed establishment of over 80,000 ha of organized and horizontally expanded plantations incorporating improved genetic resources of timber, ply and panel, pulp and paper, energy and NTFPs in association with respective

stakeholders (Parthiban *et al.,* 2022).

Clonal Licensing

Some of the released clones in Casuarina and Melia are licensed to consortium member nurseries and incubated nurseries which resulted in expansion of improved genetic resources based industrial agroforestry development. The clonal licensing also extended royalty to the institute which has been judicially incorporated for all tree breeding and improvement activities on a sustained basis

SUMMARY

Agroforestry in general and industrial agroforestry in particular is receiving significant attention and attraction across the country due to its role in extending all goods and services leading to meeting the domestic and industrial wood requirement besides satisfying the ecosystem and environmental requirements. However, the agroforestry is facing wide range of challenge and constraints which are pronounced as social, technological, organizational and marketing. Among these barriers, the technological ones are very critical and among them, the availability of proven and improved genetic resources with higher productivity, improved wood quality, short duration harvest and the associated availability of quality planting material are very

significant. Most of the plantation program exhibited varying yield and wood quality which created uncertainty in the promotion of Industrial agroforestry. Considering these issues into account, FC&RI of TNAU has designed value chain based systematic Tree Breeding plan and approach and successfully implemented in association with multiutility wood and non-wood-based industries. Over, two decades of organized Tree improvement program resulted in successful development of High Yielding Short Rotation clones amenable for multifunctional industrial utility. These clones are systematically released through the State Variety Release Committee (SRVC) for adoption by farmers and other stakeholders. Similarly wide range of short, medium and long duration clones and hybrid clones are now available as pre released clones and deployed in demonstration and operational outgrower schemes. These improved genetic resources exhibited higher productivity (over 40 m3 /ha/ annum), improved wood quality (physical, chemical, mechanical and thermo-chemical properties), short duration (18 months onwards) and attracted intensive promotion of agroforestry. The model hi-tech nursery established with all biological (Genetic resources) and physical components (infrastructure) helps to ensure the availability of Quality Planting Material. The establishment of consortium and Incubator created institutional mechanism to mass multiply and supply QPM in a decentralized approach across the country. In a holistic perspective, the tree breeding and improvement plan and approach designed, demonstrated and implemented in the state of Tamil Nadu has extended a greater scope of its adoption and replication across the country.

ACKNOWLEDGEMENT

The author expresses profound thanks to ICAR and Consortium Wood Based Industries for their continued funding support leading to development and deployment of organized tree improvement programme through value chain approach. Thanks, are also due to GOI-DBT for sustaining the funding through a project which act as a major support for continuing the development of HYSR clones amenable for multifunctional industrial utility.

REFERENCES

Food and Agriculture Organization of the United Nations. (2009). India forestry outlook study (Working Paper No. APFSOS II/WP/2009/06). Food and Agriculture Organization of the United Nations; Ministry of Environment and Forests, Government of India.

Parthiban, K. T., Arunachalam, A., Jawahar Vishnu, M. V., Revathi, S., Arasakumar, E., Madiwalar, A. F., & Kumar, P. (2022). Status of wood demand and development of industry-based outgrower schemes: An experience from Tamil Nadu. Indian Journal of Agroforestry, 24, 96–102.

Parthiban, K. T., Fernandaz, C. C., Sudhagar, R. J., Sekar, I., Kanna, S. U., Rajendran, P., Devanand, P. S., Vennila, S., & Krishna Kumar, N. (2021). Industrial agroforestry: A sustainable value chain innovation through a consortium approach. Sustainability, 13, 7126.

Parthiban, K. T., Sudhagar, R. J., Fernandaz, C. C., & Krishnakumar, N. (2019). Consortium of industrial agroforestry: An institutional mechanism for sustaining agroforestry in India. Current Science, 117, 30–36.

Parthiban, K. T. (2016). Industrial agroforestry: A successful value chain model in Tamil Nadu, India. In Agroforestry research developments (pp. 523–537). Nova Science Publishers.

Parthiban, K. T., Fernandaz, C. C., Sudhagar, R. J., & Jawahar Vishnu, M. V. (2022). Industrial agroforestry development in Tamil Nadu: A decadal analysis. Indian Journal of Agroforestry, Special Issue.

Mitra, J. (2000). Genetic improvement of fodder trees. Indian Journal of Genetics and Plant Breeding, 60, 525–533.

How to Cite this Article: Parthiban K.T.. (2025). Status and Development of Tree Breeding and Improvement of Species Amenable for Industrial Agroforestry. *Indian Journal of Agroforestry*, ***27***(2), 72-78. https://doi.org/10.48165/ija.2025.27.02.09

Table 3: List of Improved Genetic Resources (Pre-release Cultures)

S.No.	Species	Clones	Productivity (MT/ha)	Rotation (Years)	Quality
1	*Tectona grandis*	MTP TK 07	300-350	12-15	Density > 680 kg/m3 Straight cylindrical
2	*Dalbergia sissoo*	MTP DS 18	200-225	3/6/9	Density > 610 kg/m3 GCV > 4300 Kcal/kg
3	*Gmelina arborea*	FCRI GA 08	250-300	6-8	Density > 580 kg/m3 Short duration timber
4	*Swietenia macrophylla*	SM18	250-300	6-8	Density > 518 kg/m3 Veneer yield >57 % Face quality
5	*Eucalyptus* spp.	EG 09	150-250	3 and 6	Density > 700 kg/m³ Veneer yield >67 %
6	*Toona ciliata*	TC 03	150	6	Density > 541 kg/m³ Veneer yield >57% Face quality
7	*Chukrasia tabularis*	CT 03	150	6	Density > 715 kg/m³ Veneer yield >50%
8	*Acacia* hybrid	AM 9	200	3 and 6	Density > 645 kg/m3 Veneer yield >59% Pulp yield 46%
9	*Acrocarpus fraxinifolius*	FCRIAF28	150	6	Density > 607 kg/m3 Veneer yield > 63%
10	*Leuceana leucocephala*	FCRILL15	120-150	3-4	Density > 546 kg/m3 Pulp yield > 49%
	TBO's				
S.No.	**Species**	**Clones**	**Seed yield/ tree (kg)**	**Productive life (years)**	**Oil content (%)**
11	*Azadirachta indica*	MTP 01	>20	>60	> 0.8% Azar
12	*Bassia longifolia*	TNML 2	>40	>60	38 – 40
13	*Jatropha curcas*	CJH 13	>3.0	40	32 – 35
14	*Calophyllum inophyllum*	MTPCI 03	3.5 - 4.5	>60	35 - 40
15.	*Pongamia pinnata*	FCP 08	>60	>40	25-30