PHYSICAL PROGRESS REPORT

STRENGTHENING FORESTRY RESEARCH FOR ECOLOGICAL SUSTAINABILITY AND PRODUCTIVITY ENHANCEMENT

Submitted by

Indian Council of Forestry Research and Education, Dehradun

(Progress Report as on 31-03-2024 of the scheme "Strengthening Forestry Research for Ecological sustainability and Productivity Enhancement" funded by National Authority CAMPA)

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OF THE SCHEME

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Indian Council of Forestry Research and Education, P.O. New Forest, Dehradun- 248 006.

Team:

Dr. Rajesh Sharma, DDG (R), ICFRE, Dehradun

Dr. P.S. Rawat, ADG (RP), ICFRE, Dehradun

Ms. Ismita Nautiyal, Scientist- E, RP Division, ICFRE, Dehradun

Support rendered by:

Dr. Shaliendra Kumar, CTO, RP Division, ICFRE, Dehradun

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Abbreviations

ACZ	Agro-Climatic Zones
AFRI	Arid Forest Research Institute
AICRPs	All India Coordinated Research Projects
ARI	Agharkar Research Institute
ATREE	Ashoka Trust for Research in Ecology and the Environment
BBA	Borax-Boric Acid
BU	Bharthidasan University
Cdh	Choline dehydrogenase
CDZ	Cauvery delta zone
CFPR	Centre for Forest Policy Research
CNF	Cellulose nano-fibers
CoA	College of Agriculture
CPCs	Candidate Plus Clumps
CPMB	Center for Plant Molecular Biology
CPPRI	Central Pulp & Paper Research Institute
CPT	Candidate Plus Trees
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSO	Central Statistics Office
CSP	Chemically Superior Population
CSPs	Chemically superior populations
DLS	Dynamic Light Scattering
DLS	Dynamic Light Scattering
DNA	Deoxyribonucleic acid
DWR	Directorate of Weed Research
ERT	Electric Resistance Tomograph
FA	Furfuryl alcohol
FCRI	Forest College and Research Institute
FDC	Forest Development Corporation
FGR	Forest Genetic Resources
FRCER	Forest Research Centre for Eco-Rehabilitation
FRI	Forest Research Institute
FSP	Fiber saturation point
GBH	Girth at Breast height
GC-MS	Gas chromatography–mass spectrometry
GC-MS	Gas chromatography–mass spectrometry
GCP	Ground Control Point
GDP	Gross Domestic Product
GFM	Gass Forest Museum
GFP	Green Fluorescent Protein
GPR	Ground-penetrating radar
GUI	Graphical User Interface
GUS	beta-glucuronidase
HFRI	Himalayan Forest Research Institute
HPTLC	High-performance thin-layer chromatography
HRM	Heat Ratio Method

HRZ	High Rainfall zone
IAPS	Invasive Alien Plant Species
ICAR-KVK	Indian Council of Agricultural Research- Krishi Vigyan Kendra
ICAR-NBPGR	Indian Council of Agricultural Research -National Bureau of Plant Genetic Resources
ICFRE	Indian Council of Forestry Research and Education
IFB	Institute of Forest Biodiversity
IFGTB	Institute of Forest Genetics and Tree Breeding
IFP	Institute of Forest Productivity
IFQRG	International Forestry Quarantine Research Group
IIFM	Indian Institute of Forest Management
IISc	Indian Institute of Science
ITS	Internal Transcribed Spacer
IWST	Institute of Wood Science and Technology
JFMCs	Joint Forest Management Committees
KFRI	Kerala Forest Research Institute
LULC	Land Use / Land Cover
MLT	Multi locational trial
MOUs	Memorandum of Understanding
MWVD	Microwave vacuum drying
NBRI	National Botanical Research Institute
NCCF	Network for Certification and Conservation of Forests
NIH	National Institute of Hydrology
NPC	National Project Coordinator
NSO	Neem seed oil
NTFP	Non Timber Forest Products
PAU	Punjab Agriculture University
PCA	Principal Component Analysis
PCCF	Principal Chief Conservator of Forest
PDO	Panchayat Development Officer
PEG	Project Expert Group
PPVFRA	Protection of Plant Varieties and Farmers' Rights Authority
PSO	Pongamia seed oil
QPM	Quality Planting Material
RFRI	Rain Forest Research Institute
SAMEER	Society for Applied Microwave Electronics, Engineering and Research
SAW	Simple Additive Weighting
SDAU	Sardar Krushinagar Dantiwada, Agricultural University
SDM	Species distribution modeling
SDS	Sand Dune Stabilisation
SEM	scanning electron microscopy
SFDs	State Forest Departments
SFRI	State Forest Research Institute
SSD	Single Shot Detector
SSNCE	Sri Sivasubramaniya Nadar College of Engineering
SSRs	simple sequence repeats
SVU	Sri Venkatrswara University
SWAT	Soil and Water Assessment Tool
TAFCORN	Tamil Nadu Forest Plantation Corporation Limited

TCC	Total Cyanogenic Content
TDC	Technology Demonstration Centre
TFRI	Tropical Forest Research Institute
TGA	Thermogravimetric analysis
TNAU	Tamil Nadu Agricultural University
ToFs	Trees Outside Forests
ToP	Terms of Payment
UoH	University of Hyderabad
UV	Ultraviolet
VVK	Van Vigyan Kendra
WPG	Weight per Gallon
WPG	Weight percentage gain
WTP	Willingness to pay

"Strengthening Forestry Research for Ecological Sustainability and Productivity Enhancement"

Introduction of the scheme: To fulfill national commitments, ICFRE was funded scheme entitled "Strengthening Forestry Research for Ecological sustainability and Productivity Enhancement" by National Authority, CAMPA. The scheme works towards addressing the requirements of conserving the Forest Genetic Resources, enhancing forest productivity, strengthening of ecosystem services, sustainable use of resources, strengthening the extension of Forestry research through various scientific and technological interventions and capacity building of ICFRE personnel. The scheme is for 5 years was approved in 2020. The total outlay of scheme with 6 components is Rs. 313.67 crores.

Objectives of the Scheme are as under:

a) To undertake research aimed at enhancing the health and productivity of natural forests and plantations for augmenting ecosystem goods and services.
b) To undertake research aimed at efficient and sustainable resource use through value addition and development of appropriate technologies.
c) To establish a comprehensive national programme for conservation and development of Forest Genetic Resources.
d) To undertake policy research in forestry sector to analyze the policy gaps and determine concordant policies.
e) To undertake capacity building programmes for stakeholders, including forestry personnel, communities, tree growers and forest-based industries
f) To undertake an exclusive outreach programme taking research and technology to users through a comprehensive extension strategy

Six Components of the Scheme

i. All India Coordinated Research Projects (31 AICRPs) in collaboration with ICFRE and Non-ICFRE Institutes
ii. Programme for Conservation and Development of Forest Genetic Resources (FGR)
iii. Policy studies under Centre for Forest Policy Research
iv. Capacity Building of State Forest Departments for developing "State REDD+ Action Plans" under National REDD+ strategy
v. Operationalization of Forestry Extension Strategy and Action Plan of ICFRE
vi. Operationalization of Human Resource Development Plan of ICFRE

Component I: All India Coordinated Research Projects (31 AICRPs)

1. Component -1: All India Coordinated Research Projects (AICRPs)

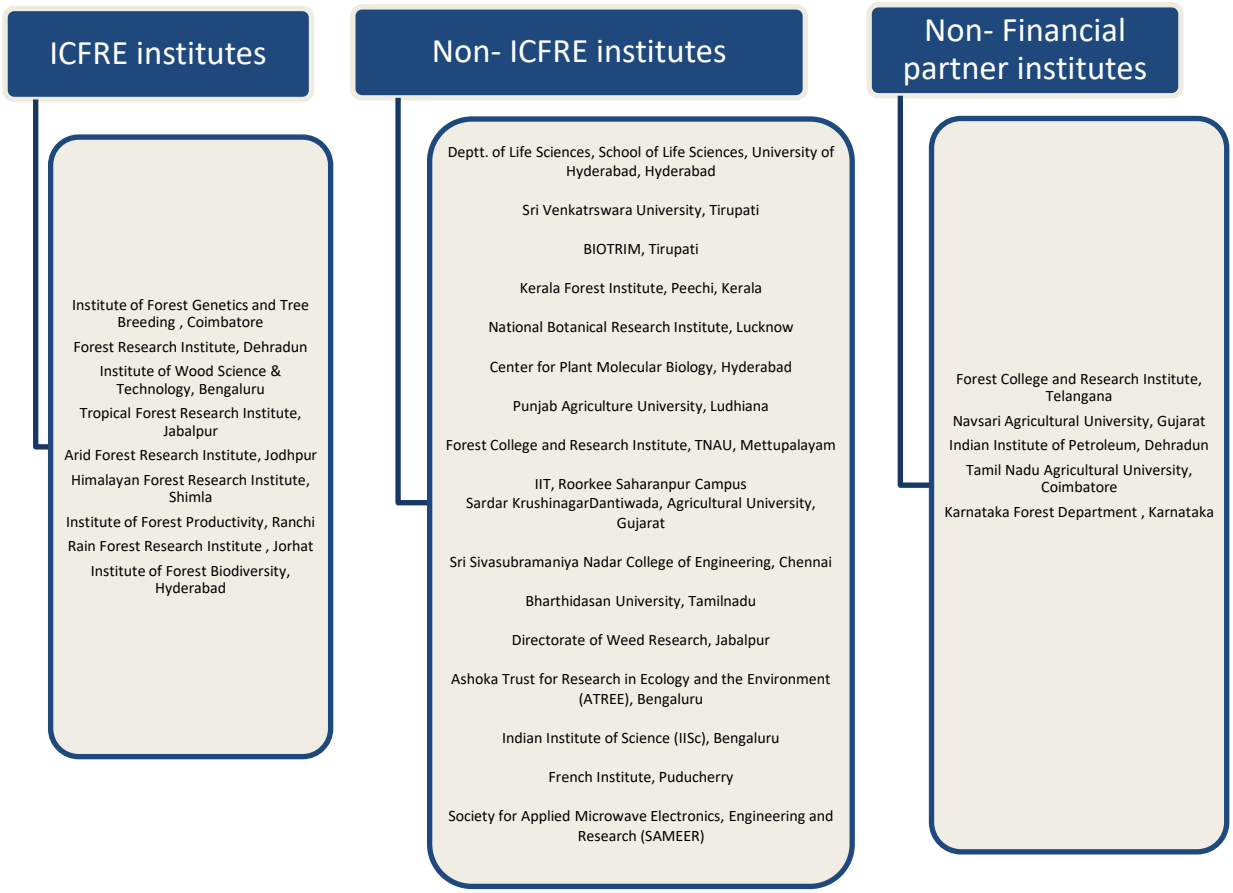
3.1 Thirty-one All India Coordinated Research Projects

AICRPs are projects, where more than one research institute and disciplines are collectively involved to address a research issue in a holistic and comprehensive manner. The emphasis is on networking of resources, capabilities and core competencies of participating institutions. All such projects are inter-institutional and inter-disciplinary.

31 AICRPs are being implemented with the help of nine ICFRE and seventeen Non-ICFRE institutes. Few other institutes are also providing inputs scientifically and technically without any financial involvement. AICRPs are divided into 13 species-based projects **and 18 subject area specific projects. Projects are listed below:**

Species Based	Theme based
• **Testing and deployment of clones and seed sources of** Casuarina **for different planting environments and end-use applications** (AICRP-1) • **All India coordinated research project on** bamboo (AICRP-2) • **Conservation, improvement, management and promotion of** sandalwood (*Santalum album*) **cultivation in India** (AICRP-3) • *Eucalyptus* **Improvement** (AICRP-4) • **Conservation and productivity improvement of** Red Sanders (*Pterocarpus santalinus*) (AICRP-8) • **Quality** teak **production: Capitalizing on cloning** (AICRP-9) • **All India coordinated research project on** *Dalbergia sissoo (AICRP-11)* • Tamarind (*Tamarindus indica*): **Domestication, conservation and deployment of genetic resources for sustenance and livelihood amelioration** (AICRP-15) • **Genetic improvement and value addition of** *Madhuca longifolia (AICRP-23)* • **Domestication, genetic characterization, improvement and diversified utilization of** poplars (AICRP-25) • **Genetic improvement of** *Azadirachta indica* A. Juss. (Neem) (AICRP-26) • **Population status, collection, characterization, and evaluation of genetic resources of** Indian Rosewood*, Dalbergia latifolia (AICRP-28)* • **All India coordinated Research Project on** *Gmelina arborea* Roxb. (Khamer or Gamhar) (AICRP-30)	• Development of dielectric heating-based processing **technologies for solid-wood, bamboo** and their composites **(AICRP-5)** • Value addition of wood and wood-based composites using **nanomaterial (AICRP-6)** • Assessment and monitoring of **invasive alien plant species** in India and formulation of strategies for management of key invasive alien plant species in different regions of the country (**AICRP-7)** • Developing **seed testing and seed storage protocols** of selected forestry species from diverse forest types **(AICRP-10)** • Assessment of **demand and supply of timber**, fuel-wood and fodder in India **(AICRP-12**) • Valuation of **forests for GDP, Green GDP** and payment of eco-system goods and services **(AICRP-13)** • **Forest fire** research and knowledge management **(AICRP-14)** • **Bio-prospecting** for industrial utilization of lesser known forest plants **(AICRP-16)** • Enhancement of **fodder availability and quality** to reduce unsustainable grazing in the forests **(AICRP-17)** • **Silvicultural interventions** for productivity enhancement and carbon sequestration in plantations of important tree species (**AICRP-18**) • Assessment of **water requirement of different forest tree species** and its impact on sub soil moisture **(AICRP-19)** • Development of **bio-pesticide products /formulations** from extracts of tree borne oil seeds and tissues of wild plants for management of insect pests **(AICRP-20)** • Development of superior **bio-fertilizer** for enhanced plant productivity **(AICRP-21)** • **Preparation of forest soil health cards** under different forest vegetations in all the forest divisions of India **(AICRP-22)** • **Combating desertification** by enhancing vegetation cover and people livelihoods in degraded drylands and deserts of India **(AICRP-24)** • Conservation and sustainable management of **wild edible fruiting species (AICRP-27)** • Sustainable management of **NTFPs** through conservation and value addition **(AICRP-29)** • **Study of climate driven effects** on Indian forests through long term monitoring **(AICRP-31)**

All India coordinated projects are being implemented in collaboration of 9 ICFRE Institutes; 17 Non-ICFRE financial partners institutes and few other institutes are also involved for scientific and technical help without financial support as given below:



Component- I AICRPs

1. All India coordinated Research project on "Testing and deployment of clones and seed sources of *Casuarina* for different planting environments and end-use applications"

1.1 Objectives:

- To evaluate clonal / family accessions for suitability to coastal, inland, waterlogged, salt-affected areas and other potential environments.
- To screen accessions for suitability to grow as nurse plants in Sandal plantations and as an alternative crop for Eucalyptus.
- To assess water and nutrient use efficiency of accessions and develop a package of cultivation practices for most productive of them.
- To evaluate the wood properties of new accessions for matching with different end uses.
- To develop and field test new hybrid combinations to select advance generation planting material for future deployment.

1.2 Progress:

This project aims at increasing productivity of Casuarina plantations in the existing cultivation area and also expanding the area of planting by providing site- and end use specific clones and seed sources. In particular emerging uses like growing casuarina as nurse plant with sandalwood trees and using casuarina as an alternate to Eucalyptus trees. It also strives to develop a package of practices for the recommended varieties through research on water and nutrient use efficiency of available germplasm. In order to sustain the current productivity and to advance the breeding programme for the future needs, new germplasm have been brought in from other countries and new combinations of hybrids made and deployed in multilocation testing. They will be a source for new varieties that will replace the currently used accessions in the near future. Five highly productive interspecific hybrid clones along with three benchmark varieties were tested in 12 diverse locations across 8 States. Five of these trials have been assessed for growth and tree form traits at the age three years which is the currently practiced rotation age for farmland casuarina clonal forestry. Six trials have been evaluated for two years' performance and the remaining one trial for the first year. In most of the test locations clone CH5 showed the best survival, growth and form traits followed by clones CH1 and CH2. They are recommended for cultivation in and areas similar to the test locations. Trials that will attain three years age during 2014 will be evaluated at the appropriate time and a final ranking of clones will be prepared pooling data from all trials. The top-ranking clone(s) will be recommended for release as an All-India Variety through the variety releasing procedure of ICFRE. Progeny trials were established in eight locations using more than 100 open pollinated families assembled from breeding populations in India, China, Kenya and Malaysia. They have been evaluated for growth and form characters at the age of two year (5 trials) and one year (three trials). Ranking of families and trees have been made using early growth data and outstanding individuals have been propagated for future field testing. These trial plots will be converted into seedling seed orchards after evaluating at the age of three years for producing genetically improved seeds to meet the demand of respective regions.

Two trials involving sandalwood trees and different clones of Casuarina haven established to select the best clonal accession to serve as nurse plant for sandalwood trees in plantations. Similary one clonal and two progeny trials have been planted in locations where Eucalyptus was grown previously. These testing will help in selecting suitable seed and clone sources to be used as alternative to Eucalyptus trees in semi-arid conditions. The water use efficiency of the three shortlisted clones and one benchmark clone was studied using Sap Flow Meter procured under the project. The uptake of water by individual trees were recorded throughout the day during different seasons in one locations.

The same study is being undertaken in a second location. Similarly the nutrient uptake and distribution by the trees have been studied by collecting wood samples from different clones and analyzing them for the presence of different nutrients. Wood properties (basic density, moisture content, fibre dimensions, pulp yield) were studied in five trials that have attained the age of three years. The remaining trials will be evaluated during 2024 and based on the results obtained, clones and families will be identified for different end uses like pulpwood, poles and fuelwood.

The long term objective of the project is to move the ongoing Casuarina breeding programme to advance generations so that the productivity and wood quality is continually improved benefitting the farmers and growers of Casuarina in the country. The progeny trials established in the project will serve as advance generation breeding populations for future selection and breeding purposes since they have drawn from existing genetically improved accessions. New interspecific hybrid clones developed in the breeding programme have been screened through and progeny and clonal screening trials. The five shortlisted clones are currently undergoing clone-proving tests along with the three clones currently used in commercial plantation (CH1, CH2 and CH5). They will be evaluated for growth and form traits during 2024 and an interim recommendation will be made for deploying new superior clones for commercial planting. Despite the several difficulties faced during the implementation of the project, every objective of the project is well on the way of its achievement and the expected outcome will be delivered while concluding the project. As detailed above, the various output from the project i.e. new superior varieties, precision cultivation package, increased accessibility of genetically improved seeds and clones and enhanced knowledge on the biology and utilization of the multipurpose species will benefit farmers and wood-based industries particularly paper industries apart from contributing to soil and climate amelioration through increased tree cover.

Fig. 1. Variable growth and poor stem form of seed source (foreground) compared to uniform and straight stems of clone CH5 (background) at three years age (Ariyalur, Tamil Nadu)

Fig. 2. Recording of water use by selected Casuarina clones using Sap Flow Meter

Highlights

- Multilocation clonal trials raised in nine States across the country (survival rate 80%). They were evaluated for growth and tree form characters at the age of two year (six trials) and three years (five trials). Clone CH5 showed consistent superior growth and recommended for cultivation in test locations.
- Twelve progeny trials raised in seven States across the country with a broad genetic base (130 families) which include germplasm imported from China, Kenya and Malaysia (survival rate 87%). Interim ranking of families and trees was prepared and initiated vegetative propagation of trees with outstanding early growth.
- Water and nutrient use efficiency of shortlisted clones were studied using Sap Flow Meter. Initiated studies on nutrient uptake and distribution in casuarina wood.
- Wood properties of fast-growing clones have been evaluated to match them for suitable end uses like pulpwood, poles and fuelwood.
- Five new hybrid clones (H3, H8, PV26 and PV27) showing early growth on-par or better than benchmark clone (CH5) have been selected from cone-screening trials and planted in clone-proving trials for final ranking and release for commercial planting

2. All India coordinated Research project on "Bamboo"

2.1 Objectives:

- Genetic improvement through identification of superior clumps, mass multiplication and ex-situ conservation
- Development of package and practices for better clump management, harvesting, development of bamboo seed storage protocols, strategies for management of pre and post flowering resources, analysis of bamboo phylogeny
- Development of processing and preservation techniques for bamboo, bamboo composites and evaluation of bamboo germplasm for structural, strength and pulp properties.
- Development of strategies for management of pests and diseases, extension and technology transfer

2.2 Progress:

Extensive field surveys were carried out in various forest areas of Uttarakhand, Himachal Pradesh, Rajasthan, Gujarat, Odisha, Jharkhand, Bihar, West Bengal, and the North-East states to find potential genotypes of various bamboo species. More than 450 new CPCs of several bamboo species were selected across the country and the superior clumps were mass propagated for their dissemination to the users. Macro- propagation of superior germplasm of selected bamboo species has been carried out and Rhizome bank of different bamboo species have been established at FRI, IFGTB, HFRI, and IFP Ranchi. A Multi Location Trial (MLT) of superior germplasm of *D. strictus* was established at Kotiya (Raebareli), Uttar Pradesh by FRI Dehradun. RFRI enumerated 43 accessions of *B. balcooa*, 65 accessions of *B.tulda*, 8 accessions of *B. nutans* and 07 accessions of *B. pallida*.

Species and Institute wise Candidate Plus clumps (CPC) selection

Institute	*Species*	*CPC*
TFRI	*Bambusa nutans*	
	Bambusa tulda	30
	Bambusa vulgaris	19
	Bambusa balcooa	20
RFRI	*B. tulda*	12
	B. balcooa	7
	B. nutans	10
	Schizostachyum dullooa	5
FRI	*Himalayacalamus falconeri* (Dev ringal)	5
	Drepanostachyum falcatum (Gol ringal)	6
	Thamnocalamus jaunsarensis (Jamura)	2
	Thamnocalamus spathiflorus (Tham)	2
	B. nutans	1
	B. tulda	1
IFGTB	*Bambusa bambos*	1
IFP	*D. strictus*	**18**
	B. vulgaris	41

	B. bambos	19
	B. tulda	31
	B. nutans	40
	D. asper	4
	P. nigra	3
	B. balcooa	22
	D. giganteus	11
	Melocana baciferra	06
	B. striata	10
HFRI	*Drepanostachyum falcatum*	33
	Thamnocalamus spathiflorus	10
	Dendrocalamus strictus	27
IWST	*D.stockii*	43
	Guadua angustifolia	03
	Thyrsostachys oliveri	03
	Total	452

For mass propagation, experiments for micro-propagation have been conducted in selected clumps of *B. cacherensis* at RFRI*, B. nutans, D. brandisii* and *D. stocksii* at IWST, *B.tulda, B. balcoa, B. nutans* and *B. polymorpha* and *D. strictus* at IFP Ranchi respectively. Micro-propagated plants of 6 selected bamboo species were hardened at IWST Bangalore and for two species viz.*D. strictus* and *D.hamiltonii in-vitro* root culturing and hardening carried out at IFP Ranchi. RFRI Jorhat produced and hardened 500 *in vitro* propagated plantlets of *B.tulda* (CPC-AP/BT/06) for planting. All of the cuttings and plant stocks are being maintained and regular tending operations are carried out. Standardization of propagation through culm cutting and macro- propagation in *S. dullooa* with talc media (Talc+ IBA) at 1000 ppm formulation and obtained 91% rooting in *S. dullooa*. Macropropagation of *B cacharensis* were done with 200, 400, 800, 1000, 1200, 2000 ppm of talc formulation (Talc + IBA) and *B. tulda* were done at 400 and 800 ppm of IBA solution and recorded 55.5% of rooting in *B. cacharensis* at 1200 ppm of IBA. *S. dullooaculm* cuttings are macropropagated at 1000 ppm and talc paste were used as a treatment and sprouting started within 2 weeks. Culm cuttings of B. balcooa are macropropagated at 2000 and 200 ppm IBA talc formulation respectively. Different experiment viz. root initiation, shoot initiation and hardening related to *In vitro* propagation for mass multiplication of several elite genotypes of Bamboo were conducted IWST, RFRI, IFP and AFRI.

In order to develop silvicultural practices for increased productivity stand /clump management and harvesting, existing mature clumps of different bamboo species have been identified for silvicultural treatments at all the participating institutes. For establishment of model plantations for demonstration and scientific cultivation, five demonstration plots have been established, one by FRI Dehradun at KVK Kashipur, three by RFRI Jorhat at Messamora gram panchyat office campus; Namsai (Arunachal Pradesh), Deroi, Sibsagar district, Assam and one by TRFI Jabalpur.One more site selected for plantation of *Bambusa vulgaris* in Kotiya, Raebareli, UP. Thinning operation and soil loosening work in selected matured clumps in demonstration plots carried out. Data was recorded on different growth parameters, casualty replacement, soil working and application of fertilizer was done in the demonstration plantation established. For eco-distribution mapping, SENTINEL satellite data was utilized for the North Eastern hill states, detailed methodology was designed for LULC map generation of the states, namely Arunachal Pradesh, Assam, Manipur, Meghalaya, and Nagaland with 87.33% accuracy. The LULC map was completed for Ariyalur, Coimbatore, Cuddalore, Dharmapuri, Dindigul, Erode, Kanniyakumari, Kallakurichi, Karur, Krishnagiri, Madurai, Namakkal, Nagapattinam, Nilgiris,

Perambalur, Pudukottai, Ramanathapuram, Salem, Sivaganga, Tenkasi, Theni, Thoothukkudi, Thiruvarur, Trichirappalli, Tirunelveli, Triuppur, Virudhunagar district with 88.22% accuracy. For evaluation of Bamboo species for reclamation of salt affected lands, two Species trial (5 species each) established in salt affected areas of Prayagraj and Banda District of U.P. and one more field trial established with 10 bamboo species at Prayagraj. For evaluation of Bamboo species for reclamation of coal mined affected area, two species evaluation trials each of 13 bamboo species established at Tirap colliery of NE Coal fields and Makum coalfields. Similarly, a third site for plantation has been identified at Ledo, OCP of North Eastern Coal Field Ledo, Tinsukia, Assam. For development of Bamboo based multipurpose windbreak models, three windbreak model plantation have been established in wind affected areas each at Champaknagar, West Tripura; Gaburcherra, South Tripura district and Lembucherra, Tripura using *Thyrsostachys oliveri* and *Bambusa polymorpha.* Selection of cover crops for plantation/cultivation were done and MPTs namely; *Parkia timoriana, Emblica officinalis* etc. were planted at Lembucherra site. Second year data pertaining to height of leading shoot, no. of nodes and internodal length etc collected from established trials. Disease survey methods were standardised. Insect and Disease surveys conducted in bamboo nurseries and plantations across various regions in northern, central and North-eastern India and collected damage causing insects/diseased samples of different bamboo species and isolated pathogen and cultured. Pathogenicity tests conducted. Life cycles of bamboo borers, defoliators and grasshoppers were recorded. The species *Murraya koenigii* and *Ageratina adenophora* were tested for antifungal potential against fungal isolates from diseased bamboo samples. It was found that 1.5% extract of *Murraya koenigii* was most inhibiting against *Pestalotiopsis* followed by *Alternaria* and *Fusarium*. Whereas, 1.5% extract of *Ageratina adenophora* was most effective against *Alternaria* followed by *Fusarium and Pestalotiopsis*. Survey was conducted in social forestry bamboo nursery and plantation at Bhanupratappur, Rajnandgaon, Chilpi, Taregaon and Rengakhar (C.G.) and observed termites and borers damage on bamboo species *D. strictus, B. tulda* and *B. arundinacea* and recorded incidence of insect pests and collected various types of damage symptoms. A field tour was conducted in the district of Rudraprayag at Maikoti Nurasary, Chamoli at Gopeshwer, Mandal, chopta, Ukhimath and Terhi district. The diseased samples of Hill bamboo i.e. *Drepanostachyum falcatum* and *Thamnocalamus spathiflorous* showing leaf spot, culm spot and culm stain were collected. The pathogens were isolated, sub-cultured and purified for future work. Regular surveys were carried out in Haryana and Uttarakhand in different bamboo nurseries, plantations and storage to check for the infestation levels of different insects. Rearing of *Lyctus africanus, Stromatium barbatum* and *P. crassicollis*in wooden, chimney and in outdoor cages is being continued. Life cycle of for *Crypsiptya coclesalis, Hieroglyphus banian* and *Pionea flavofimbriata*are completed and data is compiled. Chemical control trials were laid out in bamboo nurseries for the control of the defoliators using three contact insecticides namely Cypermethrin+Chlorpyriphos, Spinosad and Cypermethrin at different concentrations. The results showed that Cypermethrin+Chlorpyriphos was found to be most effective at 0.04 per cent concentration with 71.63% control for *C. coclesalis* and 71.03% control of *H. banian*. Cypermethrin+Chlorpyriphos were found to be most effective at 0.08 per cent concentration with 76.20% control for *Pionea flavofimbriata.* Protocol for determination of total cyanogenic glycosides content of edible bamboo shoots by picrate paper method standardized. TCC and antioxidant assay carried out for species *B. tulda, B. balcooa, B. nutans, B. bamboos, D. hamiltonii, M. beciferra* collected from various sites. Prepared list of morphological traits to be used for taxonomic and anatomical studies.Morphological data recorded depicting different characters of Total 62 species viz. *Melocanna baccifera, Drepanostachyum falcatum, Bambusa polymorpha, Bambusa vulgaris* var. *striata, Bambusa vulgaris, Bambusa tulda, Bambusa bambos, Bambusa multiplex, Schizostachyum*

pergracile, Dendrocalamus giganteous, Dendrocalamus longispathus, Dendrocalamus membranaceus, Dendrocalamus strictus, Dendrocalamus somdevai, Thyrsostachys oliveri and *Bambusa vulgaris* cv. *Wamin*. Anatomical data (**Total 10 species**) such as types of vascular bundles and epidermal peel characters (stomata, long cells, short cells, macro hairs, prickles and silica bodies) of *Dendrocalamus giganteus*, *Dendrocalamus membranaceus, Dendrocalamus longispathus, Bambusa multiplex, Bambusa tulda, Bambusa vulgaris* var. *wamin, Bambusa vulgaris* var. *striata, Bambusa vulgaris, Bambusa bambos,* and *Bambusa nutans,* were analysed.

For molecular characterization and population genetic studies, leaf samples of selected bamboo species were collected and standardization of DNA isolation protocols has been completed in several bamboo species viz. *Ochlandra travancorica*, *B. balcooa, Dendrocalamus longispathus, B. vulgaris, B.tulda, B.bambos*. Development of polymorphic SSRs is in progress in various ICFRE institutes for genotyping works. A total of 21596 SSRs were successfully developed in the de novo assembled genome of *D. longispathus*. A subset of 50 primer pairs was synthesized for validation through PCR amplification and polymorphism survey, 36 were successfully validated and 16 showed polymorphism across the samples. All the polymorphic primers were also tested for their cross-transferability in 29 other bamboo taxa. Genomic DNA was extracted from all the populations of Phyllostachys mannii and Chimonobambusa callosa, and work is under progress for the rest. Qualitative and quantitative analysis of gDNA was carried out using agarose gel electrophoresis and spectrophotometer, respectively. A total of six populations of *Dendrocalamus longispathus* have been received out of which 4 populations have been genotyped with 13 polymorphic SSRs and work is under progress for remaining populations. Developed EST-SSR markers through denovo transcriptome assembly. Based on transcriptome sequencing 176215 mono, di, tri, tetra, penta and hexa SSR were predicted. Estimation of genetic diversity of *B. balcooa* using EST-SSR marker in Northeast India completed and identified 3 distinct populations. Completed genetic diversity of *B. balcooa* in Northeast India. Tested transferability of 27 EST-SSR in *S. dullooa* and *M. baccifera.* The species of Bambusa bambos from Western ghats and Eastern ghats populations were profiled for ten polymorphic SSR primers for population genetic analysis. The populations of *Ochlandra travancorica*, *Dendrocalamus stocksii*, *Dendrocalamus brandisii* from Kerala Forest Research Institute germplasm bank was extracted for DNA for SSR profiling.The species *Ochlandra travancorica* was genotyped with ten polymorphic SSRs for the KFRI accessions. DNA bar coding work, which has been initiated for 21 bamboo species (*Phyllostachys aurea, Drepanostachyum falcatum, B. polymorpha, B. vulgaris var. wamin, D. longispathus, D. membranaceus, D. somdevai, D. strictus, Gigantochloa atroviolacea, G. albociliata, Guadua angustifolia, Melocalamus maclellandii, Melocanna baccifera, Thyrsostachys oliveri, B. tulda, B. multiplex, B. bambos, B. nutans, Schizostachyum pergracile and B. vulgaris var. striata*). DNA barcoding markers (rpoC1, rpoB, trnH–psbA, TrnL-F, TrnK-psbA, trnC-rpoB, trnD-trnT, trnT-trnL, atpF-H, PsbK-psbI, ycf1 and NdhF) synthesized. 80 samples (purified PCR products) of ten bamboo species *i.e. Bambusa bambos*, *Bambusa multiplex*, *Bambusa nutans*, *Bambusa polymorpha*, *Bambusa tulda*, *Bambusa vulgaris* cv. *wamin, Bambusa vulgaris* var. *striata, Dendrocalamus longispathus, Dendrocalamus membranaceus,* and *Dendrocalamus somdevai,* which were amplified initially, with primers *i.e.* ndhJ F1R1, ndhJ F2R2, ndhF, and psbK-I have been sent for the DNA sequencing in both directions with forward and reverse primer. The chromatograms (DNA sequence files) were examined manually for peak quality, and poor-quality sequence data (mixed or overlapping peaks). The sequence reads obtained from the forward and reverse primers were assembled into a single

continuous sequence using the BioEdit Sequence Alignment Editor, and ambiguous sites were checked and corrected manually by using original chromatograms for further analysis.

Seed storage protocols at various temperature and moisture/desiccation levels are being standardized. Viability of seeds of *B. bambos* and *D. strictus* under storage at different temperature (ambient room temperature and 5^0C) and two moisture contents (7 % and 10 %) evaluated. The seeds of *B. bambos* stored at 5^0C with 7 and 10% moisture maintained 85% viability after 22 months in storage conditions and the ones stored at ambient room temperature, lost viability completely. Seed storage trials of *Bambusa bambos* continued; seeds stored at 5°C temperature at 10% and 7% seed moisture content recorded above 85% germination after 22 months in storage conditions, which appeared to be suitable for short-term storage of the seeds of the species. *Bambusa bambos* two year-two month's and one year-ten month's old seeds collected from the Eastern and Western Ghats respectively exhibited maximum germination efficiency of about 70%–80% when stored at 10**°**C in Zip lock covers, followed by Western Ghats seeds stored at 3**°**C and -20°C that showed high germination. Cell membrane electrolyte leakage was greater in Eastern Ghats *Bamboo* seeds compared to Western Ghats seeds, measured via an electrical conductivity meter. Moisture content obtained by dry heat method, reveals that Western Ghats *Bambusa bambos* seeds hold less moisture than Eastern Ghats bamboo seeds. The seeds of *Dendrocalamus longispathus* and *Bambusa tulda* were received from Tripura Bamboo Nursery and bamboo society of India respectively. The seed morphological parameters such as seed length, seed width, seed Index had been recorded using vernier calliper, optical microscope and electronic weighing balance. Moisture content of fresh sample also has been determined using traditional oven method and moisture analyser. TZ test were done to check the viability of different bamboo seeds. Totally 170 accessions belonging to 58 bamboo species have been assembled for establishing field gene bank and are being maintained as *ex situ* conservation.

All India Bamboo Flowering Database is under development. Information on the flowering records across the country is being collected. Flowering in *Bambusa nutans* was recorded at two different times, and two different locations, at FRI Campus. Herbarium specimen in the flowering stage of *B. nutans* was prepared and submitted to DD Herbarium for authentic identification and record. Photo plates depicting different parts have been prepared and a flowering report of *B. nutans* was added to the bamboo flowering database.Flowering reports of total 48 bamboo species from different parts of the country were incorporated in the flowering database.Recent flowering data collected from different locations of northeast India. In 2023, sporadic flowering was observed in *D. longispathus* (Manipur and Mizoram), *S. dullooa* (Mizoram), *S. pergracile* (Assam), *B. bamboos* (Assam), *B. balcooa* (Assam), and *D. hookeri* (Meghalaya). Secondary data collected from literature and updated flowering database. Recorded flowering database on following bamboo species. *(Bambusa bamboos, Schizostachyum dullooa, Dendrocalamus longispathus Dendrocalamus hamiltonii, Bambusa tulda, Bambusa balcooa, Bamusa nutans, Bambusa vulgaris, Bambusa pallida, Dendrocalamus giganteus, Melocanna baccifera, Gigantochloa andamanica, Schizostachyum pergracile, Arundinaria racemose, Melocalamus compactiflorus, Dendrocalamus sikkimensis, Dendrocalmus latiflorus, Dendrocalmus hookeri, Chimonobambusa callosa, Bambusa mizorameana, Bambusa arundinacea, Bambusa multiplex, Arundinarea manii, Sinarundinarea falcate, Dendrocalamus patellaris, Schizostachyum polymorphum, Thamnocalamus aristatus, Sinarundinaria maling, Sinarundinaria hookeri, Schizostachyum fuschiianum, and Sinarundinaria griffithiana)*

Newly developed and installed bamboo bending testing machine has been optimized with loading belt. Testing with *Dendrocalmus strictus* initiated. A new four-point bamboo bending testing machine

designed, developed, installed and commissioned for testing large size bamboo pole (length-30 times of diameter) as per new Indian standard IS:6874(2008) and International standards ISO:22157 (2004/2019).

De-structured bamboo boards of *Dendrocaamus somdevii, Dendrocalamus membranaceus* and *B. tulda* were prepared with various pressure levels viz; 21.0 24.5, 28.0, 31.5 kg/cm2 and physical and mechanical testing carried out. Physical (Water absorption, General swelling, Moisture content, and Density) and mechanical tests (Modulus of rupture, Modulus of elasticity, Compression parallel to the grain, Screw withdrawal, and Hardness) of prepared boards of *Bambusa tulda* were carried out as per IS 1734 and 1708. For the protection of in service bamboos through fumigation of eco-friendly preservatives, fungi static and fungicidal property of Neem and *Pongamia pinnata* seeds oil against identified fugal strains were tested. Fumigation of *B. balcooa, D strictus and B. tulda* with 5%, 10% and 15% of Neem seed oil (NSO) and Pongamia seed oil (PSO). Determination of retention after fumigation/ treatment. Soil block bioassay of *B. balcooa B. tulda and D. strictus* fumigated with Neem seed oil with the fungus *Poria monticola.* Result shows upto 70% protection with 15% concentration of NSO. Soil block bioassay of *B. balcooa B. tulda and D. strictus* fumigated with *Pongamia* seed oil with the fungus *Pycnoporus sanguineous.* Result shows upto 75% protection with 15% concentration of PSO. Efficacy evaluation of fumigated bamboo species with NSO against sap stain fungus is under progress.

Total 24 CPCs of *D. strictus* are being studied for pulping characteristics. Proximate chemical analysis of the 28CPCs has been carried out. Among all the culms assessed so far, maximum Kraft pulp yield was recorded for CPC- 6-16 (54.85% at 16% alkali charge; 53.15% at 18% alkali charge; 50.58% at 20% alkali charge) followed by CPC-10-4 (54.43% at 16% alkali charge; 50.89% at 18% alkali charge; 48.06% at 20% alkali charge) and CPC-6-20 (53.78% at 16% alkali charge; 50.40% at 18% alkali charge; 50.30% at 20% alkali charge). Eight CPCs of *D. strictus* have been collected from the field, converted into chips and processed for further analysis. In eight processed CPCs of *D. strictus,* moisture content, ash content, silica content, cold water solubility, hot water solubility, alcohol- benzene solubility, 1% NaOH solubility, acid insoluble lignin, holocellulose content, α-cellulose content was determined TAPPI standard methods. Kraft pulping of seven CPCs of *D. strictus* at 16%, 18% and 20% chemical charge has been completed. Total pulp yield, rejects, screened pulp yield of all six collected samples were estimated. Kappa number of seven pulped samples (5-16, 8-18, 5-2, 4-4, 8-18, 17-17, 17-9) obtained from different pulping conditions at 16%, 18% and 20% chemical charge has been determined.

Established four Bambusetum/ Germplasm bank/bambusetum, one at IFP Ranchi campus and its Mander Research station, two bambusetums established by FRI Dehradun each at PAU Research Farm, Ladowal (Punjab) with 18 species and at Mansa in Research Farm of ICAR-IISWC (Indian Institute of Soil and Water Conservation), Chandigarh with 21 species, one atTFRI Jabalpur campus with 37species and one at Assam (RFRi Jorhat) with 27 bamboo species, A bambusetum was established by IFGTB with 44 species at Iduvai Village, Tirupur District, Tamil Nadu**.** Training on "Cultivation, Seasoning, Preservation and Utilization of Bamboo" was conducted jointly with BEEM Rural Development Organization, Korategere on 10 March 2023 at, Open Jail, Devanhalli. Bangalore Rural District. About 80 Prisoners (farmers) and jail staff participated in the program. Printed technical bulletin, posters and conducted trainings by various participating institutes for dissemination of information on Bamboos. A Digital Brochures on bamboo Hindi and English prepared by FRI Dehradun. IWST Bangalore has published a technical bulletin on *Dendrocalamus stocksii* in local language (Kannada) for the benefit of various end users.

Hands on handicraft making workshop on "Bamboo-The Wonder Grass" was conducted as part of World Bamboo Day Celebrations on 17th& 18th September, 2022. The workshop was conducted in association with G18 a NonGovernment Organisation based in Coimbatore. 18 participants from various backgrounds ranging from school & college students, school teachers, entrepreneurs and artisans attended the workshop. Translation of Reading material into Tamil and Malayalam has been completed. 5 posters on Bamboo Value Addition haves been prepared in English and the same has been translated into Tamil and Malayalam. A tranning programm was organised on Baans avam Ringal Adharit Hast Shilp Nirm

Highlights

- 473 Candidate plus clumps (CPCs) of 12 bamboo species were selected after field surveys across India and were mass propagated for their dissemination to the users. Established Rhizome banks of selected clumps at FRI, IFGTB, HFRI & IFP.
- Micro-propagation Protocol of 9 different bamboo species and their selected CPCs standardised. *In vitro* starter cultures for 4 species (*B. tulda*, *D. asper, D. stocksii* and *D. brandisii*) produced and sold. Produced 10,000 hardened plants from these germplasm for dissemination.
- 15 bamboo species are being tested for reclamation of salt affected lands at Prayagraj and Banda District of U.P. and 13 Bamboo species are being tested for reclamation of coal mined areas of Makum, Tirap colliery and Ledo, Open Cast Mine, NE Coal Fields Tinsukia, Assam.
- Bamboo based wind break models are being developed for the high wind affected areas of Tripura. Three windbreak model plantations established in wind affected areas each at Champaknagar, West Tripura; Gaburcherra, South Tripura district and Lembucherra, Tripura using *Thyrsostachys oliveri*and *Bambusa polymorpha.*
- Bamboo boards (de-structured) of *Dendrocaamus somdevii*, *Dendrocalamus membranaceus* and *Bambusa tulda* were prepared and their physical and mechanical properties tested as per Indian Standard 1708 and found suitable for structural purposes. This is first species specific study and recommendation can be used for industry.
- Pulping characteristics 24 Candidate plus clumps of *D. strictus* were studied. Three CPCs; DS 6-16, DS -10-4 and DS -6-20 yielded maximum Kraft pulp yield and can be recommended for clonal plantation for paper and pulp production purpose.
- Seed storage protocols developed two most distributed species; *Bambusa bambos* and *Dendrocalamus strictus.* Present storage protocol suggests that storage at 5 ^{o}C and around 7-9 % RH will maintain more than 70 % seed viability after 2 years. Also, seeds specimen of more than 12 from recently flowered bamboo species are being maintained for identification. For establishment of model plantations for demonstration and scientific cultivation, five demonstration plantations have been established.
- Flowering reports of total 48 bamboo species from different parts of the country were incorporated in the bamboo flowering database.
- For identification of bamboos, morphological for taxonomic and anatomical studies has been initiated and different characters of 62 bamboo species have been covered. Also DNA bar coding work, which has been initiated for 21 bamboo species, which is difficult to identified using traditional methods.
- Eco-distribution mapping of many bamboo is done. It is completed for Western Himalayan bamboo species and now being done for eastern species. The LULC map of *B. balcooa* for north-east states with 87.33% accuracy & *B. bambos* in Tamil Nadu with 88.22 % accuracy completed.
- Design & developed a bending testing machine capable of testing bamboo up to 40 feet length as per new Indian standard IS:6874(2008) and International standards ISO:22157 (2004/2019).
- For biological control of bamboo diseases, 1.5% extract of *Murraya koenigii* was found most inhibiting against *Pestalotiopsis* followed by *Alternaria* and *Fusarium* (the *m*ost prevalent nursery disease causing leaf spot and blight in bamboo).
- Eco-friendly preservatives like Neem and *Pongamia pinnata* seeds oil are being tested for bamboo preservation.
- Established six bambusetums at different locations for demonstration and their ex-situ conservation.

3. All India coordinated Research project on "Conservation, improvement, management and promotion of Sandalwood (*Santalum album* Linn.) cultivation in India"

3.1 Objectives: Establishment and evaluation of base population in sandalwood for breeding and conservation programs. Development of sandalwood based agroforestry system and its promotion in selected agroclimatic zones of India. Evaluation of heartwood formation, yield and chemical profiling of oil in sandalwood populations

3.2 Progress:

Developed the sandalwood breeding program. Sixty one natural populations were surveyed across six states and 985 trees were marked. Nursery was raised with 326 seed lots including 10 bulked seed lots. Established two trials at Pachamalai, Tamil Nadu (single tree selections) and Kanasar village, Rajasthan (bulked seed collections). Generated transcriptomes, small RNA, lnc RNA and methylome datasets for leaf, wood and haustorial tissues. The first single base resolution unbiased methylome maps were generated for leaf and wood. Insight into the post-transcriptionally regulated genes involved in sesquiterpene pathway and climate adaptation was identified and validated. The first set of genome-wide SSR markers were short-listed and 30 6-FAM labelled polymorphic SSR primers were genotyped in diverse sandalwood populations from Kerala, Tamil Nadu, Madhya Pradesh, Karnataka and Odisha. Genetic diversity estimated 51 genotypes from base populations. Axillary shoot induction was achieved in 12 genotypes with 47 to 97% success while adventitious shoots were induced from 8 genotypes with 13 to 100% success. Somatic embryo induction from callus and embryo maturation was achieved for 3 genotypes with 100% success. Primary and secondary hardening was achieved for 1 genotype.

Established 16 sandalwood based agroforestry trials in six states with known seed sources and economic returns from intercrop estimated. A total of 237 sandalwood based agroforestry trials established were conducted in 6 states to document the agronomic and silvicultural practices.

A total of 46 plantations in 4 Southern states were conducted and incidence of red stem borer was documented and percentage of incidence of stem borers in plantations was 3-11%. Light traps and entomopathogenic fungi based insecticides were found to be an eco-friendly method for control and management of infestation by red stem borer on sandalwood. Survey conducted in Karnataka (20), Kerala (10) and Tamil Nadu (2) and percentage of sandal spike disease incidence was 38.37% in Karnataka; 34% in Tamil Nadu and 46% in Kerala. Seeds and seedlings from the symptomatic trees were found positive to phytoplasma.

Survey of 73 plantations in Karnataka was conducted and ERT data was collected. The linear regression model using actual and ERT heartwood data predicted similarity of 90 % with R2 = 0.95. The data was shared with 73 farmers. Prepared a video on estimation of heartwood using ERT in standing trees of sandalwood. Carbon isotope composition (13C/12C) analysis of 315 wood samples using IRMS completed. Preliminary analysis with subset of data revealed no significant correlation with stable isotope ratio and sample location. Estimation of oil content and alpha and beta santalol content using conventional solvent method was completed in 180 and 195 samples respectively. Comparison of both methods predicted 87% correlation. Correlation analysis between oil content and girth class conducted using 144 samples and 72% correlation documented.

Highlights

- Sixty one natural populations were surveyed across six Indian states and 985 trees were selected as seed source. Further, nursery was raised with 326 seed lots including 10 bulked seed lots and base population trials were established at Pachamalai, Tamil Nadu with single tree selections and Kanasar village, Rajasthan with bulked seed collections.
- A 199.92 Mb hybrid sandalwood genome assembly using long reads from ONT and short reads from Illumina platform was generated and the final chromosomal level draft genome had 123 contigs with N50 of 23.37MB. A total of 28,895 protein coding genes were predicted and 87% were annotated.
- Sixteen agroforestry trials were established at Rajasthan (2), Gujarat (1), Madhya Pradesh (2), Tamil Nadu (3), Punjab (2) and Karnataka (6) with known seed sources and economic returns from intercrops were estimated from few trials.
- Survey was conducted in 150 sandalwood based agroforestry plantations in 8 agro-climatic zones of Karnataka and the study revealed that the preference of secondary host depended on the agro-climatic condition, local market demand and farmers' knowhow. In the Eastern dry zone, the preferred host was mulberry while mango, Melia and pomegranate were planted in the Northern dry zone. The predominant secondary hosts in the Central dry zone were mahogany, arecanut and pomegranate. Mulberry, teak and banana were cultivated as the main host in Southern dry zone of Karnataka.
- A total of 46 plantations in 4 Southern states were surveyed and incidence of red stem borer was documented. The percentage of incidence of stem borers in plantations was 3-11%. Light traps and entomopathogenic fungi based insecticides were found to be eco-friendly method for control and management of infestation by red stem borer in sandalwood plantations.
- The heartwood content in standing trees was estimated using Electrical Resistivity Tomography (ERT) in 73 plantations in Karnataka. Analysis of tree growth and soil properties across different agro-climatic zones indicated that the Northern dry zone including Bagalkote, Belgum, Bellary, Bijapura, Dharwad, Koppal districts was more suitable for sandalwood cultivation while coastal zone including Dakshina Kannada, Udupi districts were least suitable for the species growth.
- Survey was conducted in Karnataka (20), Kerala (10) and Tamil Nadu (2) and percentage of sandal spike disease incidence was recorded as 38.37% in Karnataka; 34% in Tamil Nadu and 46% in Kerala. Seeds and seedlings from the symptomatic trees were found positive to phytoplasma.

4. All India coordinated Research project on "Eucalyptus improvement"

4.1 Objectives:

- To identify the superior Eucalyptus clones across different regions
- To improve the growth vigour and adoptability of genotypes through Inter-specific hybridization.
- To identify and introduce new germplasm /species to suit various climatic conditions and end uses.
- To establish Progeny tested Clonal Seed Orchard for production of quality seeds
- To generate *Eucalyptus* transgenics/ transgrafts with enhanced salt and insect tolerance for confined field trials.
- Identification of secondary development specific miRNAs and polymorphism in their target sites for cataloging new molecular markers for wood formation in *Eucalyptus tereticornis*.
- To understand the water and nutrient requirement of Eucalyptus.
- To popularize new clonal varieties and assess the impact of the introduced clonal varieties.

4.2 Progress:

In Component 1: IFGTB: About 82000 plants of second generation clones (about 200) were mass multiplied. About 44700 clonal plants were individually numbers and transported to IFB, IFP, TFRI, CSFER, FRI, AFRI. Established germplasm bank with 285 clones. Established 3 MLTs at Marakkanam, Thiyagadurgam and Thimmalai. Planted MLTs have been maintained and recorded with growth data. **IFB:** Three adoptive MLTs, (Mulugu, Mulakalapally and Jaheerabad) have been established. Maintenance and growth data has been collected from all the established 3 MLTs. **FRI:** Clonal trials at Krishi Vigayan Kendra, Pratapgarh was established with 67 eucalyptus clones. The second and third MLTs were established in FRI campus and Kachnari, Gopamau, UP. Maintenance and six-monthly growth data was recorded in all three MLTs. **TFRI:** Established 3 MLTs at TFRI campus, Bargi range, Jabalpur and at Samnapur, Mandla. Casuality replacement and watering were carried out. Survival and growth data recorded in the established MLTs.**AFRI:** Established 3 MLTs at ARS, Mahua (Junagarh Agriculture University), Mohangarh, Jaisalmer and Linch, Mesana. Maintenance all the established 3 trials, growth data collected and casuality replacement carried out. **IFP:** Established 3 MLTs at Chandwa, Latehar, Birsa Agriculture University Farm, Kanke and Harhad, Hazaribagh. Casuarlity replacement, maintenance and growth data collection from the planted MLTs were carried out. **ERC:** Established 3 MLTs at Pratapgarh, Bigahiya-Prayagraj and Andawan, Prayagraj. Watering, maintenance and data collection were carried out in all the planted MLTs.

In Component 2: Based on progeny growth parents were selected and 12 hybrid combinations were made. Branch cuttings were grafted on seedling root stock and grafts established successfully for 10 clones. Successful grafts were established in field to induce flowering for controlled pollination. Totally 12 hybrid crosses generated and 3 hybrid progeny trials were established at Kunnathur, Salem and Thiyagadurgam with about 4000 hybrid plants. The trials are maintained and growth measurements are recorded every six months. Best performing individuals were tagged and monitored for selection.

Under Component 3: Identified three naturalised populations of E. grandis in Sathiyamangalam, Naduvattam and Kodaikanal and selected 20 plus trees. In *E. tereticornis* base population trial at Panampally and Karunya, selected 20 plus trees and collected with pollen for hybridization. Selected E. tereticornis plus trees were multiplied and planted in the germplasm bank. Seedlings of 25 seedlots of 6 species were grown and one field trial for *E. pellita* and *E. urophylla* established in Thalamalai. *E. cloeziana* could not survive. Seedlings of *E. longirostrata, E. moluccana* and *E. sideroxylon* have been raised and established one population trial at Thiyagadurgam. Land preparation for planting second trail has been completed in Thiruvannamalai, Tamil Nadu.

In **Component 4:** Selected 25 clones of *Eucalyptus camaldulensis* based on the progeny growth performance for raising the seed orchard. Collected seeds from CSO, Karunya and raised 2740 stock for grafting. Collected stem cuttings from selected 25 clones of Eucalyptus from CSO Karunya and CSO Kurumbapatty carried out grafting with a success of 37-45%. Out of 2550 grafts 960 survived. Established one CSO at Gudalur research station (1.0 ha). Recorded casuality count at Gudalur and carried out casuality replacement. Completed two field maintenance activities for CSO-Gudalur in January 2023 and January 2024. Carried out soil working and manure (vermicompost) application @250g / plant once in July 2023 and again gave manure (vermicompost) application @500g / plant in Jan 2024 at six months interval. Recorded growth data.

In Component 5: Development and Evaluation of MSPRP2 driven transformation constructs: MsPRP2 promoter sequence of *Medicago sativa* was used for designing salt inducible root specific *EcHKT1;1*hpRNA construct (MsPRP2:*EcHKT1;1* hpRNA:HSP), using which the following five transformation constructs were developed. a) pCAMBIA1305.1::MsPRP2:*EcHKT1;1*hpRNA:HSP; b)pHKN29::MsPRP2:*EcHKT1;1* hpRNA:HSP c) pCAMBIA1305.1::MsPRP2:*GUS*:HSP, d) pHKN29::MsPRP2:*GUS*:HSP and e) pCAMBIA1305.1::MsPRP2:*GFP*:HSP. Selected vectors were used for generating transgenic events of Eucalyptus. MsPRP2 promoter-driven *GFP* expression in callus and MsPRP2 promoter-driven *GUS* expression in salt treated and untreated roots of Eucalyptus composite plants showed that the synthetic promoter designed based on truncated promoter sequence of *PRP2* gene from *Medicago sativa* was able to drive gene expression preferentially in callus and root tissues of *Eucalyptus* and was salt inducible. Sonication- assisted *Agrobacterium tumefaciens* mediated transformation experiments using the developed GFP vectors were used to improve transformation efficiency in Eucalyptus.

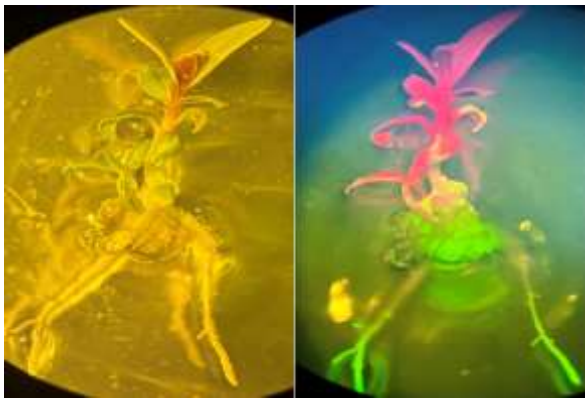


Fig 3. MsPRP2:*GFP* expressed transgenic event

Fig 4. Hardened *Li* hpRNA transgenics

Generation and Evaluation of RNAi transgenic plants: Agrobacterium mediated transformation experiments were carried out using CaMV promoter driven *EcHKT1;1* hpRNA construct and *MsPRP2* promoter driven *EcHKT1;1* hpRNA construct to generated transgenic events. The transgenic event, B9, generated using CaMV promoter driven *EcHKT1;1* hpRNA construct showing 87.6 % downregulation were multiplied, and hardened in transgenic greenhouse. Similarly, the MsPRP2*EcHKT1;1* transgenic event was multiplied and hardened in green house for further characterization. Salt stress analysis of CaMV:*EcHKT1;1* transgenic event, MsPRP2:*EcHKT1;1* transgenic event and non-transgenic Ec-53 control plants was carried out by subjecting to incremental NaCl treatments. No significant difference in salt tolerance levels was observed between the CaMV:*EcHKT1;1* transgenic event, MsPRP2:*EcHKT1;1* transgenic and the respective non-transgenic control plants. The putative *Li* hpRNA transgenics were also multiplied and PCR confirmed with T-DNA specific primers. The PCR confirmed *Li* transgenics were rooted and hardened in transgenic greenhouse for further characterization.

Development of Transgraft approaches: Protocols were optimised for micrografting. Twenty micrografted plants were generated with a graft success of 56 % under tissue culture conditions. The *in vitro* grafted plants were rooted and hardened in the greenhouse. The generated *MsPRP2: EcHKT1:1* plants would be used for generation of transgrafts under greenhouse conditions and graft transmission of RNAi.

Fig 5. Hardened Ec-53 control and MsPRP2*EcHKT1;1* transgenics for generation of transgraft

In Component 6: Integrated analysis of RNA and small RNA was conducted and 9 conserved and 7 novel miRNAs were predicted. Sixty six miRNAs belonging to 34 families were specific to secondary development and transcription factor, SQUAMOSA promoter binding protein and Cellulose synthase (*CesA9*) had maximum miRNA targets. Marker-trait association was conducted with 12 SNPs across 20 genotypes. A total of 2 SNPs were associated with holocellulose content, 1 SNP with lignin content and 40 SNPs were associated with fibre parameters at $P<0.01$.

In Component 7: Standardization of GPR was continued for studying the root architecture. Growth measurements and biomass assessment were carried out in the clonal trials of Eucalyptus at Marakkanam, Thiyagadurgam, Ariyalur and Karaikudi. The growth and field data collected were digitized. Biochemical analysis of the soil, leaf and bark samples collected from all the clonal trials have been analysed for nutrient level for all the 4 study sites.

In Component 8: Baseline data collection on the spread of Eucalyptus clones of IFGTB along with other varieties has been completed in the districts of Ariyalur, Cuddalur & Pudukottai. IFGTB-EC-4 is largely planted by paper mills and farmers in these districts. These plantations were visited and growth data collected. Private farmers cultivating IFGTB-EC-4 in 14 districts of Tamil Nadu from secondary sources. A video on Cultivation practices of Eucalyptus clones in dry lands has been completed for creation on awareness among the farmers of Tamil Nadu. Eight first generation clones of Eucalyptus have been multiplied clonally. Three Demo plantations established for the released clones of IFGTB at Thiyagadurgam, Andimadam and Thalamalai.

Highlights

- About 200 second generation clones have been multiplied by IFGTB and tested by IFB, IFP, TFRI, CSFER, FRI, AFRI each in three multi-locational trials (MLTs). Accordingly, IFB established MLTs in Mulugu, Mulakalapally and Jaheerabad, FRI established MLTs in Pratapgarh, FRI campus and Kachnari, Gopamau, UP, TFRI established MLTs in TFRI campus, Bargi range, Jabalpur and at Samnapur, Mandla, AFRI established MLTs in Mahua (JAU), Mohangarh, Jaisalmer and Linch, Mesana, IFP established MLTs in Chandwa, Latehar, BAU, Kanke and Harhad, Hazaribagh, ERC established MLTs in Pratapgarh, Bigahiya-Prayagraj and Andawan, Prayagraj. The participating institutes were given with two trainings on MLT data handling.
- In order to produce new hybrids, clones with high breeding value were cross pollinated and hybrid progeny trials were established in Thiyagadurgam, Salem and Kunathur. Top 1% of the trees in the trial have been marked for further observation and selection. In order to produce interspecific hybrids with *E. pellita* and *E. urophylla,* seedlots have been imported from CSIRO and a base population trial for these species have been established in Thalamalai.
- MsPRP2 promoter-driven *GFP* expression in callus and MsPRP2 promoter-driven *GUS* expression in salt treated and untreated roots of Eucalyptus composite plants showed that the synthetic promoter designed based on truncated promoter sequence of *PRP2* gene from *Medicago sativa* was able to drive gene expression preferentially in callus and root tissues of *Eucalyptus* and was salt inducible. The putative *Li* hpRNA transgenics were multiplied and hardened in transgenic greenhouse.
- For identification of secondary development specific miRNAs in E. tereticornis, association analysis was conducted and 9 conserved and 7 novel miRNAs were predicted. Sixty six miRNAs belonging to 34 families were specific to secondary development and transcription factor, SQUAMOSA promoter binding protein and Cellulose synthase (CesA9) had maximum miRNA targets. Marker-trait association was conducted with 12 SNPs across 20 genotypes. A total of 2 SNPs were associated with holocellulose content, 1 SNP with lignin content and 40 SNPs were associated with fibre parameters at $P<0.01$.

5. All India coordinated Research project on "Development of dielectric heating-based processing technologies for solid-wood, bamboo and their composites"

5.1 Objectives:

- To develop dielectric heating (radio frequency and microwave) based wood/bamboo processing technologies.
- Developing protocols for application of dielectric heating in wood and bamboo based composite preparation for improved efficiency and product quality.
- Evaluating the value addition and cost benefits /commercial aspects of the DH based processes.

5.2 Progress:

Component 1A:Design and development of RF based wood processing systems

- **Major Achievements:**
  - ✓ Customised mechanical design of vacuum dryer for wood ready
  - ✓ Functionality of the system demonstrated to IWST scientist.

Component 1B: Design and develop MW-Vacuum based wood processing system

The Microwave Vacuum Dryer

A lab scale MW vacuum drying system was fabricated and lab scale studies on microwave vacuum drying completed and these studies helped in designing and fabrication of the pilot scale microwave vacuum dryer.

Designing, fabrication and installation of a pilot scale microwave vacuum dryer completed.The vessel length of microwave vacuum dryer is 2000 mm (6.5 feet) and diameter is 450 mm (1.5 feet). Microwave vacuum dryer consist four magnetrons of 1.5 kW capacities each and has a convective heating system also. The vacuum tank is provided with a trolley on wheels and rails for loading and unloading of the timber outside the vacuum tank. MW chamber is insulated from out-side with rockwool insulation. Vacuum and MW can be applied simultaneously/ discontinuously along with real time data acquisition and logging e.g. power consumption, temperature of wood layers, air temperature etc.

Drying of tree trunk (without sawing) and products development:

Tree trunks and logs are in cylindrical shapes. Pith portion, which has propensity to develop cracks during drying, is removed by sawing before conventional drying. Sawing results in huge `loss of wood material (40-50%) as round/ cylindrical shape is converted into parallelepiped/ cuboidal shapes. Three trunks of three species (*Eucalyptus* hybrid, poplar and *Melia dubia*) were evaluated for drying behaviour under microwave vacuum dryer. The results for poplar tree trunks were exceptionally good as no severe drying degrades for the diameter upto 2 feet (girth) were observed. For the trunk of diameter 3 feet, some surface cracks appeared, however, crack originated from pith was minor and didn't pose severe quality concerns. Eucalyptus, being a very refractory species, is seldom used for manufacture of solid wood products. Logs of Eucalyptus (2 feet girth) and branch wood (1-1.5") girth were microwave vacuum dried. Except of some surface checks, no severe defects were observed. Melia dubia logs (2-2.5' girth) when microwave vacuum dried freshly felled (within a week of felling), were dried satisfactorily, however, logs of the same trees when dried after 45 days (air dried), resulted in end cracks (from the pith portion) extending not more than 8-10" in length. Thus, the experimental results indicated that the plantation grown trees trunks can be dried successfully to make high end products as some products were developed from microwave vacuum dried tree trunks.

Microwave vacuum drying of *D. asper* and *B. tulda* bamboos and development of some products:

Microwave vacuum dryer was used to dry *D. asper* and *B. tulda* bamboo species. Results indicate that good quality drying of bamboos may enable to develop high quality handicrafts like turnery. MWV dried *D. asper* gave excellent results when subjected to carving.

Estimation of energy consumption in microwave vacuum drying:

Based of literature and tools/ facts available for estimation of energy consumption in conventional methods of drying (electrical/ steam heated kilns), it was estimated that the conventional kilns consume approximately 2 units of energy in evaporation of 1 kg of water from wood during drying. Whereas, the microwave vacuum dryer was found to consume electrical energy in tune of 3.75 to 4.25 units for the removal of 1 kg of water during the drying of wood/ bamboo.

Six mature culms of *Bambusa balcooa* were collected and divided into three parts: top, middle and bottom. These parts were further subdivided into small round specimens so that each specimen had atleast 1-2 nodes. The specimens/ parts were randomly divided into four groups. These four groups were given four treatments: microwave pre-treatment high intensity followed by drying in conventional kiln, microwave pre-treatment low intensity followed by drying in conventional kiln, drying directly in microwave vacuum dryer, drying directly in conventional kiln. Drying time, color, stresses, defects and energy consumption etc were recorded for each treatment.

The results indicate that drying time was reduced significantly when microwave pre-treatment was given. High intensity microwave treatment resulted in higher defects and lower intensity treatment resulted in almost no defects. However, the defects arisen after MW pre-treatments didn't advanced further during conventional drying. Purely conventional kiln drying resulted in longest drying time and highest drying defects. Colour of the bamboo was improved from pale whitish tone to golden brown. Status of the drying stresses also gave interesting patterns.
Large size wood specimens of *Melia dubia* (5" x 5") cross section were dried in MWVD in four batches. In conventional kiln drying using steam heated kiln, it may take 1.5 to 2 months (1000-1200 h) to dry these sizes of the timber. In MWVD, it took, approximately 13.5 h in 2-4 drying runs. However, mean electrical energy consumtion was found to be 39 units/CFT or 10.3 units/ kg. The electrical units consumption is 2.75 times higher as compared with the drying of thinner section of wood (1.5" thick).

Approiximately 5" x 5" cross-section sleepers								
Name of the planks	**Volume**	**Initial MC%**	**Final MC%**	**Weight of water removed**	**Electrical units**	**Time duration (h)**	**units/ cft**	**Units/ kg water**
S1,S2,S3 & S4	2.1	38	8.3	5.801	68.35	15.16		
A,B,C,D	2.25	61	12	10.467	96.55	20		
X	0.932	44.5	9.8	3.674	41.52	9.25		
Yand Z	1.09	50	11	4.08	42.94	9.5		
Grand total	**6.372**			**24.022**	**249.36**		**39.1**	**10.3**
Mean		**48.375**	**10.275**			**13.4775**		

However, as compared with the time duration, the drying is much faster than conventional methods.

Component 2 : Developing RF based Phyto sanitation protocols for wood

During a visit to SAMEER Mumbai,valuable insights were gathered from discussions with Dr. Harsh and his team regarding the fabrication of DH systems. Noteworthy experiments involving the heating of round bamboo specimens at different power intensities provided valuable insights. In particular, observations highlighted the importance of power intensity in achieving uniform heating, with lower intensity resulting in non-uniform heating and the emergence of localized hot spots. Additionally, monitoring of MW leakage during the process was conducted by the SAMEER team, further contributing to our understanding of system safety and efficiency. A comprehensive presentation was

delivered to Dr. Harsh and team, providing an overview of phytosanitary treatment methods in accordance with ISPM-15 utilizing RF and MW heating systems. Topics covered included power intensity, dielectric properties, heating rate, and uniformity.

Preliminary trials were conducted at IWST using green wooden blocks for phytosanitary treatment. This involved meticulous temperature recording at varying depths, facilitated by the use of thermocouples. Moreover, temperature profiling within the wood, encompassing measurements at hot spots, reflectance temperature, and emissivity, was achieved through the demonstration of the Testo 883 temperature imaging system. In an effort to enhance our capabilities for future trials employing various DH systems, the acquisition of a thermal imager was successfully completed. Publication of a collaborative paper with PSU in the Forest Products Journal. The paper addresses strategies to enhance the uniformity of RF heating for phytosanitary treatment.

Published a paper as co-author in Forest Products Journal in collaboration with PSU focusing on improving uniformity of RF heating for phytosanitary treatment. Delivered a seminar in hybrid mode on "Dielectric Heating in Wood Processing" with 97 participants from industry, researchers and other stakeholders. Invited attendee in the International Forestry Quarantine Research Group (IFQRG) on Phytosanitation and Quarantine of Wood and WPM held as a virtual symposium during November 7-28, hosted by IPPC Secretariat, FAO, Rome, Italy. Overall, these achievements mark substantial progress in our pursuit of effective phytosanitary treatment methodologies and compliance with ISPM15 standards. We look forward to building on these successes in the upcoming period.

Component 3: Optimization of the resin curing using RF waves for panel products

Recruited the JPF. Lops and tops of poplar, high frequency tube for RF curing equipment and chemicals procured. Particles of lops and tops of poplar prepared and particle boards using urea formaldehyde adhesives for preliminary trials prepared with different duration of RF application and different pressure. Testing of physical and mechanical properties of prepared particle boards for preliminary trials were carried out. Based on preliminary trials particle boards of thickness 12 mm and 18 mm were prepared at different pressure levels (250 psi, 300 psi and 350 psi) for different time duration (9 minutes, 12 minutes and 15 minutes) and physical and mechanical properties of the particle board samples were tested. Fibre boards of 12 mm thick with measurement of energy usage/consumption were prepared at different pressure levels (250 psi, 300 psi and 350 psi) for different time duration (9 minutes, 12 minutes and 15 minutes) and physical and mechanical properties of the particle board samples were tested.

Component 4: Developing protocols for bamboo straightening and/or bending using microwaves

Appointed Junior Research Fellow (27th Jan. 2020). Held interaction meeting with SAMEER regarding the possible design of RF drying system and also with wood based industries at Gandhidham. It was observed that RF based adhesive curing systems are functional in one teakwood processing unit. Discussions on the proposed system were held. However, due to extended lockdown in Mumbai, design of the RF vacuum system could not be finalized. Final MoU with SAMEER has been signed and sent to ICFRE. The experiments were carried out to compare loss of moisture via MW drying and to compare drying rates of different intensities of microwave with air seasoning of bamboo. *Dendrocalamus strictus* samples of around 1 m length were harvested from field station. These samples were continuously kept submerged in water. The water saturated samples were used for different experiments. The samples were MW irradiated at different intensities (1200 watts, 1600 watts and 1800 watts) and the conveyor belt speed was kept constant i.e., 60 mm/sec. Drying was done in a 20 minute cyclic manner where samples were exposed to the MW for 20 minutes and then left out to cool for 20 minutes duration consecutively. The loss in weight after each cycle was recorded. It was observed that the drying rates depend on the intensity of microwave. Samples exposed to higher intensity dried faster as compared samples irradiated at lower intensity (1800w> 1600w > 1200w). Under these experimental conditions the samples did not develop defects and also retained their original colour. Four bamboo species were dried in domestic MW at different intensities (900

wattsand 450 watts). The effect of MW on rate of drying was studied. Most of the bamboo species achieved 10% moisture content after 10 to 11 cycles of drying (1 cycle= 2min MW + 20 min cooling time). The effect of mw on strength properties is under study. We have visited SAMEER Mumbai and studied the dielectric constant of different wood species under different moisture content. Bending of solid bamboo culms obtained from *D. stocksii* was attempted using MW unit available at IWST, Bangalore. The bamboo culms were curved and retained its position after the support was taken out, however, splits and breaking of fibres can also be seen. Microwave based bamboo processing unit has been delivered to IWST, Bangalore on third week of March 2024. All the necessary electrical and plumbing fittings work has been completed. Final installation and demonstration of machine is in progress at IWST, Bangaluru by the team of Scientists of SAMEER Mumbai.

- **Major Achievements:**
  - ✓ Four port rectangular applicator is designed and optimised.
  - ✓ Thermal analysis of rectangular applicator completed
  - ✓ Design on 1:4 equal Power divider is completed and Development is under progress.
  - ✓ Design and fabrication of Magnetron Launcher completed.
  - ✓ Design of E Bend, H Bend and waveguide flanges are completed.
  - ✓ Design of Microwave Plumbing has been finalised and CAD design is completed.
  - ✓ Raised tender of Microwave subsystems components and purchase is under progress.
  - ✓ 2D Detailed Drafting of all sub-components completed
  - ✓ All microwave subsystems are developed and integrated with 5 kW microwave source.

Component 5: Green Dimensional Aspect in Wood Turning of Plantation Grown Timber.

- Conventional kiln drying of Eucalyptus and melia completed.
- Eucalyptus log were rip into the plank in sawmill by various thickness (4cm,6cm,7cm),
- Ripped planks were again ripped with different width size (4cm,6cm,7cm), lumbers and it was again cross cut in different length (30cm,60cm) on cross cut saw.
- Initial moisture content of unturned eucalyptus samples recorded: **39.86%**
- Surface roughness of unturned eucalyptus samples is: **10.16 micro meter.**
- Initial experiment was started in eucalyptus planks. 10 Eucalyptus planks were dried in Microwave seasoning kiln. Before seasoning of planks, its initial moisture content was about **37.06%**.
- Planks were exposed to the microwaves for about 21 hours at room temperature to 47^{o}C and the moisture content was reduced to **25.8% with lot of surface cracks**
- 60 samples of rubber wood in (5cmx5cmx30cm) size from the market procured and then turned 30 samples out of them.
- Average Initial Moisture content of Turned Samples=**40.29%**
- Average Initial Moisture content of Unturned Samples=**33.79%**
- After this 30 turned and 30 unturned rubber wood samples were kept for microwave seasoning, after 8 cycles the moisture content come out **11.12%** in turned samples &**9.36%** in unturned samples.
- average energy consumption of all 8 microwave cycles**=2.73Kwh**
- turned 40 samples of eucalyptus in size (4cmx4cmx30cm) & (6cmx6cmx30) . and turned 10 samples size of (6cmx6cmx60cm)**.**
- Surface roughness of turned samples of eucalyptus came out **6.51µm.**

Component 6: Developing moisture measurement system for wood/bamboo

- **Sub-system specifications:**

Sr. No.	Parameter	Targeted Value
1.	Operating Frequency	5.81 GHz
2.	Transmission Power	7 dbm (5mW)
3.	Measured Parameter	Attenuation and Phase Shift

4.	Measurement Method	Microwave Transmission based
5.	Range of Moisture Measurement	7 to 40%
6.	Accuracy	±0.5%
7.	Data Interface	RS232/Ethernet
8.	User Interface	Touch Panel LED Display
9.	Power Supply	230 V AC

Moisture measurement of wood was performed using the microwave based system developed by SAMEER, Mumbai. For the experiments, testing mode in the equipment was divided into four groups according to selected density class. Experimental samples were obtained from eleven wood species (Melia, Silver oak, Shisham, Pine, Mesopsis, Beech, Jackfruit, Banyan, Teak, Casuarina and Rubber wood) and moisture content was measured using MW based moisture measurement system at different operating modes. Wood samples were first saturated with water, and then gradually dried by keeping these samples in an oven at 103^{o}C temperature for drying in order to reduce the moisture content. The voltage and moisture content was measured after every one hour till the samples are dried fully. The data acquisition system is developed with amplitude based calibration and accordingly graphical user interface (GUI) was developed. The moisture content obtained from microwave-based moisture measurement system was compared with moisture content calculated from oven dry method.

During the recent experiments and caliberation work variation between moisture content measured using oven drying and microwave-based moisture measurement system was not more than ±3% for most of the species studied.

Component 7: Developing protocols for chemical modification using DH based heating

Chemical modification of wood with acetic anhydride was very slow in conventional heating and after 240 minutes of reaction, the weight percentage gain (WPG) in Rubberwood was only about 14% and that in Radiata pine was about 21%. Under microwave heating, an WPG of about 12-13% could be obtained in 10 min reaction time in both the species. Though the reaction was faster under microwave heating, yet the desired level of modification (WPG of 18-20%) could not be achieved. Hence the use of catalyst is being experimented to accelerate the reaction further.

Component 8: Optimizing MW treatment for improving treatability of wood

Defect free specimens of size 100x 25 x 6 mm^3 (for termite mound test), 30 x 3.8 x 3.8 cm^3 (for Grave yard test), 10 x 3.8 x 3.8 cm^3 (for retention analysis) and 2 x 2 x 30 cm^3 (for MoE and MoR test) were prepared from *E. hybrid* and *M. dubia*. The samples were pre-treated with MW irradiation at different intensities (360, 480, 600, 720, 840 and 960 MJ/m^3). MW pretreated samples were than treated with CCA, CCB, ZiBOC and Borax boric acid preservatives at 6% conc. *M. dubia* samples were treated by full cell pressure method by applying 150 lbs pressure for 2 h whereas *E. hybrid* samples were treated by full cell pressure method at 150 lbs pressure for 2 h followed by dipping for 24 h in preservative solution. Effect of MW intensity on of MoE and MoR shows upto 15% decrease in MoR and upto 20 % decrease in MoE in case of Eucalyptus hybrid and upto 14.8% decrease in MoR and upto 17.7% decrease in MoE in case of *M. dubia* when exposed to different MW intensity. Anatomical studies to see the effect of MW irradiation showed increase in vessel diameter with the increase in MW intensity in both the species. Retention studies showed that in *M. dubia* optimum retention (12-16 kg/m^3) with different preservatives is obtained in samples pretreated at 720 MJ/m^3 and 840 MJ/m^3 MW intensity followed by pressure treatment at 150 lbs/in^2 pressure. Where as in Eucalyptus hybrid maximum retention (8-10 kg/m^3) with different preservatives was obtained in samples pretreated at 960 MJ/m^3 MW intensity followed by pressure treatment at 150 lbs/in^2 and dipping for 24 hrs in preservative solution. Treated samples along with control were installed in termite mound for termite mound test and in timber test yard for stake test. Samples were removed from the termite mound and assessed

for damage by termites after 3rd termite season. Result showed all MW pretreated samples treated with CCB, ZiBOC, CCA preservatives showed slight termite attack i.e. upto 10% degradation. Whereas the control and borax boric acid treated samples showed bad attack of termites i.e upto 50% and above damage in both the species. Thirteenth and Fourteenth periodical inspection after 39 and 42 months of samples installed in the test yard carried out. Results shows that treated samples showed protection from damage as compared to the control samples. After 42 months of installation in *M. dubia* samples pretreated at 840 MJ/m^3 MW intensity and treated with CCA, CCB and ZiBOC preservatives showed very slight termite attack (i.e. upto 5% degradation) and all other samples showed slight termite attack i.e upto 10% degradation. Whereas control samples and borax- boric acid treated samples of *M. dubia* showed bad attack of termites i.e. 26 % to 50% degradation. In E. hybrid CCA, CCB and ZiBOC treated samples pretreated at 840 and 960 MJ/m^3 MW intensity showed very slight termite attack (i.e. upto 5% degradation) and all other samples showed slight termite attack i.e upto 10% degradation. Whereas control samples and borax- boric acid treated samples of E. hybrid showed moderate to bad attack of termites i.e. 10 % to 50% degradation.

Highlights

- Designing, fabrication and installation of a "pilot scale microwave vacuum dryer" completed.Two bamboo species *Bambusatulda* and *D. asper* and three wood species Poplar, Eucalyptus and *Meliadubia*microwave vacuum drying characteristics evaluated and number of products developed.
- Large size wood specimens of *Melia dubia* (5" x 5") cross section were dried in MWVD in four batches. In conventional kiln drying using steam heated kiln, it may take 1.5 to 2 months (1000-1200 h) to dry these sizes of the timber. In MWVD, it took, approximately 13.5 h in 2-4 drying runs.
- However, mean electrical energy consumption in MWVD was found to be 39 units/CFT or 10.3 units/ kg water removal. The electrical unit's consumption is 2.75 times higher as compared with the drying of thinner section of wood (1.5" thick). Fabrication, testing and integration of "Microwave based moisture meter system" for wood is completed. The calibration of developed Microwave based moisture meter system is being carried out.
- In the green wood Turning, *Melia dubia* and eucalyptus green wood were turned to expose the end grain all along around the wood in order to increase drying rate from end grain surface during conventional drying. Results of these studies showed that within the short period moisture content are reached to below FSP(fiber saturation point) as compare to unturned green wood, the same process was applied for the Provisional patent on "End grain drying of green turned timber" and got patent No.62188 dated 16-06-2022.
- Microwave Pretreatment of difficult to treat wood species i.e. *M. dubia* and E. hybrid resulted in improvement in preservative penetration and retention. *M. dubia*exhibited through and through impregnation of preservatives i.e. 100% after the microwave pre-treatment followed by preservative treatment as compared to partial impregnation in control samples. E. hybrid exhibited 60-70 % Impregnation of preservatives after the microwave pre-treatment followed by preservative treatment as compared to 5-10% impregnation in control samples.

6. All India coordinated Research project on "Value addition of wood and wood-based composites using nonmaterial"

6.1 Objectives:

- To develop nano-material embedded ecofriendly wood preservatives/coatings
- Improvement of quality of low density woods by impregnating with nano-filler blended resins
- Improving properties of wood composites using nano materials
- To develop nano cellulose based composite material

6.2 Progress:

Termite resistance of untreated and linseed oil nano-emulsion containing nano-ZnO and nano-CuO treated rubberwood specimens, after 3 months of termite exposure showed that the untreated samples were affected due to termite attack whereas some samples treated with nano-emulsions started initiation of termite attack. Wood treated with ZnO and CuO loaded nano-emulsions remained unaffected and showed no attack. After 6 months of exposure, the untreated specimens were heavily attacked with more than 50% deterioration. Nano-emulsion treatment without nano materials also failed to protect the samples from termite attack. However, samples treated with 30% linseed oil nano-emulsion loaded with 2.0% nano-ZnO and nano-CuO performed very well in comparison to untreated rubberwood.

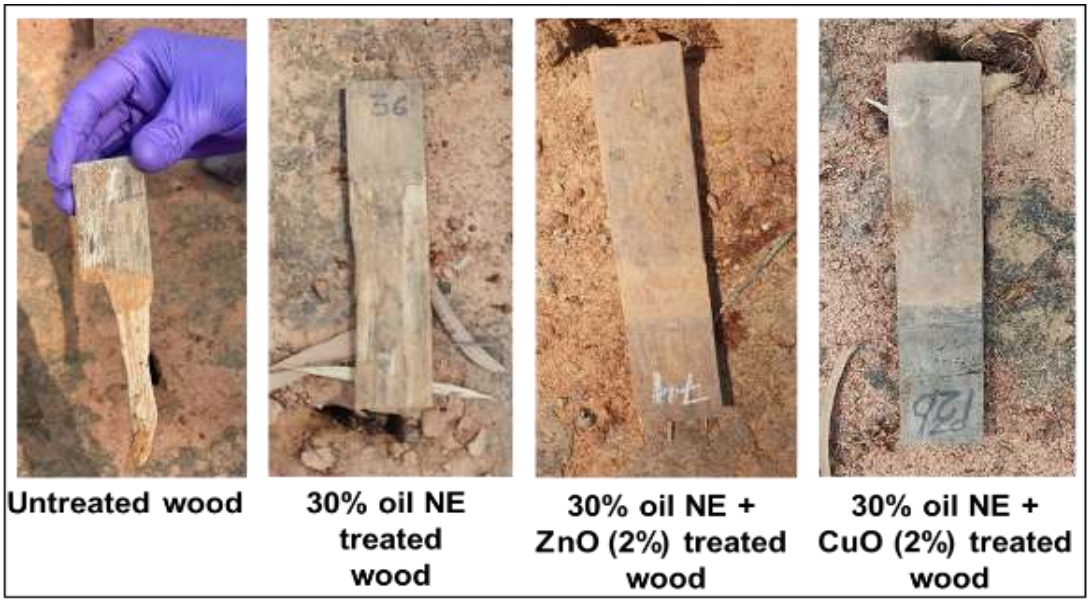


Fig 6. Visual observations of termite attack in untreated and linseed oil nano-emulsion (30% oil content) containing ZnO and CuO nanoparticles (2.0 wt.%) treated rubberwood specimens after 6 months of installation.

Large number of medium density fiber boards were prepared using *Melia dubia* fibers and nanoparticles dispersed resin system. Addition of 2% nanoclay with 20 minutes of ultrasonication in urea formaldehyde resin system was found to reduce formaldehyde emission by 50% as compared to control particle/fiber boards.

Fig. 7 Medium Density Fiber boards

To prepare Nano-Wood Composites (NWC), the process parameters for curing of nano-particle (Boron Nitride and ZnO) fortified furfuryl alcohol (FA) resin was optimized. A significant improvement in Anti Swelling Efficiency (ASE), a measure of dimensional stability, was observed with FA treatment. Maximum ASE was 74% in Poplar wood and 54% in Melia wood. The difference in ASE values is due to higher WPG (23%) in Poplar as compared to Melia (12%). Poly Vinyl Acetate (PVA) was not very effective in improving dimensional stability of wood. For mechanical properties, the addition of nanoparticle significantly improved the surface hardness in both PVA and FA treated wood. However, for other properties such as compressive strength perpendicular to grain and static MoE, only FA and FA with nano-particle treatments could produce significant improvement. Resin impregnation also improved the resistance against biodegradation. Fortification of PVA with higher concentration of ZnO nanoparticle, significantly improved the decay resistance (from non-durable class to very durable class) as well as termite resistance (control samples of poplar perished in 6 months but treated samples are still intact after 12 month). FA treatment alone was quite effective against decay and termite attack and addition of nano ZnO further improved the resistance against biodegradation.

Cellulose Nano Fibers (CNFs) synthesized from different lignocellulosic fibers were characterized for their dimensions, crystallinity and thermal stability. The study revealed that the prepared CNFs were having diameter of about 10-15 nm irrespective of the base lignocellulosic material. It was also found that one-time processing (Single pass) in high pressure homogenizer was sufficient to achieve the nano dimensions. The crystallinity of CNFs was found to decrease with multiple processing of fibers in the homogenizer.

The potential of CNFs was explored as the binding agent in wood adhesion and fiber boards were prepared with varying concentration of CNFs and fillers like calcium carbonate and thermos-plasticized starch. The effectiveness of CNFs in bonding wood fibers was established. Further, addition of fillers resulted in the significant improvement in the physical and mechanical properties of the boards.

Synthesized wood coating material by adding TiO_2 in PVA, CNF and fruit extract. 1% TiO_2 in PVA exhibited good dispersibility and also better thermal stability. Compared to PVA film, PVA-CNF-E films were having higher heat resiatance. 1 wt% TiO2 concentration considered as standard for the coating material, striking a balance between UV resistance and film transparency. This formulation also exhibited excellent antibacterial activity.

Table 1: Anti-bacterial activity of coating material

Films (PVA/CNF/Extract/ TiO_2)	***Diameter of zone of inhibition (ZOI) (in mm)***			
	Gram-positive bacteria		***Gram-negative bacteria***	
	Staphylococcus aureus	***Bacillus subtilis***	***Escherichia coli***	***Pseudomonas aeruginosa***
PVA/CNF/E	*16*	*18*	*22*	*20*
PVA/CNF/E/1wt%TiO_2	*20.5*	*26*	*22*	*24.5*
PVA/CNF/E/3wt%TiO_2	*24.5*	*22.5*	*26*	*20.5*
PVA/CNF/E/5wt%TiO_2	*26*	*22*	*24*	*24.5*
PVA/CNF/E/7wt%TiO_2	*24*	*24.5*	*18*	*18.5*
PVA (Control)	***8***	***8***	***8***	***8***

Highlights

- Eco-friendly wood preservatives/coating of linseed oil emulsion embedded with zinc oxide (ZnO) and cerium oxide (CeO_2) nanoparticles embedded developed.
- A patent filed on 'An improved wood coating material' (Patent No. 202311033227 dt. 11-5-2023) in collaboration between ICFRE and IIT-R. Improved wood coating was developed from Cellulose Nano Crystals synthesized from dry leaves of fig tree (*Ficus auriculata*). It can be used commercially for the coating purpose of wood and instruments used in hospitals.
- Published 03 papers and presented 05 papers in national seminars.

7. All India coordinated Research project on "Assessment and monitoring of Invasive Alien Plant Species (IAPS) in India and formulation of strategies for management of key Invasive Alien Plant species in different regions of the country"

7.1 objectives:

- To assess the spatial extent of selected IAPS using Remote sensing and GIS
- To assess the various ecological impacts of selected IAPS in the country
- To predict the future spread of selected IAPS using Species Distribution Models
- To explore bioprospecting and other utilization potential of selected IAPS
- To develop cost effective methods for eradication and control of selected IAPS
- To standardize restoration models for invaded areas with native species and develop a compendium on IAPS in collaboration with the SFDs

7.2 Progress:

The project aims to map the spatial extent of selected Invasive Alien Plant Species, their impact on native plant diversity, their future invasion/spread potential using Species Distribution Models and their utilization potential with a view to come up with species-specific management strategies.

Spatial mapping studies showed that *Prosopis juliflora* occupied 8.10 Lakhs ha area while *Acacia mearnsii* has occupied 25478.36 ha area in Tamil Nadu. About 31% of the study area in the states of Chhattisgarh, Jharkhand, and West Bengal is presently susceptible to invasion by *Lantana camara*. The modelling of the potential distribution sites for *L. camara* showed that about 31% of the study area in the states of Chhattisgarh, Jharkhand, and West Bengal is presently susceptible to invasion by *Lantana camara*. It is predicted that by 2050, the very high suitability habitat in the country for *P. juliflora* has been predicted to increase by 24% (584,499 sq.km) and 28% (602,603 sq.km) while for *Acacia mearnsii* it is predicted to decrease by 48% (2255.80 sq.km) and 52% (1927.61 sq.km) under RCP 2.6 and RCP 8.5, respectively.

The studies on impact of selected IAPS on the native plant diversity, and soil physico-chemical properties in different habitats showed that under Lantana invaded sites in Madhya Pradesh, regeneration of native species affected by 40-70% compared to non-lantana area. Further, the species composition and richness are more under open compared to Lantana invaded areas. Studies on impact of Prosopis on the native plant diversity in different habitats showed decreased species diversity (Herbs 2.72; Shrubs 0.14; Trees 0.12) in the invaded site than the control site (Herbs 3.04; Shrubs 1.09; Trees 0.97). Similarly, the Prosopis invaded sites showed higher soil nitrogen content (from 221 to 340 kg/ha) than the control sites (from 203 to 261 kg/ha). The studies on the impact of *P.juliflora* on soil moisture and humidity using sensors, showed that soil moisture and humidity was lessor in the invaded sites than the control sites.

Bioprospecting potential of *Prosopis* and *Acacia mearnsii* has been explored. Briquettes from *P. juliflora* biomass were produced at 7 ± 2% and 18 ± 2% moisture contents and it was found that the briquetted produced at less moisture content crumbled during abrasion and shown no proper binding, whereas, good quality briquettes were obtained at 18±2% moisture content. The potential of *A.mearnsii* bark as a source of natural dye for textile industries showed that optimum dye extraction occurred in 30% methanol with five-hour extraction time and the material to liquor ratio of 1:50.

Pre-emergence herbicides proved to be more efficient in controlling Lantana in experimental sites. Release of bioagent *Teleonemia scrupolosa* for biological control of Lantana under net house conditions did not cause any damage during October to March. The efficacy of fungal isolates (*Fusarium oxysporum* and *Pestalotia palmarum*) on controlling *Mikania* under control condition and the host range of the fungal isolates are being evaluated. Manual removal of *M. micrantha* after germination was found effective to check its climbing on the trees. The host range of a seed bruchid (*Caryedon gonagara*) is being assessed for its efficacy in biological control of Prosopis. Restoration trials established in *P. juliflora* (Pudukkottai, Tamil Nadu), *L. camara* (Solan forest division, Himachal Pradesh; Jabalpur, Madhya Pradesh) and *M. micrantha* (Dissoi RF, Assam) invaded areas are being monitored for the survival, growth and regeneration of native plant species.

Highlights

- Spatial mapping studies showed that *Prosopis juliflora* occupied 8.10 Lakhs ha area while *Acacia mearnsii* has occupied 25478.36 ha area in Tamil Nadu. About 31% of the study area in the states of Chhattisgarh, Jharkhand, and West Bengal is presently susceptible to invasion by *Lantana camara*. By 2050, the very high suitability habitat in the country for *P. juliflora* has been predicted to increase by 24% (584,499 sq.km) and 28% (602,603 sq.km) while for *Acacia mearnsii* it is predicted to decrease by 48% (2255.80 sq.km) and 52% (1927.61 sq.km) under RCP 2.6 and RCP 8.5, respectively.
- The studies on impact of selected IAPS on the native plant diversity, and soil physico-chemical properties in different habitats showed that under Lantana invaded sites, regeneration of native species affected by 40-70% compared to non-lantana area.
- The studies on the impact of *P.juliflora* on soil moisture and humidity using sensors, showed that soil moisture and humidity was lessor in the invaded sites than the control sites. The Prosopis invaded sites showed higher soil nitrogen content (from 221 to 340 kg/ha) than the control sites (from 203 to 261 kg/ha).
- Studies on Bioprospecting potential of *Prosopis* showed that good quality briquettes can be obtained at 18±2% moisture content. The potential of *A.mearnsii* bark as a source of natural dye for textile industries showed that optimum dye extraction occurred in 30% methanol with five-hour extraction time
- The efficacy of Bio-control agents for Mikania and Prosopis are being evaluated under in vitro condition. Restoration trials established in *P. juliflora* (Pudukkottai, Tamil Nadu), *L. camara* (Solan forest division, Himachal Pradesh; Jabalpur, Madhya Pradesh) and *M. micrantha* (Dissoi RF, Assam) invaded areas are being monitored for the survival, growth and regeneration of native plant species.

8. All India coordinated Research project on "Conservation and productivity improvement of Red Sanders"

8.1 Objectives:

- To establish base populations of Red sanders with germplasm from natural populations.
- To select plus trees of Red sanders and lay multilocational progeny trials.
- To refine and develop silvicultural techniques for Red sanders.
- To develop molecular resources and techniques for Red sanders.

8.2 Progress:

Component 1: (Implemented by IFB and BIOTRIM)

In this component, six provenances have been delineated in the natural range of *P. santalinus* using GIS based spatial analysis. The provenances were surveyed and seeds were collected from 145 trees during 2022. Nurseries were raised at IFB Hyderabad and BIOTRIM, Tirupati. Altogether, 2757 seedlings have been raised for the two planned provenance trials.

Component 2: (Implemented by IFB)

In this component, current distribution map was generated by plotting the GPS coordinates recorded during the fields surveys as well as the historical data obtained from the Andhra Pradesh Forest Department. Further, this presence-only data was used in Maxent model to predict potential suitable habitats for *P. santalinus* cultivation. Potential habitat suitability maps have been generated for Andhra Pradesh and whole of India. The component is complete.

Fig. 8. Redsanders progeny trial established at Nelhal, Karnataka (Latitude-13.095°N, Longitude-77.857°E).

Component 3: (Implemented by IFB, IWST, IFGTB, AFRI and BIOTRIM)

In this component 72 plus trees have been selected using the grading criteria developed for Redsanders. Seeds were collected during 2020-21, 2021-22, 2022-23 and nursery was raised at IFB and BIOTRIM. These half-sib progenies were used to establish two progeny trials at Nelhal, Karnataka and Mangapuram, Andhra Pradesh, respectively.

Component 4: (Implemented by IFB and IFGTB)

In this component, rooting trials with softwood cuttings and stump coppice shoots were taken up. Softwood cuttings treated with 2000 ppm IBA gave 55% rooting success. Likewise, air layering of stump coppice shoots, treated with a combination of NAA 3000 and IBA 3000 ppm gave 70% rooting success. Vegetative propagation was further explored through grafting and rooting of micro shoot rooting trials. Grafting was carried out in 35 plus trees. Altogether, 545 number of grafts were prepared. Four micro-coppice shoot trials with 16 hormone treatments were laid under polytunnels at IFB.

Component 5: (Implemented by S V University)

In this component, best explant (axillary bud), best basal medium (MS medium), concentrations of PEG, Activated Charcoal, Citric Acid (0.7%) and PVP (1.5%) were optimized to nullify effects of Phenols and Flavonoids. Multiple shoot induction and shoot elongation were achieved in TDZ (2 mg/l) + Kn (3.0-4.5 mg/l) and TDZ (2 mg/l) +BAP (3.0 -4.5mg/l) medium. Root initiation was observed at ½ strength MS Medium + coconut water 2ml + IBA 0.5mg.

Component 6: (Implemented by IFGTB)

In this component, two strains of Rhizobium, five species of AM fungi (*Glomus geosporum, G. fasciculatum, G. aggregatm, Acaulospora* sp. and *Sclerocystis* sp.*)* and one species of Phosphobacteria (*Bacillus megaterium)* were isolated and multiplied for use in nursery and plantations. Nursery trial with VAM and Rhizobium inoculated seedlings showed more root nodules compared to control and commercial nursery seedlings. Seedlings inoculated with Rhizobium and Phosphobacteria showed higher dry biomass than the other treatments. A field trial plot was established at Puliangudi Village, Thenkasi, Tamil Nadu with Red sanders seedlings inoculated with AM fungi, Rhizobium and Phospobacterium alone, and in various combinations. 90% survival was recorded in the field trial plot. Better growth was recorded in Rhizobium inoculated seedlings compared to the control.

Component 7: (Implemented by University of Hyderabad)

In this component, DNA extraction procedure and PCR conditions for RAPD, ISSR and cross-species SSR markers were optimized and polymorphic RAPD (20), ISSR (20) and cross-species SSR markers (06) were identified. The combined data generated with RAPD, ISSR and SSR, consisting of 303 amplified and 242 polymorphic bands was subjected to STRUCTURE analysis to estimate the genetic relationship among 40 germplasm accessions of *P. santalinus.* The population STRUCTURE analysis partitioned the accessions into 2 distinct genetic groups (K = 2) with admixtures detected in both the genetic groups. *De novo* transcriptome analysis in two diverse accessions of *P. santalinus* identified 40,389 EST-SSRs. A total of 37,923 primer pairs were designed for the EST-SSR repeats using Primer 3.0 software. 75 EST-SSR primers were synthesized and screened, out of which 26 primers detected polymorphism in the initial screening done on 5 germplasm accessions. Allelic data generated with 10 EST-SSR primers revealed high level of polymorphism in the 59 natural population accessions with a mean PIC value of 0.800. Fifty-seven (57) plus trees were characterized with six polymorphic EST-SSR markers. High polymorphism was observed with a mean polymorphic content of 0.749. The number of different alleles per loci ranged from 4-13 with a mean Na of 7.167. The Shannon's information index ranged from 1.110 to 2.409 with a mean of 1.623.

Component 8: (Implemented by IWST)

In this component, survey was taken up in 78 plantations in Karnataka, Tamilnadu and Andhra Pradesh. ERT data, actual heart wood data and soil samples were collected. A tomogram library was prepared with the ERT data. Correlation analyses were performed with the ERT and actual heart wood data, and regression equations developed to predict heart wood content based on ERT readings. The component is complete.

Component 9a and b: (Implemented by IWST and CSIR-NBRI)

In this component, 652 Red sanders heart wood cores were analysed for stable carbon isotope ratio ($^{13}C/^{12}C$) at the Central Instrumentation Facility of CSIR-NBRI, Lucknow. Part of this data was statistically analysed, however, no geographic variation was detected. Stable carbon isotope composition ($^{13}C/^{12}C$) of α-cellulose component was analyzed for 60 samples and the IRMS data was analyzed statistically. In another subcomponent, two chemical compounds were isolated, purified from methanolic extract of Redsanders heart wood. One compound was characterized and identified. Characterisation and identification of the second isolated compound was continued.

Highlights

- Two nurseries and three field trials have been established. The geographic location of these nurseries and field trial plots are given below.

Sl. No.	Infrastructure type	Location	GPS coordinates
1	Redsanders nursery	IFB, Hyderabad	Latitude-17.555155°N Longitude-78.445608°E
2	Redsanders nursery	BIOTRIM, Tirupati	Latitude-13.65779°N Longitude-79.43934°E
3	Redsanders progeny trial plot	Nelhal, Karnataka	Latitude-13.095°N Longitude-77.857°E
4	Redsanders progeny trial plot	Mangapuram, Andhra Pradesh	13.63877°N, 79.33089°E; 13.63815°N, 79.33092°E; 13.63868°N, 79.33036°E; 13.63817°N, 79.33028°E;
4	Field trial plot to assess effect of biofertilizer	Puliangudi Village, Thenkasi district, Tamil Nadu	Latitude-9.1725°N Longitude-77.3956°E

- Potential habitat suitability maps for *P. santalinus* have been generated for Andhra Pradesh and whole of India. 72 plus trees have been selected adopting check tree method of selection.
- Vegetative propagation of *P. santalinus* through air layering of coppice shoots optimized. Two strains of Rhizobium, five species of AM fungi (*Glomus geosporum, G. fasciculatum, G. aggregatm, Acaulospora* sp. and *Sclerocystis* sp.*)* and one species of Phosphobacteria (*Bacillus megaterium)* have been isolated for use as biofertilizer in Redsanders nursery and plantations. Twenty-six polymorphic EST-SSRs have been identified for *P. santalinus* germplasm management.
- Genetic diversity was estimated from the allelic data generated with 20 polymorphic EST-SSRs involving 59 accessions from natural populations.
- 57 plus trees were characterized with 8 polymorphic EST-SSR primers. The PIC values, number of alleles per loci, effective number of alleles, allelic sizes and frequencies, observed heterozygosity and expected heterozygosity were recorded. Regression equations have been developed to predict heartwood content of standing Redsanders trees using Electric Resistance Tomography readings.
- Altogether 622 wood samples were processed and analyzed for carbon isotope ratio ($^{13}C/^{12}C$). However, the statistical analysis of this dataset could not differentiate the geographic locations of the analysed samples. Two chemical compounds were isolated from heartwood extract of Redsanders and characterized.

9. All India coordinated Research project on "Quality teak production: capitalizing on cloning"

9.1 Objectives: Evaluation of existing teak clonal plantations. Mass production of new clones and evaluation through multi-location trials. Disseminate package of practices for cultivation in farmlands

9.2 Progress:

The AICRP aimed to popularise short rotation (SR)teak clones raised through tissue culture. The clones are established in ~100 ha in different states (Kerala, Tamil Nadu, Chhattisgarh, Maharashtra, Punjab, Gujarat, Karnataka, Jharkhand, West Bengal and Madhya Pradesh and Telangana) is under evaluation. At the end of five years, data reveals that the trees have attained a height of 12-15 m with an average girth of 40- 50 cm while seedlings as control have shown an average height of 8m with about 25-30 cm girth. The technology has been extended to the following:

S. No.	Commercial Facility	State	Status	Progress
1	HU Gugle Biotech	Karnataka Maharashtra	Licensee	**Production in full swin Supplied in bulk based orders.**
2	Mukund Biotech	Madhya Pradesh	Licensee	**Initiated in March 2024.**
3	Meristem Biotech	Karnataka	MoU for ToT	**Bulk production initiated.**
4	Jagadamba Biotech	Karnataka	MoU for ToT	**Supplied to ICFRE-IFGT based on orders.**
5	Santhi Clonal Nursery	Tamil Nadu	MoU for ToT	**Technology adoption**
6	HiFi Biotech	Tamil Nadu	MoU for ToT	**Technology adoption**
7	Adithya Biotech	Karnataka	MoU for ToT	**Technology adoption**
8	DevLeela Biotech	Chhattisgarh	MoU for ToT	Technology adoption

A revenue of Rs. 30.00 lakhs and a royalty of Rs. 45.00 lakhs has been realised through sale of plants. A documentary on TC teak cultivation and management practices was released on YouTube (https://www.youtube.com/watch?v=Fms-ApH5eLY). FAO selected the research as a success story showcasing the impactful use of tissue culture technology to meet the needs of smallholders in India, marking a significant step forward in the global efforts to achieve a wood secure nation (https://doi.org/10.4060/cc8940en)

Fig 9. One Year and Eight Months Growth in Clone 05 at Chichgarh, Maharashtra (ICFRE-TFRI)

Fig. 10. 2.5 year old trees at Melaiyur, Tamil Nadu (ICFRE-IFGTB)

Fig. 11. Plantation site, Bazpur, Uttarakhand (ICFRE-FRI)

Highlights

- The project targets to strengthen mass clonal propagation of identified trees of teak using tissue culture technology and popularize large-scale short rotation clonal teak agroforestry plantations. Partner institute of ICFRE optimised production of clonal plants of teak from identified mature trees.
- Field demonstration trials for growth performance evaluation established in about 100 ha across states of Kerala, Tamil Nadu, Chhattisgarh, Maharashtra, Punjab, Gujarat, Karnataka, Jharkhand, West Bengal and Madhya Pradesh. Early growth results reveal that at the end of 4 years, the plants have attained a height of 10-12 m and a girth of 40-45 cm.
- About 50 per cent of the trials are raised with the support of the Forest Departments of Kerala and Chattisgarh and Forest Development Corporations of Maharashtra. Encouraged with the initial results, Chhattisgarh forest department purchased 7.0 lakh plants for the state's green plantation programme of the year 2023-24.
- State forest departments have requested additional demonstration trials in the department lands of West Bengal, Madhya Pradesh, Andhra Pradesh, Maharashtra, and Gujarat.
- Mass multiplication and easy access of quality planting stock to farmers and other planters is achieved through public-private partnership and commercial tissue culture facilities which are involved in agricultural crop propagation signed MoU with ICFRE-IFGTB and ICFRE-TFRI for licensing and multiplication.

10. All India coordinated Research project on "Developing seed testing and seed storage protocols of selected forestry species from diverse forest types"

10.1 Objectives: It envisages to develop a complete package on seed technology like seed collection, seed processing, handling, viability, storage physiology and developing seed storage protocols and nursery techniques of rare, endangered and threatened and less explored but important forestry species (77 species).

10.2 Progress:

The objective of the project is to develop the fruit and seed maturity indices for identifying the optimal time for their collection, study the germination behaviour and storage physiology and develop seed storage protocols for the species from diverse forest types.

Population survey: Survey for identifying the seed sources completed for all 78 species.

- Phenological observations were recorded in 8 species viz *Garcinia gummi-gutta, Garcinia indica, Vateria indica, Lophopettalum wightianum, Hopea parviflora, Knema attenuata, Mammea suriga and Schleichera oleosa* at various locations like Agumbe, Sirsi, Gersoppa, Makutta and Sampaje in Karnataka
- Seed maturation studies completed in the 10 species: *Buchnania lanzan, Putranjiva roxburghii, Butea monosperma, Kydia calycina, Hymenodictyon excelsum, Santalum album, Boswellia serrata, Salvadora persica, Capparis decidua* and *Anogeissus latifolia*.
- Seed maturation studies were continued in: *Mallotus philippensis, Sterculia villosa Stereospermum chelonoides, Cochlospermum gossypium, Feronia limonia, Commiphora wightii, Pterospermum acerifolium* and *Salix tetrasperma*

Mature seeds of Acer pictum wre collected from Chakrata FD, *Stereospermum chelonoides* from Dehradun FD; *Chukrasia tabularis*, *Pinus kesiya* were collected from Meghalaya.; that of *Phoebe goalparensis* from Lakhimpur and *Dipterocarpus macrocarpus* from Jorhat, Assam.

Seed Germination behaviour:

Seed germination studies were conducted on seeds and pretreatments devised for enhancing the same in dormant seeds.

Species	Pretreatment	Germination (%)
Acer pictum	Cold stratification (2 months) and GA3 (0.05%) soaking for 24 hours	**14 (5% in untreated seeds)**
Anogeissus latifolia	Soaking in GA3 (1000 ppm) 24 hours	**6.67 (1.33% in untreated seeds)**
Boswellia serrata	Mechanical scarification due to hard seed coat followed by soaking in gibberellic acid (750ppm) for 24 hours	**41.7% (3.4% in untreated seeds)**
Buchnania lanzan	Mechanical scarification + soaking in thiourea (0.5%) solution for 24 hours	**75 (31% in untreated seeds)**
Capparis decidua	two days soaking with bavistin and warm water	**54.6 (11.67% in untreated seeds)**

Nyctanthus arbor-tristis	pericarp removed and scarification + GA3 (500ppm) soaking for 24 hrs	**58 (27% in untreated seeds)**
Salvadora persica	**soaking in cooling warm water overnight**	**24 (6.7% in untreated seeds)**

Seed pretreatment studies are under progress for *Symplocos cochinsinensis* and *Maesa indica*. Seeds of Stereospermum chelonoides and *Memecylon umbellatum* do not require any pretreatment.

Seed Storage physiology

Seeds of different species were stored at various temperatures after desiccation and their germination was evaluated periodically. Seeds exhibited longevity as under:

Species	**Storage temperature (0C)**	**Storage period (months)**	***Germination (%)***
Albizia julibrissin	5	33	*74*
Alnus nitida	5	21	*30*
Betula alnoides	-5	33	*25*
Betula utilis	-10	39	*27*
Chukrasia tabularis	4	12	*80*
Hymenodictyon excelum	5	30	*85*
Kydia calycina	15	33	*34*
Pinus kesiya	4	10	*41*
Pinus merkusii	4	14	*41*
Prunus cerasoides	2	33	*23*
Pterospermum acerifolium	5	21	*95*
Schleichera oleosa	20	4	*31*
Sterculia villosa	5	30	*56*
Stereospermum chelonoides	5	36	*80*
Sorbus lanata	-10	39	*36*
Rhododendron campanulatum	-10	39	*29*
Tsuga dumosa	**15**	**9**	***43***

- Seed desiccation studies showed *Memecylon umbellatum* as recalcitrant and *Murraya paniculata* as intermediate seeds. Seed storage studies on *Symplocos cochinsinensis* and *Leea indica* are under progress.
- Seed storage trials were completed in 12 species viz. *Albizia odoratissima, Butea monosperma, Bischofia javanica, Cipadessa baccifera, Elaeocarpus serratus, Erythrina suberosa, Heteropanax fragrans, Maesa indica, Stereospermum chelonoides, Kydia calycina, Hymenodictyon excelsum, Nyctanthes arbortristis*.

Correlating seed storage category with ecological parameters:

The morphometric characters and moisture content of the fruits of study species were recorded. Ecological parameters such as rainfall, relative humidity, temperature recorded for each study location.

Fig 12. Nursery Trial of *Betula utilis*

Fig. 13. Propagation Trial of *Sorbus lanata*

Highlights

- Species population survey for identifying the seed sources completed for all 78 species in 12 states.
- Fruit and seed maturation studies for optimum time of their maturity conductedfor 66 species
- Seed germination protocol (alongwith nature of dormancy, if any and pretreatments required) for 72 species developed. This will be used for quality evaluation of seedlots and raising planting stock in the nursery
- Seed desiccation studies conducted so far, revealed orthodox nature of seeds in42 species and recalcitrant nature of seeds of 18 species.
- Seed storage studies being carried out for 60 species. For a majority of the species systematic seed storage studies for durations exceeding one month are being conducted for first time.
- Seeds (orthodox) of 12 species were stored successfully for over two years retaining above 50% germinability.
- Nursery trials wrt., the effect of potting media, time of sowing, depth of sowing, container, effect of growth regulators on rooting, etc. for *Prunus cerasoides*, *Betula utilis, Sorbus lanata, Anogeissus latifolia, Capparis decidua, Salvadora persica* and *Boswellia serrata* being conducted.

11. All India coordinated research project on "*Dalbergia sissoo*"

11.1 Objectives:

- Screening *Trichoderma* spp. isolates against important Shisham pathogens viz., *Fusarium solani* and *Ganoderma lucidum*
- Development of protocol for extent of infection using biochemical markers
- Survey of shisham populations/areas for incidences of shisham mortality in the states of Bihar, Jharkhand, Madhya Pradesh, Chhatisgarh, Rajasthan, West Bengal, Uttar Pradesh, Uttarakhand, Delhi, Punjab, Haryana, Himachal Pradesh & Jammu & Kashmir and North Eastern states.
- Selection of genotypes/populations/areas unaffected/resistant to disease incidence
- Raising planting stock of selected genotypes in the nursery
- Artificial inoculation of shisham by *Fusarium solani* and *Ganoderma lucidum* for identifying disease resistant germplasm in the nursery and field.
- Raising quality planting stock of resistant genotypes for afforestation programme. Extension, Technology transfer and Capacity

11.2 Progress:

Disease surveys were conducted in Jammu and Kashmir, Himachal Pradesh, Punjab, Haryana, Uttar Pradesh, Uttarakhand, Bihar, MP, Chhatishgarh, Assam, Rajasthan, Gujrat, West Bengal and Jharkhand. Symptoms (wilting, oozing and stag head appearance) and signs (sporophore) associated with diseased Shisham trees have been recorded, samples of rhizospheric soils, roots, ooze, sporophore and bark tissue with ooze have been collected from diseased Shisham trees and also geo-coordinates of the locations have been also noted. After survey, identification of microbes completed by morphological, microscopic features and using DNA barcoding. All the fungal isolates were maintained in mineral oil and PDA slants for further studies.

FRI: From survey of Punjab, Haryana, UP and Uttarakhand; 33 *Fusarium* species complex isolates, 8 *Ganoderma lucidum* –isolates and 3 *Verticillium*-like fungal isolates. Also, pathogenicity testing of 15 *Fusarium* isolates has been proved under glasshouse conditions.

HFRI: Shisham populations of 64 sites in Himachal Pradesh were surveyed for disease incidence, and soil samples, diseased plant parts and fruiting bodies of *Ganoderma lucidum* were collected. Shisham populations in 48 sites were recorded healthy. The severity of disease was recorded in the range of 5-20% in Kangra district, upto 60% at Birplasi in Soaln district, upto 22% infection was recorded in Sirmaur district and within 11-21% range in Una, district. 27 sites in Jammu, Samba and Kathua districts of Jammu and Kashmir, Union territory were surveyed and 5 sites were recorded to have 12-17% infection. The soil samples collected from surveyed sites were analysed to have clay to sandy loam texture, 6.5-8.30 pH, and 30-65% moisture content. In total 22 isolates of *Trichoderma* spp., 10 isolates of *G. lucidum* and 3 isolates of *Fusarium* were isolated and cultures are being maintained on PDA. 22 isolates of *Trichoderma* species were screened against 10 isolates of *G. lucidum* and 3 isolates of *Fusarium by* dual culture method. The growth inhibition was recorded in the range of 10-77%. Local waste like, sugar bagasse, wheat bran, wheat straw; needles of *Cedrusdeodara*, *Pinus roxburghii*, *P. wallichiana*, *Abiespindrow*, and foliage of *Parthenium hysterophorus*, *Ageratinaadenophora* and *Lantanacamara*were tried as substrates for mass multiplication of *Trichoderma* species. Maximum

spore count 1.41×10^6 spore/g was recorded on *P. roxburghii*needle powder supplemented with potato dextrose broth and yeast extract. The prepared mass inoculum administered to diseased trees at Nalagarh and Bilaspur. Cuttings from 33 CPTs were collected and raised in polybags and nursery beds at VVK Dharampur, Mandi. For the identification of most virulent pathogen isolates, 2-year-old shisham seedlings were inoculated with mass cultures of pathogens by soil drenching method and injuries were given to seedlings for successful infection.

RFRI Jorhat: A total of 101 soil samples were collected from Shisham plantations of different areas of Assam and 47 microbial isolates has been isolated. Of these twenty six (26) *T. harzianum*, thirteen (13) *T. atroviride* and eight (8) *Fusarium solani* was isolated from the collected soil sample. Nineteen (19) fruiting body of *Ganoderma lucidum* and one fruiting body of *G. sessile* were collected and pure culture was done. New pathogen *Phellinus trumulae* was found on *D. sissoo* causing root rot in Dhemaji district of Assam. Dual cultural assay of *Trichoderma atroviride* and *Trichoderma harzianum* strains proved their highest efficiency against *Ganoderma lucidum* and *Fusarium solani* with inhibition percentages of 70.01 and 69.81%. For mass multiplication of *Trichoderma* spp. cultivation protocol was developed using agricultural waste biomass rice husk. Nursery experiment growth performance data such as shoot height, root length, collar diameter, volume, fresh weight and dry weight was recorded and tabulated of plus tree seedlings inoculated with *Trichoderma harzianum* and *T.atroviride* at three months interval.For ground verification and occurrence of *D. sissoo*, GPS data was recorded. A total number of 414 trees was recorded, out of which (90) trees were found infected, (50) trees were found dead and a total of (53) plus trees were also recorded. A total of 274 trees were found unaffected. Prepared mass inoculums for field trials.

AFRI Jodhpur: Rhizopsheric soil samples (35) have been collected from south-eastern Part of Rajasthan during this half year. Total 15 trichoderma species were isolated and their cultural characters and growth pattern as well as their growth behaviour in different spent material have been studied. No new isolate of Fusarium and Ganoderma have been isolated during this period. Soil samples from Jaisalmer from shisham plantation was collected and out of the dead shisham two unidentified fungi has been isolated, 3 *Trichoderma* from Soil of healthy plant was also isolated. Experiment for pathogenecity testing of fusarium isolates and of *Ganoderma* isolates has been done. All the *Trichoderma* isolates were treated on the Shisham seedling to study the efficacy of isolates and to select best among them. Soil samples from 3 districts of Rajasthan (Churu, Sikar and Jhunjhunu) and 7 districts of Gujarat (Sabarkantha, Banaskantha, Arawalli, Dahod, Rajpipla, Dang, Navsari) were collected and isolation of microbes is in process. Disease/mortality incidence has been calculated by laying plots in plantations of shisham. Study of growth activity of *Trichoderma* isolated is in process and data is being recorded at quarterly intervals.

TFRI, Jabalpur: From MP and Chattishgargh regions, 98 soil samples from 26 sites were collected from the *Dalbergia sissoo* rhizosphere region. 42 isolates of *Trichoderma spp.* isolated from soil samples. Multiplied in broth culture. 16 isolates of *Fusarium spp.* isolated from soil samples. Multiplied in broth culture. 09 isolates of *Ganoderma spp.* isolated from soil samples. Multiplied in broth culture. Dual culture tests of 15 *Trichoderma* spp. were screened against 03 isolates of *G. lucidum* and 07 isolates of *Fusarium solani*. 5 *Trichoderma* spp. were also screened against four isolates of bacteria. The growth inhibition was recorded in the range of 6-70% in *G. lucidum*, 25-85% in *F.solani and* 5-45% in Bacteria. *Trichoderma sp.* application in diseased tree in field. Studies of the effect of *Trichoderma* on Shisham seedling health in nursery is undergoing. *Trichoderma* isolates (10) were sent to FRI, Dehradun for Molecular identification.

IFP Ranchi: The field survey of mortality and distribution of Shisham in the states of Jharkhand, WB and Bihar revealed that wide distribution of *D. sissoo* in Bihar with dominance in Rohtas, Sasaram and Aurangabad districts. The field surveys also revealed that *D. sissoo* mortality mostly in Rohtas and Gaya. The field surveys of Araria and Purnia revealed wide distribution of *D. sissoo* along road side and plantation under the natural landscape. In Jharkhand, the distribution of *D. sissoo* is mostly occurring along roadside but some block plantations have also be established by the SFD; in Loharadga, where wide mortality in *D. sissoo* patch in this plantation block. The *Ganoderma* samples collected from some of sample sites representing the locations of Jharkhand and Bihar have been screened and analysed by the Pathology Division, FRI, Dehradun. The desired GIS layers for modelling species distribution were prepared. The required climate models representing two climate scenarios Climate model MIROC5, IPSL_5A_LR, IPSL-CM6A-LR and MIROC6 have been downloaded and digitised for the Indian administrative boundary. The distribution data collected from Himachal Pradesh and Jammu & Kashmir were compiled for preparation of distribution maps and further these will be used as the input layers for the Habitat and Hazard modelling. The point distribution map of Eastern region, Himachal Pradesh and Jammu &Kashmir depicting affected and non-affected samples has been prepared. The habitat suitability map for eastern region of India has been prepared. The habitat suitability map for the current scenario indicates suitable habitats of *D. sissoo* occurring in the eastern, central and upper southern part of the study area. The prominence of distribution was occurred in the eastern part of the study area encompassing Bihar.

Tree improvement approach

Surveys were conducted in different regions of Jammu and Kashmir, Himachal Pradesh, Punjab, Haryana, Uttar Pradesh, Uttarakhand, Bihar, MP, Assam, Rajasthan, Gujrat, West Bengal and Jharkhand for study the disease infected area and subsequently selection of disease free/resistant mature candidate plus trees (CPTs) and seed/propagule collection from them. In total, 275 CPTs selected across India against the productivity and disease resistance. Criteria developed for selection of Plus Trees of *Dalbergia sissoo*. First selection the best tree of a population as candidate plus trees (CPT) and 10 comparison trees, around the CPT. Then observation of its parameter was taken.The comparison shall be carried out on the basis of difference between the various parameters selected for the study. On the basis of the observed parameters, plus trees were selected and their passport data prepared. These CPTs were scored on point basis of 100 and those securing 85 were selected as plus trees.In assessment process of plus trees, 30 marks out of 100, were awarded for disease symptom free, and hence any disease incidence even after selection of CPTs were liable to included a zero score for disease incidence and hence that CPT was failed as Plus tree. Assessment process is still going on and 72 are declared as disease free and productive plus tree, whose germplasm would be collected and assessed in progeny trials and also directly may be used for creation of Gene banks, seedling and clonal seed orchards, vegetative multiplication gardens, clonal multiplication nurseries and may be even distributed for large scale plantations. Progeny trials will be used such a way that it can be turned in to 1.5 generation improved seed orchards.

A brief detail of geographical distribution of selected CPTs and plus trees are as follows:

- 72 CPTs and 24 Plus trees were selected from Punjab, Haryana, Uttarakhand, and UP.
- 85 CPTs and 33 plus trees of Shisham were marked in Himachal Pradesh and Jammu and Kashmir.
- 34 CPTs were selected in MP and Chattishgarh.
- 18 CPTs and 6 plus trees were selected from Bihar, West Bengal and Jharkhand.

- 53 CPTs and Plus Trees were selected from different district of Assam.
- 13 CPTs has been marked in Rajasthan and Gujarat.

Also, during 1990's, Forest Research institute, Dehradun has selected more than 100 CPTs of Shisham having straight stem and good. On the basis of performance FRI DS-14 was released as a variety in 2011. An indirect selection method was developed using biotechnology to reduce this lengthy process, this method takes 2-4 years to select the resistant germplasm using Gnotobiotic model. Under this system, plantlets and callus is being grown in tissue culture and the callus infected by live disease inoculums under *in vitro* sterile conditions. Disease resistance callus from genotypes of *D. sissoo* is selected, first by ocular observation and then using disease estimation using HPLC and proteomic studies.

In above pathogenic strains (H5 and H7) of *Fusarium solanii* were used for disease resistant trials of shisham genotypes under Gnotobiotic *in vitro* condition based on earlier validated experiments. First figure is of callus in control, second and third pictures are of H5 and H7 infected callus. Genotype FRIDS 14 and FRIDS 232 which were resistant and susceptible, respectively from earlier experiments were used as standard. In this experiment, we had tested three new genotypes and 2 (FRIDS 113 and 239) had showed resistant after 9 days of incubation against strain A5 but susceptible to strain A7. Genotype 23 had showed more susceptibility than genotype 232. Callus cultures of 50 genotypes have been established from the nodal explant of selected genotypes on MS media supplemented with various concentration of BAP, NAA and 2,4-D. Genotypes with established callus cultures were also maintained by doing sub-culturing at regular intervals. Cell suspension culture of four genotypes has been re-initiated and protocol for optimal growth and viability of cells has been standardised. Disease assessment is being done using biochemical markers.

Nursery: Seeds of CPTs were collected. Seedlings were raised and maintained in nursery for the CPTs collected during previous year and earlier raised progenies were managed in the nursery. Also cuttings of promising genotypes are being maintained in nursery. More than 50 genotypes (some from earlier collection) are being propagated and under maintenance. More than 1500 ramets have been prepared from cuttings obtained from CPTs.

- Seed orchards/Germplasm bank of disease resistant germplasm of Shisham:

Mirpur Haryana: 4.2 ha; Bhithmera, Haryana: 4.2 ha; Near Mohand, Shivalik division, UP: 0.42 ha

- Vegetative multiplication garden/ clonal multiplication area:

Saharanpur, UP: 0.1 ha; ICFRE-FRI, Dehradun: 0.1 ha

- Under Honourable Forest Minister of UP, a research and extension MOU with UP state FD and ICFRE-FRI done to tackle shisham mortality.

Extension:

- Standard of procedure developed and provided to UPFD for identification and reporting shisham mortality.
- Workshop and trainings for extension of the technologies

FRI team is helping in developing strategies to curb shisham mortality in UP. In November, 2022 FRI team hold one day workshop on shisham mortality at Lucknow. Workshop was chaired by PCCF and HoFF, UP and attended by all CCFs and DFO's. UPFD staff was trained and material supplied for raising Gene Bank (Shiwalik) and VMG (Saharanpur) under guidance of FRI. This was followed by two another

meetings chaired by Honourable Forest Minister of UP. *Trichoderma* cultures were given to develop *Trichoderma* assisted nursery of shisham. Field staffs were trained in *Trichoderma* applications in nursery and also in trees. Also *Trichoderma* cultures and its application training were provided to Gonda Forest division staff for nursery application. Also *Trichoderma* treated shisham plants were supplied to Assam forest Department.

Highlights

- Surveys of Shisham mortality in growing area of Jammu and Kashmir, Himachal Pradesh, Punjab, Haryana, Uttar Pradesh, Uttarakhand, Bihar, MP, Chhatishgarh, Assam, Rajasthan, Gujarat, West Bengal and Jharkhand for disease were completed. Disease identified on the basis of symptoms (wilting, oozing and stag head appearance) and signs (sporophore) associated with infected or dead Shisham trees. The severity of disease was recorded in the range of 5-20% in Kangra district, up to 60% at Birplasi in Solan district, up to 22% infection was recorded in Sirmaur district and within 11-21% range in Una, district oh HP and 5 sites were recorded to have 12-17% infection in Jammu and Kashmir. In Assam survey revealed that out of 414 trees observed 90 trees were infected and 50 trees were dead rest were 274 trees were found unaffected.
- Across the regions, disease causing pathogens; 60 *Fusarium* species complex isolates, 27 *Ganoderma lucidum* –isolates 3 *Verticillium*-like fungal isolates and disease bio-controlling 118 isolates of *Trichoderma* spp. were accumulated and being maintained for further studies. A new pathogen *Phellinus trumulae* was found on *D. sissoo* causing root rot in Dhemaji district of Assam.
- The desired GIS layers for modelling species distribution were prepared. The required climate models representing two climate scenarios Climate model MIROC5, IPSL_5A_LR, IPSL-CM6A-LR and MIROC6 have been downloaded and digitised for the Indian administrative boundary. The point distribution map of Eastern region, UP, Uttarakhand, Punjab, Haryana, MP and Chhatisgarh, Himachal Pradesh and Jammu &Kashmir depicting affected and non-affected samples has been prepared. The habitat suitability map for eastern region of India has been prepared. The habitat suitability map for the current scenario indicates suitable habitats of *D. sissoo* occurring in the eastern, central and upper southern part of the study area.
- In total, 275 disease free/resistant mature candidate plus trees (CPTs) selected across India against the productivity and disease resistance after surveys in Jammu and Kashmir, Himachal Pradesh, Punjab, Haryana, Uttar Pradesh, Uttarakhand, Bihar, MP, Assam, Rajasthan, Gujarat, West Bengal and Jharkhand and subsequently selection of and seed/propagule collection from them. Forest Research institute, Dehradun has selection of more than 100 CPTs of Shisham having straight stem and good growth from earlier selection.
- Biotechnological approach applied to diagnose disease early, a method has been developed and this also may be used as an indirect selection method was developed using biotechnology to reduce this lengthy process, this method takes 2-4 years to select the resistant germplasm.
- Pathogenic strains (A5 and A7) of *Fusarium solanii* were used for disease resistant trials of shisham genotypes under Gnotobiotic *in vitro* condition based on earlier validated experiments. First figure is of callus in control, second and third pictures are of A5 and A7 infected callus. Genotype FRIDS 14 and FRIDS 232 which were resistant and susceptible, respectively from earlier experiments were used as standard. In this experiment, we had tested three new genotypes and 2 (FRIDS 113 and 239) had showed resistant after 9 days of incubation against strain A5 but susceptible to strain A7. Genotype 23 had showed more susceptibility than genotype 232.

12. All India coordinated research project on "Assessment of demand and supply of timber, fuel-wood and fodder in India"

12.1 Objectives: Demand and supply of timber, fuel-wood, fodder

12.2 Progress:

Assessment of Fuelwood Consumption in Cremation and Burial Practices in India.

The preliminary assessment shows that India required 2.42 to 2.83 MT of fuelwood for cremation and burial, equivalent to 3.8 to 4.5 *M CUM Round Wood Equivalent (*RWE) volume amounting 17.9 to 20.7 billion INR, consisting of cutting of equal to 5.64 to 6.59 million trees.

Assessment of Fuelwood Consumption in Small Restaurants in India.

The preliminary assessment shows that small restaurants in India consumed 0.55 MT to 0.77 MT of fuelwood, equivalent to 0.87 to 1.22 *M CUM* RWE volume amounting 3.94 to 4.47 billion INR, consisting of cutting of 1.29 to 1.80 million trees.

Un-recorded Removal of Timber, Fuelwood and Fodder from Forest in India

Zone-wise proportion (%) of Households in fringe villages for extracting Un-recorded forest resources

Zone	Himalayan	Dry & Desert	Central	Eastern	Southern	North-East
Timber	0.48	0.18	0.38	0.41	0.21	0.3
Fuelwood	0.64	0.53	0.61	0.46	0.56	0.51
Grazing	0.6	0.76	0.72	0.72	0.61	0.32

Household Fuel Energy Transition and Attributable Factors in a Developing Economy, India

The analysis of NSSO survey of 2.76 lakh households in India for accounting the transition of cooking and heating energy in Indian households indicated that energy transition follows "Fuel stacking theory" rather than "Energy ladder theory" i.e. households continue to prefer different energy sources for different purposes. The modeling results that income and wealth growth push households to use clean fuel; however, landholding and household size adversely affect the clean fuel usage.

International Trades of Wood Products in India

In FY 2021-22, the total quantity of approximately 60 M CUM RWE of wood products was traded internationally with 46 M CUM RWE under import and 14 M CUM RWE under export. The percentage share of Indian wood products export in total value of Indian exports has increased from 0.2% in 2001 to 1.2% in 2021, whereas the percentage share of Indian wood products import in total value of Indian imports is anchoring around 1.5% during the period. In India, the import and export value for wood products during 2021-22 was US$7344 M and US$4948 M respectively.

State wise household consumption of timber, fuelwood and fodder from forest in India during 2023(Preliminary)

State/UT's	Timber (M ft^3 RWE)		Fuelwood (MT)	Fodder (MT)
	Fixture	Furniture		
Uttarakhand	1.06	0.44	4.061	7.83
Haryana	2.15	0.76	2.06	3.37
Punjab	1.71	0.61	0.33	8.82
Bihar	9.74	3.55	9.71	9.99
Jharkhand	3.01	1.32	2.98	3.12
West Bengal	3.61	1.35	7.61	9.63

Assam	3.52	2.12	0.30	3.26
Meghalaya	0.28	0.19	0.00	4.60
Chhattisgarh	1.59	0.97	2.62	4.50

Highlights

- Household surveys of approximately 21,500 households have been completed and around 5000 remains. The survey will be used for estimation of forest resources by the households.
- Analysis for Wood in International Trade (Import and Export) for quantity and value has been completed and document has been made.
- Analysis for Fuelwood being used in cremation has been completed for across country and document has been made.
- Analysis for Fuelwood being used in small restaurants has been completed for across country and document has been made.
- Analysis for Unrecorded removal of forest resources from fringe villages has been completed and document has been made.
- Analysis for Forest resource utilization (timber, fuelwood and fodder) by the households across 11 states has been estimated and Leaflet for 11 states has been developed.

13. All India coordinated research project on "Valuation of forests for GDP, green GDP and payment of eco-system goods and services"

13.1 Objectives:

- To develop methodologies for forest valuation, both direct and indirect. To determine the contribution of forests to the GDP of India, the value of ecosystem goods and services per unit area for different forest types, the replacement cost of forests when diverted for non-forestry purposes

13.2 Progress:

Forests provide ecotourism services various physical and mental health benefits to the visitors. Based on the visitor's survey of 29 eco-tourism sites across country, the preliminary results shows that estimated median willingness to pay (WTP) of the visitors was around 353 rupees per person per visit using the Double Bound Contingent Valuation Method and the average WTP of a site correlates with accessibility and infrastructure rather than forest types. In 17 out of 29 sites, we found a positive relationship between expenditure (a proxy for income) and WTP which indicates the need for product differentiation which in turn increases the revenue. Forest provides pollinations services, specially, pollinators of Insecta order residing in the forest and contributing for pollination for neighbouring agricultural fields. The pollination services for Sabhawala site, Uttarakhand containing FT 3 was estimated to be 22100 rupees ha^{-1} using the Maximum Forage distance-based method, dependency ratio and market price based methods. Various edaphic, climatic and biological settings of the region govern the composition, growth, structure of forests and the ecological processes that underlie the delivery of various ecosystem services. The supporting services consisting of habitat and biodiversity services of all the sixteen forest types of India was estimated based on associated indicators of the services using data from Remote Sensing and secondary sources. The habitat service was defined through climatic and bio-physical parameters; and the biodiversity service was estimated based on the flora and fauna diversity. Various indicators were aggregated by assigning weight using Analytical Hierarchical approach and the value of the both services was estimated using benefit transfer method. The results suggest that littoral and swamp forest had maximum habitat services and tropical semi-evergreen forest had maximum biodiversity service and tropical wet evergreen forest had maximum supporting services. The annual per hectare economic value of habitat, biodiversity and supporting services from different forest types of India was estimated to be US$ 4,330.71/ha, US$ 5,987.38/ha and US$ 10,624.23/ha, respectively. The annual economic value of habitat, biodiversity and supporting services from Indian forests was US$ 303,506.09 million, US$ 419,609.45 million and US$ 744,570.85 million, respectively. In totality, tropical dry deciduous forest, tropical moist deciduous and tropical semi-deciduous forest had higher economic value for supporting service as compared to other forest types.

Highlights

- Household surveys of approximately 21,500 households have been completed and around 5000 remains. The survey will be used for estimation of forest resources by the households.
- Analysis of Pollution abetment service for all forests of the country has been completed.
- Analysis of Habitat and Biodiversity ecosystem service for all forest types of the country has been completed.
- Analysis of Soil erosion control services of all forest types has been completed.
- Survey for ecotourism services for 29 sites has been made consisting around 14,500 tourist surveys.
- Methodology for tangible and intangible services has been refined.
- Survey and analysis of Pollination services for one site of forest type 3 has been made.

14. All India coordinated research project on "Forest Fire Research and Knowledge Management"

14.1 Objectives: Generating knowledge and capacity building to minimize the devastating impact of forest fires; to carry out research on forest fire and to develop appropriate management strategies for the forested areas which are most vulnerable to forest fires.

14.2 Progress:

ICFRE-Forest Research Institute, Dehradun

Under objective-1 during 1st October, 2023 to 31st March 2024, baseline data has been collected from Subtropical Pine Forest 2 sites (for less than two year) in Almora Forest Division, 5 sites (for less than two year) were surveyed in Rudraprayag Forest Division (2 site), Garhwal Forest Division (3 site). As of March 2024, a total of 36 sites were covered out of which 34 sites were surveyed in subtropical pine forest for open and dense category. 1 site in tropical dry deciduous and 1 site in tropical moist deciduous forest were surveyed for less than two-year site category.

Details of the total sites covered till March 2024 is given in below table.

Site No.	*Forest Type*	*Name of Site*	*Canopy Density*	*Site Category*	*Division*
1.	Tropical Dry Deciduous	Sidh 01	Dense	Less than two years	Haridwar
2.	Sub-Tropical Pine	Agshwara 2A	Dense	Less than two years	Garhwal
3.	Sub-Tropical Pine	Utai 9	Dense	Less than two years	Garhwal
4.	Sub-Tropical Pine	Pujargaon Reserve 7B	Dense	Less than two years	Narendra Nagar
5.	Tropical Moist Deciduous (Mixed)	North Lachhiwala	Dense	Less than two years	Dehradun
6.	Sub-Tropical Pine	GiniyaDoli C-3	Dense	Less than two years	Almora
7.	Sub-Tropical Pine	Gainad Van Panchayat	Dense	Less than two years	Bageshwar
8.	Sub-Tropical Pine	Agastmuni beat; C-1	Dense	Less than two years	Rudraprayag
9.	Sub-Tropical Pine	North Adwani Beat C-02	Dense	Less than one year	Garhwal
10.	Sub-Tropical Pine	North (Uttari) Binsar Comp No-35	Dense	Less than one year	Bageshwar
11.	Sub-Tropical Pine	Paikham com-08	Open	Less than one year	Almora
12.	Sub-Tropical Pine	Gananath com-08	Open	Less than one year	Almora

13.	Sub-Tropical Pine	Jhakhani Comp - 4	Open	Less than two years	Rudraprayag
14.	Sub-Tropical Pine	Sigad comp.-02	Open	Less than two years	Garhwal
15.	Sub-Tropical Pine	Adwani compartment 05	Open	Less than two years	Garhwal
16.	Sub-Tropical Pine	Doodhatoli-06 comp. no. 01	Open	Less than two years	Garhwal
17.	Sub-Tropical Pine	Augustmuni compartment 01	Open	Less than two years	Rudraprayag
18.	Sub-Tropical Pine	N Binsar compart-035	Dense	Less than two years	Bageshwar
19.	Sub-Tropical Pine	Advani comp-02	Dense	Less than two year	Garhwal
20.	Sub-Tropical Pine	Paikham com-08	Open	Less than two years	Almora
21.	Sub-Tropical Pine	Gananath com-08	Open	Less than two years	Almora
22.	Sub-Tropical Pine	Pujargaon Reserve 7B	Dense	Less than three years	Narendra Nagar
23.	Sub-Tropical Pine	GiniyaDoli C-3	Dense	Less than three years	Almora
24.	Sub-Tropical Pine	Gainad Van Panchayat	Dense	Less than three years	Bageshwar
25.	Sub-Tropical Pine	Agastmuni beat; C-1	Dense	Less than three year	Rudraprayag
26.	Sub-Tropical Pine	Almora, Someshwar; Lodh; Comp-14	Dense	Less than one year	Almora
27.	Sub-Tropical Pine	Almora, Ranikhet; Richi Soni	Dense	Less than one year	Almora
28.	Sub-Tropical Pine	Garhwal, Pokhra	Dense	Less than Three year	Garhwal
29.	Sub-Tropical Pine	Paithani	Dense	Less than Three year	Garhwal
30.	Sub-Tropical Pine	Almora, Ranikhet; Richi Soni	Dense	Less than Two year	Almora
31.	Sub-Tropical Pine	Almora, Someshwar; Lodh; Comp-14	Dense	Less than Two year	Almora
32.	Sub-Tropical Pine	Jhakhani Comp - 4	Open	Less than Three year	Rudraprayag
33.	Sub-Tropical Pine	Agastmuni beat; C-1	Open	Less than Three year	Rudraprayag
34.	Sub-Tropical Pine	Sigad comp.-02	Open	Less than Three year	Garhwal
35.	Sub-Tropical Pine	Adwani compartment 05	Open	Less than Three year	Garhwal
36.	Sub-Tropical Pine	Doodhatoli-06 comp. no. 01	Open	Less than Three year	Garhwal

The analysed data by FRI Dehradun is placed here in following sequence.

1. Biodiversity index for completed sites
2. Soil data (Nitrogen, Phosphorus, Potassium, and pH) analysis
3. 5-C (Carbon) pool data analysis
4. Fodder Biomass
5. Timber Volume
6. Fuel wood

Highlights

- Baseline data on timber, fuelwood, fodder, NTFP, floral biodiversity (including Invasive alien species), carbon storage, carbon sequestration, soil nutrients from 224 burnt and 224 unburnt sites out of 307 targeted sites from forest five types viz., Tropical Semi Evergreen Forest, Tropical Wet Evergreen Forest, Tropical Moist Deciduous Forest, Tropical Dry Deciduous Forest, Sub-Tropical Pine Forest covering 15 States viz., Uttarakhand, Himachal Pradesh, Madhya Pradesh, Maharashtra, Chhattisgarh, Odisha, Andhra Pradesh, Telangana, Karnataka, Tamil Nadu, Kerala, Assam, Meghalaya, Mizoram, Nagaland has been collected. Data digitization is completed for all the sites. Analysis of data is going on simultaneously.
- Mapping and categorization of fire prone areas in five pilot districts viz., Amravati, Aizwal, Kadapa, Pauri Garhwal and Idukki based on historical fire data and ecological model is in progress. Collection of historical fire data from FSI is completed. Collection of Worldclim data, DEM data, Aridity index data, Evapo-transpiration data, data on forest characteristics is completed. Collection of fuel characteristic and socioeconomic data on anthropogenic variables/ preventive interventions is in progress and will be completed by the end of this year. Teams have collected data on fuel load and socio-economic from Pauri Garhwal district. Mapping and model building will be done by the end of this year.
- The firefighting hand tools along with fire safety clothing is being developed with collaboration with the following expert institutes. ICFRE-FRI has collaborated with expert institutes like UPES Dehradun, IIT Roorkee and DRDO, New Delhi for designing and developing firefighting equipment/ tools.
- Development of Kit-1 (Rake (Arrow type, Nail Type, Peg tooth type/ multi-function), Fire beater, Fire broom (Jhapa), Torch, Water bottle, Pathal (modified sickle), Tool kit bag, Adjustable rod), Kit-2 fire safety dresses (Jump suit, Fire gloves, Helmet with face shield, half face respirator, Face protector hood, Googles, Safety boots) and Kit-3 (leaf blower) by UPES is completed. Feedback on Field testing shared with UPES.
- Fire safety helmet with face shield and fire suit has been received from CFEES, DRDO and same has been sent to Uttarakhand Forest Department for field testing in the ongoing fire season.

15. All India coordinated research project on "Tamarind (*Tamarindus indica* Linn.): Domestication, conservation and deployment of genetic resources for sustenance and livelihood amelioration"

15.1 Objectives:

- To develop a National Registry and a National Germplasm Bank of Tamarind towards initiating systematic domestication in the country.
- To shortlist high yielding tamarind genetic resources and deploy them with site specificity and precision silviculture methods across multi-locations in order to accomplish higher yield in avenue, farm and industrial plantations.
- To build a National Tamarind Consortium for channelizing superior raw material from genetically improved selections to various industrial stakeholders thereby improving the overall product quality and enhancing the economy.

15.2 Progress:

Phenological and reproductive variations in different tamarind clones are being documented using genetic resources available in Tamil Nadu, Karnataka, and Andhra Pradesh. The study observes variations in flowering patterns, with 65 percent of the clones showing mid-flowering, 20 percent early flowering, and 15 percent late flowering. Fruits were collected from 80 tamarind clones available in Tamil Nadu, Telengana and Gujarat and assessed the morphomertic variations Viz., fruit weight, length, width, thickness, seed weight, shell weight, pulp weight, fiber weight, number of seeds per fruit, pulp-to-seed ratio, and pulp-to-shell ratio. Out of 80 tamarind clones screened for crown type, 60 percent exhibited semi-erect crowns, 20 percent had drooping crowns, and 20 percent had erect crowns. The height of the clones ranged from 4.57 m to 8.85 m, and the girth at breast height varied from 25.96 cm to 56.37 cm. The crown cover area differ from 3.00 m to 5.20 m. Fruit length varied from 4.60 cm to 16.48 cm, fruit width from 1.24 cm to 2.34 cm, and the number of seeds per fruit ranged from 3 to 12. Pulp weight varied from 6.87 g to 15.63 g among the different clones. Variations in fruit length, width,

Wide variation in phytochemical traits viz., total soluble solids (7.97% to 14.68%), pH (2.67 to 3.51), titrable acidity (5.19 to 14.53), reducing sugar (12.15% to 47.25%), non-reducing sugar (10.77% to 40.35%), total sugar (16.84% to 55.61%), total ascorbic acid (3.20% to 7.11%), protein (1.35 mg/g to 4.38 mg/g), carbohydrates (1.21 to 3.54), lipids (1.24 mg/g to 3.12 mg/g), phenols (0.15 mg/g to 0.29 mg/g), flavonoids (2.76 µg/mg to 6.54 µg/mg), tannins (0.34 mg/g to 1.41 mg/g), and tartaric acid (6.13% to 19.65%).

Clones were categorized based on various characteristics including canopy shape, bark color, growth habit, type of foliage, bearing habit, bud color, petal color, pod shape, pod color, and pulp color. Canopy shapes included 25 clones with circular canopies, 35 with semi-circular canopies, and 20 with vast canopies. Bark colors were light brown for 29 clones, brown for 41 clones, and dark brown for 10 clones. Growth habits were upright for 7 clones, semi-spreading for 54 clones, and spreading for 19 clones. Foliage types were dense for 48 clones and sparse for 32 clones.

Regarding bearing habits, 45 clones were identified as regular bearing, while 35 were alternate or irregular bearing. Bud colors included pink for 35 clones, red for 30 clones, and pinkish white for 16 clones. Petal colors were pink for 34 clones, reddish white for 30 clones, and pinkish white for 16 clones. Pod shapes included 8 curved clones, 32 semi-curved clones, and 40 straight clones. Pod colors were classified as brown for 46 clones and grey for 34 clones. Pulp colors were brown for 56 clones and reddish brown for 24 clones. Identification and marking of 8 heritage Tamarind trees in Coimbatore District. The preparation of the national Tamarind registry is under progress. Multiplied 20 high productive clones of red, sweet, and sour Tamarind at the germplasm bank of IFGTB and produced 5000 grafts from the selected clones. The clonal materials were shared with AICRP partner institutions for establishing multi-location clonal trials in Telangana and Gujarat.

Eight multi-location clonal trials of Tamarind were established at Neyveli, Cuddalore (1 Ha); Kangeyam, Tiruppur (1 Ha); Mellur, Madurai (1 Ha) in Tamil Nadu; Bayala, Tumkur in Karnataka (1 Ha) and Mulugu, Hyderabad (1 Ha) in Telangana, Centre for Crop Improvement, SDAU, Banaskantha (1 Ha); Agricultural Research Station, SDAU, Mehsana (1 Ha) and Cotton Research Station SDAU, Talod, Gujarat (1 Ha). The field trials were established in a Randomized Block Design at an espacement of 5m x 5m with 20 clones in Tamil Nadu and 15 clones in Karnataka and Hyderabad and each clone was replicated 4 times. Maintained the multi-location clonal trial of Tamarind at IFGTB field research station, Neyveli, Cuddalore Dt., Kangeyam, Tirupur Dt., Melur Madurai Dt and Bayala, Tumkur. Inter ploughing, weeding, and application of fertilizers have been carried out. Seeds were collected from the Urigam trees for restocking and replanting of the trees. Tamarind plantation was established at Idayankottai, Ottanchathiram Taluk, Peramandur, Rettanai, and Gopalapuram in Vilupuram district Tamil Nadu with community participation in road avenues, tank bunds, and community lands. Community plantations at panchayat lands in Kallimandhayam Temple, Othaiyur, Thoppakavalasu, Kuthilippai, and Bhodakaadu and Mullainagar panchayats, Dharmapuri district; Pallipatti, Krishnagiri Dt; Kallimandhayam, Ottanchatram premises of 31 schools, tank beds, and lake beds with 5000 seedlings planted at a spacing of 10 m x 10 m.

Collected 40 Tamarind clones from the clone bank available in ICFRE-IFGTB and Tamil Nadu Forest Department, University of Horticultural Science, Bengaluru, Bhagalkot, Indian Institute of Horticultural Research Institute, Horticultural Research Station, Anandhapur, PCKV, Aurangabad, and Gujarat Agricultural University. Selected and prepared the land at ICFRE-IFGTB-FRS, Neyveli, Dry Land Agricultural Research Station, TNAU, Karaikudi, Tamil Nadu. Base line data were collected on Tamarind fruit pulp and seed processing groups in Theni and Dharmapuri districts. About 1000 families were involved in Tamarind processing and value addition in the above said districts. Interactive meeting was held with the farmer's forum in Anaikatti for the formation of Tamarind Consortium for value-addition and marketing. Identified and collected about the women's self-help group involved in Tamarind value addition and marketing for imparting training. The formation of Tamarind consortium for enabling the value chain of Tamarind seed gum is initiated. MOU is signed with ICFRE-IFGTB-TNAU, Coimbatore for the development of value-added products in Tamarind and training to the different stakeholders. Standardized the level of incorporation of Tamarind seed gum for the value-added products like Jam and Jelly. Physiochemical properties of Tamarind seed gum incorporated Jam and Jelly. Products such as Tender Tamarind pickle and Tamarind flower gulkhand. Evaluated variations in biochemical characteristics of Tamarind seed kernel powder extracted from 7 different Tamarind clones.

Incorporated TSG in Pineapple jam and guava jelly & evaluated the biochemical traits and consumer acceptability of the different value-added products. Developed Tamarind wines from red, sweet, and sour Tamarind with Belgian wit yeast and red wine yeast. Quantified variations in the physiochemical properties and evaluated the sensory attributes for consumer acceptability. Developed Ready to Drink Squash and Jelly from Sweet Tamarind infused with Red Tamarind color extract and validated the product for physiochemical and sensory attributes.

Highlights

- Passport data in 55 tamarind clonal selections on aspects such as flowering pattern, reproductive behavious and fruit morophometrics clones documented for a developing National Tamarind Registry.
- Gum (Xylogucan) recovery percentage assessed in 22 clones that finds usage in food processing industry.
- Established Eight Multi-location Clonal Trials (MLCT) of tamarind at Neyveli, Cuddalore,Kangeyam, Tiruppur; Melur, Madurai in Tamil Nadu. Farm Forest trial with famers at Bayala, Karnataka and Mulugu, Hyderabad, Banaskantha Agricultural Research Station, SDAU, Mehsana and Cotton Research Station SDAU, Talod, Gujarat.
- Four Clonal Demonstration Trials were established at Community land at Pallipatti, Dharmapuri PeriaNaickenpalayam, Coimbatore and Villupuram (1 acre each). Established avenue and block plantations in panchayats roads, temples, schools, avenues and village roads for stocking livelihood improvement of the rural population.
- Developed tamarind based value added products such as *Tender tamarind pickle* and *tamarind flower gulkhand*, *Squash*, *wine* and evaluated phytochemical and organoleptic properties of the product.

16. All India coordinated research project on "Bioprospecting for industrial utilization of lesser known forest plants"

16.1 Objectives:

- Survey, evaluation and prioritization of the targeted LKFPs
- Systematic chemical screening of the populations of the prioritized LKFPs and identification of their chemically superior genotypes.
- Identification of industrially viable genotypes among the chemically superior genotypes.
- Standardization of produce specific protocols for downstream processing of industrially viable genotypes.
- Development of technology for production of value added marketable products from qualitatively qualified commercial produces of the industrially viable genotypes.
- Extension of the project outcome to various stakeholders for generation of awareness towards plantations of promising LKFPs, commercial applications and improving livelihoods.

16.2 Progress:

For chemical screening of *Sterculia urens* populations, samples of gum of 2 populations located in Didiyapada and Godhra (Gujarat) were collected. Chemical screening of 17 populations of *Pithecellobium dulce* for content of their fatty oils isolated from the seeds was completed. Chemical examinations of 25% aqueous methanol extracts isolated from the leaves of 13 populations (210 accessions) of *Neolitsea pallens* located in Himri, Khajjiar, Kotgarh, Bharana Link Road, Nankhari, Dalhousie, Sathias, Dugli Village, Jahal-Devidarh Road, Taklech, Gahan, Shankar Dehra and Majhrana (Himachal Pradesh), and lyophilized arils of the fruits collected from 9 populations (90 accessions) of wild grown *Punica granatum* located in Potters Hill, Shalagat, Ajga, Vashni, Deothal, plata, Nadukhar, Hiwan, Shoty Village (Himachal Pradesh) with the aid of LC-QTOF-MS/MS, for identification and inter- population variability of marker compounds was completed. Data were acquired and their processing using chemometrics tools and interpretation was continued.

UPLC-QTOF-MS/MS assisted metabolomic study coupled with chemometric analysis of 25% aqueous methanol extracts isolated from *Prinsepia utilis* leaves collected from 14 different locations (273 accessions) led to the identification of 80 compounds and their interpopulation variability. This finding highlights the rich phytochemical diversity of *P. utilis* leaves. Among these, 57 were marker compounds, mostly phenolic compounds, with 56 of them were previously unreported. Notably, the most abundant marker compounds included malic acid, Kaempferol 3-(2''-rhamnosylrutinoside), isorhamnetin 3-rutinoside 4'-rhamnoside, clovin, kaempferol 3-sophorotrioside 7-rhamnoside, kaempferol 3-sophoroside 7-glucoside, and quercetin 3-[rhamnosyl-(1->2)-rhamnosyl-(1->6)-glucoside].The discovery of 57 marker compounds, especially phenolic compounds, provides essential information for the characterization and quality control of *P. utilis* leaves. These marker compounds can serve as chemical fingerprints for the plant, aiding in its authentication and standardization. The population located in Munsyari, Uttarakhand, was identified as the Chemically Superior Population (CSP) due to its highest compound count (80) and extract yield (30.46%) among 14 populations.

Of the 18 populations of *Cinnamomum cecidodaphne* examined for their essential oil content and the 15 populations of *Pithecellobium dulce* examined for their fatty oil content, the population of *C. cecidodaphne* located in 22 Mile (West Bengal) and the population of *P. dulce* found in Jammukhadi (Jharkhand) were identified as chemically superior populations (CSPs).

Physico-chemical characterization of the needles/ leaves derived essential oils and fatty oil isolated from CSPs of *Cupressus torulosa* found in Ogla, (Uttarakhand), *Neolitsea pallens* located in Dalhousie (Himachal Pradesh) and *Prinsepia utilis* grown in Kanasar (Uttarakhand), respectively was carried out. LC-QTOF-MS assisted analysis of bark derived dye from chemically superior population of *Buchanania axillaris* located in Lenkagadda beat for determination of its chemical composition was carried out. Data were acquired and their analysis was continued. GC-MS assisted chemical examinations of the rhizomes derived essential oils isolated from 4 CSPs of *Cyperus rotundus* located in Annupur, Dindori (M.P.); Korba and Manendragarh (Chattisgarh) were examined. Data were acquired and their analysis was continued.

Developed a validated HPTLC method for simultaneous quantification of ursolic Acid, betulin, lupeol and β- sitosterol in leaf, stem, and flowers of *Woodfordia fruticosa*. This method enhances the accuracy and efficiency of quality assessment, contributing to the standardization of *W. fruticosa* products in pharmaceutical and herbal industries

UPLC-QTOF-MS analysis of *Punica granatum* peels derived 25% aqueous methanol extract , as well as its bioactive two distinct fractions (ethyl acetate and n-butanol) was carried out. Data were acquired and their analysis was continued.

Fabrics, including wool, silk, and cotton, were dyed with the *Punica granatum* peels derived dye and mordanted using two natural ones, baheda and amla. The CIElab* values for the dyed fabrics were also determined which demonstrated durability of dyed textiles.

Ex vivo antioxidant activity of *Prinsepia utilis* seed oil and *Neolitsea pallens* leaves essential oil was carried out using 2,2'-Azobis(2-amidinopropane) dihydrochloride (AAPH) assay. Data were acquired and their analysis was continued.

To develop a practical formulation for field application, different concentrations of *Cupressus torulosa* CSP's essential oil (0.5, 1.0, 1.5, 2.0, 2.5, 3.0 ppm) solutions made in acetone were incorporated into chalk. These oil infused chalks were then evaluated for their insecticidal efficacy against pests namely *Sitophilus oryzae, Rhizopertha dominica,* and *Carpophilus dimidiatus* commonly found in stored rice, dal, and peanuts, respectively. KT_{50} of the oil was 72 min. irrespective of the pest. The *in vitro* cytotoxic potential of the essential oil isolated from the CSP of *L. cubeba* was tested against B16-F10 (mouse skin melanoma cell line) and MDA-MB-231(human breast cancer cell line) cancer cells. The oil exhibited significant cytotoxicity against MDA-MB-231 (human breast cancer cell line), with an IC_{50} value of 52.64 ± 7 µg/ml.

The essential oils isolated from CSPs of *Cupressus torulosa, Neolitsea pallens, Litsea cubeba* and *Cyperus rotundus* were evaluated for their performance in scent blends for incense sticks. The oils demonstrated their suitability, as their aromatic profile harmonized effectively with other fragrances, making them a viable option for use in incense production. Herbal wound healing cream and gel formulations from methanol extracts of CSPs of *Woodfordia fruticosa* flowers and *Careya arborea* bark were prepared. Evaluation of bioactivity of these formulations was in progress.

Protocol for isolating fatty oil from *M. nudilflorus* seeds has been standardized to ensure optimal yield and consistent quality. Procedure for making Ink from *Mallotus philippensis* fruit pericarp derived dye was also standardized.

For establishment of *ex-situ* germplasm bank and demonstration plots, (i) Cuttings of *Punica granatum* and *Neolitsea pallens* were planted in polybags at Potter Hill nursery. Cuttings of *Prinsepia utilis* were planted in polybags at Shillaru nursery. The seeds of *Cupressus torulosa* were sown on an experimental basis in these nurseries; (ii) *Vitex negundo* cuttings were also planted, while seeds of *Pithecellobium dulce* and *Mallotus philippensis* were sown in the nursery; (iii) Mature fruits of *Buchanania axillaris* from Kurmidda beat, Kandukur Range, Amangal forest division, were collected, and seeds were extracted. Various treatments including GA_3

concentrations and mechanical scarification were applied to enhance germination, and the treated seeds were planted in nursery beds. Fruits of *Gardenia resinifera* were collected from Moddulagudem, Ankhoda, Peddapally, and Peddabanda. Seeds underwent germination trials with pre-soaking and various treatments to enhance germination, including GA_3 concentrations and hot water treatment; (iv) Various treatments were applied to improve the germination potential of *Litsea cubeba* seeds, and different treatments were applied to *Carallia brachiata* cuttings to facilitate nursery propagation; (v) propagation of *Woodfordia fruticosa* and *Anogesus pendula* plantlets via vegetative methods has been initiated.

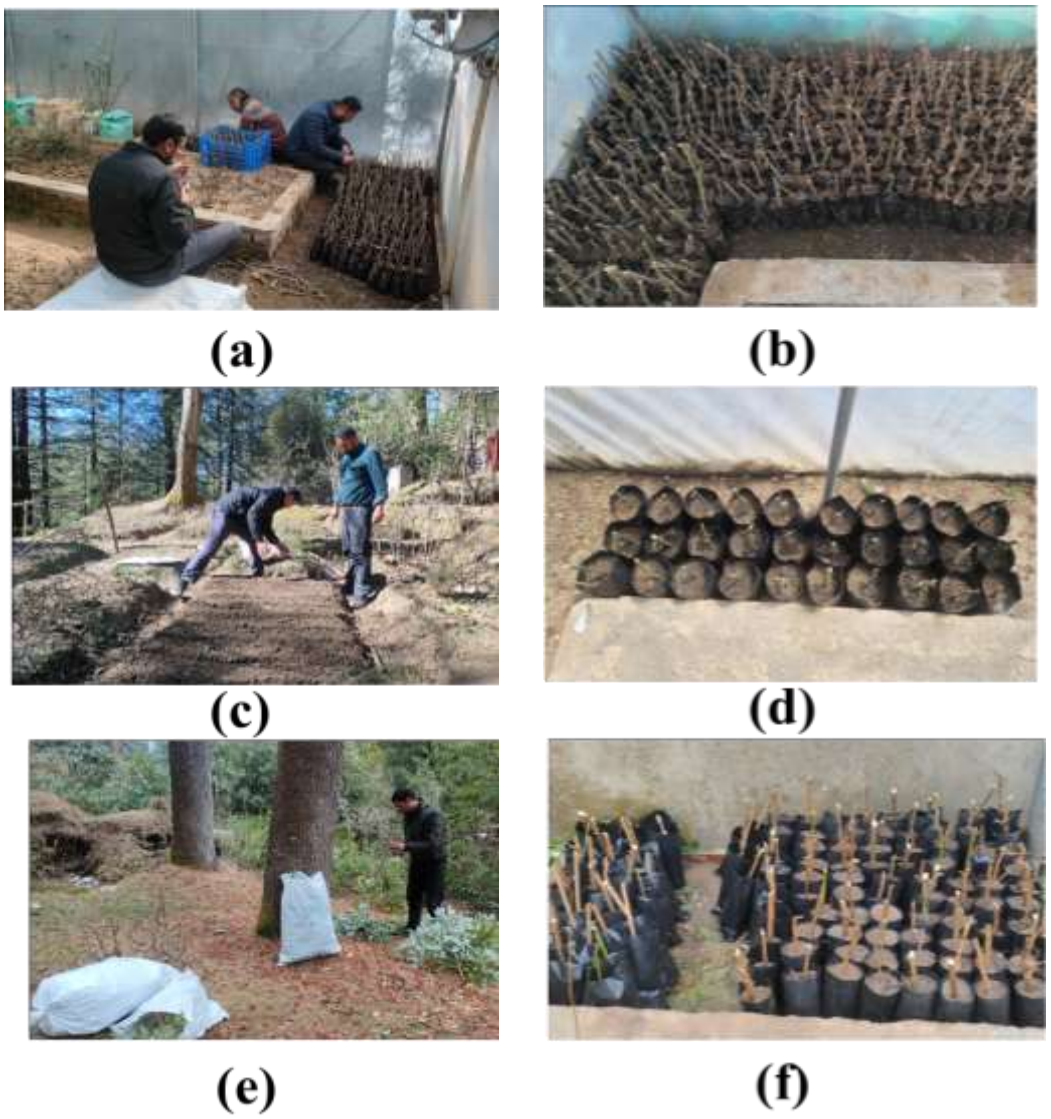


Fig. 14. Vegetative Propagation of (a) & (c) *Cupressus torulosa; (b)Punica granatum* ; (d) *Prinsepia utilis; (*e) and (f) *Neolitsea pallens* in Nurseries

In reference to patent on Herbal hair colouring composition and method for preparation thereof. (Patent Application No. 202341023759; Dated 30/03/2023) reply of First Examination Report was filed and subsequent hearing was done. In reference to patent on “A process for recovery of natural dye from Soymida febrifuga bark” (Patent Application No. 202341007697; Dated 07/02/2023), application for NBA approval was prepared and submitted.

Fig. 15 Collection of fruits of chemically superior population of *Citrullus colosynthis*

Highlights

- Based on the documentation and analysis of information for 50 **lesser-known forest plants (**LKFPs), followed by the development of a structured format, 25 LKFPs were prioritized for further investigation. A valuable technical database with comprehensive botanical, chemical, and medicinal information on 50 LKFPs was created, serving as a resource for bioprospecting of these plants and providing directions for future studies. 443 populations of 25 LKFPs occurring in different agro-climatic conditions, along with geo-coordinate recording, were identified. This knowledge serves as a valuable resource for researchers and policymakers. Chemical screening of 406 populations of 23 LKFPs for fatty oils, essential oils, natural dyes and bioactive compounds led to the identification of 72 chemically superior populations (CSPs) of 23 LKFPs suitable for industrial applications
- Discovery of previously unreported chemical compositions of essential oils from CSPs of *Cupressus torulosa* (needles)*, Litsea cubeba* (fruits)*, Cperus rotundus* (rhizomes) and fatty oils of *Prinsepia utilis, Balanites aegyptiaca* and *Mallotus nudiflorus* opened up new possibilities for applications in medicine, cosmetics, fragrances and biodiesel. A comprehensive UPLC-QTOF-MS/MS metabolomic study, coupled with chemometric analysis, identified 80 compounds, including 57 marker phenolic compounds, mostly unreported, from *Prinsepia utilis* leaves. These marker compounds can serve as chemical fingerprints for the plant, aiding in its authentication and standardization. The Munsyari, Uttarakhand population stood out as a chemically superior population with the highest compound count (80) and extract yield (30.46%) among 14 locations. The essential oils from CSPs of *Cupressus torulosa, Neolitsea pallens, Litsea cubeba,* and *Cyperus rotundus* were assessed for their performance in scent blends for incense sticks. Their aromatic profiles blended effectively with other fragrances, establishing them as a viable option for incense production.
- Confirmation of the insecticidal properties of the essential oil from CSP of *Cupressus torulosa* against *Sitophilus oryzae, Rhizopertha dominica,* and *Carpophilus dimidiatus* commonly found in stored rice, dal, and peanuts, respectively. offered a natural pest control solution for stored grains. Protocols for the recovery of natural dyes in commercially viable yield from the peels of *Punica granatum*, barks of *Soymida febrifuga, Buchanani aaxillaris*, and *Careya arborea*, fruits of *Mallotus philippensis,* and flowers of *Woodfordia fruticosa*, were standardized and subsequently applied in chemical screening of the populations of these LKFPs, with potential uses in textiles, cosmetics, and allied industries. *Punica granatum* peel dye proved versatile for vibrant fabric dyeing and as a coloring agent for food, beverages, and cosmetics. A validated HPTLC method enabled precise quantification of ursolic acid, betulin, lupeol, and β-sitosterol in the leaf, stem, and flowers of *Woodfordia fruticosa*, enhancing quality control for pharmaceutical and herbal products.
- Various marketable products including herbal hair colorants from natural dyes derived from *Woodfordia fruticosa* flowers and *Soymida febrifuga* bark; formulations for managing diabetes and topical herbal gel for pain relief; six captivating scent blends using *Cyperus rotundus* essential oil for their use in perfume, cream and shampoo; four scent blends using essential oils of *Cupressus torulosa, Neolitsea pallens, Litsea cubeba* and *Cyperus rotundus* for incense sticks; a Golden ink from fruit pericarp derived dye of *Mallotus philippensis*; and cookies from *Pithecellobium dulce* seeds were developed. Noteworthy antioxidant activity, cytotoxic activity and antibacterial properties of *Litsea cubeba* essential oil; and potent antioxidant and anti-inflammatory effects of ethyl acetate and n-butanol fractions of 25% aqueous methanol extract of *Punica granatum* peels suggested therapeutic potential of these materials in combating oxidative stress, bacterial infections, cancer and inflammation. Identified 10 industrially viable populations of 9 LKFPs namely *Cupressus torulosa* (CT)*, Neolitsea pallens* (NP)*, Cyperus rotundus* (CR)*, Litsea cubeba* (LC)*, Prinsepia utilis* (PU), *Mallotus nudiflorus* (MN), *Punica granatum* (PG)*, Soymida febrifuga* (SF), *Careya arborea* (CA) *and Woodfordial fruticosa* (WF) for their utilization into production of essential oils (CT, NP, CR and LC), fatty oils (PU and MN), and natural dyes (PG, SF,CA and WF) which can be utilized in aroma, food, cosmetics, pharma- and agriculture industries.

17. All India coordinated research project on "Enhancement of fodder availability and quality to reduce unsustainable grazing in the forest"

17.1 Objectives:

- Standardising planting, management, protection and fodder sharing procedures for enhancing tree fodder availability in fodder scarcity regions of India
- Improving nutritive value and storage life for greater fodder availability during lean period
- Capacity building of project personnel and stakeholders in raising high-yielding fodder plantation

17.2 Progress:

The major focus of the project is on field trials at the nine institutes of ICFRE in their mandate regions. Fast growing tree species suitable to the site have been planted in different spacings in high density and managed with different frequencies of coppicing. Grass species have also been planted.

The same set of experiments has been laid out at all sites. Species have been selected by institutes keeping in view the site conditions. The statistical design and experimental details have been provided by the NPC. The espacements for trees are: 1m x 1m, 1.25m x 1.25m and 1.5m x 1.5m. Fodder harvest frequencies are: Once/year, twice/year and thrice/year. Field trials are successfully running in 18 sites. The no. of sites where field trials are being successfully maintained are: 3 each for IFP, TFRI and IFGTB, 2 each for AFRI, HFRI and IWST and 1 each for FRI, IFB and RFRI. (Against a target of 24 sites, field trials were laid out at 20 sites. AFRI and IWST could not lay out trials at 1 site each due to delay in getting land and poor rainfall. IFB and RFRI were not able to conduct field trials at 1 site each due to delay in allotment of land. Two field trials were lost due to natural calamities). RFRI has planted only grasses in the trial. The field trials are doing well. Coppicing and fodder collection have been undertaken when plantation completed at least one year age, plants of the species were growing vigorously and reached threshold size. Plants responded well to coppicing and resprouted producing multiple shoots.

At Parasi, Dheemarkheda District Katni, M.P., average half yearly yields of 1560, 1215 and 1439 g/tree were obtained for *Moringa oleifera*, 2125, 1565 and 1735 g/tree for *Sesbania grandiflora*, 1450, 1217, 1337 g/tree for *Morus alba* and 590, 703 and 746 g/tree for *Melia azedarach*. After two years in Idar Gujarat greatest plant biomass was found to be 2799.30 g/tree in *A. excelsa*. *Albizia procera* yielded 2.80 and 3.27 kg/plant fodder during first and second harvests in March 2023 and March 2024 in Warangal, Telangana. In Palladam, Tamil Nadu *Gliricidia sepium* yielded 89.58 and 334.17 g/tree in two harvests while *Leucaena leucocephala* produced 160.25 and 845.50 g/ tree in first and second harvests. In Uttar Pradesh at Prayagraj, 2900 kg/ha fodder has been recorded in *Moringa oleifera* at 1m x 1m spacing at two years age.

Yearly fodder yield of 464.30 qtl/ha was obtained in *Setaria sphacelata* from three harvests at Jorhat during September 2022 to August 2023. Yield in *Pennisetum purpureum*2 (hybrid Napier) was 462.40 qtl/ha while *Megathyrsus maximus* (Guinea grass) yielded 269.12 qtl/ha. Yield of grasses viz. *Chloris gayana* and *Cenchrus ciliaris* were 39.3 and 71.7 qtl/ha in Warangal, Telangana. Fodder is being tested for nutritional value for following parameters: dry matter, ash content, crude fibre, crude protein, ether extract and nitrogen-free extract. Nutritive value of fodder species at time of fodder harvest have been determined at all institutes, except TFRI where work is in progress. For instance, moisture, crude protein, crude fat, crude fibre, total ash and acid insoluble ash content percentage at Kalsi, Dehradun were 11.46, 17.44, 2.59, 17.96, 0.15 and 8.64 percent in *Ficus racemosa*, 8.34, 17.41, 3.76, 29.79, 0.04 and 5.20 in *Bauhinia*

purpurea, 8.74, 20.37, 5.24, 22.98, 0.38 and 7.35 percent in *Grewia optiva* and 14.25, 22.67, 3.45, 12.67, 1.26 and 11.36 percent in *Morus alba***.**

A commercial repellent Herboliv Plus was tested for effectiveness at FRI. The repellent was effective for 5-6 days only. Demonstration was conducted for people in Village Thangaon, Dehradun on making of silage for 100% sorghum (pure sorghum), 90% sorghum + 10% *Bauhinia* and 90% sorghum + 10% *Celtis.* The silage was found to be of good quality. Hands-on training was imparted by NPC to project staff of various institutes on silage making. The NPC obtained online training on fodder management at ICAR- Indian Grassland and Fodder Research Institute (IGFRI) Jhansi.

Highlights

- Coppicing operation has been carried out in fodder plantations at all institutes. Plants resprouted and produced multiple shoots with vigorous growth. This allowed starting fodder harvest in plantations at 1-2 years of age.
- More fodder production is being recorded in 1m x 1m spacing than in 1.5 m x 1.5 m spacing upto 2½ years age. The following tentative estimates of fodder are available from the trials:
  - *Ailanthus excelsa* produced a total of 324.41 quintal/ha biomass in two harvests upto the age of 2½ years in plantation at 1 m x 1m spacing at Idar, Himmatnagar, Gujarat while *Moringa oleifera, Azadirachta indica* and *Zizyphus mauritiana* yielded 148.16, 27.60 and 22.02 quintal/ha respectively at that age.
  - The greatest biomass yield in Jaisalmer, Rajasthan at the age of 1½ years was 57.00 quintal/ha obtained from one harvest in plantation at 1 m x 1m spacing followed by *Zizyphus nummularia* 5.64 quintal/ha. Grasses yielded more than trees at this site with *Panicum turgidum* yielding 262.80 quintal/ha followed by *Lasiurus sindicus* 156.24 quintal/ha and *Cenchrus setigerus* 91.06 quintal/ha.
  - Growth in the hilly region of Himachal Pradesh and Uttarakhand has been slow. At Chakhra, Junga, district Shimla, HP, at 2½ years age maximum 6.01 quintal/ha biomass was obtained in one harvest from plantation of *Morus alba* at 1mx1m spacing followed by 5.21 quintal/ha from *Bauhinia variegata*, 1.52 quintal/ha from *Celtis australis* and 1.06 quintal/ha from *Grewia optiva.* At other sites in the region fodder has not been harvested so far due to slow growth. Grasses yielded more than trees at the above site: tall fescue (*Festuca arundinacea*) 23.7 quintal/ha and Napier grass (*Pennisetum purpureum*) 15.9 quintal/ha.
  - At Prayagraj, 197.5 quintal/ha biomass was obtained from *Gmelina arborea* upto 2 years age at 1mx1m spacing followed by 108.5 quintal/ha from *Bauhinia purpurea* and 70.5 quintal/ha from *Moringa oleifera.*
  - At Parasi, Dheemarkheda, District Katni (Madhya Pradesh) *Sesbania grandiflora* aggregated the greatest biomass (598.17 quintal/ha) in three harvests upto 2½ years age followed by *Moringa oleifera* (447.00 quintal/ha), *Morus alba* (417.33 quintal/ha) and *Melia azedarach* (231.60 quintal/ha). Yield of grasses was less than trees. *Pennisetum purpureum* recorded 186.47 quintal/ha in four harvests upto 2½ years age followed by *Dichanthium annulatum* 89.20 quintal/ha and *Cenchrus ciliaris* 58.05 quintal/ha.
  - At Village Mangatta, Rajnandgaon (Chhattisgarh) *Pennisetum purpureum* recorded greatest biomass (388.13 quintal/ha) in three harvests at 1½ years age followed by *Cenchrus ciliaris* (229.05 quintal/ha) and *Megathyrus maximus* (162.27 quintal/ha). *Sesbania grandiflora* trees at about nine months age produced 93.93 quintal/ha biomass in one harvest.

- At Jorhat, hybrid Napier (*Pennisetum purpureum*) recorded highest 660.06 quintal/ha in four harvests upto age of 2 years followed by Setaria (*Setaria sphacelata* (562.60 quintal/ha) and Guinea Grass (*Megathyrsus maximus*) (407.26 quintal/ha).
- At Narsampet, Warangal, Telangana *Albizia procera* produced greatest quantity of biomass with a yield of 596.67 quintal/ha in two harvests upto 1¾ years age followed by *Albizia lebbeck* 68.17 quintal/ha.
- At Myrada, Talamalai, Tamil Nadu *Gliricidia sepium* aggregated greatest 95.05 quintal/ha biomass from two harvests upto 2 years age. At Weavers Park, Palladam, Tamil Nadu, *Leucaena leucocephala* produced 96.08 quintal/ha upto 2 years – the greatest quantity of biomass – followed by *Gliricidia sepium* 37.43 quintal/ha, *Hardwickia binata* 10.23 quintal/ha and *Albizia lebbeck* 7.32 quintal/ha.
- At Madathukulam, Tiruppur, Tamil Nadu *Gliricidia sepium* yielded maximum 48.33 quintal/ha upto 1½ years age followed by *Leucaena leucocephala* 33.77 quintal/ha, *Hardwickia binata* 15.67 quintal/ha and *Albizia lebbeck* 11.33 quintal/ha.

- Fodder has been analysed by eight institutes for nutritive value parameters such as crude protein, crude fibre, crude fat, total ash and acid insoluble ash content.
- To conserve green fodder and increase its storage life, silage has been prepared by FRI by using 100% sorghum (pure sorghum), 90% sorghum + 10% *Bauhinia purpurea* and 90% sorghum + 10% *Celtis australis* without use of chemicals. The silage was relished by cattle and goat. Proximate analysis is in progress.
- Hands-on training was imparted by NPC to project staff of various institutes on silage making.
- FRI demonstrated the technique of silage making to the people of one village in Dehradun district without use of chemicals. AFRI created awareness about silage making in Tree Growers Mela in

18. All India coordinated research project on "Silvicultural interventions for productivity enhancement and carbon sequestration in plantations of important tree species"

18.1 Objectives:

- To study the effect of various micro-irrigation regimes in block and boundary plantations of Teak, Gmelina, Adina, and Cadamba
- To investigate effect of various tree density on qualitative and quantitative improvement in rainfed plantations of Ailanthus, Neem and Pungam in block and in boundary planting
- To investigate effect of various tree density on qualitative and quantitative improvement in Adina plantations
- To investigate effect of mixed planting of Casuarina and *Acacia auriculiformis* with Teak on qualitative and quantitative improvement in plantations in block and in boundary planting.
- To investigate the influences of silvicultural interventions on wood quality
- To assess carbon sequestration potential and financial analysis of plantation of important tree species under varied silvicultural interventions.

18.2 Progress:

In the recent years, trees outside the forests (ToFs) is receiving increased attention and play a vital role in increasing wood supply and enhancing livelihood support to the farming communities. However, there exists dearth of information on optimum silvicultural requirement particularly in water and spacing requirements. The study also envisages on assessment on the complimentary benefits of mixed planting systems particularly mixed planting of teak with N-fixing trees like Casuarina/ *Acacia auriculiformis*. The institute-wise progress made till now under this project is as below:

IFGTB completed assessment on growth in 42 boundary and 15 block planting of Teak. Completed assessment on growth in 29 *Gmelina arborea* plantations. Carried out analysis of data collected from block and boundary plantations of teak & Gmelina. Collected data in 18 boundary plantations and 12 block plantations of Neem; 14 boundary and 4 block plantations of Pongamia;11 block plantations and 6 boundary plantations of Ailanthus. Completed establishment of block plantation of mixed planting of Teak & Casuarina in three locations viz., Kangeyam, Kundadam and KVK-Myrada. Completed establishment of block plantation of mixed planting of Teak & *Acacia auriculiformis*in three locations viz. Kundadam, Kangeyam and Dindigul. Completed establishment of mixed boundary planting of Teak &Casuarina in three locations – Kanchipuram, Tiruppur and Dindigul. Established Teak & Acacia mixed boundary planting in one location - Kangeyam.

TFRI completed assessment on growth in 26 Gmelina plantations under different management regime and data were compiled. Completed assessment on growth in 8 Haldina plantations. Established and maintained field trials of *Haldina cordifolia* under spacing -3m x 3m and 5m x 5m with pit size 30 cm^3 and 45 cm^3 at farmer's field, Dheemarkheda village, Katni District and recorded data on growth performance (Height) – 0.72m @ 3m x 3m and 0.76m @ 5m x 5m and Collar diameter (cm) – 3cm @ 3m x 3m and 2.7cm @ 5m x 5m. Established and maintained field of *H. cordifolia* under spacing - 3m x 3m and 5m x 5m with pit size 30cm and 45cm at Tropical Forest Research Institute, Jabalpur (M.P.) and recorded growth performance (Height) range – 1.3m @ 3m x 3m and 0.85m @ 5m x 5m and Collar diameter – 15cm @ 3x 3m and 13cm @ 5m x 5m. Established and maintained mixed block plantation of Teak + Casuarina @ 1:1 at Bodla,

Kawardha(C.G.). Recorded growth range of Teak 0.58m and Casuarina 0.85m. Established and maintained mixed block plantation of Teak + *Acacia auriculiformis* @ 1:8 at farmers field, Dheemarkheda village, Katni(M.P.). Recorded growth performance of Teak 0.38m and *Acacia auriculiformis* 0.62m.

Established and maintained the field trial of teak in boundary planting at 2 m spacing. Planting Casuarina on either side of the teak row under irrigated condition. Established and maintained the field trial under mixed Boundary plantation of Teak and *Acacia auriculiformis* under rainfed condition at Farmers field in Village- Parasi, Dheemerkheda, Katni. Recorded growth range of Teak 1.85m and CD – 9cm and in *A. auriculiformis* – 3.25m and DBH – 16cm. Established and maintained mixed boundary plantation of Teak and Casuarina at Mangatta village Chhattisgarh (C.G.). Recorded growth ranges of Teak - 0.71m @ 2m x 2m and Casuarina- 0.88m @ 1m x1m. Established and maintained the mixed boundary plantation of teak with *Acacia auriculiformis* at farmer's field of Hinotiya, Barela, Jabalpur district and recorded growth performance of *A. auriculiformis* (Height – 3.50m and DBH – 24cm) @ 1m x 1m and recorded Teak height – 1.20m and DBH – 16cm @ 1m x 1m. Established and maintained mixed block plantation of Teak + Casuarina @ 1:1 at Bodla, Kawardha(C.G.). Recorded growth range of Teak 0.58m and Casuarina 0.85m. Established and maintained mixed block plantation of Teak + *Acacia auriculiformis* @ 1:8 at farmers field, Dheemarkheda village, Katni(M.P.). Recorded growth performance of Teak 0.38m and *Acacia auriculiformis* 0.62m.

In IWST, survey of teak plantations was completed i.e 15 block plantations and 15 boundary plantations of teak were completed. Documented the data of teak plantations and calculated the biomass value of 15 block and boundary plantations of teak. Established the field trials under mixed block plantation of Teak and Casuarina in two ratios viz, 1:1 ratio and 1: 3 ratios under irrigated condition. Growth data of teak and casuarina has been recorded. Established boundary plantation of Teak and Casuarina in 5 acres land at Nidagal village, Pavagada (T), Tumkur (D).

AFRI recorded growth data in International Provenance Trials of Neem in AFRI and also in scattered trees of Neem in Jodhpur. Recorded growth data height, girth, basal diameter and crown diameter of Ailanthus, Neem and Pongamia. Mostly Ailanthus, Neem and Pongamia are in scattered distribution. Collected data from 6 block plantationsand 8 boundary plantations of Neem. Collected data in2 block plantations and 15 boundary plantations of Pongamia. Assessed growth in 9 block plantations and 2 boundary plantations of Ailanthus. Collected data from block plantations of *Azadirachta indica, Ailanthus excelsa* & *Pongamia pinnata* at Barmer, Jaisalmer and Bikaner in Rajasthan. Collected data from block plantations of *Azadirachta indica, Ailanthus excelsa* & *Pongamia pinnataat* Rajkot, Surendranagar, Tapi in Gujarat.

FCRI documented growth biometry and calculated volume production in 109 Block plantations and 92 Boundary plantations of farm grown teak under 3 age class (5-10, 10-15 ,15-20 years) in North Eastern, North Western Cauvery delta and western zones of Tamil Nadu. Yield model construction and validation was developed for Tectona grandis in all three age classes (5-10 years, 10-15 years and 15-20 years) with particular reference to Western agro-climatic zone (WZ) of Tamil Nadu. Analysed and documented wood quality parameters such as heartwood, sapwood, bark content and wood density with respective age classes on two agroclimatic zones namely North eastern zone (NEZ) and North western zone (NWZ) of Tamil Nadu. Metabolic profiling of teak heartwood samples collected from different agroclimatic zones were analysed by using Gas chromatography–mass spectrometry (GC-MS). Twenty seven Block Plantations of farm grown Teak was accessed in High Rainfall zone (HRZ) of Tamil Nadu. Twenty three Boundary Plantations of farm grown Teak was accessed in High Rainfall zone (HRZ) of Tamil Nadu. Wood properties of farm grown teak under 3 age class (5-10,10-15, and 15-20 years) for Southern agroclimatic zone (SZ) was accessed. The Carbon sequestration potential of selected 20 Block and 20 Boundary plantations for two agroclimatic zones Cauvery delta Zone (CDZ) and Western zone (WZ) was estimated. Analysed and documented growth biometry of 5 Block Plantations of Cadamba.

Besides the growth biometry of Cadamba under drip irrigation trial is estimated at Forest College & Research Institute trial.

Fig. 16. Haldina field trial at Dheemarkheda, MP

Fig. 17. Growth measurement in 2-year-old Teak + Casuarina mixed Block plantation trial plot in Muthur village, Tiruppur district of Tamil Nadu

Highlights

- Completed analysis of data collected from existing plantations of teak and salient observations showed that: **In boundary plantations**: productivity of these irrigated plantations was 3.61 m3/ha/year in plantations which are irrigated weekly once, 3.31 m3/ha/year in plantations receiving irrigation once in 15 days and 2.68 m3/ha/year in plantations receiving irrigation monthly once. Mean productivity of rainfed teak plantation was 1.95 m3/ha/year. **In Block plantations**: productivity of these irrigated plantations was 7.10 m3/ha/year in plantations which are irrigated weekly twice and 5.20 m3/ha/year in plantations receiving irrigation weekly once. Mean productivity of rainfed teak plantation was 2.70 m3/ha/year.
- Completed analysis of data collected from existing plantations of **Gmelina** and salient observations showed that: productivity of these irrigated plantations was 23.2 m3/ha/year in plantations which are irrigated weekly twice, 18.6 m3/ha/year in plantations which are irrigated weekly once and lowest productivity of 16.1 m3/ha/year was recorded in plantations receiving irrigation once in 15 days.
- The data on growth of Gmelina in the existing plantations showed the best growth under sprinkler irrigation system as compared to other system and rainfed conditions.
- Based on preliminary observations, among two pit sizes studied, 45 cubic cm pit size was found to be good for better establishment and greater early growth of Haldina.
- **Growth and quality assessment of farm grown teak in Tamil Nadu:** Among different agro-climatic zones of Tamil Nadu, maximum clear bole volume (0.4102 m3), mid diameter (0.48 m) and total volume (2.8207 m3) were recorded in Western zone under age classes of 15-20 years. Further, maximum Wood density (0.80 g cm^{-3}) as well heartwood volume (0.433 m^3) were recorded in boundary plantations of western agroclimatic zone.
- **Growth of teak under mixed planting system:** Preliminary observations on growth of teak in 2-year-old mixed plantation trial plot at Muthur village in Tiruppur district of Tamil Nadu showed that greater girth (20.2 cm) and height (7.92 m) growth was recorded under Teak + Casuarina in 50:50 proportion when compared to pure teak (Girth – 17.9 cm; Height – 7.48 m) and Teak + Casuarina in 25:75 proportion (Girth – 17.4 cm; Height – 6.65 m). Further, there was greater percentage (34.4%) of bigger girth trees (having girth above 20 cm) under trial plot with Teak + Casuarina in 50:50 proportion than in pure teak plot (17.3%) and in plot with Teak + Casuarina in 25:75 proportion (25.6%). The interim results are encouraging for promoting Teak + Casuarina based mixed plantations for harnessing three-pronged benefits viz. i) enhancing productivity ii) reducing of planting stock requirements up to 50% and iii) providing short-term and interim economic returns to the teak growers through harvesting of Casuarina in 3rd or 4th year of planting.

19. All India coordinated research project on "Assessment of water requirement of different forest tree species and its impact on subsoil moisture"

19.1 Objectives:

- To quantify water requirement for transpiration of selected forest tree species commonly used for plantation by various State Forest Departments.
- To quantify the cumulative effect of evapotranspiration and infiltration on subsoil moisture.
- To develop correlation between transpiration rate and subsoil moisture status for species under study.

19.2 Progress:

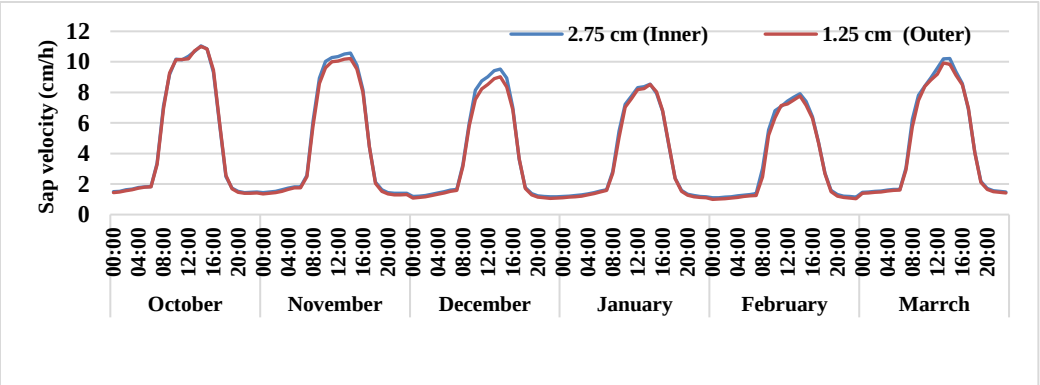
This All India Coordinated Research Project aims at identifying the best suitable forest species for plantation under different rainfall conditions in the country with an objective to maximise water yield from a catchment. Under the study, nine forest tree species **(***Prosopis juliflora, Azadirachta indica, Anogeissus latifolia*, *Tectona grandis, Pinus roxburgii, Quercus leucotrichophora, Shorea robusta, Terminalia tomentosa, Melia dubia***)** are being studied by the participating institutes at ten experimental sites.

1. **Champion Block, FRI, Dehradun**
2. **Mussoorie watershed, Dehradun**
3. **Sanjay Van, New Delhi**
4. **Nali, Suwakholi, Dehradun**
5. **Sitamata Wildlife Sanctuary, Rajasthan**
6. **AFRI expt. area, Jodhpur**
7. **IFGTB, Coimbatore**
8. **TFRI Expt. area, Jabalpur**
9. **Mawai Forest Range, MP**
10. **Kanha NP, MP**

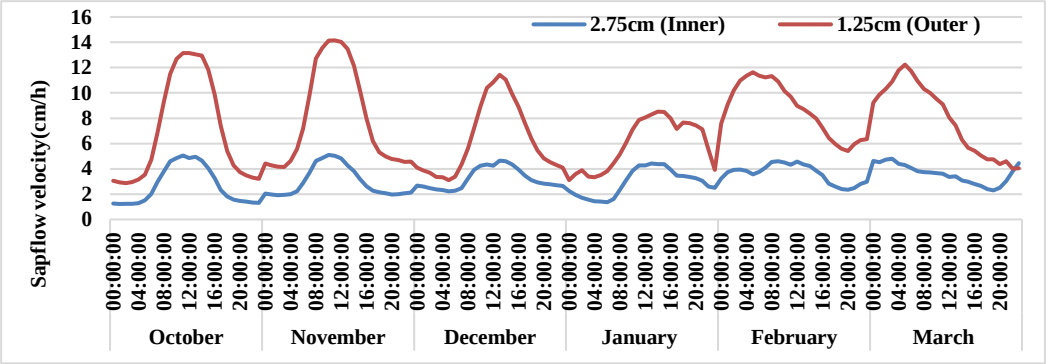
Protocol for instrumentation, data recording, and design of the experiment has been finalized and the major equipment, 144 sap flow monitoring systems, have been procured (36 for each participating institute). Installation of sap flow monitoring systems completed by all the partner institutions for the respective species.

Soil profiling and root zone identification have been done at all the partner institutes (*Shorea robusta* forest, Champion Block, FRI; *Prosopis juliflora* forest, Sanjay van, New Delhi; *Quercus leucotrichophora*, Binog wildlife sanctuary, Mussoorie; *Pinus roxburghii*, Suwakholi, Dehradun; *Tectona grandis*, *Anogeissus latifolia* forest, Sitamata wildlife sanctuary; *Azadirachta indica*, *P. Juliflora* at AFRI, Jodhpur; experimental site at Coimbatore, TFRI campus, Mawai rest House, East Mandla forest division and Kanha Tiger Reserve) in their respecting experimental sites. The soil moisture variation is being measured by multi-profile soil moister and temperature sensor (Make Odyssey) installed at the study sites. The soil moisture sensors are located at 0-20cm, 20-40cm, 40-60cm, 60-80cm, and 80-100cm.

Data on sap flow recorded so far reveals that there is a distinct variation in sap flow rate recorded from the inner and outer areas of sapwood with a significantly higher flow rate in the outer area, though the difference varied species to species. In *Pinus roxburghii* the variation was non significant whereas in *Shorea robusta* it was very prominent.



Diurnal pattern of sap velocity in *Pinus roxburghii* (Chir Pine)



Diurnal pattern of sap velocity in *Shorea robusta* (sal)

Among the four species studied at IFGTB Coimbatore, greater mean daily transpiration was recorded in *Tectona grandis* (28.79 litre per day) followed by *Azadirachta indica* (16.88 litre per day). A low mean daily flows was recorded in *Prosopis juliflora* (9.08 litre per day) and *Melia dubia* (7.52 litre per day).

Water use /transpiration in *Quercus leucotrichophora* (oak) varied between 37 and 49.7 liter/day from October 2023 to March 2024, with a sap velocity of 3.45 to 5.85 cm/hour at the Mussoorie watershed. The water use was 24.8 to 35.5 litre per day in *Pinus roxburghii* with an average of 30.1 litre per day during the same period. Transpiration rate of 3 to 9 liter per day was recorded in *Prosopis juliflora* at Sanjay Van, New Delhi from October 2023 to March 2024. In *Anogeissus latifolia* the mean transpiration for January, Fenruaryand March 2024 was 3.89,3.42 and 1.65 liter/day at Sitamata Wildlife Sanctuary, Rajasthan whereas 23.3 liter/day transpiration was recorded from Kanha Tiger Reserve. In *Azadirachta indica* average transpiration rate of 16.88 liter/day was recorded from the experimental site at IFGTB, Coimbatore. In *Shorea robusta* average transpiration rate of 34.17 liter/day and 23.3 liter/day was recorded from FRI, Dehradun, and Mawai forest, MP, respectively. The mean transpiration rate recorded in *Tectona grandis* (teak) was 28.79 liter/day at IWST, Coimbatore, and 9.0 liter/day at TFRI experimental site, Jabalpur. One year data on water used in transpiration suggest that *Anogeissus latifolia* used more water (23.3 liter/day) compared to *Terminalia tomentosa* (19.6 liter/day) in Kanha Tiger

Reserve making it less useful in terms of water yield from a watershed. Similarly, under the climatic conditions of Coimbatore *Azadirachta indica* (10 liter/day) and *Melia dubia* (liter/day) may be more suitable than *Tectona grandis* which used more water for transpiration. However, more data for a longer period are required to substantiate these findings. Observations on the correlation between transpiration and soil moisture suggest that a rainfall induced increase in soil moisture in coinciding with a low rate of transpiration during that period which might be attributed to low vapour pressure deficit. Weather parameters are recorded at the experimental sites through automatic weather stations.

Highlights

- Data on sap flow recorded so far reveals that there is a distinct variation in sap flow rate recorded from the inner and outer areas of sapwood with a significantly higher flow rate in the outer area, though the difference varied species to species. In *Pinus roxburghii* the variation was non significant whereas in *Shorea robusta* it was very prominent.
- *Quercus leucotrichophora* (oak) at the Mussoorie watershed used more water (40.58 liter/day) during October 2023 to March 2024 compared to *Pinus roxburghii* (at Nalli, Suwakholi) with an average of 30.1 litre per day during the same period.
- The relationship between transpiration rate and vapor pressure deficit (VPD) suggests that a higher transpiration rate is associated with a higher value of VPD and a lower value of transpiration rate corresponds to lower VPD.
- Initial observations on the correlation between transpiration and soil moisture suggest that a rainfall induced increase in soil moisture is coinciding with a low rate of transpiration during that period which might be attributed to low vapour pressure deficit. Soil moisture and transpiration data throughout the year are required to establish a reliable correlation.
- A rainfall induced increase in soil moisture is coinciding with a low rate of transpiration during that period which might be attributed to low vapour pressure deficit.

20. All India coordinated research project on "Development of Biopesticide products/formulations from extracts of tree borne oil seeds and tissues of wild plants for management of insect pests"

20.1 Objectives:

- To tests the efficacy of the biopesticidal formulations of **Tree PAL^{H}** and **Crawl clean** at multi locations across the country against targeted forest pests.
- Bioassay directed characterization of active principles or compounds from selected tree borne oil seeds and plant tissues.
- To develop biopesticidal formulations using most effective bioactive principles for the management of insect pests of forestry crops.

20.2 Progress:

ICFRE-IFGTB supplied Tree PALH and Crawl clean to participating institutes of ICFRE institutes to ascertain their efficacy under laboratory, nursery and field conditions at prescribed dosages (0.5 5 & 1.0 %) against different key insect pests of different forestry crops at different locations in different seasons at different jurisdiction areas of respective institutes. Over all efficacy of Tree PALH tends to be better with high mortality rates in all the tested insects at multi locations than Crawl clean. Tree PALH evaluated against 15 different key forest insect pests viz., defoliators, puff gall, mealybug, gall infestation etc. of 17 different forestry crops revealed that it effectively managed the key pests (60 to 100 % larval mortality) both in laboratory and field conditions with no phytotoxicity.

Bioassay directed chromatographic isolation and identification bioactive compounds from the various parts of 11 targeted tree borne oil/plant species of ICFRE institutes revealed the presence of various bioactive compounds having antifeedant, larval mortality, and oviposition activities. Bioassay of botanicals extracts of tree borne oil/plant species tested on target insect pests showed significant mortality. LC50 values of 0.90, 0.98, and 0.94 were obtained for B. albiflora extract against the defoliator Plecoptera reflexa and 0.94, 0.96, and 0.96 g against the insect pest Agrotis ipsilon respectively with significant effect at $p \leq 0.05$.

The seed oil having active constituents especially fatty acids such oil oleic acid, palmitic acid, stearic acid and linoleic acid with insecticidal properties was preformulated and found to have synergetic effect when tested against the targeted insect pests of forestry importance.

Fig. 18 Field evaluation of Tree PAL^{H} on teak defoliators

Highlights

- Lab and field evaluation of Tree PAL^{H} and Crawl clean across the nation at the prescribed dosages against insect pests of various tree crops at different jurisdiction areas of respective institutes recorded that the efficacy of Tree PAL^{H} ranging between 60-100% tends to be better with high mortality rates in all the tested insects at multi locations than Crawl clean with no phytotoxicity effects.
- Bioassay directed isolation, identification of active compounds of potential sources of target plant sample with insecticidal properties using various chromatographic techniques at respective institutes, identified bioactive compounds with potential insecticidal activity and need to evaluate across the country.
- Evaluation of the insecticidal property of the active compounds for determination of LC 50 & LC 90 showed significant larval mortality with positive correlation at different time intervals.
- The seed oil having active constituents with insecticidal properties was preformulated and found to have synergetic effect when tested against the targeted insect pests of forestry importance.
- From the field experimental data it was observed that the 1% concentration / dose was optimum to manage the defoliators and successive infestation on crops was not found. Significant effects such as biomass, GBH etc., was increased after the treatment period.
- A short film on biopesticides developed has been made and released in Farmers Mela on the theme "Tree cultivation in coastal areas" held at Puducherry U.T on 17th February, 2024. .
- A trade mark on Tree PAL^{H} –Biostimulant has been obtained.
- 50 Litres of Tree PAL^{H} has been prepared under MDTC and earned revenue of Rs.50,000/-

21. All India coordinated research project on "Development of superior bio-fertilizer products for enhanced plants productivity"

21.1 Objectives:

- To evaluate the efficacy of different bio-fertilizers (both commercial and IFGTB developed) on quality seedling production in nursery for developing potential bio-fertilizer consortia.
- To determine the bio-control efficacy of bio-fertilizers against soil/root borne pathogens of seedlings in nursery.
- To assess out-planting performance of bio-fertilizers inoculated plants in different field conditions.
- To conduct training-cum demonstration about the bio-fertilizer production technology to various stakeholders to improve their livelihood.

21.2 Progress:

The aim of this project is to find more suitable and efficient bio fertilizers than commercial bio fertilizers in the selected tree species for growth improvement in field. ICFRE IFGTB developed 5 bio-fertilizers such as VAM fungi *Azospirillum brasilense, Azotobacter chroococcum*, Phosphobacteria, Potash Mobilizer and 1 biocontrol agent (*Trichoderma viride*) have been mass produced and supplied 5 litres each together with 10 kg VAM bio-fertilizer to the participating Institutes of ICFRE viz., FRI, Dehra Dun, IWST, Bangalore TFRI, Jabalpur, AFRI Jodhpur and RFRI, Jorhat for nursery application. Seedlings of targeted tree species under this project *viz*., *Santalum album, Gmelina arborea, Dalbergia sissoo Capparis decidua* and *Melia dubia* have propagated in the nursery with inoculations of biofertilizers. The inoculated biofertilizers showed improved growth and biomass in the nursery and thus improved planting stocks were transplanted in the field. The siderophores were identified in biofertilizers that helps to control the pathogens in the lab as well as nursery.

Fig. 19. Developed Biofertilizers from ICFRE- IFGTB

The siderophore producing biofertilizers were tested for the antagonistic activity against pathogens like *Fusarium oxysporum* and *Rhizoctonia solani*. The inoculated seedlings were transplanted and the growth data collected. Two trainings on biofertiizer and AM fungi were conducted for the stake holders of Karnataka and Punjab.

Locations of field trials

Institute	No. of trials	Location	Year of planting	Species
IFGTB	1	Dharmapuri, Tamilnadu 12.0898° N, 78.4061° E	2022	*Gmelina arborea*
	2	Thenkasi, Tamilnadu 9.1725 °N, 77.3956 °E	2022	*Santalum album* *Melia dubia*
AFRI	2	Mohangarh, Jaisalmir, Rajasthan: 13.0827° N, 77.8525° E	2022	*Dalbergia sisoo* *Santalum album*
	1	Malajal, Barmer, Rajasthan	2023	*Capparis decidua*
TFRI	2	Pandariya Chhpara, Seoni, M.P: 22.1255° N, 80.0172° E	2023	*Dalbergia sisoo* *Santalum album*
FRI	1	Dudhai, Vikasnagar Uttarkand	2023	*Melia dubia*
IWST	3	Attivitaa Village, Hoagate, Bangalore	2022	*Santalum album*, *Gmelina arborea* *Melia dubia*
RFRI	3	Sotai Village, Jorhat: 22.1255° N, 80.0172° E	2022	*Santalum album*, *Dalbergia sissoo* *Gmelina arborea*

Highlights

- ICFRE- IFGTB has developed 5 biofertilizer and 1 biocontrol products which are used in the selected commercial trees such as *Gmelina arborea, Melia dubia, Santalum album, Dalbergia sissoo and Capparis decidua*.
- Nitrogen fixers (Azospirillum, Azotobacter), Phosphate solubilizers (Bacillus, AM fungi), Potassium mobilizers *(Frateuria aurantia*), and biocontrol agent (*Trichoderma*) were applied in these selected trees under this project.
- The biofertilizers Azospirillum, Azotobacter, and Bacillus were found that they are capable to control the pathogen as they are producing siderophores.
- The antagonistic activity also confirmed that biofertilizers are efficient to control the pathogens like *Fusarium oxysporum* and *Coletotrichium gelosporoides*).
- The tissue nutrient contents (N P K) were also showed higher in the ICFRE- IFGTB biofertilizer inoculated plants. The improved tree species of *Dalberia sissoo, Santalum album, Gmelina arborea* and *Melia dubia* were planted by the respective institutes across the country.
- The consortia generally identified as the combination of AM fungi +PSB+ KSB + *Azospirillum* in all seedlings in nursery. ICFRE biofertilizers promoting the tree crops better than the commercial biofertilizers in terms of growth.

22. All India coordinated research project on "Preparation of Forest Soil Health Cards under different Forest Vegetation in all the Forest Divisions of India"

22.1 Objectives:

- To prepare forest soil health cards under different vegetations and adjoining degraded land in all the Forest Divisions to enhance deficient nutrients through sustainable management practices and making plantations more successful
- To diagnose forest soil fertility related constraints with the help of standard procedures, uniform sampling, data compilation and analysis thereof and to suggest divisional level management practices
- To promote soil test-based nutrient management practices in different forest vegetations in the forest divisions for enhancing nutrient use efficiency
- To build capacities of officials / field level staff of SFD's for promoting nutrient management practices for effective plantations
- To strengthen the Forest Soil Testing Laboratories and develop a network with state owned soil testing laboratories.
- To launch a forest soil health card portal on website for easy access to the various stakeholders.

22.2 Progress:

HFRI, Shimla: The soil parameters like pH, EC, Bulk density, Organic Carbon, N, P, K, Zn, Cu, Fe, Mn etc. has been estimated from the soil samples collected from forest divisions. Total 1905 soil samples were collected from the various sampling points of Himachal Pradesh and 1275 soil samples were collected from the various sampling points of Jammu & Kashmir UT. Total 3333 (95%) soil samples have been gathered, and 28768 (68%) laboratory analysis have been completed.The Forest Soil Health Cards of two territorial forest divisions of Ladakh UT *viz.,* Leh and Kargil has been released by Sh. Bhupender Yadav, Hon'ble Union Minister for Environment, Forest and Climate Change, Government of India. Preparation of Forest Soil Health Cards of Himachal Pradesh is in progress.

FRI, Dehradun: Total 1560 sample were collected from 520 FID from UP forest division likewise 520 bulk density samples were also collected. Total 69 samples were collected from 23 FID of Uttarakhand forest likewise 23 bulk density samples were also collected from above 23 sites. Approximately 1560 Soil samples collected from different parts and different forests and non-forests sites of Uttar Pradesh were analysed. Total 69 Soil samples collected from different parts and different forests and non-forests sites of Uttarakhand, were analysed under the project for given 12 parameters (pH, EC, SOC, av. NPK and micronutrients (B, S, Cu, Zn, Fe and Mn). Approximately 74% of soil samples have been gathered, and 55% of laboratory analysis have been completed. Conducted Pre-release Consultation Meeting regarding Forest Soil Health Cards of Punjab on 21st March 2024 at forest complex, Mohali, Punjab. Data compilation regarding Uttarakhand have been completed and preparation of FSHC is under progress. FSHCs of Haryana, Delhi and Chandigarh have been released.

IFGTB, Coimbatore: Soil samples (3085 Nos.) were collected from 1031 sampling points covering different forest types. Processed soil samples were analysed for the various physico-chemical properties and bulk density. Total 97% of soil samples have been gathered, and 81 % of laboratory analyses have been completed thus far. Forest Soil Health Cards for two divisions of Puducherry UT were prepared. The Hon'ble Minister for Environment, Forest & Climate Change, Shri. Bhupender Yadav released the cards on 20th May 2023. Forest Soil Health Cards for 28 territorial forest divisions of Tamil Nadu were prepared and a Pre-release exercise was undertaken. The FSHCs of Tamil Nadu were released by Smt. Leena Nandan, IAS, Secretary, MoEFCC during the 61st Board of Governors meeting of the Indian Council of Forestry Research and Education, held on February 19, 2024.

Fig. 20. Forest Soil Health Card Release

TFRI, Jabalpur: Soil samples from 124 forest divisions and 2083 FIDs (63 forest divisions; 975 FIDs of MP and 34 forest divisions; 530 FIDs of Chhattisgarh and 27 forest divisions; 578 FIDs of Maharashtra) were collected. Around 71 percent soil samples were collected and 75 percent of collected samples has been analysed. Forest Soil Health Cards for 63 forest divisions in Madhya Pradesh were prepared and a pre-consultation meeting was held in Bhopal on March 15, 2023. Shri Bhupender Yadav, Hon'ble MoEF&CC, New Delhi, unveiled the Forest Soil Health Cards for Madhya Pradesh on May 22, 2023, at ICFRE, Dehradun. A "Capacity Building Programme for Promoting Soil Test-Based Nutrient Management Practices" was organized for Range Officers and Deputy Rangers (100 in total) from 15 forest divisions (across 4 circles) of the Madhya Pradesh State Forest Department (MPSFD) on February 1, 2024, at TFRI, Jabalpur. Additionally, the soil analysis data for Chhattisgarh was finalized, and standard values for Chhattisgarh forest soils were drawn, leading to the draft preparation of Forest Soil Health Cards for Chhattisgarh.

IFB, Hyderabad: The collection of soil samples has been completed from the 49 forest divisions of Telangana. The soil samples collected from 49 forest divisions of Telangana state and 37 divisions of Odisha, processed and analysed for 12 parameters. Processed soil samples from 49 forest divisions of Telangana. 77% of the laboratory analysis work has been completed. Soil Health Cards have been prepared for 49 territorial forest divisions of Telangana. A stakeholders' pre-release consultation meeting on FSHC has been scheduled at Aranya Bhavan on April 6th, 2024, and similar consultations planned for the FSHC program in Odisha in due course.

IFP, Ranchi: Forest soil health cards of 31 forest divisions of Jharkhand state were prepared, released and distributed in December 2022. Soil sample collection, processing and analysis of samples from representative sites in all 24 Forest Divisions of West Bengal has been completed. The Forest Soil Health Card for West Bengal have been prepared excepting mangrove area. Soil sample collection and analysis of 21 Forest Divisions out of a total of 28 Forest Divisions of Bihar has been completed. About 97% of the soil samples have been collected, and approximately 87% of the laboratory analysis have been undertaken.

AFRI, Rajasthan: A total of 492 soil samples have been collected. Analysis of 8 parameters out of 9 divisions from the 12 mentioned divisions has been completed, while analysis for the remaining 3 divisions is ongoing. Approximately 71% of soil samples have been collected and 47% has been analyzed. Collected KML files of Gujarat forest boundaries, and a certified list of territorial divisions of Gujarat.

RFRI, Jorhat: Total of 2178 sampling points were selected on the basis of composition and density of forests. Overall, till date a total of 1516 sampling points has been covered and 4548 samples of three depths were collected from 33 divisions of Assam, 8 divisions of Tripura, 6 division of Meghalaya, 10 division of Mizoram, 12 divisions of Nagaland and 10 divisions of Arunachal Pradesh. The bulk density of all 1516 samples were analyzed, 3283 samples were analysed for pH, EC, SOC, potassium, phosphorus and nitrogen, sulphur and 2587 samples were analyzed for micronutrients (Fe, Mn, Zn, Cu and B). In this current half year, a total of 432 sampling points have been covered from Meghalaya, Mizoram and Nagaland state. 1296 samples were collected from three depths from above mentioned states. All the collected samples 432 samples were analyzed for Bulk density, 540 samples were analyzed for pH, EC, SOC, Phosphorus, Sulphur, Nitrogen, Potassium and 342 samples were analyzed for Micronutrients (Fe, Mn, Zn, Cu and B). Total 69% of soil samples have been collected, and about 57% of laboratory analyses have been completed at this point. Remaining soil samples will be analysed in due course of time.

IWST, Bangalore: A total of 5136 Soil samples have been collected from three states (Goa, Karnataka and Andhra Pradesh). Approximately 81% of both soil samples and laboratory analyses have been completed. Goa state soil health card were prepared and are being examined and verified. Compilation and analysis data of Karnataka and Andhra Pradesh is in progress.

Overall, 79 percent soil sampling and 66 percent sample analysis have been accomplished countrywide. FSHC Web portal is under development in collaboration with National Informatics Centre, Dehradun for easy access to State Forest Departments and other end users.

Highlights

- All the nine ICFRE institutes collected total 34102 soil samples and 340415 analysis were made for 12 comprehensive parameters.
- The forest soil health cards for Jharkhand (31), Puducherry (2), Ladakh (2), Haryana (22), Delhi (4), Chandigarh (1), and Madhya Pradesh (63) has been released by Shri Bhupender Yadav, Hon'ble Union Minister of EF&CC, GoI, New Delhi. FSHCs for 28 divisions of Tamil Nadu were released by Smt. Leena Nandan, IAS, Secretary, MoEFCC.
- A "Capacity Building Programme for Promoting Soil Test-Based Nutrient Management Practices" was organized for Range Officers and Deputy Rangers (100 in total) of Madhya Pradesh State Forest Department on 1st February 2024 at TFRI, Jabalpur.
- 79 per cent soil sampling and 66 per cent sample analysis have been accomplished countrywide. FSHC Web portal is under development in collaboration with National Informatics Centre, Dehradun for easy access to State Forest Departments and other end users.

23. All India coordinated research project on "Genetic improvement and value addition of *Madhuca longifolia*"

23.1 Objectives:

- To select and characterize germplasm using morphological and physico-chemical markers.To study the status of natural regeneration in areas of its distribution.To develop value added products and assess their shelf life and nutraceutical value.
- To estimate genetic diversity parameters at molecular level.To produce quality planting material from selected phenotypically superior trees.
- To establish vegetative multiplication gardens/clonal seed orchards at different locations.
- To document ITKs for post harvest techniques of mahua.To identify and develop improved variety/cultivar. (Second phase)

23.2 Progress:

At ICFRE-TFRI, Jabalpur, saponin content was estimated in seeds of 81 Candidate Plus Trees (CPTs) and it was found in the range of 1 -3 %. Maximum 3% saponin was recorded in seeds of Tree no. 6 from Raigad, Maharashtra. Experiments were performed for better ethanol production from Mahua flowers through fermentation of sugars in anaerobic conditions using activated yeast. Three experiments were conducted for formulation of ethanol using Guava, Indian gooseberry and lemongrass. Taste and fragrance were enhanced by the additives. Maximum alcohol content recorded in distilled liquor was 45-50 %. Leaf samples were collected from 60 selected CPTs and DNA extraction (Doyle and Doyle, 1987) along with quantification was carried out. Scions were collected from selected CPTs of Madhya Pradesh, Chhattisgarh and Maharashtra and cleft grafting was carried out. 175 grafted plants were produced. Quality planting material produced through seeds collected from 61 selected CPTs was maintained in the nursery. VMGs at ICFRE-TFRI, Jabalpur and Guru Ghasi Das University, Bilaspur, Chhattisgarh were maintained through regular watering and weeding. Natural Regeneration studies were carried out at Umaria, Madhya Pradesh, Surajpur and Balodabazar Chhattisgarh. Post-monsoon regeneration data was collected. Range for abundance was recorded from 2.64 -5.98 %, frequency from 29-62 % and density from 2.4-5.7 %. Maximum abundance, frequency and density was observed at Balodabazar, Chhattisgarh. A booklet entitled 'Indigenous Traditional Knowledge in *Madhuca longifolia* (Mahua) prevalent in India' was published. This booklet summarizes the information related to ITK practices which were collected by all the participating institutes and centers.

At ICFRE-IFP, Ranchi, scions were collected from 35 selected CPTs. Grafting was carried out in 252 rootstocks. Air layering was also performed on 20 selected trees. Grafted plants of 13 selected trees were produced. Seedlings of 38 selected CPTs have been raised in the nursery. Established vegetative multiplication garden of grafted mahua was maintained.

In ICFRE-IFGTB, Coimbatore, leaves were collected from 3 selected CPTs from Tirupur and 4 CPTs from Coimbatore, Tamil Nadu. Flowers and stem cuttings (scions) were collected from 3 selected CPTs from Tirupur, 3 CPTs from Salem, 2 CPTs from Coimbatore and 2 CPTs from Madurai, Tamil Nadu. Sugar analysis was carried out in flowers from 10 trees and oil percentage was estimated in seeds of 15 trees. DNA extraction and quantification was carried out from leaves of 15 CPTs from different locations. Samples were sent for transcriptome analysis to synthesize the SSR primers. Scions were grafted and 150 grafted plants were produced and maintained. Clonal orchard established at KVK, MYRADA, Thalamalai, Tamil Nadu was maintained. 2 acre land has been allotted from Agalya foundation Palakkad, Kerala and Kerala Forest Department Corporation to establish the VMG of *M. longifolia*.

Fig.21. Established Vegetative Multiplication Garden, Recording of data (Length and collar diameter) in Vegetative Multiplication Garden at ICFRE-TFRI, Jabalpur

In ICFRE-IFB, Hyderabad, for pathogen identification, genomic DNA was isolated from the pathogen causing blight disease in *Madhuca longifolia*. Three genomic regions (*ITS*, *tef1*, *tub2*) were amplified. Sanger sequencing of amplicons is in progress. Scions were collected from 70 CPTs selected in Kamareddy, Banswada, Chinthuru, Telangana, Rayagada and Sundargarh, Odisha and Yellandhu, Manuguru and Vizianagaram, Andhra Pradesh. Grafting was performed on 402 rootstocks with an average success rate of 45.3%. Scions were grafted and 182 grafted plants were produced and maintained.

At ICFRE-ERC, Prayagraj, Estimation of oil percentage from seeds of 20 selected CPTs was carried out. Oil % was found in range 44 - 64 %. No natural regeneration in the survey area was observed. In the nursery, 1200 seedlings were maintained. Established Seedling Seed Orchard (SSO) was maintained. Morphometric data for CPTs and biochemical parameters was compiled.

At ICFRE-SDC, Chhindwara, Leaves and bark samples were collected, processed in powder form. The samples were extracted for further product development. Mahua Wound healing cream sample was formulated for further testing of IS 6608-2004. It was found that the developed cream samples complied as per IS 6608 : 2004 specifications for the tested parameters viz. pH, thermal stability, total fatty substance content, total residue and heavy metals content. Work was conducted for development of market linkages for the developed products. Optimized toothpowder sample was prepared in bulk for distribution of samples to various stakeholders and conducting several field surveys for consumer acceptability. Structured questionnaire was developed and distributed to 100 consumers and feedbacks were obtained for overall acceptability of the developed product. Further testing of developed toothpowder sample as per BIS specifications is under progress. Mahua chocolate samples were prepared for testing and increasing the shelf life for one year. Work is under progress for development of herbal soaps and toothpaste products. Mahua nutraceutical chocolates, mahua cream, handwash and toothpowder were displayed as exhibits during the visits of stakeholders to Van Vigyan Kendra for promotion and further developing market linkages for the same.

Selected Candidate Plus Trees (CPTs) of Mahua

Institutes	Numbers of selected CPTs	Locations
ICFRE-TFRI, Jabalpur	460	Chhattisgarh, Madhya Pradesh,

		Maharashtra
ICFRE-IFGTB, Coimbatore	100	Tamil Nadu, Kerala
ICFRE-IFP, Ranchi	150	Jharkhand, Bihar, West Bengal
ICFRE-IFB, Hyderabad	282	Odisha, Telangana Andhra Pradesh
ICFRE-ERC, Prayagraj	160	Uttar Pradesh

Establishment of Vegetative Multiplication Gardens and Seedling Seed Orchards at different locations

Institutes	Number of VMGs	Number of SSOs	Month and Year of Plantation	Location
ICFRE-TFRI, Jabalpur	2	-	- September 2022 - July 2023	- TFRI campus, Jabalpur, Madhya Pradesh (Lat. 23^0 5′ 54″ N, Long. 79^0 59′ 20″ E) - Guru Ghasi Das University campus, Bilaspur, Chhattisgarh (Lat. 22.12287^0, Long. 82.140572^0)
ICFRE-TFRI, Jabalpur		1	July 2023	- Guru Ghasi Das University campus, Bilaspur, Chhattisgarh (Lat. 22.12287^0, Long. 82.140572^0)
ICFRE-IFGTB, Coimbatore	1	-	March 2023	- KVK, Myrada, Thalamalai, Tamil Nadu (Lat. 11.37452^0 E; Long. 77.00099^0 N)
ICFRE-IFP, Ranchi	1	-	August 2022	- IFP campus, Ranchi, Jharkhand (Lat. 23.35866^0 E; Long. 85.24677^0 N)
ICFRE-IFB, Hyderabad	1	-	August 2023	- IFB campus, Hyderabad, Telengana (Lat. 17.55^0 N, Long. 078.44^0 E)
ICFRE-ERC, Prayagraj	-	1	September 2023	- Village Basahara, Prayagraj, Uttar Pradesh (Lat. 26.628^0 E; Long. 82.646^0 N)

Highlights

- The process of producing grafted quality planting material of *Madhuca longifolia* (mahua) for the purpose of domestication was standardized through cleft grafting and 1900 grafted plants were produced.
- Five Vegetative Multiplication Gardens have been successfully established with grafted Mahua plants at (1) TFRI campus, Jabalpur, Madhya Pradesh, (2) IFP campus, Ranchi, Jharkhand (3) KVK, Myrada, Thalamalai, Tamil Nadu, (4) Guru Ghasi Das University campus, Bilaspur, Chhattisgarh and (5) IFB campus, Hyderabad, Telengana.
- Two Seedling Seed Orchards have been successfully established at (1) Guru Ghasi Das University campus, Bilaspur, Chhattisgarh and (2) Basahara, Prayagraj, Uttar Pradesh.
- 1152 Candidate Plus Trees (CPTs) of Mahua have been selected throughout its natural distribution range in India.
- FSSAI license certificate has been awarded to ICFRE-FRCSD, Chhindwara for a period of one year for the developed food products under the project.
- Mahua chocolate (nutraceutical bar) has been developed from dried flowers.
- Herbal Antibacterial Hand wash gel formulation and Herbal cream developed from *Madhuca longifolia* plant parts was found to be safe and effective.
- Toothpowder samples prepared in bulk from mahua leaf and bark was distributed to various stakeholders and consumer acceptability tests were conducted.
- Alcohol content of 45-50 % was recorded in the liquor distilled from mahua flowers. Taste and fragrance were enhanced by the additives.
- Leaflet entitled "*Madhuca longifolia* (Mahua): A Useful NTFP Species of Madhya Pradesh" has been published in English and Hindi.
- A booklet entitled 'Indigenous Traditional Knowledge in *Madhuca longifolia* (Mahua) prevalent in India' was published.

24. All India coordinated research project on "Combating desertification by enhancing vegetation cover and people livelihoods in degraded dry lands and deserts of India"

24.1 Objectives:

- Survey and selection of indigenous herbs/grass, shrubs, and trees species and their combinations for effective use in various restoration programmes
- People mobilization and development of live fencing around a cluster of farmer's field for soil and water conservation to enhance farm production and people livelihoods.
- Restoration of degraded hills, hillslopes, sand dunes, ravines and saline areas through introduction of new genotypes/ varieties/ species and natural resource conservation in different landscape.
- Assessment of the impact of different species under afforestation/reforestation on vegetation recovery, soil health improvement and carbon storage. Popularization of ecological, environmental and economic benefits of improved practices of mitigation of the effect of land degradation and desertification among the local people

24.2 Progress:

This project is focusing on combating desertification covering treatments of farmlands, community lands and degraded forest lands as well as restoration works. In farmland treatment, live fencing or boundary plantation around a cluster of farmer's field has been done in various parts of country (Rajasthan, Madhya Pradesh, Himachal Pradesh and Tamilnadu) for increasing tree/vegetation covers on farmlands and conserving soil and water with co-benefits of farm protection and enhanced farm production.

ICFRE-HFRI, Shimla

Survey carried out in Cold Desert area at Tabo, Poh, Maine, Lalung and Gue areas of Himachal Pradesh and at Meru, Opasi and Shey area of Ladakh region for knowing tree, shrub and associate species. The dominant species found in Himachal Pradesh were *Populus nigra, Salix alba, Juniperus polycarpos, Rosa webbiana, Colutea nepalensis, Hippophae rhamnoides, Populus ciliata, Salix fragalis, Myricaria squamosa, Artemisia brevifolia, Lonicera sp, Cousinia thomsonii, Plantago tibetica,* etc. Whereas, in Ladakh region, main species found were *Populus nigra, Salix alba, Salix fragilis, Rosa webbiana, Hippophae rhamnoides, Rosa webbiana, Artemesia brevifolia., Plantago tibetica, Pedicularis sp.* etc. Survey was carried out in five villages i.e, Tabo, Sushna, Maine, Lalung and Gue for selection of cluster of farmers for live fencing and for establishing snow harvesting structures. The snow harvesting devices/ structure were constructed at Tabo, Lalung, Maine, Gue and Sushna for augmenting water supply to the selected clusters of farmers. Collected seed and cutting of *Populus nigra, Salix alba, Rosa webbiana, Juniperus polycarpos, Elaegnus angustifolia, Hippophae rhamnoides* for raising nursery stock. The maintenance of nursery stock of *Populus nigra (3500), Salix alba (4000), Juniperus polycarpos (500), Elaegnus angustifolia (2000)* etc. is continue. The plantation of *Seabuckthorn (350), Rosa (300), Salix (400) and Poplar (400)* was carried out along the field boundaries of five villages. The area of 1.50 ha plantation at Badami Bag, Leh and 11 ha at Sushna, Gue and Tabo in cold desert region of Himachal Pradesh has been selected. The plantation of *Juniperus polycarpos* in 1.50 ha area has been done at Badami Bag, Leh and its maintenance is continue. The plantation of *Populus nigra, Salix alba, Juniperus polycarpos, Rosa webbiana*, *Hippophae rhamnoides and Elaeagnus angustifolia* has been carried out in 10.50 ha area in 3mx3m spacing at Sushna and Tabo area of

cold desert in Himachal Pradesh. The observations on plant growth parameters of planted species were recorded. The soil samples were collected from the plantation area and estimated the various soil parameters. The maintenance of planted species at Sushna and Tabo area of Lahaul & Spiti district of Himachal Pradesh is continue.

Fig. 22 Nursery Stock of *Populus nigra* at Tabo (Spiti)

Fig. 23. Plantation of *Juniperus polycarpos* at

ICFRE-AFRI, Jodhpur

There are four component of project running in AFRI, Jodhpur, these component are following:

1. Live hedge fencing or boundary plantation

Cluster of Chouradia village of a group of five farmer's land (26.622679 N and 72.29394 E) and Cluster of Khet Singh Nagar a group of three farmer's land, (26.63372 N and 72.319355 E) situated in Setrawa area, Jodhpur (Rajasthan). Due to browsing problem, caring of plantation with protection was only focused in 400 running meter along the farm boundary in 4.50 ha area at Chouradia cluster and 1100 running meter along the farm boundary in 25.00 ha area at Khet Singh Nagar cluster. Plantations were maintained through weeding and soil working. The survival of seedlings is 43% and height and collar diameter of seedlings are 38 cm and 0.45 cm, respectively in Chourdia cluster. The survival of seedlings is 64% and height and collar diameter of seedlings are 42 cm and 0.51 cm, respectively in Khet Singh Nagar. *A. senegal* is slow growing thorny tree species of Indian desert and browse in last year resulted poor growth and survival of the seedlings. Economics was calculated in both Kharif and Rabi season.

2. Restoration of degraded forest land (*sandy plain)*

For restoration of degraded sandy plain plantation has been done at Karah Jod, Jaisalmer, Rajasthan in 15 ha area. 4410 nos. of seedlings of indigenous tree species like *Prosopis cinerarira, Azadirachta indica, Vachellia nilotica, Ziziphus mauritiana and Salvadora oleoides* in 4mx5m spacing were planted in experiment-I. 648 seedlings of each indigenous shrub species like *Z. nummularia, Vachellia jacquemontii, Cordia gharaf and Mytenus emarginata* planted in 3mx3m spacing at experiment -II at Karahjodh Jaisalmer site. Different soil amendments treatment like Biochar, Hydrogel Neempati Sewage sludge and Consortium of bio fertilizer has been applied in planted tree and shrub species in the site.Treatment wise survival were recorded in Salvadora oleoides 65.43%, 70.46%, 71.33%, 70.53% and 72.33% in Hydrogel, Biochar, Consortium, Neempati and Sewage sludge followed by *P. cineraria* 76.53%, 74.86%, 73.43%, 74.96% and 70.66%, Z. *Mauritiana* 71.33%, 73.33%, 70.56%,72.86% and 71.66%, *V. nilotica* 65.54%, 64.43%, 62.66%, 60.93% and 60.13, *A. indica* 60.50%, 54.66%, 49.56%, 55.50% and 56.43%. Growth parameter were recorded of *Prosopis cinerarira*, average height 42.50 cm, collar girth 4.13mm followed by *Azadirachta indica* average height 37.2 cm, average collar girth 3.21mm *Vachellia*

nilotica average height 52.5 cm, average collar girth 5.36cm and *Ziziphus mauritiana* average height 49.65 cm, average collar girth 4.21mm *Salvadora oleoides* average height 39.25 cm, average collar girth 3.90mm in experiment-I. Ggrowth parameter was recorded of *Z. nummularia*, average height 22.10. cm, collar girth 2.10mm followed by *Vachellia jacquemontii*, height 35.32 cm, collar girth 3.21mm *Cordia gharaf* height 59.52cm, collar girth 7.21mm and *Mytenus emarginata* height 31.24 cm, collar girth 2.54mm in experiment II. Soil samples have been collected from the site and analysis has been done for pH, EC available NH4-N, NO3-N PO4-P, SOC and soil moisture after plantation. Physical and chemical analysis of soil samples including soil organic carbon is completed. Soil pH ranging from 8 to 8.8, EC 0.0149ms to 0.0154 ms, whereas, organic carbon 0.25 %, available to 37.5 Mg/ha, and NO3-N range from 43.9-65.85 kg/ha. Soil moisture analysis in summer session (month of June -2023) 0-30 cm soil depth, range 0.2% - 3.6%, and 30- 60 cm depth, 0.40% -3.84% 60 -90cm 0.28% - 2.47%
Proper irrigation and other maintenance works have been done.

3. Restoration of reactivated sand dune

For stabilize reactivated sand dune with suitable surface cover species in hot arid region plantation has been done on 10 ha Land at reactivated sand dune at Udasar, Nokha, Bikaner, Rajasthan.Site has been selected at Udasar, Nokha at Forest land. MoU has been signed between PI and DFO, Bikaner. Relevant literature was collected, and species shorted out. Initial vegetation data and soil sampling collected and analyzed. Six shrub species were planted in between the old plantation as well as in the gaps (*Vachelia jacqumontii, Calligonum polygonoides, Ziziphus nummularia Lycium barbarum, Leptadenia pyrotechnica and Mytenus emarginata). (Average height data Vachelia jacqumontii-150.0cm, Calligonum polygonoides 32.58, Ziziphus nummularia- 135.80.cm, Lycium barbarum 48.26cm, Leptadenia pyrotechnica 179.20cm and Mytenus emarginata 84.66cm.)* Seed of *Cassia aungustifolia, cenchrus ciliaris* and *Lasiurus sindicus* were also sown as cover species to *check the wind erosion. For* monitoring and study of sand drift and erosion status points have been marked in treated and untreated area. Initial data noted and Soil deposition and erosion recorded twice in a year.

Fig. 24 Overview of reactivated sand dune site Udasar, Nokha, Bikaner, Rajasthan

Fig. 25. Cassia aungustifolia as cover crop at Udasar site Bikaner, Rajasthan

Fig. 26. Lasiurus sindicus grass established at Udasar site Bikaner, Rajasthan

Fig. 27. Cenchrus cilliaris grass established at Udasar site Bikaner, Rajasthan

4. Degraded hill

Main objective of this experiment is to improve the livelihood of the people by rehabilitating the degraded hilly area. The area was protected by getting fencing work done around the project land. Layout work was done by dividing the research area into 90 plots. After drilling, pits of 2.5 cubic feet were prepared by blasting. Treatments of cow dung, sewage slug and hydro gel were placed in the good soil in the plantation pits, six species were taken which are good for this hilly area. Since this is a hilly area, half moon structures were built to collect water in the trunks of plants. Trenches were constructed to divert rain water throughout the area. Sowing of Dhaman grass was done over the trenches. Plantation work completed in July-August 2022 . In the year 2023, *Euphgorbia* and *Gengan* saplings were planted in between the plantations. For the maintenance of the experimental field, work like watering the plants, soil work, removing weeds from the plants were done. Soil samples are collected once a year. Plant growth is taken twice a year. To protect plants from pigs, mulching of stones was done in the bowls, which. People will collect Dhaman grass and feed it to their animals. Local people have been very supportive in implementing this project.

ICFRE-TFRI, Jabalpur

The eco-restoration model comprises plantation of 7 tree species (*Acacia catechu, Acacia tortilis, Azadirachta indica, Anogeissus pendula, Commiphora wightii, Aegle marmelos and Emblica officinalis*) in 22.68 ha area alongwith 3 biofertilizer treatments (Rhizobium, Azotobacter and Azospirillum) in 3 graded doses (5%, 10% and 15%) and 3 mulches (Wheat husk, Stone pebbles and Leaf litter) to conserve the soil moisture and enhance the nutrients status of soil following factorial RBD design in 3 replications with the spacing of 5m × 5m. During October 2023 and

March 2024, three field trips were made for plantation of Carissa carandas in the Esah Shikaripura cluster and bund formation in the farm boundaries for augmenting water harvest. Further in March 2024, application of third dose of biofertilizers (Rhizobium, Azotobacter and Azospirillum) and mulching (Wheat husk, stone pebbles and leaf litter) following factorial RBD design on plantations raised on Chambal ravines were carried. Mortality replacement in these plantations were carried out in July 2023, therefore the current rate of survival is 100% as on December 2023, but the survival after summer will be recorded in July-August 2024. *Azadirachta indica, Commiphora wightii and Acacia tortilis* were found to have performing better among five species. supported the growth and survival. The average height and diameter of plantation of five species carried out in TFRI site at *Useth, Morena* are as follows: Average height (cm) and diameter (mm) of Acacia catechu (Khair) was recorded to be 24.65 and 4.66 respectively. Average height (cm) and diameter (mm) of *Acacia tortilis* (Tortilis) was recorded to be 88.7 and 11.51 respectively. Average height (m) and diameter (mm) of *Azadirachta indica* (Neem) was recorded to be 81.9 and 11.29 respectively. Average height (m) and diameter (mm) of *Anogeissus pendula* (Kardhai) was recorded to be 53.7 and 7.1 respectively. Average height (m) and diameter (mm) of *Commiphora wightii* (Guggal) was recorded to be 80.75 and 14.76 respectively. Nine check dams of different sizes were constructed over the deep gullies of ravines as the part of soil and water conservation measures to facilitate water regimes in the plantation sites. Thereafter seeds of *Acacia nilotica* seeds were sown in three rows over the nine check dams. The purpose of seed sowing in the check dams is achieved. The seedlings of *Acacia nilotica* is densely grown and the soil erosion is significantly reduced due to the construction of these check dams. The impact of carrying out these plantations, protection work, soil treatment and biofertilizer treatment before and after the plantations will be carried out during this half year to highlight the improvement that has occurred in terms of biodiversity of herbaceous flora and soil quality.

ICFRE-FRI, Dehradun:

The ICFRE-Forest Research Institute, Dehradun has planted 6.5 hectares of arid/degraded land in Uttar Pradesh and Punjab. A total of thirteen species, including *Acacia catechu, Dalbergia latifolia, Aegle marmelos, Dalbergia sissoo, Bambusa bambos, Dendrocalamus strictus, Draphanostachym falcatum, Phyllostachys aurea, Salvadora persica, Terminalia bellirica, Butea monosperma, Chukrasia tabularis, and Toona ciliata* were planted in a five-hectare area in Babina (Jhansi, U.P.) in September of 2023. After recording initial soil parameters at the plantation site, additional soil moisture conservation measures were put in place. These included excavating pits (2500 total, measuring 0.45 x 0.45 x 0.45 m^3) perpendicular to the slope to catch water runoff and constructing staggered trenches (1000 total, measuring 3.00 x 0.65 m^3) to further obstruct water flow.

The second plantation site was the CUP campus in Bhatinda, Punjab. In February 2024, ten different species were planted in a 1.5 hectare area: *Dalbergia sissoo, Dalbergia latifolia, Toona ciliata, Acacia catechu, Aegle marmelos, Bambusa bamboos, Dendrocalamus strictus, Draphanostachym falcatum, Terminalia bellirica,* and *Butea monosperma*. Similar soil moisture conservation measures were applied, including the excavation of pits (900 in total, sized at 0.45x0.45x0.45 m^3) accompanied by furrows.

Fig. 28 Staggered trenches prepared at plantation site Babina (Jhansi).

Fig. 29 Straight furrows prepared at plantation site CUP campus (Bhatinda).

Fig. 30 Acacia catechu sapling planted at plantation site Babina (Jhansi).

Fig. 31 Toona ciliata sapling planted at plantation site CUP campus (Bhatinda).

ICFRE-IFGTB, Coimbatore

Planting of *Casuarina sp*. and neem seedlings as boundary plantations was completed in cluster of nine farmers field in 2.7 ha in the Cauvery delta and Southern agro-climatic zones. Observation on growth of boundary plantations of *Casuarina sp.* and neem planted in the Southern and Cauvery delta zones were recorded. Identification of lands for establishment of field trials in the Southern, Western, North-eastern, Cauvery delta and North Western Agro climatic zones was completed. Soil samples collected from the selected salt-affected farmers field were analyzed for various physico-chemical properties. Field trial was established in 5.70 ha of farmer's field affected by salt ingression in the Western zone at Karalayam village, Erode, in the Cauvery delta zone at Rathinampillai Pudur village, Karur, and, in the North-eastern zone at Gopalapuram village, Villupuram. Seedlings of *Pongamia pinnata, Azadirachta indica, Glyricidia sepium,* and *Thespesia populnea* were planted as hedge rows at 2 m spacing between rows and 2 m spacing between trees. The width of each alley is 4 m.

Fig. 32 Boundary plantation Collection of soil samples in boundary plantation of *Azadirachta indica* Thoppadaipatty village, Ramanathapuram, Tamil Nadu

Fig. 33. Glyricidia sepium planted in the North-eastern zone, Gopalapuram village, Villupuram, Tamil Nadu

Fig.34. Recording observation on growth of *Thespesia populnea* in the Cauvery delta zone, Rathinampillai Pudur village, Karur, Tamil Nadu

Fig.35. Thespesia populnea planted in the North-eastern zone Gopalapuram village, Villupuram, Tamil Nadu

ICFRE-IFP, Ranchi

Site has been selected at Kiriburu (Iron mine of Steel Authority of India). Detailed literature surveyed and species suitable for different mined burdened soils were screened in for further research. Studied the trees and shrubs and the associated herbaceous vegetation in the vicinity. Survey was carried out in the vicinity of the site regarding the biodiversity and analysis was done. Suitable species (Trees, Shrubs and herbs) have been screened in on the basis of literature survey and the indigenous species in the nearby ecosystem of the site. Soil samples have been collected from the site and analysis has been done. 6 different type of soil amendments were decided on the basis of chemical analysis of the soil. Nursery has been raised of the screened species. On the slopes of the selected site at Kiriburu, continuous contour trenches and staggered contour trenches were prepared to check the water flow and hence the soil erosion and plantation on slopes were carried out. After site levelling, layout and design and pit digging, plantation of screened species with different soil amendments has been done in 7.70-hectare area. Proper maintenance of plantation has been done in regular intervals.

Fig. 36. Overall view of Kiriburu Study area

Fig. 37. Plantation at Kiriburu site

Highlights

- Live fencing around farmer's fields has been done in total 12 villages Rajasthan (2 villages), Madhya Pradesh (2 villages), Himachal Pradesh (5 villages) and Tamilnadu (3 villages) by direct seed sowing and through seedling. Bunds, trenches and snow harvesting structures are being maintained at selected sites.
- Restoration of degraded landscape like semistabilised dunes, saline lands, degraded hills, hillslopes, ravines and mine overburdens areas have been targeted under this project and field trials/plantation established in total **91.58 ha** area at various parts of country.
- Plantations have been established on different type of degraded land covering **91.58 ha** area (degraded hills **12** ha. Jodhpur, Rajasthan, degraded sandy forest area 15 ha. Jaisalmer, Rajasthan, reactivated sand dune **10** ha. Bikaner, Rajasthan, ravine area **22.68** ha. Morena, Madhya Pradesh, hillslopes **12.0** ha. Himachal Pradesh, salt affected soil **5.0** ha, Uttar Pradesh & **1.5** ha, Punjab, Mine overburden area **7.70** ha Jharkhand, and Saline soil area **5.70** ha Tamilnadu).

S. No.	Institute	Type of degraded land	Plantation area
1	ICFRR-AFRI, Jodhpur	Degraded hill	**12.00**
2	ICFRR-AFRI, Jodhpur	Sand Dune (reactivated)	**10.00**
3	ICFRR-AFRI, Jodhpur	Sandy plain(degraded forest land)	**15.00**
4	ICFRR-HFRI, Shimla	hill slope	**12.00**
6	ICFRR-TFRI, Jabalpur	ravines	**22.68**
7	ICFRR-IFP, Ranchi	Mine over burdened area	**7.7**
8	ICFRR-IFGTB, Coimbatore	Salt affected soil	**6.50**
9	ICFRR-FRI, Dehradun	Saline soil	**5.70**
	Total area		**91.58**

25. All India coordinated research project on "Domestication, genetic characterization, improvement and diversified utilization of poplars"

25.1 Objectives:

- Standardization of cultivation practices for native poplars
- Introduction trials of *Populus alba* in high altitude areas of Uttarakhand and Arunachal Pradesh and *P. gamblei* in Gangetic plains
- Genetic improvement of *P. deltoides* and *P. gamblei* through classical tree improvement and molecular approaches and their DNA characterization
- Management of major insect pests and diseases of native and exotic poplars
- Assessment of wood quality and studies on diversification of usage/products from poplars

25.2 Progress:

Field trials of 16 clones of *P deltoides* have been laid out at following number of sites: 4 sites by FRI, one site by HFRI and one site by IFP. The same set of clones has been planted as per statistical design prescribed by NPC. The trials are being maintained. Clone FS-31 and FS-32 have recorded greater height and dbh at four sites. Data of a 22-year-old provenance trial of *P. ciliata* located at Kulu, H.P., has beencollected and analysed. A research paper on the field trials has been accepted for publication in an international journal.

Fig.38 Clonal trial of *P. deltoides* at FRS Bir Plassi, Nalagarh, Solan, HP

Field trials on effect of spacing and soil working technique on *P. ciliata* has been established at Gue village of Lahaul Spiti dist. of Himachal Pradesh. An experiment on effect of hydrogel dose and mulch on *P. alba* has also been raised in the field at Gue village of Lahaul Spiti dist. of Himachal Pradesh. Experiment has been concluded on vegetative propagation of *P. gamblei* through branch cuttings. Cuttings of *P. alba* alonwith *P. ciliata, P. nigra and Salix alba,* after receipt from HFRI, have been planted in nursery for introduction trials by FRI and RFRI. The introduction trial will be established during monsoon season of 2024. Seedlings of *P. gamblei* have been raised in the nursery by RFRI and supplied to FRI and IFP for conducting introduction trials. Introduction trial has been set up by FRI, while IFP will establish the trial during monsoon season of 2024. Studies on DNA extraction and standardisation of DNA markers are underway in FRI, HFRI and RFRI.

Surveillance of insect pests and diseases has been completed by HFRI, FRI, IFP and RFRI. A calendar of insect pests of *P. deltoides* was prepared. Natural biocontrol agents of different insect pest were recorded belonging to Braconidae, Inchnomonidae, Mucidae and Eupelmidae groups. Bio-efficacy experiments on Entomo-pathogenic nematode (EPN) and two new insecticides for management of leaf defoliator *Clostera sp.* were conducted under laboratory conditions. The following two new diseases of *P. deltoides* were recorded: Calonectria leaf blight of poplar and Tip and shoot blight of *P. deltoides*. *Colletotrichum* sp., *Alternaria* sp. and *Botryosphaeria* sp. were found pathogenic on *P. deltoides* in detached leaf assay. The pathogenicity of *Calonectria* sp. was tested on 10 clones. This is probably the first report ofthis pathogen on poplar in India and worldwide. *Trichoderma* isolate was tested for antagonistic potential against three *Alternaria* isolates and *Calonectria populi* using dual culture technique.

Wood of *P. gamblei* has been collected after obtaining permission from Nagaland Forest Department and studies on wood properties are in progress at ICFRE-Institute of Wood Science & Technology, Field Station Kolkata. Oriented strand board (OSB) has been made from small diameter wood and waste wood of *P. deltoides* in laboratory with suitable treatments. Studies are underway on testing the OSB.

Seasonal incidence of insects found in *Populus deltoides* in the field

S. No.	Species Name	Damage	Seasonal incidence
1.	*Acraea terpsicora*	Defoliator	June, July, August, September
2.	*Artaxa guttata*	Defoliator	July, August, September
3.	*Ascotis selenaria*	Defoliator	June, July, August, September, October
4.	*Botyodes asialis*	Defoliator	May, June, September
5.	*Botyodes diniasalis*	Defoliator	August, September
6.	*Botyodes principalis*	Defoliator	April, September, October, November
7.	*Cheromettia apicata*	Defoliator	July, August, September, October, November
8.	*Chrysodeixis eriosoma*	Defoliator	April, October
9.	*Clostera cupreata*	Defoliator	May, June, July, August, September
10.	*Clostera fulgurita*	Defoliator	April, May, June, July, August, September, October, November
11.	*Cupha erymanthis*	Defoliator	April, May, June, July
12.	*Eupterote undata*	Defoliator	July, August, September
13.	*Hyposidra talaca*	Defoliator	May, June, July, August, September, October, November, December
14.	*Olene inclusa*	Defoliator	April, May, November
15.	*Olene mendosa*	Defoliator	October
16.	*Orgyia postica*	Defoliator	May, September, October, November
17.	*Oxyrachis tarandus*	Sap sucker	March, April, May, June, July, August, September, October, November
18.	*Patania ruralis*	Defoliator	July, August

19.	*Phalanta phalantha*	Defoliator	March, April, May, June, July, August, September, October
20.	*Ricania speculum*	Sap sucker	April, May, June, July, August, September, October
21.	*Syntomoides imaon*	Defoliator	April, May, June, July

Highlights

- Field trials of 16 clones of *Populus deltoides* are progressing at six sites in Himachal Pradesh, Punjab, Haryana, Uttar Pradesh and Bihar. Clones FS-FRI-31 and FS-FRI-32 are among the best performers at four sites in Hoshiarpur (Punjab), Yamunanagar (Haryana), Saharanpur and Kushinagar (both in Uttar Pradesh), at the age of two years as they exceeded about 15 cm in dbh and height ranged from 11 to 14 m. Field trials on spacing x soil working technique for *Populus ciliata* and hygroscopic gel dose x mulch for *Populus alba* are doing well at the age of one year. Introduction trial of *Populus gamblei*, a native poplar species of north-eastern India, has been established at Dehradun (Uttarakhand) during March 2024.
- DNA profiling of native species viz. *P. alba, P. ciliata, P. gamblei* and exotic *P. deltoides,* is in progress at HFRI, FRI and RFRI. Oriented strand board were made from wood waste of *Populus deltoides* during 2023-24 at FRI and their quality testing, is underway. Seasonal incidence of insect pest spectrum in *Populus deltoides* has been studied in Himachal Pradesh, Punjab, Haryana, Uttar Pradesh and Uttar Pradesh and a calendar of seasonal incidence has been prepared. Natural enemies viz. the parasitoid *Netalia testacea* (Hymenoptera: Ichneumonidae) and the predator crab spider, *Camaricus formosus* (Araneae: Thomisidae) of minor pests of *P. gamblei* were recorded from nursery in Assam.
- *Ceratocystis* sp. was identified as a causal agent of a serious wilt disease of *P. deltoides*. The disease was successfully managed by root application of Trichoderma sp. in a farm field at Kalesar, Haryana. The novel species (Calonectria populi Aditi Saini & Shailesh Pandey, sp. nov.) found by the team, has been registered with MycoBank (MycoBank number 849371). *Trichoderma* isolate is being tested for antagonistic potential against three *Alternaria* isolates and *Calonectria populi* using dual culture technique.

26. All India coordinated research project on "Genetic Improvement of *Azadirachta indica* A. Juss. (Neem)"

26.1 Objectives:

- Identification of superior genotypes and seed sources from different agro-climatic zones of India for high Azadirachtin and oil content.
- Chemical evaluation of seed samples collected by different Institutes from different agro-climatic zones of India. Genetic Characterization of high azadirachtin and oil yielders identified after three years.
- Phenology and Reproductive biology studies. Development of genetic transformation methods for frost/cold tolerance .Production of Azadirachtin through cell suspension culture

26.2 Progress:

In AFRI, Jodhpur: Neem seeds were collected from the marked 100 CPTs from Gujarat (agro-climatic zone-13) and 87 from Rajasthan (agro-climatic zone-14). Completed the processing, depulping, and drying of seeds collected from 187 CPTs. Data on Aza content was received from Amity. For ACZ 13, the azadirachtin content was ranged from 309.21 to 2572.84 ppm and for ACZ 14 the azadirachtin content ranged from 224.54 to 2124.69 ppm, respectively. Similarly Oil percentage for ACZ 14(Rajasthan) ranged from 21.05 and 51.33 and for ACZ13 (Gujarat), ranged from 51.82 to 20.44.

Transformed cell lines were further sub-cultured as callus. Developing micro shoot cultures have been transferred to shoot elongation medium further to be transferred to root induction medium. Putative double gene transformed cultures are growing well and are being maintained by regular sub culturing. Fresh inoculation was done on 1.5 mg/ml 2,4-D using leaf explants for fresh co cultivation experiments for transformation of single gene of *cdh*.

At IWST, Bangalore: As per the recent allotment of change of Agrozone, survey was made in various locations in Karnataka. Trees were selected from different villages. 84 trees from 12 districts Viz. Tumkur, Bidar, Bagalkot, Chitradurga, Dharwad, Gubbi, Kadur, Kalaburgi, Kollegal, Mysore, Vijaypur and Yadigiri. Fruits were collected from already selected trees at the time of fruiting season. collection. In addition survey and fruit collection were made from Telangana. Fruits were collected from 100 trees of which 84 trees from Karnataka and 16 trees from Telangana. The quantity of seeds collected from the trees were varied. All the 100 seed samples were sent to Amity University for estimation of Azadirachtin content. Estimation of oil content was carried out for all the 100 seed sources at IWST, Bangalore. The concentration of Azdadirachtin varied from 485.29 to 4643.45 ug/g of seed and the oil percentage varied from 14.5 to 46.4 %.

During the second consecutive year fruits were collected from 96 exiting selected trees (4 trees were absent due to fire and felling), seeds were extracted and processed. The Processed seeds were used for estimation of azadirachtin and oil. The oil content varied from 16.7% to 44.69% and the concentration of Azadirachtin varied from 0.0238 to 0.5765 ug/g of seed.

In IFGTB, Coimbatore : Quantified variations among 220 seed lots in the fruit and seed traits such as fruit length, fruit breadth, fruit area, fruit perimeter, fruit aspect ratio and fruit total ratio; seed area, seed length, seed breadth, seed perimeter, seed aspect ratio and seed total ratio; 100 seed weight, and 100 kernel weight. Significant differences were recorded among the CPTs for all morphometric traits.

Completed the reproductive biology studies in neem. Recorded the flower visitors, Morphometric data of Neem flower, time of anthesis, breeding system and palynology. Standardized pollen storage technique for long time storage. Breeding experiments such as autogamy, allogamy, geitogamy were tested. Studied variations in the flowering and fruit setting pattern in different populations. Callus were initiated from explants like flowers and leaf in fifteen different media combinations. Flower callus were well initiated in solid media, while leaf callus induction was very minimal. Some modifications are made in media composition to increase the leaf callus induction rate. Initiated flower and leaf callus were transferred to suspension cultures and are being maintained. Culture conditions like pH, temperature, light and media compositions were standardized for all the cultures. Aza content were estimated in through HPLC, Azadirachtin Standard (Merck) was used for the analysis. To increase the aza content in cell lines different Elicitors like Jasmonic acid, methyl Jasmonate and Salicylic acid treatment was given in the concentration of 2-10mg/L. RNA was isolated from one month old leaf callus, flower callus and Neem seed. Quality and quantity of the RNA was checked using gel and Nanodrop further the samples were sent for Transcriptome analysis.

In TFRI, Jabalpur: Surveys were carried out and tours were conducted in different locations of Madhya Pradesh and Uttar Pradesh in Agroclimatic zone 8. 100 CPTs of Neem were selected from Gwalior, Guna, Hoshangabad, Jabalpur, Katni (M.P.), Jhansi and Lalitpur (U.P.). Neem fruits (approx. 1.5 kg fruits per tree) were collected from each selected tree. Geographical locations of selected trees were noted using GPS. Morphometric data viz., total tree height, clear bole height, GBH, and crown diameter was recorded for the selected trees. Soil Type, Humidity, Temperature of the site was noted. Fruits were de-pulped, cleaned, and shade dried, for the purpose of total oil extraction from different locations using Soxhlet apparatus. Morphological data (Fruit length, width, and weight) of the fruits was recorded. Seeds were extracted from the fruits and morphological characterization of seeds (Seed length, width, and weight) was carried out.Seeds were extracted from fruits and oil extraction from kernels was carried out. Total oil content from 100 samples of Neem seeds collected from 100 selected CPTs have been completed in 2022. The range of total oil % is Min.18.38 to Max. 53.97. This year in 2023-24 also tours were conducted to various parts of Madhya Pradesh such as Sohagpur (Hoshangabad), Jabalpur, Guna and Gwalior and in Uttar Pradesh such as Jhansi and Lalitpur, for the collection of fruits from the selected Neem trees. Approx. 3 to 4 kg fruits were collected from each Neem tree. Morphological data of the trees, fruits and seeds were recorded. All the seed samples were sorted, packed and tagged with new coding of the year 2023-2024, for sending them to Amity University, Noida, U.P. 100 Neem seed samples were dispatched on 26/07/2023 to Dr. Nutan Kaushik, Director General, Food and Agriculture Foundation, Amity University, Noida, U.P. from ICFRE-TFRI, Jabalpur, M.P. and samples were received by Amity University on 31/07/2023. Seeds were extracted from fruits and oil extraction from kernels is completed. So far, the total oil from all 100 samples of Neem seeds has been extracted. The range of total oil % is Min. 28.12 to Max. 61.19. Morphometric data of seeds were recorded. Statistical analysis and tabulation of previously collected morphometric data of trees and total oil content data of Madhya Pradesh and Uttar Pradesh will be carried out. Analysis of soil samples from all the locations is going on. So far, pH and EC from all the soil samples have been completed.Phenological data related to number of branches, leaf fall, leaf initiation, flower initiation and peak flowering was recorded for 30 trees of three different locations of Madhya Pradesh (Jabalpur and Katni). Standardization of the DNA extraction protocol is being carried out. For that purpose, 2 methods viz., Modified Doyle & Doyle (1987) and Mandaliya et al. (2019), were chosen and performed. Out of these 2, only modified Doyle & Doyle showed optimum results.

In IFP, Ranchi: Survey was undertaken in agro climatic zones 3, 4, and 7, comprising districts in Jharkhand, West Bengal, Bihar, and Uttar Pradesh. So far, 349 phenotypically superior CPTs have been chosen. For each selected tree, data on tree height, GBH, crown diameter, number of branches, and so on were collected. The biochemical analysis of the Azadirachtin content and

kernel-oil estimation in 100 CPTs chosen from each of the three agro climatic zones, viz., 3, 4, and 7 is completed as first and second assessment (2022 & 2023). The kernel-oil percentage showed significant variation among the accessions ranging from 36.51% to 58.86% in the year 2022. For the year 2023, the kernel oil varied between 27.78% to 66.92% Whereas, significant variation among Azadirachtin content of the accessions was also identified both in 2022 & 2023. For 2022, the Azadirachtin content ranged between 2561.13 PPM (µg/g seed) to 19.64 PPM (µg/g seed). For 2022, the Azadirachtin content ranged between 3160.76 PPM (µg/g seed) to 39.37 PPM (µg/g seed). Fruits were collected in two years (i.e. 2022 & 2023) from the 100 selected trees of each agro climatic zones 3, 4 and 7 and the seeds were processed. Variations in fruit and seed attributes were quantified among collected seed lots for the year 2022 and 2023. Flowering, fruiting and leaf phenology data of CPTs from different locations were recorded in their respective sessions. Estimation of fruit yield was carried out during the fruit collection of selected CPTs in field (during 2023) and the data was analysed. Additionally, soil samples were collected from the CPTs and the samples are being analysed for nutrient content and other parameters.

At IFB, Hyderabad

- **First Year:**
  - ✓ Selection of CPTs (100) was completed and geo-coordinates of the trees have been recorded from 4 districts of the Maharashtra- Buldhana, Akola, Amravati and Yavatmal different locations. All the geo cordinates are recorded for the future reference. Collection of fruits from 100 trees has been completed. The fruits were de-pulped, seeds dried and packed with labelling and dispatched to Amity University, Noida (First year). Neem seed oils content from 100 CPTs were determined using Soxhlet method.
  - ✓ Data showed the variation in oil content (%) ranged from 67.65±2.2 to 24.7±1.2. The highest content was found in J051 (67.65%) followed by J040 (63.15%) and J043 (61.6%) whereas lowest oil content was recorded in J068 (24.7±1.2).
  - ✓ Data on Aza content was received from Amity which showed that aza content varied from 760.34 ppm to 70.21 ppm. The highest was recorded in J038 (760.34) followed by J036 (736.18) and J045 (717.21) while J094 showed lowest azacontent (70.21). Soil analysis was also done (pH- 7.1 to 8.44; EC- 0.15 to 0.99; AN(Kg/ha)-40.09to 196.94; AP (Kg/ha)-2.0 to 39.0; K(Kg/ha)-100.25 to 989.5)
- **Second Year:**
  - ✓ Extensive tour has been done for second year to collect fruits from 100 selected CPTs of 4 district of Maharashtra and places were revisited based on the GPS locations. Total 95 trees fruits sample have been collected from the selected CPTs of Maharashtra namely Amravati (19), Akola (14), Buldhana (35) and Yavatmal (27) while 05 were diseases or cut (1 cut, two pruned, and two diseases). Fruits were de-pulped, dried, packed with new code (series-C) and dispatched to Amity University, Noida for aza content analysis.
  - ✓ Neem seed oils content from 95 CPTs were determined using Soxhlet method. Data showed the variation in oil content (%) ranged from 51.9 to 27.1. The highest content was found in C172 (51.9%) followed by C174 (51.0%) and C186 (49.6%) whereas lowest oil content was recorded in C104 (27.1)..
  - ✓ Data on Aza content was received from Amity. The obtained data showed that aza content varied from 2980.16 ppm to 358.16 ppm. The highest was recorded in C125 (2980.16) followed by C181 (2717.10) and C123 (2417.77) while C156 showed lowest aza content (358.16).
  - ✓ Morphological data of seed have been recorded.
  - ✓ Collected soil samples were analyzed. pH- 7.1 to 8.44; EC (dS/m) - 0.15 to 0.99; Organic Carbon(%):-3.3 to 10 ; Nitrogen (kg/ha) – 15.05 to 58.96.

Highlights

- Selections of 1000 Neem seed sources have been completed from All 9 Agroclimatic zones by the 6 ICFRE institutes associated under the project. Fruits were collected from all the selected 1000 seed sources during the fruiting season in the year 2022. These were processed (depulped, dried, and packed) as per the common approved methodologies by each institute respectively. The processed seeds were subjected to quantitative estimation for Azadirachtin (by Amity University, Noida) and oil content (by respective institute). The results from the first-year collection indicates Azadirachtin content ranging from 4643.45 PPM and 12.84 PPM. Second year results indicates highest Aza content of 6914.425 PPM and lowest of 39.37 PPM. These initial results indicate trees from Agroclimatic zones 10 (Southern Plateau & Hills) and 11 (East Coast Plains & Hills), both from Southern India to be having higher azadirachtin content. However only the 3-year data analysis will lead to conclusive recommendations and identification of best CPTs and agroclimatic zones. The second year (2023) fruit collection has also been successfully completed by all 6 institutes and the seeds are being processed and dispatched for Azadirachtin quantification currently.
- For the second consecutive year, seeds were collected from 929 seed sources from the 9 different agroclimatic zones during the fruiting period (June-July) in the year 2023. The seeds were processed as per the standard SOP that includes de-pulping, drying followed by the estimation of Azadirachtin using HPLC and oil estimation. Compared to the data obtained last year, there was found variation in both Azadirachtin and Oil concentration. Total oil content ranged between 16.67% (ACZ-10A) to 66.92% (ACZ-4). Highest Aza content was reported from zone10B that was 6914.42 ppm and lowest 39.37ppm were reported from zone4. Results indicate that the maximum Azadirachtin content was found in the seed sources of agroclimatic zone 10 B and 10 A both from the southern part of India.
- The information on flowering and fruiting phases was recorded in different accessions of Neem. Data was recorded on different pheno-phases such as leaf fall, leaf fleshing, initiation of flowering, peak-flowering, and initiation of fruit. Data on flower visitors, morphometric data of Neem flower, time of anthesis, breeding system and palynology were collected. The occurrence of natural pollination both by wind and insects indicates ambophily in Neem. Insect pollinators were predominantly represented by Hymenoptera and Lepidoptera. Apis spp. are the most effective pollinators.
- Gene transfer protocol for neem has been standardized using *Agrobacterium tumefaciens.* Genetically transformed cell lines were further sub-cultured as callus. Genetically transformed cell lines (both single transformed callus having *glyIII* gene as well as double transformed calli with *cdh* gene) were further maintained in active growth state through repetitive sub-culturing. Fresh Co-cultivation experiments were conducted using *Agrobacterium tumefaciens* harboring plasmid with *Choline dehydrogenase* (*cdh*) gene. Putative double gene transformed cultures are growing well and are being maintained by regular sub-culturing. Putative transformed in *vitro* shoots with *glyIII* gene inserted developed roots on the half MS supplemented with auxin treatment. *Gus*-histochemical assays were repeated on microshoots giving positive results with appearance of blue coloration.
- Callus initiated from various explants like flowers, leaf and embryos in fifteen different media combinations were maintained. Flower and leaf callus were transferred to suspension cultures and were maintained. Aza estimation was done by colorimetric method and through HPLC. Highest Aza content was highest in flower callus cell line followed by leaf. To increase the azadirachtin in cell lines elicitor treatments were given and the accumulation has been estimated. RNA was isolated from one month old flower callus, leaf callus and seed samples Transcriptome analysis is being done for identification of genes involved in azadirachtin pathway.

27. All India coordinated research project on "Conservation and sustainable management of wild edible fruiting species"

27.1 Objectives:

- To study the distribution pattern, natural regeneration and ethno-botanical uses of selected wild edible fruiting species . To identify superior plants of selected wild edible fruiting species based on fruit production and quality and physical parameters of plant. To standardize the techniques of propagation through seeds and vegetative parts for mass multiplication
- To standardize potting media, irrigation schedule, shade and fertilizer requirements for production of Quality Planting Stock of selected wild edible fruiting species
- To conserve the selected germplasm as seeds and by vegetative meansTo study the factors affecting sustenance of the species in natural habitat.
- To Study the performance of the germplasm at different locations. To produce value added products from wild fruits . Extension of the technology for livelihood support

27.2 Progress:

At ICFRE-TFRI, Jabalpur, phyto-sociological and ethnobotanical research was conducted on *Semecarpus anacardium* and *Flacourtia indica* across forty sites in central India. Observations revealed that both species are now found only in scattered populations (1-3 trees per location) within the central Indian forests due to the overexploitation of *Semecarpus anacardium* fruits and seeds, and declining populations of Flacourtia indica due to cattle browsing. Ethnobotanical data highlighted the high value of both species, not only for their wild fruits but also for medicinal purposes, emphasizing the urgent need for their conservation. Fifty superior trees of both *Semecarpus anacardium* and *Flacourtia indica* were identified in Madhya Pradesh, Maharashtra, and Chhattisgarh based on fruit, seed, and plant characteristics. Additionally, the identification of superior trees was primarily based on physical characteristics due to the lack of fruit availability for yield comparison and the overexploitation of existing plants for local tribal needs.

Standardization of seed ecophysiology, germination, pretreatment, and nursery protocols was achieved for both species. While vegetative propagation methods showed limited success, seed-based propagation emerged as the most viable option. Maturity indicators utilizing fruit and seed color were developed, and seed germplasm conservation protocols are currently under investigation. Multi-location trials involving seed germplasm from twenty-five selected superior trees of each species were established at three locations in central India. While *Flacourtia indica* showed good survival rates, *Semecarpus anacardium* exhibited poor survival due to various biotic and abiotic factors. Various products including Sweet candy, Orange pickle and Green pickle were prepared from *Semecarpus anacardium,* with ongoing nutritional analysis at an NABL accredited laboratory.

ICFRE-FRI, Dehradun surveyed regions (Forest Divisions): surveyed forest Divisions of Uttarakhand, Punjab, Haryana and UP and Ripe fruits of *Ficus palmata* and *Pyrus pashia* were collected. Ethnobotanical survey was done from forest fringe villages of the surveyes forest Divisions. No. of Quadrats laid for survey: Uttarakhand (290) + Punjab (40) + Haryana (90)+ Uttar Pradesh (50) No. of product prepared: 08 from both the fruits. Products are being tested for their shelf life. Identified 50 *Pyrus pashia* and 29 *Ficus palmata* superior trees. No. of trials for vegetative propagation: Three potting mixtures and three net shades have been tried. Three treatments 1. Without hormones, 2. With IBA 3000 ppm & 8000 ppm (trial) 3. With IBA 6000 ppm 4.NAA 3000 ppm & 6000 ppm has been tried. Natural regeneration data analysis for *Pyrus pashia* and Ficus palmata in Punjab and Haryana was done and data was represented graphically.

Experiments to standardize propagation techniques, potting media, irrigation schedules, shade, and fertilizer requirements for the production of quality planting stock of the selected wild edible fruit species have been conducted. Propagation of species by air layering is being studied. Nutritional Analysis of fruits: TSS , Moisture %, Total Ash %, ,Crude fibre and Crude fat , Vitamin-C for *Pyrus pashia* fruits and Ficus palmata fruits has been done. Germplasm has been established at 4 sites (2 each species). Papers have been published in journals and presented in international conference and a brochure on *Pyrus pashia* has been prepared.

ICFRE-HFRI, Shimla: Surveyed and selected 26 sites for *Myrica esculenta* and 21 sites for Prunus cornuta in Kullu, Mandi, Chamba, Kinnaur, Sirmaur and Shimla districts of Himachal Pradesh and Kathua district of Jammu. Morphological and physical characteristics of the tree were recorded, and superior trees (52 superior plants of *M. esculenta* and 42 trees of Prunus cornuta) were marked. Collected fruits were processed in the laboratory to record physical parameters like fruit shape and size, seed size, seed weight, pulp to seed ratio etc. Nutritional analysis of *P. cornuta* and *Myrica esculenta* fruits were done for Carbohydrate, Protein and Crude fat. Moisture content of the seeds was also analysed. In case of *Prunus cornuta* maximum Carbohydrate content is found in fruits collected from Rupi (6.54%), protein in Kufri (3.88%), Crude fat in Rakchham (5.4%). For *Myrica esculenta* Pulp to seed found maximum in Kotmorus ST1 (3.39) and minimum in FRF Tandula site (1.53). Crude fat content recorded maximum in Majhgaon ST1 (5.26%). For potting media trials in *Myrica esculenta* maximum survival rate percentage (95%) recorded in T2 (50% Sand + 50% soil). Air layering grafting of *Myrica esculenta* with 3 treatments (T1: Soil treatment, T2: Fresh cow dung, T3: Soil+ Aloe vera) was done at Shilly forest Solan. Best rooting recorded in T3 treatment. Laid laboratory seed germination trials of Prunus cornuta with different chemical treatments i.e. GA3 500ppm, 1000 ppm, SNP 5mM, 10mM, and cold stratification of seven and fourteen days. The air layering rooted grafts transplanted in poly bags at FRS Shilly Solan and survival data is being motored at regular intervals. Seed Storage viability data recorded for the seeds stores at 5 degree Celsius after 3, 6, 9 and 12 months of storage. Prepared a review manuscript and published two articles on *Myrica esculenta* and on P. cornuta in magazines.

Fig. 39. Source wise sedlings trial of Myrica esculenta in poly bags at Model Nursery Baragaon Shimla

ICFRE-IFGTB, Coimbatore: Surveyed and identified populations of *L. acidissima* in Sivagangai, Ariyalur, Theni, Krishnagiri, Thiruvarur, Pudukottai, Mayladuthurai, Tiruppur, Erode, Coimbatore, Salem, Thanjavur, Tenkasi, Tiruvannamalai, Tirunelveli, Virudhunagar, Madurai, Perambalur, Trichy, Dindigul, Dharmapuri, Tiruvallur, Ranipet, Kanchipuram, Vellore, Kallakurichi, Karur, Tirupattur & Palakkad (29 populations). Surveyed and identified populations of *P. dulce* in Coimbatore, Erode, Salem, Dharmapuri, Thiruvannamalai, Tirupur, Madurai, Virudhunagar, Pudukottai, Tenkasi, Tirunelveli, Tiruvallur, Vellore, Dindigul, Kallakurichi, Thanjavur, Mayladuthurai, Nagapattinam, Tiruvarur, Trichy, Karur, Krishnagiri, Theni, Kanyakumari, Viluppuram, Ariyalur, Perambalur, Ramanathapuram, Thuthukudi, Namakkal & Palakkad (31 populations). Regeneration studies were done15 Districts). Conducted the Ethno botanical survey at forest fringe villages. Arrived at CPT selection criteria for *Limonia acidissima* (GBH 80-100 cm, 50 fruits/crown quarter) and *Pithecellobium dulce* CPTs (GBH 80-250 cm , 100 fruits/crown

quarter) based on fruit yield. Selected 242 CPTs of *Limonia acidissima* and recorded tree passport data, geo-coordinates of the CPTs. Selected 163 CPTs of *Pithecellobium dulce* and recorded tree passport data, geo-coordinates of the CPTs. Collected fruits, processed, standardized and carried out fruit and seed morphometric characterization through image analysis for 40 CPTs of *L. acidissima* and 50 CPTs of *P. dulce.* Fruit quality for taste, sweetness, colour, aroma, nutrients such as total fibre, total Carbohydrates, ascorbic acid and Total Soluble Solids for *L. acidissima* and *P. dulce*. Analysis of Nutritional parameters were done for 40 CPT's of *L. acidissima* and 50 CPTs of *P. dulce.* Seed germination studies in *Limonia acidissima* on fresh seeds (MC 5-7%). No pretreatment was required. Carried out seed germination studies in *Pithecellobium dulce* on fresh seeds at 54.4% moisture content. Completed the standardization of requirements for quality planting stock production for Limonia and Pithecellobium. Effect of Bag size, potting mixture, sowing depth, germ. temperature, container type, effect of shade were completed. In Limonia carried out Air layering but did not give positive result. Grafting experiment was repeated but only 17.5% success was obtained, but their survival rate after one month was negligible. Hence seed propagation has been concluded to be the suitable method. Rooting of stem cuttings of *Pithecellobium dulce* showed that 5-7mm diameter thick apical stem cuttings are suitable for vegetative propagation than 8-10 mm of stem cuttings. In Pithecellobium control resulted in better rooting than different concentrations and combination of growth regulators by powder dip method. Liquid dip was not successful. Air layering was also successful in Pithecellobium giving 65% rooting. The survival after one month was also good (96%)on hardening. Wedge Grafting of *Pithecellobium dulce* gave 27.5% result and survival after one month was 90%.Standardization of requirements for quality planting stock production for Limonia and Pithecellobium was carried out. Effect of Bag size, potting mixture, sowing depth, germ. temperature, container type, effect of shade were completed. Recorded growth data and calculated the germination percentage, Seed Vigor Index and sturdiness quotientIn *P.dulce* at 45% seed moisture germination was 92.5% which drastically declined at 10% MC to 55% viability and further reduced at 5% MC indicating it as a shortlived seed.Limonia seeds stored at room temp., 20º C, -20 º C , 8 º C, -80 º C were tested for viability at regular intervals upto 12 months and all are found to show good viability with room temperature giving 69% viability and highest at -20 º C recording 90% viability. Raised CPT-wise seedlings of *P. dulce* for 50 CPTs and Limonia for 40 CPTs and hardened. Totally *Limonia acidissima.*- 1960 seedlings and *Pithecellobium dulce* - 3010 seedlings have been transplanted and being hardened. At the different study areas recorded factors such as temperature, rainfall, anthropogenic activities, other biotic and abiotic factors on sustenance of the study species. Effect of Shade, weed and soil on germination and seedling growth was completed for *Limonia acidissima* and *Pithecellobium dulce*. Completed fruit maturity studies in *P. dulce.* Pink fruits recorded highest germination of 92.5% while greenish pink showed 67.5% and green fruits recorded 50% germination. Fruit maturity studies in *L. acidissima* showed that fruits fallen from the tree recorded higher germination (77.5%) than those harvested from the trees (42%). Successfully established germplasm bank of Pithecellobium dulce in at Panampally (0.25 ha) , Neyveli (0.5ha), Gudalur (0.4 ha). Established germplasm bank of *Limonia acidissima* at Panampally (0.1 ha), Kurumbapatti (0.3 ha) and at Gudalur (0.3 ha).

Fig.40. Establishment of *Pithecellobium dulce* germplasm at Kurumbapatti, Salem

Fig. 41. Establishment of *Pithecellobium dulce* germplasm at Kurumbapatti, Salem

Fig. 42. Pithecellobium dulce germplasm establishment at Neyveli

Fig. 43. Pithecellobium dulce germplasm establishment at Neyveli

ICFRE-RFRI, Jorhat: A comprehensive survey across various regions of Assam examined the distribution and regeneration potential of *Spondias pinnata* and *Prunus jenkinsii.* The survey extended to villages in Dhemaji, Kakoi RF, Majuli, and Namsai, Arunachal Pradesh, as well as homestead gardens in Golaghat district and Namsai. It involved assessing 15 plots (10m x 10m) in each RF/WLS and collecting ethno-botanical data from 12 fringe villages in Cachar district, Assam, and Namsai, Arunachal Pradesh. Population and regeneration data from 40 quadrats across eight different study sites were analyzed, revealing varying regeneration potentials. Ecological data showcased diverse densities and IVI values across regions. Surveys in Sivasagar and Choraideo districts involved collecting fruits, cuttings, and saplings of both species, with seeds sown in nursery beds and some kept in seed germinators for further study. Ethnobotanical uses were documented, with *Spondias pinnata* fruits utilized fresh or processed into jams and pickles, and *Prunus jenkinsii* fruits consumed similarly or processed into jams/jellies. *Prunus jenkinsii* tender shoots were employed for dye preparation. Fifty *Spondias pinnata* cuttings, 3-5 cm in diameter, treated with varying hormone concentrations (100/200/500 ppm of IAA/IBA/NAA), showed highest survival (80%) with IBA at 200 ppm after two months. In a separate experiment, IBA at 600 ppm resulted in 100% survival. A 1:1:1 mixture of forest topsoil, dry cow dung, and coarse sand proved effective for propagation.

Furthermore, 47 genetic resources of *S. pinnata* and 18 of *P. jenkinsi*i were identified, and 10 superior plants were selected based on physical parameters. Trials were conducted for cuttings and air layering, yielding maximum survival rates. Additionally, hormone treatment experiments and nursery propagation techniques were explored, demonstrating effective results for both species. Transplantation and plantation efforts were carried out at RFRI campus, recording year-wise growth and high survival rates. A total of 1500 planting materials of *S. pinnata* and 1000 of

P. jenkinsii were developed by seeds, with an additional 400 and 200 respectively by cutting and air layering. Overall, this initiative significantly contributes to the conservation and propagation of these valuable plant species in the region

ICFRE-IFP, Ranchi: Survey in forest areas and villages markets of Ranchi, Dumka, Simdega, Ramgarh, West Singhbhum, Godda, Hazaribagh, Khunti, Deoghar, Gumla, East Singhbhum, Palamu, Garhwa, Pakur, Sahibganj, Lohardaga, Latehar and Saraikela Kharsawan districts have been done and documented wild fruits found in the region. Identification of 65 wild edible fruits and information on their botanical description, habitat, importance and their use by ethnic groups have been recorded through framed questionnaire after discussions with villagers/farmers. Information on list of species present and the dominant species have been documented. Frequency, abundance and density of the recorded sample and calculation of Shannon index and IVI of recorded data is being done.

Dominant species found in forest areas are *Diospyros melanoxylon*, *Buchnania Lanzan*, *Schleichera oleosa*, *Semecarpus anacardium*, *Aegle marmelos*, *Solanum torvum*, *Artocarpus heterophyllus*, *Syzygium cumini*, *Madhuca indica*, *Ziziphus mauritiana*, *Tamarindus indica*, *Solanum nigrum*, *Mangifera indica*, *Coccinia grandis*, *Momordica charantia*, *Phoenix sylvestris, Woodfordia fruticose and Carissa spinarum.* Presence of 13 wild edible fruit species is found less in the forests as per population of the species observed during quadrat sampling. 72 no. of village markets have been surveyed dealing with sale and purchase of wild edible fruits in 51 blocks. 28 wild edible fruit species are found to be sold in village markets. Wild edible fruits sold in village markets are *Tamarindus indica, Madhuca indica, Solanum torvum, Semecarpus anacardium, Diospyros melanoxylon, Spondias pinnata, Buchnania lanzan, Mangifera indica, Aegle marmelos, Artocarpus heterophyllus, Syzygium cumini*, *Ziziphus mauritiana, Momordica charantia, Phoenix sylvestris, Terminalia bellerica, Terminalia chebula, Phyllanthus emblica, Momordica dioica, Borassus flabellifer, Coccinia grandis, Shorea robusta, Ficus racemosa, Schleichera oleosa, Psidim guajava, Carissa spinarum, Tamilnadia uliginosa, Morus alba.* Wild edible fruits that dominate the market in sale are *Tamarindus indica, Semecarpus anacardium, Diospyros melanoxylon, Buchnania lanzan* and *Madhuca indica.* Market location, Market rates, amount collected, amount sold, amount consumed and duration of collection of wild edible fruits have been documented. Geotagged information has been documented. Distribution map of documented 72 village markets dealing with sale of wild edible fruits has been prepared. KML file of recorded data has been prepared.

Highlights

- Completed seed germination studies in *Semecarpus anacardium, Limonia acidissima* and *Pithecellobium dulce.* Completed fruit maturity studies in *Pithecellobium dulce* and *L. acidissima*. In vegetative propagation studies stem cutting of *Flacourtian indica* pre-treated with 1000 ppm IBA produced maximum shoot and root and (Girth of 0.4-0.5cm) was suitable for rooting. In *Semecarpus anacardium* air-layering was found suitable. Rooting studies on *Pithecellobium dulce* showed that 5-7mm diameter thick stem cuttings are suitable for vegetative propagation than 8-10 mm of stem cuttings. Air layering experiment of *Myrica esculenta* showed very good results.
- Progeny and plantation trail of *Semecarpus anacardium* and *Flacourtia indica* was carried out at three locations i.e. at ICFRE-TFRI, Jabalpur (MP); Guru Ghasidas University, Bilaspur (CG) and FRC-SD, Chhindwara (MP). Established germplasm bank of *Pithecellobium dulce* in at Panampally (0.25 ha), Neyveli (0.5ha), Gudalur (0.4 ha) and germplasm bank of *Limonia acidissima* at Panampally (0.1 ha), Kurumbapatti (0.3 ha) and at Gudalur (0.3 ha). Germplasm bank of *Ficus palmata* established at Tehri Forest Division and Mussoorie Forest Division while, germplasm bank of superior trees of *Pyrus pashia* established at Tehri Forest Division and Chakrata Forest Division.
- Prepared value added product (20 Nos) (Karonda chips, Energy drink, Karonda Powder, Khatmithgoli, Karonda Candy, Karonda Pickle, Cherry Karonda, Honey Spread and Iron Capsule from *Carissa carandas*; Molu candy, Molu Jam, Molu pickle, Molu Murabba, from *Pyrus pashia and* Himalyan Fig Jam, Himalyan Fig Candy, Dried Himalayan Fig, Fig Squash from *Ficus palmate*; Sweet candy, Orange pickle and Green pickle from *Semecarpus anacardium*) from various wild edible fruiting species

28: All India coordinated research project on "Population status, collection, characterization and evaluation of genetic resources of Indian Rosewood, *Dalbergia latifolia*"

28.1 Objectives:

- Undertake studies on population structure and natural regeneration in different forest areas.
- Selection of superior trees from identified populations.
- Clonal propagation of identified superior trees and establishing of Field Gene Bank (FGB).
- Characterization and evaluation of the clones. Undertake studies on reproductive biology.
- Seed collection, establishment of germplasm banks and progeny trials.
- Quantify genetic variation in different populations and creating baseline data on diversity.
- Understanding mating / breeding systems in different populations using molecular markers.
- Undertake research on seed technology, Silvicultural practices, nursery and plantation techniques, root inhabiting microsymbionts as well as harvesting and selling of timber.
- Develop agro-forestry models with *D.latifolia* as tree component.
- Monitor insect pests and diseases of nurseries and plantations and develop suitable management practices.
- Identification of bioactive principles from *D.latifolia*.

28.2 Progress:

Thorough field surveys were conducted in Karnataka, Kerala, Tamil Nadu, Madhya Pradesh, Jharkhand, Uttarakhand, Uttar Pradesh, and Punjab, to study population structure, and regeneration pattern. Recorded associated species, phenology information, and Lat-long Data. Using 653 survey locations prepared distribution map for *D. latifolia*. Identified and selected 596 Plus Trees across India. Recorded morphometric data. Collected seeds from identified plus trees were shared among different institutes and raised seedlings. Established multi-locational progeny trials *cum* germplasm banks in 12 locations in India using Random Block Design (RBD). [Chandwa, Latehar (Jharkhand), Mohabata Chapra, East Champaran (Bihar), Jabalpur (2 trials) (Madhya Pradesh), Madahalli and Yenekallu (Karnataka), ICFRE-FRI Dehradun (Uttarakhand), Simariya Pachimi Block, Jhansi (Uttar Pradesh), and Central University of Punjab, Bhatinda (Punjab). Further maintenance of established field germplasm banks has been carried out at each location. Population surveys in Purulia, Banpura, and West Midnapur (West Bengal) revealed that there was no *D. latifolia* and it was *D. lanceolaria* populations. Clonal propagation protocol of *D. latifolia* was standardized from root cuttings. DNA isolation protocol was standardized for *D. latifolia.* 223 SSR markers are being synthesized. Polymorphic SSR markers will be selected to quantify genetic variation in different populations as well as to understand mating/breeding systems in different populations. Studied reproductive biology and pollinator diversity of *D. latifolia*.

Qualitative and Quantitative tests for flavonoids are done with *D. latifolia* leaf, bark, and hardwood (root). Isolation of bioactive flavonoid compounds is being carried out with *In-vitro* antioxidant and anti-cancerous tests. Diseases surveys were conducted on *D. latifolia* in different state's natural forests, plantations, and nurseries. Leaf symptoms included blighted leaf margins, brown to ashy brown, and circular to irregular spots. The major species identified were *Colletotrichum* sp., *Fusarium* sp., *Alternaria* sp., and *Pestalotiopsis* sp. A total of twenty-two insect

species of different groups have been observed and fourteen were categorized as defoliators and eight as sapsuckers**.** Seasonal incidence of all the 22 insects-pest were recorded. Identified and reported infestation of *Euplatyplus paralellus* (pin-hole borer) on living trees of *D. latifolia.* It is a first report in India and elsewhere. Identified associated fungi as *Fusarium oxysporum* which was found to cause wilt, loss of leaves, etc. Suggested control measures.

Fig: 44 Establishment of progeny trail of Dalbergia latifolia at Madahali

Fig: 45 Establishment of progeny trail of Dalbergia latifolia at Yenekal

Highlights

- Through field surveys in Karnataka, Kerala, Tamil Nadu, Madhya Pradesh, Jharkhand, Uttarakhand, Uttar Pradesh and Punjab, studied population structure, and regeneration pattern. Recorded associated species, phenology information, and Lat-long Data.
- Using 653 survey locations information prepared PAN India distribution map for *D. latifolia*.
- Identified and selected 596 Plus Trees across India. Recorded morphometric data- tree height, clear bole, pod, and seeds length, width, and weight. Collected seeds from identified plus trees were shared among different institutes and raised seedlings. Seedlings were used to establish progeny trials and also distributed to farmers/stakeholders.
- Established multi-locational progeny trials *cum* germplasm banks in 12 locations in PAN India using Randomized Block Design (RBD). [Chandwa, Latehar (Jharkhand), Mohabata Chapra, East Champaran (Bihar), Jabalpur (Madhya Pradesh), Bilaspur (Chhattisgarh), Dehradun (Uttarakhand), Simariya Pachimi Block, Jhansi (Uttar Pradesh), Central University of Punjab, Bhatinda (Punjab), Madahalli and Yenekallu (Karnataka). Further maintenance of established field germplasm banks has been carried out at each locations.
- Population surveys in Purulia, Banpura, and West Midnapur (West Bengal) revealed that there was no *Dalbergia latifolia* and it was *D. lanceolaria* populations. Clonal propagation protocol of *D. latifolia* was standardized from root cuttings. DNA isolation protocol was standardized for *D. latifolia.* 223 SSR markers are being synthesized. Polymorphic SSR markers will be selected to quantify genetic variation in different populations as well as to understand mating/breeding systems in different populations.
- Studied reproductive biology and pollinator diversity of *D. latifolia*. *D. latifolia* was found to be cross-pollinated and honey bees were the major pollinators.
- Qualitative and Quantitative tests for flavonoids are done with *D. latifolia* leaf, bark, and hardwood (root). Isolation of bioactive flavonoid compounds is being carried out with *In-vitro* antioxidant and anti-cancerous tests.
- Diseases surveys were conducted on *D. latifolia* in different state's natural forests, plantations, and nurseries. Leaf symptoms included blighted leaf margins, brown to ashy brown, and circular to irregular spots. The major species identified were *Colletotrichum* sp., *Fusarium* sp., *Alternaria* sp., and *Pestalotiopsis* sp.
- A total of twenty-two insect species of different groups have been observed and fourteen were categorized as defoliators and eight as sap-suckers**.** Seasonal incidence of all the 22 insects-pests was recorded. Sap-sucker were recorded as: *Psyllidae*, *Drosicha stebbingi*, *Myzus persicae*, brown marmorated stink bug *Halyomorpha halys, Leptocentrus taurus, Leptocorisa* sp*., Ricania speculum,* and Leaf footed bug. Defoliator insect species were recorded as: *Orgyia postica, Somena scintillanus, Trypanophora semihyalina Hyposidra talaca, Plecoptera reflexa, Ectropis bhurmitra, Apoderus crenatus*, *Acrocoelopus cretaceous, Chrysochus cobaltinus*, *Gastrophysa viridula, Olene inclusa, Orgyia postica,* and *Somena scintillanus.*
- Identified and reported infestation of *Euplatyplus paralellus* (pin-head borer) on living trees of *D. latifolia* from a 5-year-old plantation at Chitradurga, Karnataka. It was a first report from India and elsewhere. Further, identified associated fungi as *Fusarium oxysporum,* which was found to cause wilt, loss of leaves, etc. Suggested the control measures. The infection by pin-head borer may seriously threaten the Indian rosewood.

29. All India coordinated research project on "Sustainable management of NTFP's through conservation and value addition"

29.1 Objectives:

- To identify superior germplasm of NTFPs yielding species
- To standardize and domestication of package of practices
- To standardize sustainable harvesting techniques of NTFPs
- To document Indigenous Traditional Knowledge(ITKs) on medicinal formulations used for treatment of different chronic diseases in different regions
- To standardize post harvesting process and value addition techniques of NTFP's for providing sustainable livelihood. To develop value chain. Capacity building of different stakeholders

29.2 Progress:

Objective-I To identify superior germplasm of NTFPs yielding species

Surveyed and collected germplasm of *Curcuma angustifolia* (Tikhur) and *Sapindus laurifolius* (ritha) from Maharashtra and Madhya Pradesh. Saponin glycoside contents (26.5-49.5%) was estimated in germplasm of *Sapindus laurifolius* (10 locations). **(FRC-SD, Chhindwara)**. Assessed quality (phenol , flavonoid, tannin and alkaloid content) of *Eclipta alba, Averrohea carambola, Acacia concinna, Miliusa tomentosa* fruits. Saponin content was estimated in *Acacia concinna*. **(AFRI).** *Shorea tumbuggaia* barks from two population (from 8 trees) were collected from Talakona forest area and Tirumala Forest area of Tirupati division of AP. 5 germplasm of *C. speciosus and G. superba* from Odisha **(IFB).** Conducted field survey and collected GPS data for 9 populations of *Costus speciosus,* 5 for *Aporosa octandra,* 1 for *Hydnocarpus kurzii*, were collected from Golaghat, Nagaon, Karbi Anglong dist of Assam. Superior germplasm of *H.kurzii* was identified based on quality and quantity of active chemical ingredient from fatty oil of seeds.

Fig. 46. Seedlings of CPTs of *Mesua ferrea being Maintained at Udai Singh Jote, Nursery, Sukna*

Percentage dye yield estimated for total 25 samples of different germplasm from Bark and Leaves of *A.octandra* using optimized standard protocol of extraction*.* The superior germplasm of high quantity yield of dye identified form *A. Octandra.* Total phenol and flavonoid contents were determined in collected germplasm of *Tacca integriofolia* and *Costus speciosus* to identify superior germplasm. **(RFRI).** Maintained the established field gene bank of *Taxus wallichiana*, *Thymus serpyllum, Rheum australe* and *Aconitum heterophyllum* at FRS Shillaru (Shimla) and FRS Brundhar (Kullu) and recorded the survival and morphological data periodically. GC-MS screening of fresh leaf samples and powdered dried leaf samples of *Thymus serpyllum* essential oil was done. Taxol content was estimated in 19 samples of *Taxus wallichiana* leaf and bark. Maximum taxol content was seen in the samples collected from Ranikot (Chamba) in both bark (2.252µg/100 mg) and leaf (2.297µg/100 mg). Minimum taxol content in leafwas seen in the samples from Bashleu (1.092µg/100 mg) and in the barkit

was seen in the samples from Chhoth kanda (1.282µg/100 mg) **(HFRI).** Seedlings from CPTs of *Oroxylum indicum*, *Mesua ferrea* and *Dellinia indica* were maintained in the nursery . Phytochemical analysis of different plant parts of *Dillinia indica* (leaf, stem), *Paederia scandens* (leaf, stem), *Mesua ferrea* (leaf, stem, bark) and *Oroxylum indicum* (leaf, stem, bark) were carried out. **(IFP).** Collected germplasm were extracted for GCMS and HPLC analysis **(FRI)**

Objective-II To standardize and domestication of package of practices

Domestication trials of *Aconitum heterophyllum* rhizomes and *Taxus wallichiana* were conducted with different spacing treatments at Shillaru, Shimla and Jagatsukh, Manali, respectively. Established seed germination trials of *A. heterophyllum* in sand at lab conditions. Cold stratification (5°C) was given for 20, 30, 50 and 70 days. **(HFRI).** Prepared fields for raising quality planting stocks (QPM) of *U. picta* for domestication at farmer's fields. **(TFRI).** Experiments were laid out for standardization of propagation protocol for *Sapindus laurifolius* and *Curcuma angustifolia.* Total 1200 seedlings were raised from the best germplasm, Chhindwara source and distributed (100 Seedlings) to farmers and other stakeholders. **(FRC-SD, Chhindwara).** Conducted propagation trails of *Miliusa tomentosa, Averrohea carambola and Acacia concinna.* **(AFRI).** Conducted propagation trails of *Diploknema butyreacea, Dioscorea deltoidea* and *Desmodium* gangeticum **(FRI).** Propagation experiments were laid out for *Aporosa octandra, Hydnocarpus kurzii,* through stem cuttings in three (3) different growth media with 3 rooting hormones IAA, NAA, IBA with 3 different treatments (200, 300, 500, 800, 1000ppm) at RFRI campus Jorhat. **(RFRI)**

Objective-III To standardize sustainable harvesting techniques of NTFPs

- Documented the harvesting methods of NTFPs *Picrorhiza kurroa* and *Pinus gerardiana* (Kanom village of Kinnaur district in Himachal Pradesh) **(HFRI),** *Myrica esculenta (Kafal), Valeriana jatamansi (Tagar,* Tehri and Chakrata Forest Divisions **(FRI),** *Hyptis suaveolens, Butea monosperma* and *Cassia tora* in M.P. , M.H. and C.G. **(FRC-SD),** Nux-vomica from Nagarkunool district, Telangana, *Decalepis hamiltonii* from Tirupati **(IFB),** *Costus speciosus,Dillenia indica, Schumannianthus dichotomus*, *Phryniumcapitatum* **(RFRI)**
- Experiments were carried out for standardization of sustainable harvesting of NTFPs yielding species *A. paniculata* , *T.chebula,* S. *anacardium, C. fistula, O. indicum* , *W. tinctoria, H. isora, D. gangeticum* and *Curculigo orchioides* **(TFRI),** *Averrohea carambola* and *Phyllanthus acidus* **(AFRI),** Nux-vomica and *Decalepis hamiltonii* **(IFB),** *Dillenia indica, Livistona jenkinsiana, Aporosa octendra* and *Thysanoleana latifolia* **(RFRI).**

Objective-IV To document Indigenous Traditional Knowledge (ITKs) on medicinal formulations used for treatment of different chronic diseases in different regions.

Ethno-medicinal knowledge on 4 major disease -Cardiovascular, Arthritis , Bronchitis, Diabetes and other diseases were collected by all institutes.

Objective-V To standardize post harvesting process and value addition techniques of NTFP's for providing sustainable livelihood

Experiments were undertaken for standardization of processing and value addition of *Dillenia indica, Garcinia pedunculata, H. kurzii, Pheobe coperiana* barks of *Aporosa octandra,* rhizome of *costuss peciosus, Livistona jenkinsiana* and *Tacca integrifolia* **(RFRI),** *Balanites aegyptiaca, Phyllanthus acidu, Butea monosperma* and *Averrohea carambola* **(AFRI),** *Sapindus laurifolius***(FRC-SD),** *Strychnos nuxvomica* , *Terminalia bellerica fruit* ,*Decalepis hamiltonii* **(IFB).** A low cost solar dryer was developed to domesticate in interior rural areas for processing of NTFPs/ medicinal plants. Prepared value added products from *Feronia limonia* (Murraba and pickle), *Tamarindus indica* (Squash) **(AFRI)** *Madhuca longifolia* (Jaggary) and sugar-free candy **(IFP)**. Butter, lip balm, mosquito-repellant incense sticks prepared from *Diploknema butyreacea*

cake/residue and additives **(FRI)**. Herbal anti-inflammatory wound healing cream, herbal toothpaste were developed complied as per BIS 6608 : 2004 specifications and tested parameters viz. pH, thermal stability, total fatty substance content, total residue and heavy metals content **(FRC-SD).** A shampoo is prepared from *Dillenia indica* seed pulp along with other herbal constituents, determination of shelf life, toxicity test under process and natural dye is prepared from bark of *Aporosaoctendra.* **(RFRI).** Collected the samples of *Hedychium spicatum* rhizomes, dried and powdered for the preparation of wound healing cream. Various tests/trials were conducted to prepare the herbal cream with different proportions of ingredients. **(HFRI).**

Objective-VI To develop value chain

Quality of marketed samples of *Podophyllum hexandrum* (22.717mg GAE/g) and*Fritillaria roylei* (9.88 mg GAE/g) **(HFRI).** Six different market places of M.P. and were visited and major NTFPs high in demand viz. *Sapindus laurifolius* (Ritha), *Tinospora cordifolia, Gymnema sylvestre, Moringa oleifera, Cassia tora, Withania somnifera, Butea monosperma flowers, Andrographis paniculata,, Curculigo orchiodes* were collected, processed and assessed quality. *Curcuma angustifolia* (Tikhur) starch samples collected from different sources viz. market and SHGs from MS, CG and MP were analyzed for their physico-chemical parameters. **(FRC-SD).** Nutritional evaluation of marketed samples of fruits of *Annona squamosa*, *Ziziphus mauritiana*, *Ziziphus numularia*, *Syzygium cummuni*, *Manilkara hexandra, Cucumis melo, Citrullus lanatus*, *Prosopis cineraria* ,*Cassia tora*, *Cordia dichotoma*, *Phyllanthus acidus* , *Aegle marmelos* (Bael) and *Annona squamosa. Samples of* NTFPs- *Sterculia* gum*, Terminellia chebula, Terminellia bellerica, Cassia tora seeds, Emblica officinalis*, *Tamarindus indica*, *Asparagus racemosus were*collected from Surat, GSFDC, Vadodara and GSFDC Dhanvantri Kendra, Rajpipla **(AFRI).** Collected samples of *Phoebe cooperiana, Livistona jenkinsiana*,*Garcinia pedunculata, Schumannianthus dichotomus* and *Dillenia indica* from different villages of Assam **(RFRI).**

Market samples from Haridwar, Tanakpur and Ramnagar were analysed for quality parameters-moisture content, extractive values, total ash content (**FRI).** Visited NTFPs markets of Bhadrachalam, Achampet, Narsampet (Telangana), collected samples of *Terminalia chebula* fruit pulp and assessed quality **(IFB).** Information were collected by all institutes from different markets in regions under jurisdiction and documented gaps from collection to consumer.

To develop value chain of the developed products, various stakeholders viz. State Forest Department (SFDs), Chhindwara were identified and approached for developing market linkages of the developed products. Other local herbal industries were also approached and products were displayed to the respective authorities. Registration number **21423210001180** has been received from Govt. of Madhya Pradesh, Food and Drugs Administration, Food Safety and Standards Authority of India (FSSAI) for general manufacturing. Registration certificate and license has been issued on 24.7.2023 and is valid till 23.7.2024.

Target groups viz. Women Self Help groups were identified for dissemination of the technologies developed. Conducted Meeting with District Ayush Officer, Chhindwara for developing Market Linkages of developed Herbal Products. Herbal value added products were displayed to various stakeholders - NABARD Bank officers, farmers, SHGs, women and State rural livelihood mission officers, Chhindwara District during inauguration of Van Vigyaan Kendra, Chhindwara.Technologies developed under the project were also showcased through Van Vigyaan Kendra, Chhindwara **(FRC-SD, Chhindwara).**

Objective-VII Capacity building of different stakeholders

Leaflets in Bilingual prepared for distribution to stakeholders

- Nursery technique for raising seedlings of *Desmodium gangeticum* (Salparni)
- Nursery technique for raising seedlings of*Embeliatsjeriam-cottam*(Roem. & Schult.) A. DC (Baivadang)

- Hari Om Saxena, Ganesh Pawar, Sant Kumar, Dheer Agnihotri and Neelu Singh (2024). Chemical screening, identification of superior germplasm, nursery technique and ex-situ conservation of *Embeliatsjeriam-cottam* (Roem. & Schult.) A. DC. Presented orally/ Abstract published in souvenir of National Seminar on "Frontier Areas of Research in Forest and Wildlife Sciences" held at GGV, Bilaspur, CG on 24th January, 2024, page no. 31 (Paper ID: FORAB29).

- Hari Om Saxena, Samiksha Parihar, Ganesh Pawar, Sant Kumar, Dheer Agnihotri (2024). Chemical screening, identification of superior germplasm, nursery technique and ex-situ conservation of some threatened medicinal plant species of central India. Invited talk/Abstract ppublished in souvenir of National Seminar on "Cultivation, Conservation and Utilization of Medicinal plants in North Bengal" held at Siliguri, West Bengal on 13- 14 March, (2024), page no. 44. **(TFRI)**. Extension material was prepared and displayed in VVK FRC-SD. Awareness programme was conducted on 25.7.2023 for the identified target groups viz. Women Self Help groups of Chhindwara District for dissemination of the technologies developed. Awareness cum –training programme (5 no.) was conducted for aanganwadi workers and SHGs. **(FRC-SD).**
- Published Research paper in Biological Forum – An International Journal title Diploknema butyreacea (Roxb.) H. J. Lam (Chyura): A Viable Livelihood Option for Hill Communities of Uttarakhand. Phamphlets/ brochers on *Dioscorea deltoidea, Diploknema Butyreacea Gentianna Kurroo* and *Desmodium gangeticum* has been prepared. **(FRI)**
- ICFRE-Institute of Forest Biodiversity (ICFRE-IFB), Hyderabad organized a one-day training program on **"Sustainable Management of NTFPs through Conservation and Value addition"** for Forest Officials of Koraput Forest Circle at Wildlife Crime Control & Coordination Centre, RCCF Office, Koraput, Odisha on 23rd January 2024 under **Van Vigyan Kendra (VVK)**. About 55 Forest Officers, BSc. Forestry students and Media of Koraput forest circle participated in the training program. Established germplasm demonstrated to different stakeholders/dignitaries during training programme/visit. **(IFB).** Training programes were conducted **(AFRI)**

Highlights

- Germplasm of 30 species have been collected from 640 locations in different states.08 germplasm banks have been established.
- Assessed quality – morphology and bio-chemicals Phenol, alkaloids, saponin, Flavonoid, Taxol, terpenoid, tannins, Embelin, Diosgenin, Phytostrerol, Diterpene, etc. as per the availability in collected germplasm. Taxol content was estimated in germplasm of *Taxus wallichiana* from 19 locations, maximum taxol contents (bark - 2.252 µg/100 mg and leaf - 2.297 µg/100 mg) was observed in the samples, collected from Ranikot (Chamba). Diosgenin content (0.01 to 0.8%) was estimated in germplasm of *Costus speciosus* (15 locations) rhizomes, highest concentration of diogenin was determined in Alliguda, Mulugu district (Telangana). Saponin glycoside contents (26.5-49.5%) was estimated in germplasm of *Sapindus laurifolius*, collected from Madhya Pradesh and Maharashtra (10 locations).
- The propagation trails (22/27 species) have been standardized for the establishment of different targeted species. A propagation trial of *Rheum australe* was conducted through cold stratification, 66.66% germination was observed after 75 days. Standardized sustainable harvesting protocols of *Casia fistula, Oroxylum indicum, Wrightia tinctoria* barks, roots of *Desmodium gangeticum* and *Curculigo orchioides* and fruits of *Helicteris isora*.
- Harvesting techniques of NTFPs yielding species (45) have been documented. Standardized sustainable harvesting protocols of *Casia fistula, Oroxylum indicum, Wrightia tinctoria* barks, roots of *Desmodium gangeticum* and *Curculigo orchioides* and fruits of *Helicteris isora*.
- Ethno-medicinal knowledge on 4 major disease -Cardiovascular, Arthritis , Bronchitis and Diabetes were collected by different institutes from 294 villages.
- A low cost solar dryer was developed to domesticate in interior areas for processing of NTFPs/ medicinal plants. A natural dye was extracted from bark of *Aporosa octendra.*
- Prepared value added products from *Feronia limonia* (Murraba and pickle), *Tamarindus indica* (Squash) and *Madhuca longifolia* (Jaggary). Mosquito-repellant incense sticks prepared from *Diploknema butyreacea* cake/residue and additives. Herbal anti-inflammatory wound healing cream was developed complied as per BIS 6608 : 2004 specifications and tested parameters viz. pH, thermal stability, total fatty substance content, total residue and heavy metals content. Developed cream was found to be effective for healing skin disease- Eczema**.**
- Marketed samples of different NTFPs (52 species) were collected from different state mandis.Local traders, forest departments, self help group were approached for marketing of the value added products to determine the value chain of NTFPs/value added products.
- FSSAI license with registration number 21423210001180 was obtained on 24.7.2023 by ICFRE-SDC, Chhindwara to develop market linkages. Brand name "एक पहल प्रकृति की ओर" EPPKO for marketing of NTFP products developed under project

30. All India coordinated research project on "*Gmelina arborea* Roxb."

30.1 Objectives:

- To establish Germplasm bank of *G.arborea* and evaluate genetic diversity using morphological and molecular markers.
- To establish and evaluate *G.arborea* based agroforestry systems in the selected regions of India.
- To screen major insect – pest of *G.arborea* and its management in monoculture as well as in agroforestry system .
- In-situ evaluation of wood (density, stiffness, mechanical and physical properties) in standing trees using non-destructive / less invasive tools.
- To develop value chain in *Gmelina* based industrial agroforestry.
- To disseminate package of practices and develop farmer's friendly 'mobile app' for *G.arborea*.

30.2 Progress:

A total of 525 CPTs were identified (315 in Jharkhand, Bihar & West Bengal; 101 in Chhattisgarh; 39 in Maharashtra; and 70 in Madhya Pradesh) under the project. Established 9 progeny trials in selected sites i.e. 02 in Haryana, 01 in Uttar Pradesh, 03 in Jharkhand, 02 in Madhya Pradesh & 01 in Chhattisgarh and 1 clonal trial at TFRI, Jabalpur. Observations on Survival percentage of different progenies have been recorded in established field trials and found 95 - 97 % and growth traits including plant height (ranged from 2.25 m to 3.6 m), Collar Diameter (ranged from 37.5 mm to 51.30 mm) in TFRI. A total of 40 microsatellite markers (SSR primers) have been synthesized by the partner institutes i.e. IFP, Ranchi (20) & IFGTB Coimbatore (20). These primers were amplified with different clones of *G. arborea* for molecular characterization of selected CPTs. 68 accessions were evaluated for genetic diversity assessment by utilizing 20 SSR primer and additional 48 families from Thuvarankurichy trial were collected.

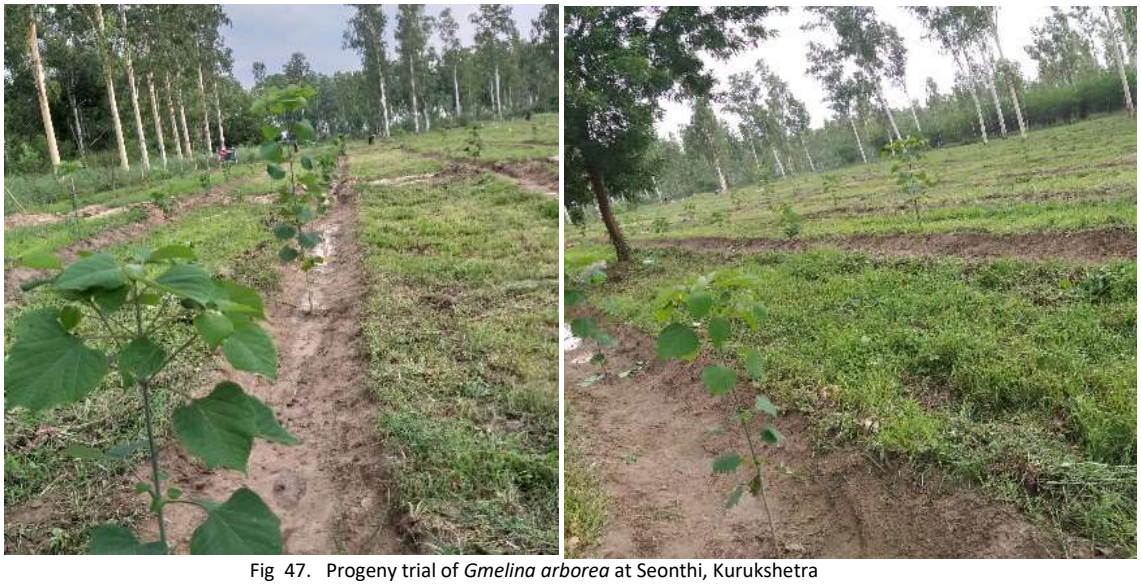


Fig 47. Progeny trial of *Gmelina arborea* at Seonthi, Kurukshetra

DNA isolation protocol has been standardized from 135 CPT at IFP; 48 at IFGTB & 90 at TFRI. 4 CSO were developed by the RFRI, Jorhat. Total of 9 *Gmelina* based Agroforestry system were established and standardized by TFRI, IFGTB and IFB for southern, central tropical regions of India. Major insect – pests viz. leaf webber- *Pagyda* spp, *Megalurothrips peculianis*, *Oxia nitidula*, *Ectropis bhurmita, Odontotermus sp*, *Macrotoma fisheri* and *Indarbela quadrinota* and *Phyllocnistis amydropa* of *G. arborea* were observed from plantation as well as in nurseries of Madhya Pradesh and Chhattisgarh. Laboratory bioassay was also conducted to test the efficacy of bio-pesticides against leaf webber, results revealed that Spinosad 45% (0.0125%), Azadirachtin 10000 PPM (0.02%), NSKE (Neem Seed Kernel Extract) (5%) was found effective with maximum mortality of 83.33, 75.0, and 66.66 % mortality of larvae at 72 hours after treatment (HAT) respectively. Biology of the key defoliator of the *G. arborea* were studied in the laboratory condition. A pest calendar was also prepared based on the nature of damage and intensity of attack in nurseries and plantations. In-situ evaluation of wood in standing trees using non-destructive / less invasive tools, selected 5 trees in a plantation located at Vellore, Tamil Nadu for procurement. Collected pilodyn penetration depth and acoustic velocity in 264 trees (68 trees belonging to 31 progenies from Salem planation, 20 trees from Nallal plantation, 85 trees belonging to 15 progenies from Neyveli plantation, 26 trees belonging to 9 progenies and 65 trees belong to 16 clones from Trichy plantation) in order to evaluate the wood density and dynamic modulus of elasticity respectively. Increment core samples from these progenies were also collected to measure the moisture content and actual wood density. Determined the dynamic modulus of elasticity (DMoE) from the acoustic data. Five logs were received from Nagaland forest department. Samples were prepared for graveyard testing to assess the termite resistance of wood. Collected the physical and mechanical properties of *G. arborea* wood from literature tested at both green and dry condition. This data will serve as the benchmark for comparison. Value Chain studies were carried out to record the utilization of Gmelina wood in the selected region of India. Karnataka, Tamilnadu and Kerala have potential market for Gmelina wood & people are engaged in manufacturing value added products. Survey was also conducted in the 40 timber depots located in eight different districts of Southern Tamil Nadu, Madhya Pradesh (5 sawmills and 20 timber merchants at Seoni); Maharashtra (131 sawmills and timber merchants at Jalgaon and adjacent areas) & Chhattisgarh (50 sawmills and timber merchants at Raipur, Durg, Kabirdham & Rajnandgaon) for assessing the wood demand and and supply chain of Gmelina.

Fig. 48. Establishment of clonal trial at TFRI campus, Jabalpur

Highlights

- **A total of 525 CPTs** were identified (**315 in Jharkhand, Bihar & West Bengal; 101 in Chhattisgarh; 39 in Maharashtra; and 70 in Madhya Pradesh**). Established **9 progeny trials** in selected sites i.e. 02 in Haryana, 01 in Uttar Pradesh, 03 in Jharkhand, 02 in Madhya Pradesh & 01 in Chhattisgarh and 1 clonal trial at TFRI, Jabalpur.
- Observations on Survival percentage of different progenies have been recorded in established field trials and found 95 - 97 % and growth traits including plant height (ranged from 2.25 m to 3.6 m), Collar Diameter (ranged from 37.5 mm to 51.30 mm) in TFRI.
- A total of **40 microsatellite markers** (SSR primers) have been synthesized by the partner institutes i.e. IFP, Ranchi (20) & IFGTB Coimbatore (20). These primers were amplified with different clones of *G. arborea* for molecular characterization of selected CPTs.
- **68** clones were evaluated for genetic diversity assessment. Genomic DNA isolation protocol has been standardized and genomic DNA of 135 CPT at IFP; 48 at IFGTB & 90 at TFRI has been isolated by using the developed protocol.
- **4 CSO** were developed by the RFRI.
- **Major insect – pests** viz. **leaf webber-** *Pagyda* spp, *Megalurothrips peculianis*, *Oxia nitidula*, *Ectropis bhurmita, Odontotermus sp*, *Macrotoma fisheri* and *Indarbela quadrinota* and *Phyllocnistis amydropa* of *Gmelina arborea* were observed from plantation and nurseries of Madhya Pradesh and Chhattisgarh.
- Laboratory bioassay was also conducted to test the efficacy of bio-pesticides against leaf webber, results revealed that **Spinosad 45%** (0.0125%), **Azadirachtin 10000 PPM (0.02%), NSKE (Neem Seed Kernel Extract) (5%)** was found effective with maximum mortality of 83.33, 75.0, and 66.66 % mortality of larvae at 72 hours after treatment (HAT) respectively.
- Biology of the key defoliator of the *G. arborea* were studied in the laboratory condition. A pest calendar was also prepared based on the nature of damage and intensity of attack in nurseries and plantations.
- In-situ evaluation of wood in standing trees using non-destructive / less invasive tools, selected 5 trees in a plantation located at Vellore, Tamil Nadu for procurement. Collected pilodyn penetration depth and acoustic velocity in **264 trees** (68 trees belonging to 31 progenies from Salem plantation, 20 trees from Nallal plantation, 85 trees belonging to 15 progenies from Neyveli plantation, 26 trees belonging to 9 progenies and 65 trees belong to 16 clones from Trichy plantation) in order to evaluate the wood density and dynamic modulus of elasticity respectively.
- Increment core samples from these progenies were also collected to measure the moisture content and actual wood density. Determined the dynamic modulus of elasticity (DMoE) from the acoustic data. Five logs were received from Nagaland forest department. Samples were prepared for graveyard testing to assess the termite resistance of wood.
- Collected physical and mechanical properties of *Gmelina arborea* wood from literature tested at both green and dry condition. This data will serve as the benchmark for comparison.
- Conducted survey to record utilization of Gmelina wood for Value Chain study in different parts of India and Karnataka, Tamilnadu and Kerala have potential market for Gmelina wood & people are engaged in manufacturing different valuable products like face mask for kuchipudi dancer, artificial limb, carved articles and other value added products. Also surveyed 40 timber depots and saw mills existing in eight different districts of Southern Tamil Nadu, Madhya Pradesh and (5 sawmills and 20 timber merchants at Seoni); Maharashtra (131 sawmills and timber merchants at Jalgaon and adjacent areas) & Chhattisgarh (50 sawmills and timber merchants at Raipur, Durg, Kabirdham & Rajnandgaon) observed demand supply of Gmelina wood .

31. All India coordinated Research Project on "Study of climate driven effects on Indian forests through long term monitoring"

31.1 Objectives:

- To observe and record detailed temporal and spatial changes in structure and function of selected forest types and grasslands of India.
- Monitoring climate change driven effects on carbon regulating services and nutrient dynamics of Indian forests.
- To study impact of Climate Change on distribution of major Forest Types of India.
- Monitoring biodiversity in selected forest types with special emphasis on invasive species.
- To study and monitor health of forest soils.
- To study micro climatic effects of forests in India.

31.2 Progress:

To monitor the impacts of climate change on Indian forests ICFRE has established permanent research plots in different forest types, through its nine institutes and four outside institutes [Indian Institute of Science (IISc), Bangalore; French Institute of Pondicherry (IFP); Ashoka Trust for Research in Ecology and the Environment (ATREE), Bangalore and Kerala Forest Research Institute (KFRI)]. The project encompasses studies on detailed temporal and spatial changes in structure and function, carbon regulating services, nutrient dynamics, biodiversity, phenology, invasive species, pest and disease incidence, soil health, etc. in selected forest types.

The project inception workshop was organized at Mudumalai, Tamil Nadu on 18th February 2020 by the lead institute in collaboration with IWST Bangalore and IISc. Bangalore and was attended by all participating institutes.

Organized training of trainers (TOT) for all participating institutions at Mudumalai, Tamil Nadu on 19th & 20th February 2020 by the lead institute in collaboration with IISc., Bangalore, and other resources.

Common protocols developed and shared with all partner institutes. Web meetings of the Component Coordinator, PIs, CO-PIs/associates, and project staff working on various components were held from time to time to discuss the protocols in detail, their implementations, and difficulties faced (if any) by different institutes. All the required equipment have been procured and installed.

The biodiversity of the respective area has been studied following the belt transect method (30 transects of 250 m length) by all the institutes with the estimation of various vegetation parameters and indices. These transects are used for repeated observations on fungal species, insects, pests, pollinators, and regeneration status. High stem density, number of species, families and diversity index have been observed in the Tropical wet evergreen forests compared to the Tropical dry deciduous forests and Himalayan moist temperate forests. A book titled "Floral diversity of Kanha Tiger Reserve (Sarhi Range)'' has been published by Dr. Avinash Jain (PI) and his team, TFRI, Jabalpur which has been released by the Director General, ICFRE on 15th July 2023.

Data recorded so far suggest that *Ageratum conyzoides*, *Lantana camara*, *Chromolaena odorata, Eupatorium adenophorum* are the most common among 37 invasive species recorded across different forest types.

In Dry and moist deciduous and dry thorn forest (Mudumalai) seedlings of dominant canopy species were found to be underrepresented. However, in the Himalayan moist temperate

deciduous forest (Binog wildlife sanctuary) the canopy species (*Q. leucotrichophora*) dominated the regeneration count.

Layout and gridding of the experimental plots have been completed by all the institutes and enumeration is in progress. HFRI, Shimla; IISc, Bengaluru; French Institute, Pondicherry; ATREE; IFB, Hyderabad; TFRI, Jabalpur; IFP, Ranchi and FRI, Dehradun have completed the enumeration of all woody individuals above 1 cm diameter (DBH) in 10 ha plots following the common protocol. Enumeration is in progress in all the institutes. A total of 2,15,171 woody individuals above 1 cm DBH have been measured, mapped and tagged with unique numbers so far, covering 99.9 ha following CTFS (Center for Tropical Forest Science) protocol.

Fig. 49. Laying of the permanent plot and enumeration of woody individual ≥ cm

Basal area, girth class distribution and biomass has been estimated for the respective plots which provide essential information about the distribution of tree canopy cover and the overall density of species in the study area and ecological vitality.

A total of 2921 individuals of trees and shrubs belonging to 264 species have been geo-tagged for periodic phenological observation. Trees were monitored for both vegetative and reproductive phenologies at regular intervals. In the Himalayan moist temperate forests the peak leaf initiation was observed during March whereas, it was observed during January in Tropical wet evergreen forests. Similarly, peak flowering and fruiting period was February and April respectively, in Tropical wet evergreen forests as compared to July (just prior to the onset of monsoon) for flowering and having two peaks in March and October for fruting, in Himalayan moist temperate forests.

Observations on flowering host plants, their pollinators, and the frequency of insect pollinators are being recorded. An outbreak of Lepidopteran larvae (Defoliator) in the Seyog beat of Water Catchment WLS has been observed. One Cicada species was also found to be feeding on the sap of *Cedrus deodara* at water catchment wildlife sanctuary. Two insect species (*Antheraea perny*, *Leptocorisa oratoria*) infesting the Oak (*Q. floribunda*) at Shikari Devi were identified. *Oroplema oyamana* (Walker, 1866) (Lepidoptera: Geometridae) insect pest was first time recorded infesting *Daphniphyllum himalaense* from Binog wildlife sanctuary, Mussoorie.

Fig. 50. Oroplema oyamana

Fig. 51.Infested leaves of *Daphniphyllum himalaense*

Fungal fruit bodies and their abundance, fruiting pattern, and host preferences are being recorded along with the geo-tagging. Transect-wise insects were observed and recorded with reference to GPS Coordinates. Number of fungal species recorded was higher in the Tropical Wet Evergreen Forests compared to Tropical Dry Deciduous Forests and Himalayan Moist Temperate Forests. Published a Coffee Table Book on Macro Fungal Diversity of Kanha Tiger Reserve.

Fig. 52 Mycena sp

Fig. 53. Hemimycena sp

Fig. 54 Cookeina sp

Insect monitoring was performed by yellow pan trap, visual observation, crown trap as well as sweeping methods. Insects were observed, collected, and preserved for further identification. Insect pests and pollinators were photographed and the frequency of insects has been recorded. Though the number of species was more in the group Lepidoptera, but it was observed that group Hymenoptera was the most efficient pollinator due to their body size and hairy morphology, followed by Diptera and Lepidoptera.

Soil samples are being collected and analysed for the estimation of various physicochemical properties. Litterfall production in the study plots is being recorded through the litter trap method and litter decomposition study is being conducted.

Physiological parameters are being recorded in the dominant tree and shrub species of the study area. Soil CO_2 Flux (soil respiration) is being measured in different forest types.

Weather parameters are being recorded from the weather stations installed in the experimental sites and from the nearest weather stations of IMD to study the impact of forests on the microclimate.

Highlights

- To investigate the complex ways in which global change is impacting forest dynamics, a total of 2,15,171 woody individuals having ≥1 cm DBH have been measured, mapped, identified to species level, and tagged with unique numbers, covering 99.9 ha in six forest type groups, following common protocol.
- Floral diversity of the long term observation plots, established by 13 institutes across seven forest types of India, has been studied. High stem density, number of species, families and diversity index have been observed in the Tropical wet evergreen forests compared to the Tropical dry deciduous forests and Himalayan moist temperate forests. A book titled "Floral diversity of Kanha Tiger Reserve (Sarhi Range)'' has been published and released by the Director General, ICFRE on 15th July 2023.
- Observation on invasive species of the experimental sites has been recorded. Data recorded so far suggest that *Ageratum conyzoides*, *Lantana camara, Chromolaena odorata, Eupatorium adenophorum* are the most common invasive species.
- Insect pests and pollinators of the respective observation plots have been studied and recorded following uniform methodology. Over seventy species of butterflies have been observed as new records from the study area.
- *Oroplema oyamana* (Walker, 1866) (Lepidoptera: Geometridae) insect pest was first time recorded infesting *Daphniphyllum himalaense* from Binog wildlife sanctuary, Mussoorie.
- Number of fungal species recorded was higher in the Tropical Wet Evergreen Forests compared to Tropical Dry Deciduous Forests and Himalayan Moist Temperate Forests. Published a Coffee Table Book on Macro Fungal Diversity of Kanha Tiger Reserve.

Component II:

Programme for Conservation and Development of Forest Genetic Resources (FGR)

Component II:
Programme for Conservation and Development of Forest Genetic Resources (FGR)

4.1 What is FGR:

Forest Genetic Resources (FGRs) constitute a very important sub-set of biodiversity. Defined as "the heritable materials maintained within and among tree and other woody plant species that are of actual or potential economic, environmental, scientific or societal value". FGRs are very essential for the adaptation and the evolutionary processes of forests and trees as well for improving their resilience and productivity. In addition, the FGRs at the levels of species, populations, and individuals form a very vital and irreplaceable resource for the benefit of mankind. In India alone, more than 340 million people are estimated to be dependent upon the FGRs for their livelihoods.

Objectives:

- Preparation of comprehensive inventory of the FGRs of the country Preparation of priority list of FGRs with road map for their conservation and development.
- Collection and depositing of seed of important FGR species in Seed Banks.
- Evaluation and molecular characterization of commercially important FGRs
- Studying of genetic diversity and population structure of important FGRs
- Establishment of Field Gene Banks of FGR species
- Building a National FGR Information
- Developing a national level seed storage, research and referral center for seeds of forestry species.
- Development of comprehensive computerized database on FGR of India

Part-1

(FRI, AFRI, RFRI, IFP & HFRI)

Species prioritization work has been completed by most of the institutes and extraction of distribution records from herbarium, PhD thesisand from forest working plans has been completed by FRI, AFRI, HFRI, RFRI and IFP. Documentation of 749 species (out of 750) has been done so far across all the institutes. Regeneration and population structure status has beenrecorded for 546 FGR species in Haryana, Uttar Pradesh, Punjab, Rajasthan, Bihar and Jharkhand, and Regeneration status of has beenworked out in different forest divisons under the jurisdiction states. (Work completed= 99.86%).

Boswellia serrata

Mitragyna parviflora

Diospyros tomentosa

Calotropis procera

Erythrina resupinata

Grewia asiatica

Fig. 55 Documented FGR species

Seeds of 156 species (out of 300) have been deposited with complete passport data at Seed gene bank of ICAR-NBPGR New Delhi (Work completed= 52%). Minimum moisture content and seed viability has been tested for 161 species (out of 300) (Work completed= 53.67%). Aseptic cultures and slow growth cultures have been established for 27 (out of 32) and 16 (out of 32) FGR species respectively at FRI, IFP, RFRI and AFRI (Work completed= 90% and 50%). Synthetic seeds of *Catamixis baccharoides* and *Rhamnus triquetra* have been developed. A total of 660 accessions of 8 species have been collected for biochemical characterization from 62 different locations surveyed at FRI and AFRI. Extensive field survey for collection of diseased populations was conducted for 6 FGR species and a total of 77 diseases were assessed with 49 fungal and 10 insect infestation records.

Fig. 56 Seed collection of (a) *Aegle marmelos* (b) *Bauhinia racemosa;* Seed germination in (c) *Tamarindus indica* (d) *Butea monosperma* (e) *Hymenodictyon orixense* (f) *Neolamarckia cadamba* (g-h) Seed storage facility (-20°C) at Seed bank of ICAR-NBPGR, New Delhi

A pictorial guide of 217 prioritized species has been prepared by FRI for field working staff for authentic identification of the species. A total of 260 herbarium specimens of different FGR species have been prepared. Ecodistribution maps of 104 FGR species (out of 150) has been prepared and are in the process of upgradation (Work completed=69.33%). Seed samples of 200 species (out of 300) have been collected so far across all institutes. The seeds have been extracted, cleaned, processed and kept formedium and long term storage (Work completed= 66.67%).

A total of 15 species have been selected for genetic diversity analysis out of which sampling has been done for all the species. DNA isolation protocols have been standardized in 15 species (Work completed=100%). SSR markers have been developed for 12 species (Work completed= 80%) and in progress for 1 species. Genotyping has been completed in 5 species (Work completed= 33%) and work is under progress in 10 species. For development of nursery techniques, a total of 30 specis have been selected and the protocols have been developed for 19 species. Forthe establishment of field gene banks, 30 species have been selected and 9 field gene banks have been established for 19 species and further work is in progress in other species (Work completed= 63%). 63 species have been planted and maintained in AFRI arboretum and a FRI arboretum is enriched with 20 FGR species.

National Forest Seed and Referral Centre is in the process of development. All Civil and electrical work completed procurement ofcomputers, accessories and furniture completed and installed. Seed samples are being arranged and kept ready for display in the referralcentre. Work for the creation Forest seed information and research network has been progressing smoothly. Refurbishing of office, renovation ofthe building and laboratory infrastructure for creation of the centre has been completed.

Fig. 57 (a) Layout marking at Malajaal, Jasol (b) Watering at Malajaal, Jasol (c) Pitting work at Malajaal, Jasol (d) and (e) Planation at Malajaal, Jasol (f) Watering of *Commiphora wightii* at Malajaal, Jasol

Highlights

- Species prioritization work has been completed by most of the institutes and extraction of distribution records from herbarium, PhD thesis and from forest working plans has been completed by FRI, AFRI, HFRI, RFRI and IFP.
- Documentation of 749 species (out of 750) has been done so far across all the institutes. Regeneration and population structure status has been recorded for **546** FGR species in Haryana, Uttar Pradesh, Punjab, Rajasthan, Bihar and Jharkhand, and Regeneration status of has been worked out in different forest divisions under the jurisdiction states. (Work completed= 99.86%). A pictorial guide of **217 prioritized species** has been prepared by FRI for field working staff for authentic identification of the species. A total of **260** herbarium specimens of different FGR species have been prepared.
- Eco-distribution maps of **104 FGR species** (out of 150) has been prepared and are in the process of up-gradation (Work completed=69.33%). Seed samples of 200 species (out of 300) have been collected so far across all institutes. The seeds have been extracted, cleaned, processed and kept formedium and long term storage (Work completed= 66.67%). Seeds of 156 species (out of 300) have been deposited with complete passport data at Seed gene bank of ICAR-NBPGR New Delhi (Work completed= 52%).
- Minimum moisture content and seed viability has been tested for 161 species (out of 300) (Work completed= 53.67%)
- Aseptic cultures and slow growth cultures have been established for 27 (out of 32) and 16 (out of 32) FGR species respectively at FRI, IFP, RFRI and AFRI (Work completed= 90% and 50%). Synthetic seeds of ***Catamixis baccharoides*** and ***Rhamnus triquetra*** have been developed. A total of 660 accessions of 8 species have been collected for biochemical characterization from 62 different locations surveyed at FRI and AFRI. Extensive field survey for collection of diseased populations was conducted for **6 FGR species** and a total of 77 diseases were assessed with 49 fungal and 10 insect infestation records.
- A total of 15 species have been selected for genetic diversity analysis out of which sampling has been done for all the species. DNA isolation protocols have been standardized in 15 species (Work completed=100%). SSR markers have been developed for 12 species (Work completed= 80%) and in progress for 1 species. Genotyping has been completed in 5 species (Work completed= 33%) and work is under progress in 10 species.
- For development of nursery techniques, a total of 30 species have been selected and the protocols have been developed for 19 species. For the establishment of field gene banks, 30 species have been selected and 9 field gene banks have been established for 19 species and further work is in progress in other species (Work completed= 63%).
- 63 species have been planted and maintained in AFRI arboretum and a FRI arboretum is enriched with 20 FGR species.
- National Forest Seed and Referral Centre is in the process of development. All Civil and electrical work completed procurement of computers, accessories and furniture completed and installed. Seed samples are being arranged and kept ready for display in the referral centre.Work for the creation Forest seed information and research network has been progressing smoothly. Refurbishing of office, renovation ofthe building and laboratory infrastructure for creation of the centre has been completed.

Part-2 -FGR

(IFGTB, TFRI, IWST, IFB)

Component A-Documentation of FGR

Prepared scoring sheets for prioritizing FGR species. Prioritized 75 FGR species (extra 13 species) based on index scores calculated. Revised species list was prepared. Distribution map preparation was completed for 75 (extra 13) FGR species based on literature. Based on the ground data collected prepared and updated distribution maps for 75 (extra 9) FGR species. Ecological distribution maps based on Maxent modelling was completed for 8 species- *Albizia odorotisim, Artocarpus heterophyllus, Artocarpus hirsutus, Bauhinia racemosa, Bischofia javanica, Cullenia exarillata, Macaranga peltata, Pterocarpus marsupium* Documented and compiled the scoring sheets of the prioritized FGR species collected from different stakeholders, universities, experts for ranking. Distribution maps prepared for 10 species (*Azadirachta indica, Tamarindus indica, Tectona grandis, Thespesia populnea, Dalbergia latifolia, Pongamia pinnata, Gmelina arborea, Ailanthus excelsa, Calophylluminophyllum*) worked at IFGTB. Data compilation and updation of collected germplasm for 84 FGR species was carried out on excel sheet. Obtained ICFRE approval for developing data base management software and placed order. Inception report submitted by the vendor. Integration of Field data collection in Android Tablet **(IFGTB).** Prioritized 65 FGR species. Revised species list was prepared. Distribution map preparation based on literature was completed for 65 species. Based on the ground data collected prepared and updated distribution maps for 60 FGR species. Documented existing improved germplasm of *Tectona grandis, Pterocarpus marsupium, Litsea glutinosa* and *Dalbergia latifolia* available at the institute. Compiled data on germplasm for 60 species and the Excel database was updated **(TFRI).** 30 species were prioritised for FGR conservation . Revised species list was prepared. Distribution map preparation based on literature was completed for 30 species. Based on the ground data collected prepared and updated distribution maps for 27 FGR species. Ecological distribution modelling was performed for 1 species- *Anogeissus latifolia.* Documentation of existing improved germplasm of 1 was completed. Prepared the distribution map for Sandal-1 species of the institute. Cataloguing of individual tree data of 27 species was done and updated **(IWST).** 30 species prioritized for conservation based on index scores calculated. Revised species list was prepared Distribution map preparation based on literature was completed for 25 species. Based on the ground data collected prepared and updated distribution maps for 24 species. Potential habitat suitability/potential distribution maps were generated for 5 species (*Buchanania axillaris, Schleichera oleosa, Bridelia retusa, Sterculia urens* and *Givotia moluccana*) using Maxent model. Cataloguing of individual tree data of 25 species was done and updated **(IFB).**

Component B- FGR Collection

Field surveys were conducted to carry out relative density studies and seed sources selection at,

Tamil Nadu: Valparai, Siruvani, Kolli hills, Sitheri Hills, Vilupuram , Cuddalore, Pakka malai , Palani Hills, Chengalpat, Tiruppur, Kalrayan hills, Tiruvannamalai, Pachamalai, Srivilliputtur Grizzled Squirrel Wildlife Sanctuary, Mudumalai Tiger Reserve,Meghamalai Wildlife sanctuary, Kalakkadu-Mudanthurai Tiger Reserve, Anamalai Tiger Reserve, Niligiri Biosphere Reserve, Dharmapuri, Shervaroy Hills, Jawadhu hills, Upper Kothaiyar, Courtallam hills, Sathyamangalam Tiger Reserve, Villupuram, Kodaikanal, Madurai, Theni (27 forest divisions). **Kerala**:Nelliyampathy forest areas Agasthyamalai, Trivandrum, Palakkad, Nilambur North & South, Thrissur, Punalur, Periyar Tiger Reserve East & West, Peechi -Vazhani, Wayanad North and South, Wayanad Wildlife Sanctuary, Silent valley National Park, Munnar, Palakkad, Kottayam, Idukki, Kannur, Chimmony Tiger

Reserve, Parambikulam Tiger Reserve, Thenmala forest areas, Konni, Ranni, Kasargod, Kolikode, Mannarkkad (28 forest divisions). **Andamans:** Middle Andaman, Mayabunder, Digilipur and South Andaman (4 divisions) Through literature survey collected information on economic importance of suggested species for prioritization and prepared a presentation to support scoring process. Economic importance for the 75 species & extra 13 species in priority list were collected inorder to strategise germplasm collection.Developed a field guide to facilitate planning and survey of 75 FGR species & extra 13 species in different locations Developed and improvised population and tree selection, seed germplasm collection and conservation strategy, prepared and submitted the detailed documents. Species specific conservation strategy was derived for 75 species. In-situ conservation: 15 (extra 11) , Seed gene bank: 45, Field gene bank: 15 (extra 2). Selected seed sources/mother tree accessions for 75 FGR species (extra 10 sps.) in the various forest areas and updated. Recorded field details and individual tree passport data.

Photographs of individual parts of the seed source were taken and recorded. Relative density studies were conducted in all the study populations visited. Average Relative density was arrived for 75 FGR species (extra 10 sps.) Collected fruits of 41 species: For Seed gene bank (28 sps.).For Molecular/biochemical studies (5 sps.): Identified 15 sps. (extra 11) for *in-situ* conservation. Carried out regeneration studies for 15 sps. (extra 3 sps.) and updated **(IFGTB).** Field surveys were conducted at- **Madhya Pradesh**: North Chhindwara, South Chhindwara, South Shahdol, Mandla, Narsinghpur, Seoni, Hoshangabad, Itarsi, Raisen, Rewa, Chitrakoot, Satna, South Balaghat, Norrth Balaghat, North Lamta, Betul, Anuppur, Sehore, Gwalior, Sheopur, Bhind, Jhabua, Dhar, Khandwa, Narsinghpur, Hoshangabad, Morena, Shivpuri, Datia, Guna, Harda, Manpur, Chhatarpur, Umaria and Baihar (35 divisions). **Chhattisgarh** : Koria, Bilaspur, Dhamtari, Rajnandgaon, Jagdalpur, Kanker, Raipur, Manendragarh, Pratappur, Jashpur, Katghora, Korba, Kondagaon, Surajpur, Kondapur, West Bhanupratappur, Gaurella-Pendra-Marwahi(GPM), Kawardha, Ambikapur, Dharamjaigarh, Gariyaband, Sukma, Raigad and Balodabazar (24 divisions). **Maharashtra**: Bhandara, Chanda, Chandrapur, Gadchiroli, Allapalli, Sironcha, Brahmapuri, Nashik, Satara, Kolhapur, Yavatmal, Pusad, Pandharakawada, Nagpur, Jalgaon , Yawal, Alibag, Thane, Kolhapur, Gondia and Raigad (21 divisions). Through literature survey collected information on economic importance of suggested species for prioritization and prepared a presentation to support scoring process. Economic importance for the 75 species & extra 13 species in priority list were collected inorder to strategise germplasm collection. Developed a field guide to facilitate planning and survey of 75 FGR species & extra 13 species in different locationsA broad strategy for selection of population and trees, germplasm collection has been finalized in consultation with the project coordinator.Contributed to the improvement of population and tree selection, seed germplasm collection and conservation strategy. Consolidation of seed storage capacity is under progress to determining Species conservation strategy. Species specific conservation strategy was derived for 65 species. The SSCS forms have been prepared for, In-situ conservation: 10 , Field gene bank: 10, Seed gene bank: 45 species under preparation. Selected seed sources/mother tree accessions for 50 FGR species in the various forest areas surveyed and updated. Photographs of individual parts of the seed source were taken and recorded.Compiled passport data, image data, and morphological parameters of the 60 species. Relative density studies were conducted in all the study populations visited. Average Relative density was arrived for 50 targeted species out of 65 species. Fruits of totally 35 prioritized species were collected from identified seed sources/mother tree accessions. For Molecular/ biochemical studies, Leaf samples collected from, *Oroxylum indicum* – 16 accessions, *Cordia macleodii*- 31 accessions, *Hardwickia binata*- 20 accessions and *Dillenia pentagyna*- 10 accessions. For Biochemical studies, *Oroxylum indicum* – 70 accessions. Identified 10 species (extra 4 sps.) for *in-situ* conservation viz. *Hardwickia binata, Semecarpus anacardium, Oroxylum indicum, Stereospermum cheonoides, Boswellia serrata , Sterculia urens, Strychnos potatorum, Dillenia pentagyna, Commiphora wightii, Cordia macleodii, Cleistanthus collinus, Alangium salvifolium, Shorea robusta, Bombax ceiba.* Carried out regeneration studies for 10 sps (extra 3

sps.) *in-situ* species **(TFRI).** Field surveys were conducted at-**Karnataka**:Sirsi, Yellapura, Honnavara, Karwar, Dharwad,Cauvery WLS, MM Hills WLS , Shivamogga, Gadag, Virajpet, Chikmagaluru, Haliyal, Madikeri (13 divisions). **Goa**: North Goa and South Goa (2 divisions). **Andhra Pradesh**:Kurnool, Nandyal WLS, Anantpur, Satyasai, Tirupati and Eluru (6 divisions) Economic importance for the 30 species in priority list was collected in order to strategise germplasm collection. A broad strategy for selection of population and trees, germplasm collection has been finalized in consultation with the project coordinator. Contributed to the improvement of population and tree selection, seed germplasm collection and conservation. Determining Species conservation strategy is under progress. Species specific conservation strategy was derived for 27 species. Updation of SSCS form in progress for: In-situ conservation: 11 sps., Seed gene bank: 14 sps., Field gene bank: 2 sps. Field data and individual tree passport data for 27 tree species in different populations were recorded. Photographs of individual parts of the seed source were taken and recorded. Relative density studies were conducted in all the study populations visited and updated for 26 species. Fruits/seeds of 14 species were collected during survey from identified seed sources/ mother tree accessions in different populations, viz. *Anogeissus latifolia, Albizia amara, Albizia lebbeck, Albizia odoratissima, Terminalia arjuna, T. bellirica, T. chebula, Semecarpus anacardium, Cassia fistula, Gmelina arborea, Garuga pinnata, Hopea integrifolia, Terminalia paniculata & Wrightia tinctoria.*For Molecular/biochemical studies, Leaf/Bark samples were collected from *Lagerstroemia microcarpa, Shorea roxburghii* and *Barringtonia racemosa* **(IWST).** Field surveys were conducted at- **Telangana**: Medak, Banswada, Kotahudem, Venkatapuram, Mulugu, Tadvai, Yellandu , Armoor, Nizamabad, Sathupally, Khammam, Badrachalam, Manuguru, Palvoncha, Mahadevpur and Bhupalpally (16). **Orissa**: Rayagada , Koraput, Kalahandi North, Kalahandi South, Nabarangpur, Jeypore, Malkangiri, Ghumsur north, Ghumsur south, Phulbani (10)

Economic importance for the 30 species in priority list was collected in order to strategise germplasm collection. A broad strategy for selection of population and trees, germplasm collection has been finalized in consultation with the project co-ordinator. Species specific conservation strategy was derived for 11 species, In-situ conservation: 3, Seed gene bank: 5, Field gene bank: 3. The SSCS forms are under preparation for 19 species. Selected seed sources/mother tree accessions and recorded field details and individual tree passport data for 25 species. Individual tree passport data was collected for 3774 trees. Relative density information was recorded in all the study populations visited.Average Relative density was arrived for 24 species. Natural population of Gyrocarpus americanus has been identified in Madira range of Telangana. Natural populations of Givotia moluccana has been identified in Pitlam, Pasra, Nagareddypet, Wazedu and Ashwapuram ranges in Telangana. Natural regeneration of Givotia moluccana was observed and recorded at two ranges **(IFB).**

Component C- Seed Germplasm Storage

Collected information on seed storage behaviour to classify orthodox and recalcitrant seeds for FGR conservation. Shortlisted 45 species from prioritized list for seed banking. Standardised processing and extraction of seeds of 34 species collected for seed banking. Out of 17 species for field gene bank, standardized processing and extraction of seeds was standardized for 16 species. Seed germination / pretreatment studies were carried out for: Seed gene bank species (34 sps.), Field Gene bank species (16 sps.). Seed storage at -20ºC was carried out for 29 species. Viability tests- TTZ was standardized for 28 species (**IFGTB**). Shortlisted 45 species from prioritized list for seed banking. Standardized seed extraction and processing, seed pre-treatment for 20 species. Cold rooms construction completed in March, 2022. Seed cold room became operational . Seed storage at -20ºC was carried out for 18 species.Standardized Tetrazolium testing protocols for 18 species **(TFRI).** Shortlisted 14 species from prioritized list for seed banking and 5 for FGB. Standardised processing and extraction of seeds for 14 species collected for seed banking from different popultions from Karnataka, FGB 2 sps. Seed germination / pretreatment studies were

standardized for Seed bank -12 sps. Seed storage studies at -20°C upto 3 months was carried out for 6 species. Viability tests- TTZ was carried out for the recently collected 12 species **(IWST*).*** Standardised processing and extraction of seeds of 12 species collected for seed banking and 4 species under field gene banking. Pre treatments and germination trials were done in 7 Seed *gene bank* species. Germination / pretreatment studies were taken up and data derived for 9 species. Seed *gene bank* species: 5species viz., *B. ceiba, S. febrifuga, P. marsupium, S. potatorum, D. melanoxylon.* Field *gene bank* species: 4 species viz., *C. religiosum, S. sweitenioides, S. urens, B. retusa* Seed germplasm storage of one orthodox species was done viz., *Soymida febrifuga* **(IFB).**

Fig. 58 Seedlings of *Ailanthus excels, Syzgiun cumini, Careya arborea, Litsea glutinosa* growing innursery beds

Component D-FGR Characterization

Fruits/seeds of of 62 species (seed & field gene bank sps.) were studied for morphological parameters through image analysis. Also recorded fruit /seed weight. Recorded and updated morphological parameters of the fruits/seeds collected from different seed sources using image analyser -Seed gene bank species (33 sps.), Field gene bank species (16 species). DNA extraction protocol was standardized for the leaves samples of 5 species *Myristica malabarica*, *Dysoxylum malabaricum*, *Kingiodendron pinnatum, Cullenia exarillata* and *Mesua ferrea.* The DNA was extracted from leaf samples of 24 accessions from different populations of *Myristica malabarica* leaves from Tamil Nadu and Kerala. The DNA was extracted from leaf samples of 24 accessions from different populations (Mundanthurai, Valparai, Parambikulam, Periyar Tiger Reserve-East, Thenmala) of *Mesua ferrea* leaves from Tamil Nadu and Kerala. The DNA was extracted from leaf samples of 11 accessions from different populations (Valparai, Parambikulam, Chimmony, Thenmala) of *Dysoxylum malabaricum* leaves from Tamil Nadu and Kerala. The DNA was extracted from leaf samples of 21 accessions from different populations (Valparai, Agasthymala, Vazhachal, Nelliampathy, Periyar Tiger Reserve-East) of *Cullenia exarillata* leaves from Tamil Nadu and Kerala. The DNA was extracted from leaf samples of 8 accessions from different populations (Kolli Hills, Mundanthurai, Courtallam) of *Kingiodendron pinnatum* leaves from Tamil Nadu. Genetic diversity analysis was carried out from extracted genomic DNA from leaf samples of 24 accessions from different populations of *Myristica malabarica* from Tamil Nadu and Kerala using ISSR markers. Among 16 different ISSR primers, only 9 ISSR primers were selected which produced significant number of polymorphic bands. Genetic diversity analysis was studied for 24 accessions *of Mesua ferrea* leaves from Tamil Nadu and Kerala using ISSR markers. Among 16 different ISSR primers, only 9 ISSR primers were selected which produced significant number of polymorphic bands. Genetic diversity analysis was studied for 21 accessions *of Cullenia exarillata* leaves from Tamil Nadu and Kerala using ISSR markers. Among 16 different ISSR primers, only 9 ISSR primers were selected which produced significant number of polymorphic bands. Biochemical characterization will be updated for 5 species collected from different populations

for the following parameters, *Myristica malabarica*- Phenol, Flavonoid, *Dysoxylum malabaricum*- Terpenoids, Phenol, *Messua ferrea*- Phenol, Tannins, *Cullenia exarillata*- Terpenoids, Phenol, *Kingiodendron pinnatum*- Terpenoids, Phenol. The qualitative phytochemical screening of methanolic leaf extract of *M. malabarica*, *Dysoxylum malabaricum*, *Kingiodendron pinnatum, Cullenia exarillata* and *Mesua ferrea*was analyzed.The quantitative phytochemical analysis of total flavonoids present in methanolic leaf extract of *M. malabarica* populations ranged from 16.52-34.93 mg of quercetin equivalent/g and total phenol was ranged from 3.31- 4.16 GAE/g of sample of 5 accessions-Nelliampathy, Kolli Hills, Chimmony, Konni and Periyar Tiger Reserve-East populations. The quantitative phytochemical analysis of total phenol present in methanolic leaf extract of *Dysoxylum malabaricum* populations ranged from 3.35 – 25.83 mg of gallic acid equivalent/g of sample from 11 different accessions. The quantitative phytochemical analysis of total phenols present in methanolic leaf extract of *Mesua ferrea* populations ranged from 2.24 - 7.77 mg/g of gallic acid equivalent. Total flavonoid present in methanolic leaf extract of *Mesua ferrea* populations ranged from 14.91 – 34.98 mg/g of quercetin equivalent. The quantitative phytochemical analysis of total phenols present in methanolic leaf extract of *Kingiodendron pinnatum* populations ranged from 7.46 - 25.67 mg/g of gallic acid equivalent. The quantitative phytochemical analysis of total phenols present in methanolic leaf extract of *Cullenia exarillata* populations ranged from 3.35 – 25.83 mg/g of gallic acid equivalent **(IFGTB).** Morphological characterisation was carried out for 29 species, by image analysis and also other fruit /seed parameters. Genomic DNA of 110 trees of *Hardwickia binata,* 95 of *Dillenia pentagyna*, and 70 of *Cordia macleodii* and 80 of *Oroxylum indicum* were extracted and purified. Quantification of DNA was carried out. 20 SSR primers for *Oroxylum indicum* has been developed through transcriptome sequencing. PCR amplification of populations with four primers was carried out. SSR primers of *Hardwickia binata* were designed by collecting sequence data through NCBI database. Screening of all 29 primers was completed and PCR amplification of populations with five primers was done. Genotyping is in progress. SSR primers of *Dillenia pentagyna* were designed by collecting sequence data through NCBI database. Screening of all 22 primers was completed and PCR amplification of populations with five primers was done. Genotyping is in progress. SSR Primers of *Cordia macleodii* were designed from sequences collected through NCBI Database. Leaves of 70 trees of *Oroxyllum indicum* have been collected and processed for biochemical estimation of tannins, phenols, flavanoids and alkaloids. Sugar, phenol, alkaloid and flavonoid contents were estimated for 70 trees of 7 populations. Maximum sugar content (12.74 %) was recorded for Korba, Chhatisgarh, maximum alkaloid (28.57 %) and flavonoid content (31.25 %) for Chandrapur, Maharashtra and maximum phenol (07.21 %) was obtained for Satna, Madhya Pradesh **(TFRI).** Capturing images of fruit/seed samples for morphological characterisation and Image analysis was performed for 15 species. Standardisation of DNA extraction procedure from leaf samples was completed for 3 species. PCR conditions for molecular characterisation was standardized for *Barringtonia racemosa* with 15 SSR primers and *Lagerstroemia microcarpa* with 36 SSR primers. PCR was carried out for 7 accessions of *Barringtonia racemosa* using 15 SSR primers. Estimation of total terpenoids from leaves was performed for 7 accessions of *Barringtonia racemosa* **(IWST).** Images were taken for 12 species viz., *Soymida febrifuga, D. melanoxylon, T. chebula, S. sweitenioides, S. urens, B. retusa, P marsupium, c. religiosa, T. chebula, A. odaratissima, O. indicum, C. religiosum* for characterization using image analysis software **(IFB).**

Component E- FGR Conservation (Field Gene bank)

Strengthened FGR nursery infrastructure such as setting of poly tunnels and procurement of nursery tools. Created mother beds in the nursery. Constructed open nursery beds for raising seedlings of light demanding species. Upgraded Green shade net and created a poly house for FGR nursery. Created borewell facility in the nursery. Sweet water supply facility for the nursery was obtained. Raised seedlings, transplanted and hardened 16 Species collected from different seed sources. Established III phase electrical connection in FGR Nursery. Purchased and fixed

submersible motor and plumbing work for newly established bore well. Painting and white washing work done for both FGRM Nursery and Seed Processing unit. Fencing at seed processing unit nursery was repaired. Procured two tanks for water storage. Selected suitable area for establishing field gene bank. Communicated with TNFD and obtained approval for 40 ha at Thiruvannamalai. Fencing work has been assigned to CCU unit. Fencing post is under progress at Tiruvannamalai, where in fence concrete post has been erected and the coverage is 35 % completed. Initiated electricity connection provision for the field gene bank Dug two borewells at Tiruvanamalai for irrigating the field gene bank.Two 10 hp borewell pumps has been procured for the borewell. Tender has been placed for getting new EB connection to Tiruvannamalai field, In Gudalur research station tender has been called for fencing. Cleared 24 ha of land for field gene bank. Indent for borewell has been placed. The boundary stone of size 1.75 to 2.0 feet has been erected and sub plot in the cleared area has been demarcated and completed. About 4.5 hectares has been cleared in Gudalur research station Seedlings of field gene bank species (15) are hardened for outplanting and raising of seedlings is under progress Germplasm of Teak and *Pongamia pinnata, Cadamba* and *Mahogany* were maintained **(IFGTB).** Experiments were designed to study seed germination of 7 species. Raised seedlings, transplanted and hardened 7 species collected from different locations for field gene bank Total 21,560 seedlings were produced from various selected seed sources of Madhya Pradesh, Chhattisgarh and Maharashtra. Open sunken nursery beds were prepared for seed sowing. Polytunnels were repaired and upgraded. Digging of borewell in the nursery area of TFRI, Jabalpur was completed. Low cost poly structures consisting raised sand beds were prepared for the seed sowing of *Litsea glutinosa.* In the nursery, seedlings of 9 species viz., *Haldina cordifolia*, *Mitragyna parvifolia, Careya arborea, Buchnania cochinchinesis, Syzygium cumini, Litsea glutinosa, Carissa carandas, Saraca asoca* and *Ailanthus excelsa* were maintained. One hectare land was identified for establishment of field gene bank in Jabalpur, Madhya Pradesh. Discussions were held with CCF (Research and Extension) Maharashtra for allocation of land. Land allocation in Amravati was agreed upon for plantation activities. Communicated the Work Plan of Field Gene Bank to Amravati Forest department, Maharashtra. Land has been requested from Madhya Pradesh Forest Development Corporation forField Gene Bank. Land for establishment of Field Gene Bank at Katni KVK is being finalized. Fencing in allotted 10 ha land for establishment of Field Gene Bank at Katni KVK was completed. Irrigation facilities were maintained. Land was alloted land at Guru Ghasi Das University campus, Bilaspur, Chhattisgarh for the establishment to field gene bank of *Mitragyna parvifolia*. Land preparation has been prepared and pitting done for planting. Water facility also provided. A Field Gene Bank was established at KVK, Katni, Madhya Pradesh (lat. 23°44' N, long. 80°19' E) for Five species viz., *Haldina cordifolia, Careya arborea, Syzygium cumini, Litsea glutinosa* and *Ailanthus excelsa* and at Guru Ghasi Das University campus, Bilaspur, Chhattisgarh (Lat. 22.122870, Long. 82.1405720) for *Mitragyna parvifolia*. Seedlings were planted in randomised block design having four replications. The Germplasm bank of *Pterocarpus marsupium* located in TFRI campus and Field gene banks at KVK, Katni and Guru Ghasi Das University campus, Bilaspur, Chhattisgarh was cleaned and maintained **(TFRI).** Upgradation of nursery in IWST was continued. The exixting mistchamber is refabricated with new FRP sheets, cooling bad and exclusive water tank for cooling pad and foggers. The fogger line and electric control panel was changed. In the existing structure, replastering, white washing and painting was done 5 hectares of land was identified in Iruvakki, near Sagara under University of Agriculture and Horticultural sciences. The germplasm bank of *Santalum album* is maintained at Gottipura. **(IWST).** Fencing work was completed at Mulugu research station for the field gene bank establishment. Low tunnel mist chambers established in IFB nursery. Seedlings of three species were raised in the nursery and shifted to polybags for hardening. Land for field gene bank was identified and demarcated. Seedlings are ready for three species viz., *Sterculia urens, Bridelia retusa* and *Schrebera swieteniodes* **(IFB).**

Component F- Establishment of Centre of Excellence

Selection of JPFs /PAs through interview and appointed. Organized a one day Seminar on Forest Genetic Resources Management inviting experts from NBPGR, Hyderabad and Directorate of Oilseeds Research, Hyderabad on 5th March 2020 to brief on the FGR concepts. On 6th March 2020, conducted the Interactive meeting and launched the program on NPFGR wherein the implementation strategies were presented and discussed with networking institutes. Developed FGR prioritization mechanism through scoring. Conducted the first in-house Workshop on Prioritization of FGRs for fine tuning the scoring process on 7th July 2020 & II Workshop on 6th October 2020 at IFGTB. Circulated the FGR prioritization scoring sheets to various stakeholders (SFDs, SAUs, research institutes, wood based industries, experts) along with relevant information for scoring and prioritized the species. Oriented the JPFs /PAs on germplasm collection and assemblage through a field visit to Panampally, IFGTB research station in March 2020 and species identification excercise at Sathyamangalam Tiger Reserve on 13.7.2021. Expert advice and guidance through a discussion meeting was organized for population studies and tree identification for the FGR species on 22.4.2021. Organized an online meeting in March 2021 with networking institutes of the FGR program for fine tuning the methodology. Communicated the aims of the FGR program, its activities and outcome with SFDs seeking their support and co-operation. Placed requests for permission from SFDs for forest visits throughout the project period to carry out the field studies and collection of germplasm, sent reminders, and successfully obtained forest permission from TNFD and KFD to carry out the FGR studies. Paid forest permission fee and caution deposit to TNFD and communicated the same to different forest divisions. Communicated the land requisition letter for field gene bank to PCCF TNFD. Followed up with the SFDs for getting approval for land for establishing field gene bank and obtained land for the same. Approval for procuring field research vehicles was obtained. Placed indents and procured field truck- 1no.and Field research vehicle-1 no. Revised and updated the FGR species list. Organized an International Symposium on Forest Genetic Resource Conservation and Utilization was conducted by ICFRE-IFGTB in the 59th Annual Meeting of the Association for Tropical Biology and Conservation (ATBC 2023), at Kumaraguru College of Technology, Coimbatore. Conducted online review meetings with networking institutes of the FGR program to discuss the progress made on 6.9.2021, 22.7.2022, 9.12.2022, 27.1.2023, 13.7.2023 and 15.2.2024. Compiled details for progress made and made presentation at meeting with DIG –RT , at MoEF & CC New Delhi on 23.2.2024.

Component G- Creation of National Forestry Seed Centre

A display unit (carpellarium) for seed referral centre was created and displayed 87 species.

Fig. 59 Plants of a) *Careya arborea*, b) *Litsea glutinosa*, c) *Ailanthus excelsa*, d) *Syzgyium cumini* and e) *Haldina cordifolia* in Field Gene Bank at KVK, Katni, Madhya Pradesh

Highlights

- A scoring method was developed and prioritised 200 species involving various stakeholders. Strategies for collection and conservation of FGRs was developed
- Distribution maps prepared & updated for 180 species. Eco distribution maps completed for 4 species. Selected mother trees for 170 sps.
- Carried out regeneration studies for 22 species. Infrastructure developed for field gene bank 45 ha in Tiruvannamalai, TN
- Seed accessions – 750 collected for storage
- Standardized seed pretreatment and storage protocols for 47 species
- Conducted molecular diversity studies for 9 species, biochemical characterization for 3 species & image analysis for 75 species
- Seedlings of 20 species were produced from various selected seed sources of Tamil Nadu, Kerala, Madhya Pradesh, Chhattisgarh and Maharashtra.
- Infrastructure facilities such as borewell and fencing were completed for field gene bank at Tiruvannamalai (45 ha), by IFGTB, Coimbatore.
- Field gene bank of six species *Haldina cordifolia, Careya arborea, Syzygium cumini, Litsea glutinosa, Ailanthus excelsa* (at Katni 10 ha) and *Mitragyna parvifolia* (at Bilaspur) were established. Established seed bank in TFRI and work in progress at IFGTB
- Database management system development – 50% completed
- A display unit (carpellarium) for seed referral centre was created and displayed 78 species.

Component-III:

Policy studies under Centre for Forest Policy Research

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Policy studies under Centre for Forest Policy Research

Forest Policy Research

The Centre for Forest Policy Research (CFPR) of ICFRE has taken up the policy research studies exclusively focused on forest and environment sector. The CFPR acts as "Policy Think Tank" and undertake research on contemporary policy issued for providing inputs to Government of India for policy decisions and appropriate interventions for the better governance of forest and environment in India.

Objectives:

i. Identify the thrust areas for policy interventions for better governance of forest, wildlife and other natural resources in the country.
ii. Undertake the policy analysis of governance of natural resources and also look into the relevant legislations in a changing socio-economic scenario.
iii. Provide inputs to the Government on issues related to policy formulation & strategies for implementation.
iv. Carryout evaluation of various Government programmes/projects/policies with respect to identification of gaps in policy perspective.

Progress:

SN	Nine studies under CFPR and their status	Executing Agency	Present Status
1.	Institutions of community Participation including Joint Forest Management Committees and Eco-Development Committees, linkages with Panchayati Raj Institutions, review of their working in various regions of the country and identification of successful models and shortcomings	TERI, New Delhi	Final report submitted to ICFRE & MoEF&CC
2.	Policy issues in agroforestry including market mechanism, forward and backward linkages, regional availability, transit of forest produce, linkages with NDC targets, choice of species and utilization	NCCF, Noida	Final report submitted to ICFRE & MoEF&CC
3.	Popularization of the use of Wood and Wood Substitutes as per the National Forest Policy and Modalities for Facilitating Industries for its Optimum Utilization	NCCF, Noida	Final report has been approved.
4.	Study of grazing policies in different states and formulation of grazing policy guidelines for states	Society for Resource Planning Development and Research, Bhopal	Final report has been received.
5.	Functioning of Forest Development Corporations and their role in the present Scenario	IUCN and IORA, New Delhi	Final report received and under review by respective working group.
5.	Issues in forest certification and certifying agency	GICIA, India Pvt. Ltd. Nodia	Final report is awaited.
6.	Guidelines under Forest (Conservation) Act, 1980 for diversion of privately owned forests for non forestry uses	The ICFAI Law School, IFHE, Hyderabad	Inception report has been approved.

7	Public private partnerships in a broad perspective in forestry involving various sections of the society	SEEDS Technical Service Pvt Ltd., New Delhi.	Inception report is awaited

The details of the same are as given below

I. **Study of Grazing Policies in different States and Formulation of Grazing Policy Guidelines for States: executed by Society for Resource Planning, Development and Research (SRPDR), Bhopal.**

ToRs of the study: To study the impact of grazing policies of centre/state and recommend best practices.To suggest policy prescriptions to strengthen inter-sectoral linkages between forestry agriculture and animal husbandry.Suggest mechanisms for conservation and development of fodder and pasture/grasslands in potential areas, viz, forests, culturable wastelands, community and other lands.Suggest a framework for a comprehensive grazing (cum- fodder and pasture development) policy guidelines at national level in coherence with the National Forest Policy-1988, National Livestock Policy- 2013, Agro-forestry policy and other related policies and guidelines.To study the impact of the grazing ban in the protected areas.

Status: Draft report has approved by the Director General, ICFRE, Dehradun.

II. Popularization of the use of Wood and Wood Substitutes as per the National Forest Policy and Modalities for Facilitating Industries for its Optimum Utilization: executed by Network for Certification and Conservation of Forests (NCCF), New Delhi.

ToRs of the study: To assess the present utilization and demand of wood and wood substitutes in the country including the analysis of earlier studies. To study the factors contributing to encourage the use of wood and wood substitutes as well as factors hindering their use and to suggest remedial measures. To assess and analyze the factors promoting industries for optimum utilization of wood and wood substitutes and to suggest measures for encouraging industries and promotion of optimum utilization of wood and wood substitutes.

Status: Draft report has approved by the Director General, ICFRE, Dehradun

III. Functioning of Forest Development Corporations and their role in the present scenario: executed by IUCN (International Union for conservation of Nature) New Delhi.

ToRs of the study: To study the present role of Forest Development Corporations in the states/UTs and their economic viability To study the recent initiatives taken by these FDCs in various states/UTs, in terms of success, sustainability and profitability. To recommend programmes/activities to be taken up by the FDCs in the current scenario. To study the existing structure of the FDCs and suggest revamping wherever necessary for execution of the roles proposed for the current scenario. To study diversification perspective of FDCs in the present scenario. To study all FDC/FC existing in India.

Status: Final report is awaited and the time line of the study has been extended up to June, 2023.

IV. Issues in Forest Certification and Certifying Agencies: executed by GICIA India Pvt. Ltd., Noida, U.P.

ToRs of the Study: To analyze the existing forest certification models and suggest appropriate model for India. To assess the impacts of the costs and benefits of certification on sustainable forest management, especially with respect to forest management, trade, supply and demand of certified forest products and access to certification for stakeholders. To analyze the existing legal and policy instruments that support or discourage the use of forest certification instrument and suggest the options/means to link certification with other policy instruments for achieving sustainable forest management. To analyze the bottlenecks and changes required in the governance for realizing effective gains from forest certification. To identify the sectors and suggest a roadmap for realizing the goals of sustainability, poverty alleviation and economic growth through forest certification.

Status: Final report is awaited.

V. Guidelines under Forest (Conservation) Act, 1980 for diversion of privately owned forests for non forestry uses: executed by The ICFAI Law School, IFHE, Hyderabad

ToRs of the Study: To assess the extent of forest areas under the category of privately owned forests in the country and to analyze the demand of the individuals owning private deemed forests for bonafide/other uses. Analyse the provisions of the Forest (conservation) Act, 1980 which are in conflict with these land use requirements. Analysis of the studies conducted earlier including the recommendations prescribed. Recommendations regarding the demands and proposed amendment of the acts/rules/procedures required for conservation of such forest areas commensurate with meeting demands of private forest areas. To recommend the incentives to the forest owners keeping in view the practices in other countries and on par with the acquiring of other lands for public utility within the country

Status: Inception report has been approved.

VI. Public Private Partnerships in a broad perspective in forestry involving various sections of the society executed by SEEDS Technical Service Pvt Ltd., New Delhi

ToRs of the study: To assess the public private partnerships and contribution of various sections of the society in forestry sector in the country. To analyze the policies and instruments which aid/restrict in the public private partnerships in the forestry sector. To study the PPP models in a holistic manner on areas of partnership, terms and conditions of the contract , advantages and risks , etc., To suggest appropriate modes of partnerships for different forestry activities with various sections of society. To suggest policy changes for promotion of public private partnerships in forestry sector.

Status: Inception report is awaited

Component IV:

Capacity Building of State Forest Departments for developing “State REDD+ Action Plans” under National REDD+ strategy

Component IV: Capacity Building of State Forest Departments for developing “State REDD+ Action Plans” under National REDD+ strategy haa been completed.

Component V:

Operationalization of Human Resource Development Plan of ICFRE

Component V:

Operationalization of Human Resource Development Plan of ICFRE

The adequately trained human resource can help to optimize the use of ecosystems services and biodiversity values by the society to address local as well as global challenges such as environmental protection, forest livelihoods, expand market mechanism, climate change etc. This will also help to ensure the incorporation of ecosystem services in the development planning in all the sectors. Capacity building of human resource on continuous basis to appraise the manpower with the latest development is, therefore, extremely important for bringing in new innovations, preparedness to handle new challenges and improving the work ethos.

Objectives:

- Capacity building through induction & subsequent skill upgradation training for all categories of ICFRE Personnel i.e., scientific, technical, administrative and executive.
- Seminars/workshops & conference both national and international for scientists and senior technical officers.
- Exposure visits to senior managers.
- Other HRD Initiatives like awards, online system of appraisal, increase in remuneration of support staff and periodical seminars/conference.

Progress:

Under this component training programmes have been organized for Scientists/Technical Staff/Administrative Staff of ICFRE and Its Institutes under the Human Resource Development Plan. As per the approved HRD plan of council total 67 scheduled trainings have been conducted for 1537 participants through online/offline mode.

Financial year	Proposed trainings as per HRD Plan	Trainings executed using CAMPA fund	Induction Trainings executed using CAMPA fund	Number of Participants
2019-20	25	2	-	35
2020-21	23	21	4	601
2021-22	23	14	2	500
2022-23	21	18	1	325
2023-24	21	04	01	76
Total	113	59	08	1537

Component VI:

Operationalization of Forestry Extension Strategy and Action Plan of ICFRE

Component VI:
Operationalization of Forestry Extension Strategy and Action Plan of ICFRE

Forestry Extension

One of the most important mandate of ICFRE is extension of research findings from lab to land so that the benefit of research efforts and can be translated into gain to society in real time. As a result of years of research work, the Council has a rich tally of innovative technologies/processes to its credit. Some of these technologies are being transferred to the stakeholders through various mechanisms. Through this programmme the Council endeavors to transfer and disseminate their technologies to various stakeholders/ end-users with active participation of State Forest Departments and other institutions like Self Help Groups (SHGs), Joint Forest management Committees (JFMCs), Village Panchayats including farmers, women, industries, rural poor and unemployed youth.

Objectives:

- **Strengthening of the existing extension activities** which are already being implemented and need strengthening to get desirable results like Van Vigyan Kendras (VVKs)**,** Demo Villages **and** Farmers' Mela
- **Initiating new extension** to provide outreach to ICFRE technologies to the target groups by development/establishment of Technology Demonstration Centres (TDC) **and** Modified Direct to Consumer Schemes

Progress:

❖ **Establishment of new VVKs:** For Establishment of New VVK at Chandrapur, Maharashtra by ICFRE-TFRI, Jabalpur, Memorandum of Understanding (MoU) signed between Director TFRI and Director Chandrapur Forest Academy. Initiated activities and visited area for the establishment of Model Nursery at Lohara, Chandrapur. Shri. C. Jayakumar, Hon'ble Minister for Forests & Wildlife, Government of Puducherry declared establishment of ICFRE-IFGTB's new VVK at 'Puducherry at KVK campus, Puducherryon 17.02.2024 in Tree Growers Mela organized by ICFRE-IFGTB. Initiated the activities for establishment of new VVK.

Fig. 60 Visit for establishment of new Van Vigyan Kendra at Chandrapur Forest Academy, Chandrapur, Maharashtra

❖ **Establishment of Technology Demonstration Centre**

- TDC was established at ICFRE-IWST and was formally inaugurated on the occasion of 75th Republic day by Director, ICFRE-IWST, Bengaluru. Wood technologies and products developed by IWST over the years have been showcased at the TDC for general public especially students and scholars.
- 324 visitors were taken to TDC at ICFRE-HFRI where they were apprised about displayed technologies and products developed by the institute. They were also informed about other extension activities of the institute.General maintenance of TDC was carried out regularly. The process for repairing the roof has been initiated which was damaged during last monsoon season due to heavy rain.
- Exposure visit to the TDC was organised for 66newly appointed scientists of Central Tasar Research and Training Institute, Nagri, Ranchi Jharkhand on 21.02.2024 and forstudents of Birsa Agricultural University, Kanke, Ranchi, Jharkhand on 22.02.2024.

Fig. 61. TDC inaugurated at ICFRE-IWST on the occasion of 75th Republic day.

Fig. 62 .Visitors visiting Technology Development Center at ICFRE-HFRI, Shimla

❖ **Documentaries:** Ten documentaries and two short videos were prepared:

- Four documentaries on Tara Red, TreePal, Tree Rich Bio-booster andWindbreak technology was prepared by ICFRE-IFGTB
- Six Documentaries Films on: Lakh ki Kheti, Krishi Vaniki, Fly Ash, Micro propagation of Bamboo, Fungarium, TFRI – Trichocard. Also upgraded facility for editing short films at TFRI
- ICFRE-RFRI, Jorhat Prepared two Short Video on 'Bamboo Shoot Processing and Value Addition' and on "Documentary on Tree Growers' Mela 2024".

❖ **<u>Tree Growers Mela:</u> Six Tree Growers Mela Organized**

- *ICFRE-HFRI, Shimla*, in collaboration with Krishi Vigyan Kendra - Saru, District - Chamba, organized a Kisan Mela (Tree Grower Mela) on theme: Sustainable Development through Forestry Technologies at Kalsui Chamba on 23rd February, 2024. About 250 villagers from different Panchayats of Chamba, Bharmaour, Kasuai, Mehla, and surrounding participated in the event. During the mela, Smt. Kanchan Devi, DG, ICFRE released the documentaries- on HFRI, medicinal plants, bamboo and cold deserts; products-Him Growth booster, Him Kavach bio-insecticide and pamphlets – Himalayan Poplar, Kala poplar, Safed poplar, Balsam poplar, flowering trees and shrubs of western Himalayan Region developed by the institute

Fig.63. ICFRE-HFRI, Shimla organized Kisan Mela (Tree Grower Mela) on theme:Sustainable Development through Forestry Technologies at KalsuiChamba

- *ICFRE-IFGTB, Coimbatore* organized Tree Growers Mela on the theme of "Tree Cultivation in Coastal areas" on 17th February, 2024 at Puducherry, in collaboration with Puducherry Forest & Wildlife department. About 575 tree growers, field staff of forest departments from Puducherry, Villupuram & Cuddalore, representatives of wood based industries and FPO participated in the programme.

- *ICFRE-IWST, Bengaluru organized two Industry Institute Meet*:
  a) At Perumbavoor, Kochi, Kerala on 14 December 2023. Sawmill Owners and plywood Manufacturing Association(SOPMA) supported in organizing this meet. About 350 participants from 291 different industries benefitted from the program.
  b) At Gujarat State Forest Department training center, Gandhinagar on 08 January 2024. About 200 Wood based industry representatives and Gujarat State Forest Department officials benefitted from the program.
- *ICFRE-AFRI, Jodhpur* organized TGM at KVK, Jaisalmer on 16th March 2024. More than 300 participants including farmers, environmentalist and tree growers were participated in the mela. A short film on "Khejri Tree: Mortality, Research & Management" and Hindi Quarterly Magazine "AFRI Darpan" was also released during the programme.
- *ICFRE-RFRI, Jorhat* organized Tree Growers' Melaon 7th to 8th March, 2024. More than 500 participants including Farmers, Tree Growers, JFMC Members, Forest Officials, Students, SHG members, NGO members, members from ATMA &ASRLM, villagers from RFRI Demo Village etc. attended the event. An Exhibition was organized on the occassion where more than twenty Institutes, NGOs, Entrepreneur, Bank etc. participated in the Exhibition.

- *ICFRE-FRCER, Prayagraj* organized Tree Growers Melaon 15.03.2024. 16 stalls of various universities, KVK, plantation Companies and research organizations were established during the mela.

Fig. 64. **Magh Mela:** Forestry Extension Camp was established from 16.01.2024 to 15.02.2024 by FRCER, Prayagraj

❖ Maintenance of VVKs including networking with KVKs (VVK-R):

- **Raising of seedlings/maintenance of different species in VVKs**

ICFRE-HFRI, Shimla: VVK Longani, Dharampur, Mandi, H.P

- ✓ Maintained demonstration nursery of medicinal plants of 20 species at Shivdwala nursery by carrying out regular weeding, hoeing and watering.
- ✓ QPM of forestry species viz. Kachnar (2100), Taur (900), Teak (280), Chandan (400) Shisham (500), Amla (80), etc. raised in the nursery at Shivdwala was also maintained.
- ✓ For raising the QPM of important forestry species in demand in the region, seeds of different tree species viz. Chandan (3kg), Arjuna (3kg), Harad(3kg), Amla(1/2kg), Teak(3kg), Tour(1kg*)* was procured. Prepared nursery beds and filled up poly bags and sowing of seeds has been started.

VVK Jagatsukh, Manali, H.P.

- ✓ QPM of *Prunus armeniaca, Picrorhiza kurroa* (8000), *Angelica glauca* (4000) and *Valeriana jatamansi* (500) were also maintained
- ✓ Distributed 1200 seedlings of medicinal plants viz. *Bergenia ciliata, Ajuga integrifolia, Picrorhiza kurroa, Valeriana jatamansi, Podophyllum hexandrum, Angelica glauca, Plantago major, Acorus calamus, Bistorta affinis* etc. to various stakeholders. Besides, about 470 plants were sold to Ayurvedic dispensaries of Kullu region.

VVK, Janipur. Jammu, UT:

- ✓ Maintained 10 different poplar clones (about 4500 seedlings) at demonstration nursery Nagbani Jammu by carrying out regular weeding, hoeing and watering, etc.
- ✓ Prepared nursery beds for planting of cuttings of 10 poplar clones and planted about 4570 cuttings in nursery beds at Nagbani Jammu.
- ✓ Distributed/sold about 2850 plants of poplar clones and 25 plants of Bahera.
- ✓ Maintained demonstration plot of 20 medicinal plants (500 no.'s) viz., Amla, Arjuna, Neem, Harad, Bael Patra, Patthar Choor, Sarapgandha, Safed moosli and Stavri by carrying out regular weeding, hoeing and watering. at Nagbani nursery, VVK, Jammu, UT.
- ✓ Planted 120 plants of ten poplar clones in farmer fields at Quazi Tokriyan, Nagbani Jammu and maintained the plantation.

VVK, Badamibhag, Leh, Ladakh UT:

- ✓ Maintained demonstration plot of Juniper (300 no.'s) at VVK Badamibhag, Leh. UT.
- ✓ Maintained demonstration plot of 15 medicinal plants species raised at VVK Badamibhag, Leh by carrying out regular weeding, hoeing and watering etc.
- ✓ The planting of cuttings of Salix and Poplar cuttings in polybags have been initiated.

- ***ICFRE-IFGTB, Coimbatore*** **carried out maintenance activities in the established demo plots in VVK-MYRADA and VVK-Salem.**
- **Conducted 30 Trainings/Workshops under VVKs by ICFRE Institutes and Centres.**

Two Training programmes were conducted by ICFRE-FRI on :

- Making of Bamboo handicrafts from 29th January to 9th February 2024 at Village Ummedpur, Dehradun. There were 21 participants from Ummedpur, Dehradun with assistance of Gangotri Kaushal Vikas Evam Utthan Samiti (NGO) attended the programme at Ummedpur Village.
- Biofertilizer and its application under Agroforestry from 21st February to 23rd February 2024 at SFRI, Ladhowal, Ludhiana (Punjab). 29 participants including Frontline Staff, Punjab Forest Department and Farmers attended the programme

Four Training programmes were conducted by ICFRE-IWST on:

- Bamboo cultivation, management, seasoning, preservation and utilization at Krishi Vigyan Kendra, Margoa, South Goa on 4th October 2023. About 50 farmers participated in the program.
- Sandalwood based Agroforestry Models & its Health for farmers through KVK, Hulkoti, Gadag District on 23rd January 2024. More than 150 farmers participated.
- Sandalwood based Agroforestry Models & its Health for farmers through KVK, Dharwad on 24th January 2024. More than 70 farmers participated
- Bamboo primary processing, pest & disease management and value addition of Bamboo for farmers through Krishi Vigyan Kendra, Mudigere, Chikkamangalore District, Karnataka on 12th March 2024. More than 75 farmers benefitted from the training.

ICFRE-TFRI, Jabalpur organized 08 training programmes on:

- Value addition of Moringa and Mosquito repellent Agarbatti sticks for 18 Women from Durga, Kali & Mata Mai SHGs, Partala, Chhindwara (MP)on 22.02.2024.
- Value addition of Moringa and Mosquito repellent Agarbatti sticks for 3 SHGs on 27.02.2024.
- Organic Farming Based Agroforestry for 21 Farmers from Manegaon, Chorai, Kundalikala, Khari, Junnardev, Amarwada, Umreth, Aamta, Karabdol, Saliwada, Chhindwara (MP) on 29.02.2024.
- Nursery and cultivation Techniques of important medicinal plants and NTFPs for Farmers/Tree growers from Nagpur (MS) on 01.03.2024.
- Value addition of NTFPs /Nursery and cultivation Techniques of important medicinal plants and NTFPs for 24 Women SHGs on 18.03.2024.
- Organized two training programme on Vaniki ki Unnat Taknik - Scope of Soil Health Card and its impact for Forest Officials at Payli, Eco-center of Seoni Van Mandal on 17th January 2024 and at Chandrapur Forest Academy on 22 December 2024.

Three Training programmes were conducted by ICFRE-AFRI on :

- Quality planting materials and Nursery Management was organized under VVK, Udaipur for farmers and field functionaries at Vidhya Bhawan Krishi Vigyan Kendra, Udaipur from 30th Jan to 1st Feb 2024. 40 participants (24 forest staffs and 16 farmers) from 6 Forest Divisions of Rajasthan Forest Department participated in the training.

- Role of Forest on Soil and Water Conservation at Gujarat Forest Rangers Collage, Rajpipla (Gujarat) for field functionaries and progressive farmers from 14-16th Feb 2024 under VVK, Rajkot. The total 44 participants (33 forest staffs and 11 farmers) were attended the training.
- Agroforestry in IGNP command area of Western Rajasthanwas organized for farmers and field functionaries at Krishi Vigyan Kendra, Jaisalmer from 15-17th March 2024 under VVK, Bikaner. The total 48 participant's including forest staffs and farmers from various villages/ranges of DDP, DNP and IGNP forest Division, Jaisalmer participated in the programme.

Six Training programmes were conducted by ICFRE-RFRI on :

- Forest Based Livelihood Opportunity" in association with Krishi Vigyan Kendra, Dibrugarh under VVK programme of RFRI, at KVK, Dibrugarh, Assam from 12th to 13th February, 2024. 60 participants including Farmers, SHG members, Forest Field functionaries of Dibrugarh, Assam participated in the programme.
- Forest Based Livelihood Opportunity" in association with Nagaon Territorial Forest Division, Assam at Rekhapahar Community Hall at Northern range, Salona, Nagaon, Assam from 19th to 20th February, 2024. 48 participants including Farmers, SHG members, Forest Field functionaries of Nagaon, Assam participated in the programme.
- Cultivation and Management of Agarwood from 11-12 March, 2024 for 22 participants at Agartala by ICFRE-LEC, Agartala
- Low cost Vermicomposting techniques for Livelihood generation on 14 March, 2024 at Takarjala, Sepahijala district for 25 unemployed tribal women by ICFRE-LEC, Agartala
- Bamboo & rattan handicrafts from 05 to 07 February, 2024 for 20 participants by ICFRE-BRC, Aizawl
- Mushroom cultivation from 14-16 February, 2024 for 24 participants by ICFRE-BRC, Aizawl.

Five Training programmes were conducted by ICFRE-IFB on:

- Sustainable Management of NTFPs through Conservation and value addition under AICRP-29 at Koraput, Odisha under VVK. The program was organized on 23.01.2024 with participation of 55 forest officials.
- High-yielding interspecific hybrid clones of Casuarina at ICFRE-IFB, Hyderabad, Telangana under VVK. The program was organized on 31.01.2024 with total participation of 16 forest officials from Telangana State Forest Academy (TSFA).
- Forest Insect Pest Identification and their management in the field under Van Vigyan Kendra on 04.03.2024. A total 44 Forest officials from Telangana State Forest Academy (TSFA), participated in the programme.
- Sustainable Land Management Practices for Rehabilitating Degraded Land under Van Vigyan Kendra on 07.03.2024. A total 45 Forest officials from Telangana State Forest Academy (TSFA), participated in the programme.
- Importance of Honeybees and its role in Biodiversity conservation for BSc-Agricultural Students from Malla Reddy University, Hyderabad on 19.10.2023 under VVK at IFB, Hyderabad. A total of 70 students participated in the program.

ICFRE-HFRI, Shimla organized a training programme on "Sustainable development through forestry technologies" in collaboration with KVK Samba district, Samba, Jammu on 22th January, 2024. About 40 farmers including members of farmers, Panchayat representatives, Mahila Mandal and youth club, etc. participated in training programme.

ICFRE-IFGTB, Coimbatore organized one day training on "Red Sanders – Lords Own Tree" for the Officials of Tamil Nadu Forest Department on 27th March, 2024 under VVK, Coimbatore. The training was imparted to 25 forest officials' viz., Forest Range Officer, Forester and Forest Guard.

ICFRE-IFP, Ranchi organized three-days training on lac production in Forest Division, Godda, Jharkhand from 31.10.2023 to 02.11.2023.

- **Activities related to Networking with KVK**

ICFRE-AFRI, Jodhpur

- In the VVK training at GFRC, Rajpipla on 18th Feb 2024 lecture was delivered by Dr. Devendra Modi, Scientist, KVK, Chaswad, Narmada district.
- Meetings were conducted with KVK officials of Udaipur, Vyara, Bikaner and Jaisalmer to explore resource facilities for conducting training.

ICFRE-IFGTB, Coimbatore

- MoU signed between ICFRE-IFGTB and TNAU for collaboration in ICFRE-IFGTB for extension activities in selected three KVKs (Tiruppur, Pudukottai and Cuddalore districts) in Tamil Nadu. Accordingly, activities have been finalized to be carried out under VVK-KVK networking during the year 2024-25.
- As a part of networking activity, Five Forestry Extension Centres (Villupuram, Dharmapuri, Tanjore, Virudhunagar and Tiruppur districts) have been selected in Tamil Nadu for dissemination of ICFRE-IFGTB technologies and products.

ICFRE-IFB, Hyderabad

- ICFRE-IFB, Hyderabad team members visited Koraput, Odisha forest division and documented the available infra and nursery facilities for establishing the New VVK center at Koraput, Odisha on 23.01.2024.
- MoU signed between the ICFRE-Institute of Forest Biodiversity (ICFRE-IFB), Hyderabad, and School of Agricultural Sciences (SOAS), Malla Reddy University, Hyderabad to collaborate to promote and accelerate the progress of various disciplines of forestry and agroforestry research, education, training, and extension on 05.12.2023.
- Discussions were held with officials of KVK-Tuniki, Medak, Telangana for collaborative extension activities by the team of ICFRE-IFB, Hyderabad.

ICFRE- HFRI, Shimla maintained intercropping demonstration model plot of medicinal plants species (Kardu, Nihani and Chora) raised at KVK Rohru by carrying out regular, watering as per requirement.

ICFRE-TFRI, Jabalpur Participated in the Zonal meeting of KVKs at Jabalpur and presented activities of TFRI.

Fig. 65 ICFRE-FRI, Dehradun organizedtraining on 'Making of Bamboo handicrafts at Village Ummedpur, Dehradun.

Fig.66. ICFRE-FRI, Dehradun organized a training on 'Bio-fertilizer &its application under Agroforestry" at SFRI, Ladhowal, Ludhiana (Punjab).

Fig.67. ICFRE-HFRI organized a training programme on "Sustainable development through forestry technologies"

Fig.68. Training programme on "Productivity enhancement and additional income through agro-forestry" at VVK Longani, Dharampur by ICFRE-HFRI, Shimla

❖ Demo Village (DV):

- **New Demo Village:** ICFRE-TFRI, Jabalpur established new Demo Village at Samthal Banjari, Seoni. MoU was also signed between Director, TFRI and CCF Seoni, Van Mandal, M.P. for the Demo Village on 17th January 2024.Plantation activities with involvement of villagers were carried out at Demo village, on 21/03/2024 by Director TFRI and his team.

- **Maintenance Activities**

ICFRE-HFRI, Shimla

- Maintained the demonstration plot of medicinal plants species (20 spp.) by carrying out regular weeding, hoeing and watering.
- Made liaison with villager of DV Badagaon and enquired them about requirement of forestry specie seedlings. As per the demand of people of DV, procured/collected seeds of different tree species viz. Kachnar (1kg), Buel (1kg) and Bamboo (0.5 kg) and Paulownia for raising the plants for distribution among farmers. Prepared nursery beds and filled up poly bags (2500 no's) for sowing seeds of forestry species in the beds. Seed sowing has been carried out and nursery is maintained by regular cultural operations.

ICFRE-AFRI, Jodhpur

- DV site was protected and maintained. Irrigation, soil working and anti-termite treatment was done in 1 ha area plantation of Guggal. Survival of Guggal plants is 78% in harsh climatic condition of Indian Desert.
- Research plot of Eucalyptus of 200 clones (1000 plants) was planted in 0.56 ha area under AICRP-04 and presently survival of Eucalyptus of 200 clones is 90%. Biofertilizers were also used to enhance productivity of *Dalbergia sissoo* planted (864) in 1.08 ha area under AICRP-21 at DV site. Survival of Shisham seedlings was 30%.

Fig.69. Guggal clones plantation at Demo village, Mohangarh, Jaisalmer by ICFRE-AFRI, Jodhpur

- **Conducted Eight awareness programme/training/workshop under Demo Villages:**
  - *ICFRE-IFGTB, Coimbatore* conducted one day Exposure visit & training on ''Agroforestry models'' for the progressive farmers and village representatives from new Demo village of D. Gudalur, Dindigul district on 06th March, 2024. They were also given technical knowledge on commercial tree species like Casuarina, TC Teak and Mahogany by the species experts from ICFRE-IFGTB. The villagers were also given knowledge on "TreeGenie" Mobile app and its uses. Later they were taken to Vegetative Multiplication Garden of ICFRE-IFGTB where-in to show different facilities like Mother bed chamber, shade house and the essential requirements for mass multiplication.
  - *ICFRE-IWST, Bangalore* conducted an awareness program on "Forests, Wildlife and Environment Conservation" on 22nd March 2024 for students of Government Kannada Primary School at Demo Village, Attivatta, Hosakote Taluk, Bangalore Rural District.
  - *ICFRE-TFRI, Jabalpur* organized a Live demonstrations programme to demonstrate Mushroom cultivation and Charcoal making from weed waste for Forest Officials and women SHGs of Banjari village, Seoni district (M.P.) on 29/02/2024.

- *ICFRE-IFP, Ranchi* organised one day hands on training on"Honeybee rearing, management and honey production" in Demo village Kutam, Torpa, Khunti (Jharkhand) on 13.02.2024

ICFRE-RFRI, Jorhat conducted 4 trainings on:

- Bamboo Shoot Processing for 21 participants including SHGs, entrepreneur of Demo Village of Khonamukh, Jorhat at RFRI from29 -31 May, 2023.
- Agarwood Cultivation and Artificial Inoculation at Charingia, Bhogamukh, Jorhat from28 to 29 August, 2023 for 38 participants.
- Mushroom Cultivation at Demo village, Charingia Gaon, Khonamukh, Jorhat, Assam on 22nd February, 2024 for 30 nos. of farmers from Khonamukh area, Jorhat, Assam.
- Mushroom Cultivation at Demo village, Charingia Gaon, Khonamukh, Jorhat, Assam on 23rd February, 2024 for 12 nos. of farmers from Khonamukh area, Jorhat, Assam.

Fig.70.One day training on "Honeybee rearing, management and honey production" in Demonstration village Kutam, Torpa, Khunti (Jharkhand) by ICFRE-IFP, Ranchi.

Fig.71. ICFRE-IWST, Bangalore conducted an awareness program on "Forests, Wildlife and Environment Conservation"for students of Govt. Kannada Primary School at DV, Attivatta, Hosakote Taluk, Bangalore.


Fig.72. Live demonstrations on mushroom cultivation and charcoal making from weed waste were organized for forest officials and women SHGs of Banjari village, Seoni district (M.P.) under Demo village CAMPA Extension by ICFRE-TFRI.

- **<u>Extension Normal/Other Activities</u>**

  ❖ **Prakriti: A Scientist-Student Connect Initiative -34 Activities conducted**

  ICFRE-FRI, Dehradun

  Three days hands on training cum demonstration on seed technology was conducted for 25 students of Kendriya Vidyalaya-FRI Dehradun on 16th, 17th January and 13th February, 2024 under which following activities were done:

  - On 16th January 2024 students were allowed to perform germination experiment on seeds of various forestry species Like: *Aegle marmelos, Dalbergia sissoo, Chukrasiata bularis, Toona ciliata, Butea monosperma* etc. The seeds were kept inside seed germinator and after 21 to 30 days students were allowed to take final germination count.
  - Whereas on 17th January 2024 students were allowed to make raised nursery bed, preparation of potting mixture, filling of poly bags and sowing of seeds in nursery beds and poly bags.
  - A session on final germination count was concluded on 13th February, 2024. 25 students were divided in five groups and result of final germination is as follow: **Group-1:** *Dalbergia sissoo* (Germination%=80), **Group-2:** *Toona ciliata* (Germination%=28)*,* **Group-3:** *Aegle marmelos* (Germination%=68), **Group-4:** *Chukrasiata bularis*(Germination%=72), **Group-5:** *Butea monosperma* (Germination%=33.3).
  - After this the germinated seeds were transplanted into Ploy bags. The students were encouraged to take care of these seedlings and after 1 year plant them around the areas of their school campus.
  - Visit to different Kendriya Vidhyalay - Manauri, Bamrauli and Chhiwaki (3 Nos.) were done for interaction among Scientists and Students.

  ICFRE-HFRI, Shimla

  - A Prakrti Programme organized by institute at KV Hamirpur, HP. Students were made aware about Mission LiFE particularly on topic single use plastic reduced and also informed about Amrit Sarvoar programs. They were also made aware of importance of urban forestry and encouraged to plant trees. About 60 students actively participated in the programme.
  - Fifteen volunteers of NCC from Government Senior Secondary School, Jagatsukh visited VVK Jagatsukh Manali on 22.11.2023. They were given information about the cultivation and uses of various medicinal herbs like Karu, Patish, Vanakkadi, etc. Besides, they were also made aware about the importance of environmental protection, Amrit Sarovar Scheme and afforestation under Mission LiFE.
  - The VVK, Jagatsukh in collaboration with GSSS Jagatsukh organized an awareness programme on "mission life" on 03.10.23 and during this event, students were educated

about the advantages of utilizing public transportation to conserve energy and promote environmental sustainability.

- The mission life program was organized at Govt. High school in Marh by the VVK. Participants learned about the practice of composting kitchen waste. Additionally, the students were apprised making of food waste composting and its associated benefits on 13.10.23.
- Mission life awareness program was organized in GSSS, Leh (girls) on 16.10.23 by VVK, Leh. In this, compost making from kitchen waste or food waste was discussed and demonstrated and its benefits were also explained.

ICFRE-TFRI, Jabalpur

- Prakriti programe was organized for 300 students of class 9th to 12th of Govt H.S. School, Sagda-Jhapani, village, Jabalpur (MP) on 12.01.2024 and lecture was delivered on 'Conservation of wild animals to save forest'.
- A lecture cum Hands on demonstration on Bio-fertilizer was delivered to the school students under Prakriti Program on 21st March 2024.
- Delivered an invited lecture on 'Sustainable development' to 10th and 12th Science students, KV, 1 STC, Jabalpur (MP)
- Participated and delivered a talk as special guest in the 'KVs regional level 51st Rastriya Bal Vaigyanik Pradarshani-2023' & seminar on 'Millets for health and sustainable planet' at KV-1 STC KV, Jabalpur (MP) on 12.12.2023

ICFRE-IFB, Hyderabad

- Organized an awareness program under Mission LiFE with Vvyasa School students, Hyderabad on 06.10.2023. A total of 70 students participated.
- Organized Prakriti programme for students of Kendriya Vidyalaya, Malkapuram, Vishkapatanam, Andhra Pradesh on "Pollution and its impact on Sustainable development'' on 30th October 2023 and 31.10.2023. A total of 200 students including teachers were present in the programme.
- Organized Prakriti programme for students of Kendriya Vidyalaya, Hakimpet, Telangana and Kendriya Vidyalaya, Begumpet, Telangana on "Sustainable Development" on 15.11.2023, 17.11.2023. A total 150 students including teachers were present in the programme.
- ICFRE-CEC, Vishkapatanam, organized institutional visit for 12th standard students from Sri. Kasyap Junior College where they were taken into the interpretation center and were explained with specimens and samples in the interpretation center. A small brief explanation about the various projects carried out in the center was explained to them on 22.11.2023. A total of 40 students made the visit to the center.
- Organized Prakriti programme for students of Kendriya Vidyalaya, Bowenpally, Telangana and Kendriya Vidyalaya, Begumpet, Telangana on "Mission LiFE& Sustainable Development" on 20.12.2023, 22.12.2023. A total 115 students including teachers were present in the programme.
- ICFRE-CEC, Vishkapatanam, Andhra Pradesh organized an awareness program on Conservation of biodiversity with special emphasis on mangroves for students of Kendriya Vidyalaya Sangathan (KVS), Steel Plant, Vishkapatanam, Andhra Pradesh on 12.02.2024 under Prakriti. A total 110 students including teachers were present in the programme.
- Organized an awareness program for students of Kendriya Vidyalaya Sangathan (KVS), Bowenpally, Hyderabad, Telangana and Kendriya Vidyalaya Sangathan (KVS), Koraput, Odisha on 11.01.2024 and 24.01.2024 under Prakriti. A total 162 students including teachers were present in the programme.

ICFRE-AFRI, Jodhpur

- Organised11 awareness program for students of Kendriya vidhalaya (BSF), Pokaran, Jaisalmer; Kendriya Vidyalaya, No. 1, Army, Ratanada, Jodhpur; Kendriya Vidyalaya, No. 1, Army, Cantt. Military Area, Jodhpur, Kendriya vidhalaya, banar, Jodhpur; Kendriya vidhalaya, banar (Army), Jodhpur; PM Shree Kendriya vidhalaya (BSF), Jodhpur; Kendriya vidhalaya-1 (Army), Cant. Military Area, Jodhpur; PM Shree Kendriya vidhalaya, Jalipa cant., Barmer; PM Shree Kendriya vidhalaya No. 1 (AFS), Jodhpuron 04/10/2023, 12/10/2023,06/11/2023, 07/11/2023, 09.11.2023, 20.11.2023, 21.11.2023, 22.11.2023 under prakriti. Total 4573 students participated in these programme.
- Organised two awareness program for students of Jawahar Navodaya vidhalaya, Nasirabad (Ajmer) and Jawahar Navodaya vidhalaya, Lanva, Patan (Gujarat) on 09/01/2024 and 17/02/2024. Total 490students participated in these programme.
- Organized awareness program for students of PM Shree Govt. Sr. Sec. School, Jodhpur on 21/03/2024. Total 150 students participated in the programme.

ICFRE-IFGTB, Coimbatore organized One day training program on 'Environment and Nature Conservation' to Baralikadu Ecotourism under Prakriti program for Government School students on 26.02.2024. In total of 30 students from Government High School, Thollampalayam and Government Higher Secondary School, Karamadai participated.

ICFRE-IWST, Bengaluru organizedTraining cum demonstration on "Bamboo-Nursery and Cultivation" was conducted at the IWST- Field Research Station (FRS), Gottipura, Hosekote, Bangalore- Rural Districts for 6th, 7th and 8th grade students of Dasarhalli, Hosekote on 18 July 2023. A total of 45 students and teachers attended the training.

ICFRE-IFP, Ranchi organized environmental awareness program was conducted at Kendriya Vidyalaya, Chhapra, Bihar by Forest Research and Extension Center Hajipur, Bihar on 04.12.2023

Fig .73 ICFR- HFRI organized Mission life programme at Longni, Himachal Pradesh

Fig.74. ICFRE-HFRI organized Mission life Awareness program in GSSS, Leh (girls)

❖ **Other Trainings and awareness programme (27 activities)**

Two activities were organised by ICFRE-RFRI, Jorhat:

- ICFRE-BRC, Aizawl conducted three-day hands-on training cum Exhibition under Van Vigyan Kendra, Mizoram on Livelihood Opportunities during 26.03.2024 to 28.03.2024 for 20 participants.
- ICFRE-LEC, Agartala conducted exposure visit for student of Tripura University on 06.03.2024.

Thirteen activities were organized by ICFRE-IFB, Hyderabad:

- ICFRE-IFB, Hyderabad & School of Agricultural Sciences (SOAS), Malla Reddy University organized 07 awareness program for BSc Agriculture students of Malla Reddy University Hyderabad, Telangana under environmental studies and disaster management program

on 05.12.2023, 03.01.2024, 04.01.2024, 05.01.2024, 08.01.2024, 09.01.2024 and 21.02.2024. Total ICFRE-IFB 729 students participated in the programme.

- ICFRE-CEC, Vishkapatanam organized an interactive session for MSc. Marine Biology and Fishery students from the department of Marine living resources, Andhra University, Andhra Pradesh on 18.12.2023 under Institutional visit. A total 25 students participated.
- ICFRE-CEC, Vishkapatanam, Andhra Pradesh organized an awareness program on "Mangrove and its importance on World Wetland Day" at AU English Medium School on 02.02.2024. Overall 30 students participated.
- ICFRE-CEC, Vishkapatanam, Andhra Pradesh organized one day training program on Strengthening the institutional capacity on the Mangrove conservation on 29.02.2024 at Vishkapatanam, Andhra Pradesh. A total 30 forest officials participated.
- Organized an awareness program for BSc Life Science students from Government Degree College, Falaknama, Hyderabad on 01.03.2024 under Forestry Extension program. A total 37 students participated.
- ICFRE-CEC, Vishkapatanam, Andhra Pradesh organized one day training program on Strengthening the institutional capacity on the Mangrove conservation on 14.03.2024 at Pudimadaka, Vishkapatanam, Andhra Pradesh. A total 30 Fishermen's participated.
- Organized an interactive session for BSc students from Rani Lakshmi Bai Central Agricultural University, Uttar Pradesh on 05.12.2023 under Institutional visit. A total of 20 students participated.

Seven activities were organised by ICFRE-HFRI, Shimla:

- A group of 10 Assistant professors of ICAR sponsored winter school (January 17 to February 6, 2024) on Agroforestry: Potential Approach to Mitigate Climate Changes for the scientists of SAU's and ICAR institutes visited ICFRE-HFRI, Shimla on 03.02.2024. Scientist of ICFRE-HFRI briefed the participants about ongoing research activities of the HFRI. Also gave a detailed presentation on "Disease and their management in Agroforestry" and on "Climate Change: Insect Pests attack in Agro-Forestry Plantation".
- A group of twelve students along with 6 faculties from Jaypee University of Information Technology, Waknaghat, Solan visited ICFRE-Himalayan Forest Research Institute, Shimla on 29 December, 2023. Students were briefed about the ongoing research activities and also informed about various activities of Mission Life. Apart from this, the objectives of Amrit Sarovar schemes and importance of urban forestry were also briefly explained.
- About forty one Forestry undergraduate students from College of Forestry Navsari, Agricultural University Gujarat visited ICFRE-Himalayan Forest Research Institute, Shimla on 16 December, 2023. They were also apprised about Himalayan ecosystem and role of Himalayan region in ecology and environment.
- A group of thirty B.Sc. Botany Students from Centre of Excellence, Government College, Sanjauli, Shimla visited ICFRE-HFRI Shimla. They were apprised about research and extension activities of the Institute and briefly explained about the objectives of Mission LiFe and Amrit Sarovar Schemes and Importance of Urban Forestry on 07.12.2023
- Twenty four M.Sc. microbiology students of Govt. College of Art, Commerce and Science, Khandola, Goa visited VVK cum Field Research Station, Jagatsukh, Manali on 05.12.2023. They were apprised about various ongoing research activities at the station. They were also apprised about Mission Life and Amrit Sarovar Scheme.
- Group of 72 students along with two faculty members from College of Forestry, Ponnampet, Kodagu, KVS University of Agricultural and Horticultural Sciences, Shimoga, Karanataka visited HFRI, Shimla on 13.02.2024. They were also briefed about Mission LiFE.
- A group of thirty five students along with 2 faculties from Mizoram University Aizawl visited ICFRE-Himalayan Forest Research Institute, Shimla on 23.02.2024. Students were briefed about the ongoing research activities and also informed about various activities

of Mission Life. The students visited various laboratories of the institute and herbarium where they were briefed about the ongoing research activities and working of scientific equipment by the concerned scientist, laboratory Officer in-charge.

Two activities were organised by ICFRE-AFRI, Jodhpur:

- Organized Cycle rally under Adopting healthy lifestyle Theme at ICFRE-AFRI campus on 19/10/2023. Total 20 participants participated in the rally.
- A lecture and demonstration training on entrepreneurship on Mass production of Trichoderma was organized by ICFRE-AFRI, Jodhpur under the theme Women Empowerment and Sustainable development LiFE on 07.12.2023. Total 23 women participated in the programme.

ICFRE-TFRI, Jabalpur organized 45 Exposure Visits for Group of stakeholders (2050) including Students (college and schools) RFO batch, farmers and university professors, forest officers, dignitaries and Demonstrated TFRI technologies displayed in the museum cum interpretation centre of the Institute.

ICFRE-IWST, Bengaluru organized sensitization program on forestry and wood science, training on vocational wood working and raising of plant nursery for about 23 officials from Regional Training Center of Indian Audit and Accounts Dept. Bangalore on 28 Feb 2023 as part of their Pre-Retirement planning training program.

- One day training on “Cultivation techniques of Commercially Important Tree Species” was imparted to 26 Officials *viz.,* Forestry Extension Officer, Range Officer, & Forester of Tamil Nadu Forest Department on 29th February, 2024 by ICFRE-IFGTB, Coimbatore.
- Three-days awareness program in Diyankel, Torpa, Khunti, Jharkhand from 03 to 05 February, 2024 was organized by ICFRE-IFP, Ranchi

❖ **Participation in Melas/Exhibitions/Workshops etc.**

ICFRE-HFRI, Shimla

- Participated in the Mega Exhibition "गतिशील जम्मू कश्मीर" organized by Prayas Event and Exhibition at Jammu from March 1st to 3rd, 2024. Officers of HFRI briefed him about the technologies and products showcased in the stall developed by the institute. Students and other visitors to the stall were informed about the institute's activities. The extension materials such as pamphlets and booklets were distributed among them.
- Installed a stall in the Exhibition of Flying Shimla Fair at Glide Inn Junga, Shimla. Technologies and products developed by the institute and extension material was displayed in the stall on 12th-13th October, 2023.

ICFRE-RFRI, Jorhat

- Participated in the Exhibition of Rural Agricultural Work Experience Programme, KVK, Kaliapani, Jorhat where RFRI, Jorhat showcased the research and development activities of the Institute on 11th May, 2023.
- Participated at the one day "Farmers' Fair" organized by Regional Agricultural Research Station, Titabor and took part in the Exhibition to showcase the research and development activities of the Institute on 1st November, 2023.

ICFRE-IFP, Ranchi

- Participated in Eastern Regional Kisan Fair organized by National Institute of Secondary Agriculture (NISA), Namkum from 03.02.2024 to 05.02.2024 (Three Days) at Diyankel, Torpa, Khunti, Jharkhand
- Participated in “Nutrition, Income and Employment Enhancement through Agricultural Innovations” in Birsa Agriculture University, Kanke, Ranchi, Jharkhand from 02.03.2024 to 04.03.2024 (Three Days)

FRCER, Prayagraj established forestry Extension Camp in Magh Mela from 16.01.2024 to 15.02.2024 by**.** During the period various awareness and extension activities were conducted for students, farmers and other visitors.

Fig.75. ICFRE-AFRI, Jodhpur organized Environmental awareness programme for students of JNV, Lanva, Patan, Gujarat

Fig.76. Disseminating forestry developed technologies to RFO trainees, TFA at AFRI, Jodhpur

❖ **Publications: Three leaflets, five pamphlets and one magazine published**

- ICFRE-IWST, Bengaluru**:** Three leaflets/handouts on Package of Practices for sandalwood cultivation; Protection of bamboo; Preservative treatment with Neem oil and CNSL to increase the service life of wood have been finalized and hard copies are awaited (from press).
- ICFRE-AFRI, Jodhpur published 500 Copies of "AFRI Darpan" a Quarterly Hindi Magazine (January to December 2023)
- ICFRE-HFRI, Shimla published 5 Pamphlets on– Himalayan Poplar, Kala poplar, Safed poplar, Balsam poplar, flowering trees and shrubs of western Himalayan Region.

Fig.77. Institute information booklet (Post merger of IWST with IPIRTI) has been printed for delegates, visitors and trainees.

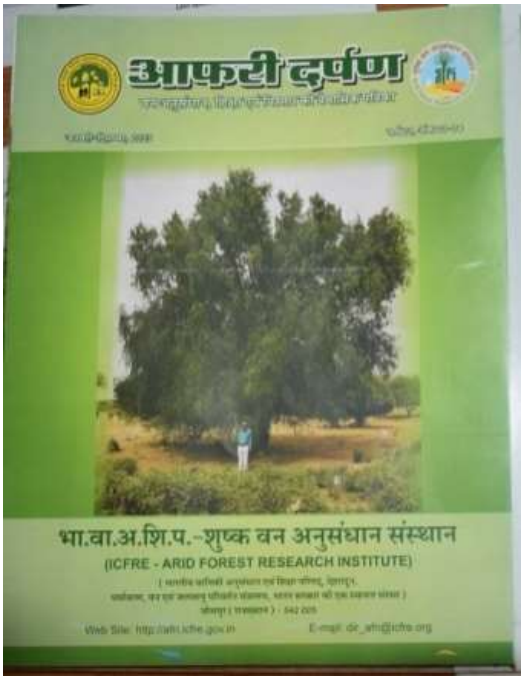

Fig.78. Publication of Quarterly Hindi Magazine –"AFRI Darapn", Jan- Dec 2023.

❖ **Celebration of Important Days/Azadi Ka Amrit Mahotsav**

- International Biodiversity Day, World Environment Day, World Day to Combat Desertification, Van Mahotsav, Earth Day and environmental important days under AKAM, Mission LiFE etc. were observed by ICFRE Institutes.

- **<u>Modified Direct to Consumer Scheme</u>**

ICFRE-IFGTB, Coimbatore

- Established a potted VMG of selected clones of *Calophyllum inophyllum*
- Distributed the TreePal^{H} Biopesticide to 32 Forestry Extension Centres of TNFD.

ICFRE-TFRI, Jabalpur

- Prepared Moringa Papads and Moringa Biscuits packaging material with FSSAI registration number and information on nutritional value, shelf life and advantages of herbal biscuits and papads.
- For developing market linkages Local herbal shopkeepers were approached and moringa biscuits and moringa papads were provided to M/s Paras Ayurvedic Jadi Buti evam Kirana Bhandaar, Chhindwara for sale.

Highlights

- Established 11 new Van Vigyan Kendras (VVKs) (Karnataka; Uttar Pradesh; Himachal Pradesh; Tamil Nadu; Meghalaya; Rajasthan; Chhattisgarh; West Bengal; Telangana; Bihar and Madhya Pradesh).
- Established 06 Demo Villages (Himachal Pradesh; Jharkhand; Karnataka; Rajasthan and Assam & Madhya Pradesh).
- Established 07 Technology Demonstration Centres (HFRI; IFP; FRI; RFRI, IWST & TFRI) & 01 Photogallery at FRI.
- Prepared 63 documentary films and Developed 04 mobile apps on 'Agroforest', 'EcoRehab', 'LKP-Info' and 'Bamboo Grow'. Organized 15 Tree Growers Mela/Institute Industry Meet.
- Conducted 185 trainings under VVKs, and DVs .
- Published 87 pamphlets, brochures, technical bulletins etc.
- Established 19 demo plots/models of different species (Guggal; *Melia dubia*; *Neolamarckia Cadamba*) Windbreak Clonal Plants at Tamil Nadu; Agroforestry model at Karnataka; Six demo plots of *Calophyllum inophyllum*, *Gmelina arborea*, Tamarind, Teak (T.C.), Cadamba, Pricision Silvicultural Technique with Teak and Casuarina, Tree Fodder Species, Medicinal Plants at Talamalai, Tamil Nadu; Four agroforestry demo plots of *Melia dubia* at Ambala, Haryana, Garhshankar, Punjab and Prayagraj and Poplar clones at Trewa Arnia, RS Pura, Jammu & one VMG of callophyllum.
- Manufactured and sold 430 reactions of ArborEasy DNA isolation kit, improved VAM Production unit for producing 2000 KG of VAM/year and distributed Mycorrhizal (VAM=AM fungi) inoculums (consortium). Also distributed the TreePal Biopesticide to 32 Forestry Extension Centres of TNFD and Prepared Moringa Papads and Moringa Biscuits with FSSAI registration number and information on nutritional value, shelf life and advantages of herbal biscuits and papads.
- Vacuum Pressure Impregnation Unit installed at ICFRE-RFRI, Jorhat for preservative treatment of Bamboo and has been given for lease to an Entrepreneur and now it has been running successfully. Now, treated Bamboo is available at affordable price.
- Around 7,26,765 QPM of various forestry species were raised.
- Prakriti: A Scientist-Student Connect Initiative: Over 822 programmes including lectures, biodiversity/nature walks, exposure visits, awareness programmes, plantation programmes, screening of documentaries etc. were conducted from 2020-2024 for various school/college students.

Research Publications, books, bulletins from the scheme “Strengthening Forestry Research for Ecological sustainability and Productivity Enhancement”

Research Publications, books, bulletins from the scheme "Strengthening Forestry Research for Ecological sustainability and Productivity Enhancement"

Research papers presented in conferences, seminars, symposia etc.

- Akil Prasath R.V, R. Mohanraj and A.Rajasekaran (2023) Prosopis juliflora invasion in Pudukkottai and Tiruchirappalli Districts of Tamil Nadu and its Socio-economic and implications, 46th Indian Social Science Congress: Interdisciplinary Thematic Panel on Ecological and Environmental Protection Movements, Bharathidasan University, 27th - 31st January, 2023.
- Anandalakshmi, R. (2023). Role of Forest seed bank in Conservation of FGR. In: Symposium on Forest Genetic Resource Conservation and Utilization organized by IFGTB at the 59th Annual Meeting of the Association for Tropical Biology and Conservation (ATBC 2023), Coimbatore during 2-6 July, 2023 at Kumaraguru College Campus, Coimbatore.
- Anandalakshmi, R., Suresh Kumar, K., Aarthi, M., Vineetha, M.V., Sathish, A., Arunkumar V. and Murugan E. 2023. Conservation and Sustainable Management of *Pithecellobium dulce* roxb. (benth.)- A Nitrogen Fixing Wild Edible Fruit. Proc. 108th Indian Science Congress, Section of Agriculture & Forestry Sciences, 3rd-7th January, 2023, Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur.
- Anandalakshmi, R, Aarthi, M, Sureshkumar, K and Sathish, A. 2024. Variability in nutritional parameters of wood apple (*Limonia acidissima* L.) from various seed sources of Tamil Nadu. In: Abstracts- DST-FIST sponsored International Conference on climate resilience – unraveling molecular solution for sustainable future conducted by Vivekanandha College of Arts & Science for Women, Namakkal on 15-16, February, 2024.
- Balasubramanian Aiyar, Sandhya M.C, Shamili Krishnaraj and Mathish Nambiar-Veetil (2020). Composite transgenics as a tool for functional analysis of genes in trees. In Abstracts of the Virtual workshop on "Clonal propagation of tree species" Organised by IWST, Bangalore on 7th October 2020. pp32.
- Bansal Richa and K. K. Pandey: Beeswax nano-emulsion incorporated with zinc oxide nanoparticles – a sustainable wood coating for UV protection. Paper presented in International Conference on Advances in Smart Materials and Emerging Technologies (ASMET 2021) (20-21Dec. 2021) organized by: Indira Gandhi Delhi Technical University for Women, Delhi, India. This paper won "Best Paper Presentation Award" (1st Prize).
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- Bhalla Piyush, Lal Mohan, Tripathi Y.C., Varshney V.K. and Singh A.K. (2022). *Cupressus torulosa* needles essential oil: Chemical composition and its biological activity In: International Conference on Biodiversity & Bioprospecting organized by Department of Plant Resources, Ministry of Forest & Environment, Govt. of Nepal from June 22-24, 2022 at Kathmandu (Nepal).

- Bhasker T, R., Dev, S. A., Balakrishnan, S. and Modhumita G. (2022). Development of neutral and adaptive genomic markers for management of Santalum album Linn.', paper presented at the Environmental Sciences, Forestry & Wildlife section, 34th Kerala Science Congress, Thiruvananthapuram, Kerala, India, 10-12 February, 2022.
- Bhatt Anjali, Tripathi Y.C., Nautiyal Raman and Varshney V.K. (2022). Extraction of natural dye from fruit peels of *Punica granatum* L. Protocol optimization using response surface methodology. In: 15th and 16th Uttarakhand State Science & Technology Congress held at Graphic Era Deemed to be University, Dehradun from June 22- 24, 2022.
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- Borpuzari, P.P; Singh, M.K. and Bhuyan, T. (2020); Agroforestry of *Gmelina arborea*: An economically important tree species, International Plant Physiology Virtual Conference *"Prospects of Plant Physiology for Climate Proofing Agriculture* December, 6-7, 2020; pp 182
- "Chemi-mechanical processing of cellulose nanofibers from bamboo and development of natural fiber-based nanocomposites". Presented in an International e-Conference on "Nanomaterials & Nanoengineering" held during February 24-26, 2022 at National Physical Laboratory, New Delhi (India)
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- Deepa M. delivered oral presentation on "Screening for establishing bioefficacy of ethnoinsecticidal plants for the development of formulations". 8-10 Dec. 2022. 3rd National symposium, Entomology -2022, PJTSAU, Rajendranagar, Hyd.
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- Garima Joshi, Shakti Chauhan (2024) "Improving the properties of polyvinyl acetate adhesive by adding cellulose nano-fibers" Poster presentation in "2nd International Conference on Novel Materials and Technologies for Energy and Environment Applications (NMTE2A)" on 17-18 February, 2024, Department of Chemical Engineering, BITS- Pilani, Hyderabad.

- Garima Joshi and Shakti Chauhan (2024) “Cellulose nanofibers from bagasse and their utilization as a binding agent for fiber boards” presented in 15th International Conference APM 2024 at CIPEET Ahmedabad.
- Joshi Garima and Shakti Chauhan**,** Poster on “Synthesis of cellulose nanofibrils and development of composites” in 3rd International Conference on Global Initiatives in Agricultural, Forestry and Applied Sciences, GIAFAS-2021 held during October 17-18, 2021 at SGRR, Dehradun.
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- Kumbhare Vishakha, Shukla Smruti and Revanth V. Development of Nutraceutical Bars from *Madhuca longifolia* (Mahua) flowers was presented as Poster presentation in National Seminar on “Securing Human Health though the use of Medicinal Plants" organized by MFP-PARC, Bhopal. Best poster presentation was awarded during the event.
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- Mayavel, A., Krishnan, S., Sivarathinavel, R.A., Ajith Kumar, A. and Nagarajan, B. 2020. Effect of grafting season and clone for deploying commercial propagation of tamarind (*Tamarindus*

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- Nisha & Sharma, S. (2023). Quercus semicarfolia Sm. In The Himalayan Region: Ecology, Importance, Dependency, Threats and Conservation Status. The 2nd International Conference on "Emerging Scenario of Science, Technology and Innovation-2023" was held on February 24th – 25th, 2023 (pp. 43-44) at the Career Point University, Hamirpur (H. P.), India.
- Pandey Shailesh participated and got 2nd position for best oral presentation on topic "Molecular taxonomy of fungal pathogens of Poplar" in 4th International Global Conference "Challenges and Opportunities in Agriculture, Horticulture, Environmental and Biotechnology Science in Current Era" on 26–27 February, 2022 organised by Department of Biotechnology & Microbiology Kalp Laboratories
- Paper communicated for publication in the conference proceedings of 'Value addition, marketing of NTFPs organized by TFRI, Jabalpur on 'Value addition to *Dilleniaindica* L. fruit - a potential Non-Timber Forest Product of North East India prepared and sent during Jan, 2022
- Paper communicated for publication in the conference proceedings of 'Value addition, marketing of NTFPs organized by TFRI, Jabalpur on 'Value addition to *Dillenia indica* L. fruit

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- Parkash Vipin, Karthikeyan, A., Megha, Gaur A., 2021. Effect of IFGTB developed biofertilizers on growth improvement of *Melia dubia* Cav. seedlings. In: 'National conference on Advances in Plant Sciences Research, PSRM-4 held on 20-21 Nov., 2021, organized by APSR and Uttaranchal University, Dehradun. (PSRM-4/NCAPSR/049).
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- Piyush Bhalla, H.R. Chitme, Mohan Lal, Y.C. Tripathi, and V.K. Varshney (2022). Chemical and biological investigation of Cupressus torulosa needles essential oil. In: International symposium on essential oils held on 4-7 September at Wroclaw, Poland.
- Piyush Bhalla, JPF, participated and presented (oral presentation) a research paper titled "Characterization of volatile and aroma active compounds in *Cupressus torulosa* needles essential oil by GC-MS and GC-O analyses" authored by Piyush Bhalla, Renuka Theregaonkar and V.K Varshney in the 53rd International Symposium on Essential Oils (ISEO 2023) scheduled held in Milazzo, Messina, Italy from September13-16, 2023
- Priya Nagaraik and Shukla S.R. "Physico-mechanical properties and characterization of nano-wood composite prepared from nano-Zinc oxide fortified furfuryl alcohol" A poster presented in an International conference on Advance Polymeric Materials (APM-2023), organized by CIPET, Bangalore.
- Priyanka S., Pattanaik S. and Padmaja G. (2022). Genetic polymorphism revealed by RAPD and ISSR markers in different accessions of *Pterocarpus santalinus* L. Poster presented in International Conference on Frontier Areas of Science and Technology (ICFAST 2022).
- Properties of Nano-Wood Composite (NWC) prepared from *Populus deltoides* impregnated with nano Zinc Oxide fortified PVAc resin. In an International e-Conference on Nanomaterials and Nanoengineering, APA Nanoforum-2022 held during 22-26 Feb, 2022 at National Physical Laboratory, New Delhi (India).
- Properties of Nano-Wood Composite (NWC) prepared from *Populus deltoides* impregnated with nano Zinc Oxide fortified PVAc resin. In an International e-Conference on Nanomaterials and Nanoengineering, APA Nanoforum-2022 held during 22-26 Feb, 2022 at National Physical Laboratory, New Delhi (India).
- Pankaj Singh, Ansarul Haque, G. Kiran, Varun Singh, Harikrishna. 2024. Screening of *Azadirachta indica* A. Juss CPTs from Maharashtra for their seed oil content and physicochemical traits for industrial and medicinal uses .p.25. In abstract book International Conference On Advances In Plant Sciences For Sustainable Future from February 07th To 09th 2024 organized by Osmania University Hyderabad.
- Ruby S. Kujur, Somnath S. Munda, Sneha Toppo & Alok Kumar (2023), Economic Importance of Wild Edible Fruits in the rural markets of Santhal Pargana. Abstract published in International Conference on "Ethnobotany, Environmental Sustainability and Multidisciplinary Researches" (ICEESMR- 2023) held on 29-30 November 2023.
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- Thakur, P. K., Kumar R., & Sharma S. (2023). Prediction Mapping Using Maxent Modelling for Habitat Suitability of the Economically Important Tree Species Rhododendron arboreum Sm. in Himachal Pradesh, North Western Himalaya, India. The 2nd International Conference on

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- Warrier Rekha R (2022) presented a paper on Smallholder teak agro forestry plantations: scope and prospects in India' during the National Webinar on "Augmenting Teak Timber in India: A way forward" (online mode) at IWST, Bengaluru.
- An abstract entitled "Genetic Improvement of Neem (Azadirachta indica) Through Selection of Superior Trees in Agroclimatic Zone Eight" Vivek Verma1* , Trilok Gupta1 , Mukesh Sonkar1 and Fatima Shirin1 was published inEnviroSummit 2024 International Conference on Climate Action, Ecology & Environment 1 March 2024 organised by The Department of Environmental Studies, MIT-WPU Pune, India.
- An abstract entitled **" बहु-उपयोगीवतेजीसेबढ़नेवालावृक्ष-एजाडिरेक्टाइंडिका (नीम)** ", विवेकवर्मा, त्रिलोकगुप्ता, मुकेशसोनकर, औरफातिमाशिरीन was published in राष्ट्रीयवैज्ञानिकसंगोष्ठीऔषधीयपादपोंकीखेती, उत्पादनिर्माणएवंमूल्यसंवर्धन 25 सितम्बर, 2023एभा.वा.अ.शि.प.-पारिस्थितिकपुनर्स्थापनकेन्द्र, प्रयागराज, pp-68.
- IFGTB organized a one day Seminar on Forest Genetic Resources Management inviting experts from NBPGR, Hyderabad and Directorate of Oilseeds Research, Hyderabad on 5th March 2020 tobrief on the FGR concepts
- On 6th March 2020, IFGTB conducted the Interactive meeting and launched the program on NPFGR wherein the implementation strategies werepresented and discussed with networking institutes.
- IFGTB conducted the first in-house Workshop on Prioritization of FGRs for fine tuning the scoring process on 7th July 2020.
- IFGTB conducted the second in-house Workshop on Prioritization of FGRs for fine tuning the scoringprocess on 6th October 2020.
- IFGTB organized an International Symposium on Forest Genetic Resource Conservation and Utilization was conducted by ICFRE-IFGTB in the 59th Annual Meeting of the Association for Tropical Biology and Conservation (ATBC 2023),at Kumaraguru College of Technology, Coimbatore.Devamanikandan, P., Lalitha, S., Anandalakshmi,R., Sureshkumar, K., Sathish, A. and Rajesh, C.2023. Mapping of Tree Species in Western Ghats for in situ Conservation. IFGTB News, 4(3&4):2.

- 1st National Conference on Plant Genetic Resource Management (NCPGRM 2022) held at National Agriculture Science Centre (NASC), Pusa Campus, New Delhi organized by ISPGR, ICAR, NBPGR, CIAT, TAAS and PPVFRA from 22nd to 24th November 2022 and received 'Best Oral Presentation Award'
- Invited lecture entitled "Implications for conservation of Forest Genetic Resources (FGR): A steppingstone for tree conservation through Sustainable Forestry Practices", delivered by Dr. Fatima Shirin, at National Seminar on Frontier Areas of Research In Forest And Wildlife Sciences, held at Guru GhasidasVishwavidyalaya, Bilaspur (C.G.) on 24th January 2024 and published in souvenior, Page no. 1-2.
- Abstract entitled **"**Development of microsatellitesmarkers for investigation in Hardwickia *binata* Roxb. in Central India", Raj Singh Yadav, Fatima Shirin, Ankur Dahayat and Naseer Mohammad, published in souvenior of International Conference on Climate Action, Ecology & Environment organized by the Department of Environmental Studies, MIT-WPU Pune held on 1st March 2024, Page no. 48.
- Abstract entitled **"**Assessment, exploration of status,diversity and conservation of vulnerable medicinal plant *Oroxylum indicum* Linn.", Irshad Ali Saudagar, Rama Soni, Sushma Maravi, Kaushal Tripathi and Fatima Shirin, published in souvenior of International Conference on Climate Action, Ecology & Environment organized by the Department of Environmental Studies, MIT-WPU Pune held on 1st March 2024, Page no. 46.
- Abstract entitled **"**Optimization of high-quality DNA extraction protocol amiable for PCR amplification through SSR marker in *Hardwickia binata* Roxb.", Raj Singh Yadav, Naseer Mohammad, Fatima Shirin, Ankur Dahayat and Harshita Agrahari, published in souvenior of National Seminar on Frontier Areas of Research In Forest And Wildlife Sciences, held at Guru GhasidasVishwavidyalaya, Bilaspur (C.G.) on 24th January 2024, Page no. 53.
- Abstract entitled **"**Adapting Forest Genetic Resource Conservation Strategies in the Era of Climate Change: Enhancing Resilience and Biodiversity", Manish Kumar Vijay, Fatima Shirin, Nanita Berry, and Nitin Kulkarni, published in souvenior of International Conference on Sustainable Natural Resource Management under Global Climate Change, held at New Delhi on 7th- 10th November 2023, Page no. 14-15.
- IFB Participated in the International conferenceon "Advances in Plant Sciences for Sustainable Future" organized by Osmania University Hyderabad. Two oral presentations was done on the morphological characterization of two species viz., *S. febrifuga* and *D. melanoxylon* using image analysersoftwares.
- Variation in some phytoconstituents of *Pyrus pashia* fruits from different locations of Uttarakhand' in 5th International Conference in GIRDAHA-2023, G.H Raisoni University, Salkheda M.P from 5th -7th October, 2023.

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Published books/technical bulletins, manuscript, brouchers and other publications

- Two Technical Bulletins on Propagation and Management of different species of Bamboos were published in English and Hindi language.
- Article on "Bamboo based multipurpose windbreak- An effective measure forreduction of wind disaster in Tripura"
- Manuscript on Smallholder teak agroforestry in the globalising world: Opportunities and challenges for India. Submitted to *Agriculture and Forestry journal*
- A brochure on management of tissue culture teak in plantations in Tamil was prepared, released during the Tree growers Mela during September 2021.Microwave processing of bamboo, *Wood is Good,* 1(2): 73-75, 2021
- R. Bansal, S. Nair, K.K. Pandey (2022) UV resistant wood coating based on zinc oxide and cerium oxide dispersed linseed oil nano-emulsion. Materials Today Communications, 103177.
- Assessment of *Prosopis juliflora* invaded lands in the semi-arid landscapes of Southern India for potential silivicultural and agricultural transition. (Communicated to CATENA - ELSEVIER - Article resubmitted after revision).
- Rekha et al. (2021) Submitted a review article on Smallholder teak agroforestry in the globalising world: Opportunities and challenges for India to the Agriculture and Forestry Journal (University of Tlemcen (Algeria)). II revision sent.
- Book published on "Tree Blossoms of northeast India".
- "Modeling potential hotspots of invasive *Prosopis juliflora* (Swartz) DC. In India", Ecological Informatics 64(7):101386. DOI: 0.1016/j.ecoinf.2021.101386.
- Printed technical bulletin, posters and conducted trainings by various participating institutes for dissemination of information on Bamboos. A Digital Brochures on bamboo Hindi and English prepared by FRI Dehradun. IWST, Bengaluru has published a technical bulletin on Dendrocalamus stocksii in local language (Kannada) for the benefit of various end users.
- AFRI published two booklets on sandal titled:
  1. Farmers' guide for white sandalwood cultivation (English)
  2. किसानों के लिए सफ़ेद चन्दन की खेती हेतु मार्गदर्शिका (हिन्दी)
- Two posters on Invasive Alien Species has been prepared.
- Red Sanders (Lal Chandan) A Green gold (English & Hindi) by AFRI
- An extension brochure 'Cultivation guide for Red sanders' by IFB
- An extension pamphlet 'An important wood boring insect pest (*Xylotrechus smei*) in Red sanders: Identification and management measures' by IFB
- An extension pamphlet 'Identification of Red sanders and Bijasal seedlings in nursery using morphological features' by IFB.
- "Wood modification with nanoparticles fortified polymeric resins for producing nano-wood composites: A review" in a journal "Bulletin of materials science".
- An extension poster 'Electrical Resistance Tomography (ERT): A Novel Technology in Forestry' by IWST.
- Leaflets in Hindi and English prepared for distribution to stakeholders
  - ✓ Nursery technique for seedlings production of *Oroxylum indicum* (Sonpatha)
  - ✓ Nursery technique for seedlings production of *Urariapicta* (Prishnaparni)
- M. K. Singh, V. Sharma, P. Kardong & N. Gayary2022. Forest Seed Identification- A Pictorial Guide for Northeast India. RFRI, Jorhat, Assam.
- Vishwanath Sharma & Manish K. Singh. 2022 LabManual For Seed Biochemistry. RFRI, Jorhat, Assam.
- Vijay, M. K. (2023). Unlocking the Secrets of *Nyctanthes arbor-tristis* Seeds: Insights into Maturity, Germination, and Storability for Successful Propagation and Conservation. In

Abstract book & Souvenir for the International conference on Green Energy & Sustainable Environmental Technology (GESET-2023) (p. 51). Raj Kumar Goel Institute of Technology, Ghaziabad: RKGIT, Save the Environment in collaboration with CSIR. Abstract ID 38.

- Vijay, M. K. (2023). Harnessing Seed Science and Technology for Climate-Resilient Tropical Forest Conservation. In Souvenir & Abstract Volume for the 5th International Conference on Sustainability Education (ICSE-2023) (p. 53). Indian Habitat Center, New Delhi: Mobius Foundation with, Bengaluru, in collaboration with ICAR-CAFRI, Jhansi. Abstract ID 14
- Leaflet for Forest Resource Utilisation for Uttarakhand has been developed.
- A booklet entitled 'Indigenous Traditional Knowledge in *Madhuca longifolia* (Mahua) prevalent in India' was published.
- A manual on *D. latifolia* (Indian rosewood) was published. The work was released by MoEF&CC during the International Day for Biological Diversity on 22nd May, 2022.
- Developed FAQs on *D. latifolia* Roxb. (Indian Rosewood) and released by ICFRE.

Videography

- Under AICRP-1, Holding the Sky – The Casuarina Story. A short film on high yielding clones and advance cultural practices. Uploaded in IFGTB Youtube channel and received 1.5K views.
- Under AICRP-3, a video was prepared on estimation of heartwood using ERT in standing trees of sandalwood.
- Under AICRP-4, a video on Cultivation practices of Eucalyptus clones in dry lands is being prepared for creation on awareness among the farmers of Tamil Nadu. Basic video shoot has been completed.
- Under AICRP-9, a documentary on TC teak cultivation and management practices was released on YouTube.
- Under AICRP-23, Indigenous Traditional Knowledge were collected and documented from different locations in Tamil Nadu and Kerala through questionnaire, photos and videos.
- A documentary "Elegance in every grain" to raise awareness on TC teak and management practices which can yield attractive financial returns was released under AICRP-9.
- Under AICRP-20, released a short-films on Biopesticide in Farmers Mela on the theme “Tree cultivation in coastal areas” held at Puducherry U.T.

Patent/Trademarks (filed/awarded)

- A patent was filed in the field of end grain drying of green turned wood on June-2022 under AICRP-5.
- Patent filed on 'Improved wood coating by IIT-R and ICFRE jointly' under AICRP-6.
- One Patent has been filled and received application number (202311033227) (IIT Roorkee and ICFRE)
- Second patent presentation has been defended and in progress. (IIT Roorkee)
- Patent filed under AICRP-16:
    - A novel formulation for the management of type-2 diabetes mellitus and complications associated with diabetes
    - Formulation and method of making a topical herbal gel formulation for the treatment of pain.
    - Herbal hair colouring composition and method for preparation
    - A process for recovery of natural dye from *Soymida febrifuga* bark.
    - A liquid herbal hair dye formulation coloring composition containing a decoction of a natural dye. (Patent Application No.202421008482; Dated 08/02/2024)
- IFP, Ranchi lab certified as: ISO 90001:2015 under AICRP-22

The shortfalls in achieving the envisaged targets of all the components of the scheme along with detailed justification:

- Funds shortage particularly under Recurring Head is affecting activities in some of the projects and institutes.
- Few plantations could not be established in 2020-2021 due to COVID therefore, there growth parameters measurement has been delayed by one year.

Glimpse of activities done in various components

Fast growth of clone CH5 (24 months old) at Chandwa, Jharkhand (IFP)

Clonal MLT at Zaheerabad, Parsapalle, Telangana by IFB

Seedlings of *Dipterocarpus indicus*

Field trial plot at Puliangudi village, Thenkasi district, Tamil Nadu

Release of short film on biopesticide in Farmers Mela

Progeny trial at Harhad, Hazaribagh (Jharkhand)

List of AICRPs with NPCs of the projects

Name of project	Name of NPCs
Component- 1 All India Coordinated Research Projects (AICRPs)	
AICRP 1 (Casuarina)	Dr. A. Nicodemus, IFGTB, Coimbatore
AICRP 2 (Bamboo)	Dr. Ajay Thakur, FRI, Dehradun
AICRP 3 (Sandalwood)	Dr Modhumita Dasgupta, IFGTB, Coimbatore
AICRP 4 (Eucalyptus Improvement)	Dr. V. Sivakumar, IFGTB, Coimbatore
AICRP 5 (dielectric heating)	Shri D.P. Khali, FRI, Dehradun
AICRP 6- (nanomaterials)	Dr. Shakti Singh Chauhan, IWST, Bengaluru
AICRP 7- (Invasive Alien Plant Species)	Dr. A. Rajasekaran, IFGTB, Coimbatore
AICRP 8- (Red sanders)	Dr. S. Pattanaik, IFB, Hyderabad
AICRP 9- (Teak)	Dr. R. Yasodha, IFGTB, Coimbatore
AICRP 10- (Seed testing and seed storage)	Dr. Manisha Thapliyal, FRI, Dehradun
AICRP 11- (*Dalbergia sissoo)*	Dr. Ajay Thakur, FRI, Dehradun
AICRP 12- (Demand and supply of timber, fuel-wood and fodder)	Dr. Rajiv Pandey, ICFRE, Dehradun
AICRP 13- (GDP, Green GDP)	Dr. Rajiv Pandey, ICFRE, Dehradun
AICRP 14- (Forest fire)	Smt. Richa Mishra, FRI, Dehradun
AICRP 15- (Tamarind)	Dr. B. Nagarajan, IFGTB, Coimbatore
AICRP 16- (Bioprospecting)	Dr. V.K. Varshney, FRI, Dehradun
AICRP 17- (Enhancement of fodder)	Dr. Dinesh Kumar, FRI, Dehradun
AICRP 18- (Silvicultural interventions)	Dr. C. Buvaneswaran, IFGTB, Coimbatore
AICRP 19- (Hydrology)	Dr. N. Bala, FRI, Dehradun
AICRP 20- (Biopesticide)	Dr. N. Senthil Kumar, IFGTB, Coimbatore
AICRP 21 (Bio-fertilizers)	Dr. A. Karthikeyan, IFGTB, Coimbatore
AICRP 22 (soil health cards)	Dr. Vijender Pal Panwar, FRI, Dehradun
AICRP 23 (*Madhuca longifolia*)	Dr. Fatima Shirin, TFRI, Jabalpur
AICRP 24 (Combating desertification)	Dr. Bhawana Sharma, AFRI, Jodhpur
AICRP 25 (Poplars)	Dr. Dinesh Kumar, FRI, Dehradun
AICRP 26 (Neem)	Dr. Tarun Kant, AFRI, Jodhpur
AICRP 27 (wild edible fruiting)	Dr. Sandeep Sharma, HFRI, Shimla
AICRP 28 (Indian Rosewood)	Dr.T.N. Manohara, IWST, Bengaluru
AICRP 29 (NTFPs)	Mrs. Neelu Singh, FRI, Dehradun
AICRP 30 (*Gmelina arborea*)	Dr.Nanita Berry, TFRI, Jabalpur
AICRP 31 (climate driven effects)	Dr. N. Bala, FRI, Dehradun
Component-II: Programme for Conservation and Development of Forest Genetic Resources (FGR)	
FGR - FRI	Dr. Santan Barthwal, NPC, FRI, Dehradun
FGR- IFGTB	Dr.R. Anandalakshmi, IFGTB, Coimbatore
Component-III: Policy studies under Centre for Forest Policy Research (CFPR)	
CFPR	• DDG (Education), ICFRE, Dehradun • ADG (Education and Recruitment Board), ICFRE, Dehradun
Component IV: Capacity Building of State Forest Departments for developing "State REDD+ Action Plans" under National REDD+ strategy (REDD+)	
REDD+	• Director (International Cooperation), ICFRE, Dehradun • ADG (BCC), ICFRE, Dehradun

Component V: Operationalization of Human Resource Development Plan of ICFRE (HRD)	
HRD	• DDG (Education), ICFRE, Dehradun • ADG (Education and Recruitment Board), ICFRE, Dehradun
Component VI: Operationalization of Forestry Extension Strategy and Action Plan of ICFRE (FES)	
FES	• DDG (Extension), ICFRE, Dehradun • ADG (Media and Extension), ICFRE, Dehradun