PHYSICAL PROGRESS REPORT OF THE SCHEME

"STRENGTHENING FORESTRY RESEARCH FOR ECOLOGICAL SUSTAINABILITY AND PRODUCTIVITY ENHANCEMENT"

Submitted by

Indian Council of Forestry Research and Education, Dehradun.

(Progress Report as on 30-9-2022 of the scheme "Strengthening Forestry Research for Ecological sustainability and Productivity Enhancement" funded by National Authority CAMPA)

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Physical Progress Report of the scheme
"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

Physical Progress Report

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

A. General Progress of all AICRPs:

- Compilation of existing knowledge/ data for all the projects completed. Equipment's (Total number) for laboratories of 9 ICFRE Institutes and 17 non-ICFRE Institutes purchased. Methodologies developed, land/sites for trials and field experiments finalized for 31 research projects.
- Priority list of species/CPTs/CPCs/locations and establishment of Clonal trials /progeny trials / MLTs etc for *bamboo, casurina, Santalum album, Pterocarpus santalinus, Dalbergia sisso, Dalbergia latifolia, Eucalypus, Poplar, Melia Azadirachta, Madhuca longifolia, Gmelina arborea* etc. finalized for 13 species-based projects.

a) Four Project Expert Group (PEG) meeting involving internal and external experts for monitoring of project conducted. The time period of the meetings held are given below:

Table 1: Meetings of PEG

1st PEG Review	For February 2020 to September 2020	November 2020, December 2020, January 2021 & February 2021
2nd PEG Review	For October 2020 to March 2021	July 2021 & August 2021
3rd PEG Review	For April 2021 to September 2021	November 2021, December 2021 & January 2022
4th PEG Review	April to June 2022	--

B. Project wise Progress of AICRPs

AICRP 1: Testing and deployment of clones and seed sources of *Casuarina* for different planting environments and end-use applications

The main aim of this project is to increase the productivity of Casuarina plantations through selection of site- and end use-specific planting material and thereby benefit farmers and wood-based industries. Two sets of field trials are taken up in the project: (i) clonal trials with the accessions already released by ICFRE in new areas and for new end uses and (ii) family trials with a broad genetic base which will function as a source of next generation clones and also as a seed orchard. Sixteen clonal trials were proposed to be planted in different States by the participating Institutes. Current status of establishment of clonal trials by the participating Institutes is given below.

Institute	No. of trials	Location of clonal trials
IFGTB	3	Ariyalur and Palapattu, Tamil Nadu; Navsari AU, Gujarat
FRI	3	Shajanpur, UP; Gillakhera and Seonthi, Haryana
AFRI	1	Mahuva, Gujarat
TFRI	3	TFRI Campus, CoA, Balaghat, and KVK, Umaria, MP
IFP	2	Arid and Chandwa, Jharkhand
IWST	2	Battemallapa and Kolar, Karnataka
IFB	2	Kondapuram, Nellore, AP; Dulapally, Telangana
Total	**16**	

Fig. 1 High survival and fast growth in 18-months old clonal trial at Dulapally, Telangana by IFB

Open-pollinated seeds were collected from 120 CPTs selected from the existing first / second generation breeding populations of *Casuarina junghuhniana*. Nursery raised with the family seedlots at IFGTB and FRI to produce planting stock for establishing progeny trials. Current status of establishment of progeny trials by the participating Institutes is given below.

Institute	No. of trials	Location of areas identified for planting	Month & year of planting	Remarks
IFGTB	1	Chettinadu, TN	September 2021	112 families
FRI	4	Shajanpur, UP; Kalanaur, Gillakhera and Hisar, Karyana	July 2021 October 2021	96 families
TFRI	1	Umaria, MP	September 2021	80 families

IFB	1	Mulugu, Telangana	September 2021	80 families
Total	**7**			

Raised 10,000 seedlings from seed collected from within the country and those imported for establishing progeny trials during 2022-23. Two hybrid clonal screening trials were established with 32 clonal and control seedlot accessions to select new high-yielding clones. Promising clones shortlisted based on early growth have been propagated and planted in a VMG for further multiplication and establishment of clonal proving trials.

Fig. 2 Progeny trial of *Casuarina junghuhniana* (age: 3 months) at Chettinad, Tamil Nadu by IFGTB

AICRP -2: All India Coordinated project on Bamboo

More than 250 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.

Fig. 3 Measurements for CPCs determination

For mass propagation, experiments for micro-propagation have been conducted in selected clumps of *B. cacherensis* at RFRI*, B. nutans* and *G. angustifolia* 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. Hardning and acclimatization was carried out for *D.strictus* at AFRI Jodhpur.

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.

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. 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. For development of Bamboo based multipurpose windbreak models, three windbreak model plantations 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.*

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 *Ageratinaa denophora* 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 *Ageratinaa denophora*was most effective against *Alternaria* followed by *Fusarium and Pestalotiopsis*.

Fig. 4 Fertilizer treatment in demo plantation

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, Mizoram, Nagaland, Sikkim and Tripura with 88.12% accuracy.

All India Bamboo Flowering Database is under development. Information on the flowering records across the country is being collected.

Total 17 accessions of *D. strictus* are being studied for pulping characteristics. Total pulp yield has been recorded in the range 44-54%, 43-53% and 42-50.5% at 16%, 18% and 20% chemical charge respectively. DNA bar coding work, which has been initiated for 21 bamboo species. 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. 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*. Established 7 Bambusetums Germplasm bank/bambusetum, 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.

Fig. 5 Nursery raising of bamboo species

AICRP-3: Conservation, Improvement, Management and Promotion of Sandalwood (*Santalum album* Linn.) cultivation in India

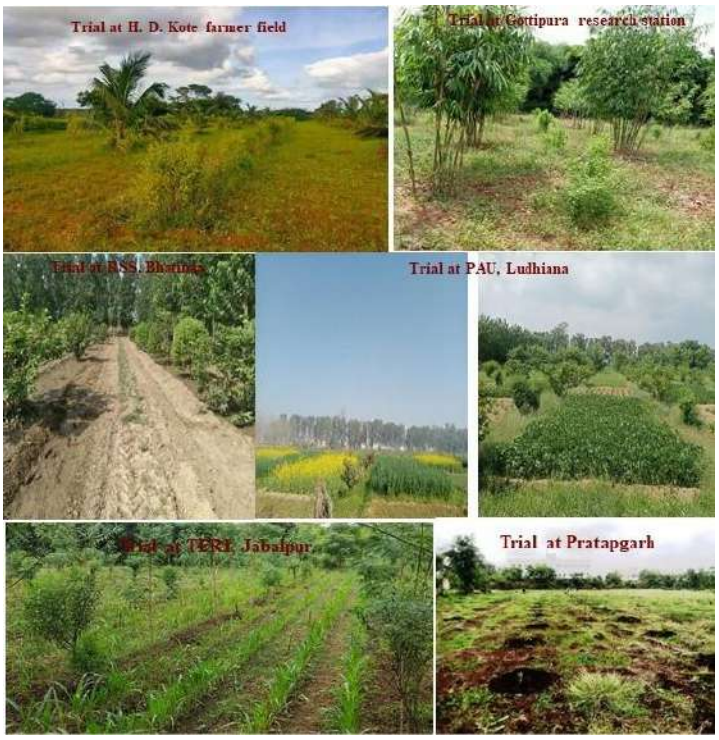

Fig. 6 Sandal based agroforestry trials

Thirty populations of sandal across the states of Rajasthan (5), Tamil Nadu (7) and Karnataka (18) were surveyed. 556 (Tamil Nadu &Karnataka) trees were marked for seed collection. The first Methylated cytosine map of *S. album* wood and leaf was generated. Integrated RNA and small RNA analysis in the wood tissues insight into to post transcriptional regulation of sesquiterpene pathway and expression of four major miRNAs were validated using stem loop quantitative reverse transcriptase. A total of 50 polymorphic SSR primer pairs were short-listed for genotyping the sandal populations. Established ten agroforestry trials with known seed sources in Tamil Nadu, Karnataka, Rajasthan, Madhya Pradesh and Punjab.

Collected Electrical resistivity tomography (ERT) data from standing trees in 45 plantations and optimized the linear regression model using actual and ERT heartwood data and documented 90% similarity with R^2 = 0.95. Carbon isotope composition ($^{13}C/^{12}C$) analysis in 110 wood samples using Isotope-ratio mass spectrometry (IRMS) was also carried out and the values ranged from -29.977 to -24.034 per mil. Estimation of oil content from 80 samples revealed variation from 0.38 – 7.63% while alpha and beta santalol in 68 samples ranged from 8.36 – 56.27% and 3.71 – 29.81% respectively. Prepared video on estimation of heartwood using ERT in standing trees of sandalwood (Available at https://www.youtube.com/watch?v=x7fTiXa8LVc).

AICRP-4: Eucalyptus improvement

IFGTB, Coimbatore multiplied about 62000 clonal plants. About 28700 clonal plants were individually numbered and transported to IFB, IFP, TFRI, CSFER, FRI, AFRI. Established germplasm bank with 285 clones. Established 9 MLTs {IFGTB (2), TFRI (2), AFRI (2), FRCER (2) & IFP (1)}. FRI established clonal trials of 67 eucalyptus clones were establishment at Krishi Vigayan Kendra, Pratapgarh.Two adoptive clonal trials were established at TFRI Campus and Bargi Forest range, Jabalpur Forest Division were maintained. Improve the growth vigour and adoptability of genotypes through Inter-specific hybridization. Fifteen and seven best performing clones were selected as seed and pollen parents respectively. Branch cuttings were grafted on seedling root stock and grafts established successfully for 10 clones.

Fig. 7 Growth of hybrid plants at Thiyagadurgam planted in Sept 2021

To identify and introduce new germplasm /species to suit various climatic conditions and end uses selected 20 plus trees of *E. tereticornis*. Coppicing of the selected trees in Panampally and Karunya carried out. One CSO at Gudalur research station (1.0 ha) established of 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 four Eucalyptus transgenic events were PCR confirmed. Twenty micrografted plants established with a graft success of 56% under tissue culture conditions. In Identification of secondary development specific miRNAs, a total of 1166 polymorphic SNPs were predicted in the miRNA cleavage sites of the target genes. To Popularize new clonal varieties and assess the impact of the introduced clonal varieties baseline information of private farmers using IFGTB-EC-4 clones of Ariyalur, Cuddalur & Pudukottai have been completed. A Demo plot of released clones of IFGTB has been established in an area of 1.0 Ha in the ICAR-KVK, MYRADA at Thalamalai. A video on Cultivation practices of Eucalyptus clones in dry lands has been completed for creation on awareness among the farmers of Tamil Nadu.

AICRP-5: Development of dielectric heating-based processing technologies for solid-wood, bamboo, and their composites

Fig. 8 RF Vacuum Dryer

Under component design and development of RF based wood processing systems, customised mechanical design of RF based Vacuum Dryer for Wood is ready. Functionality of the system demonstrated to IWST scientist. Under Design and development of MW-Vacuum based wood processing designing, fabrication and installation of a pilot scale microwave vacuum dryer completed. The vessel length of microwave vacuum dryer is 6.5 feet and diameter are 1.5 feet. Microwave vacuum dryer consist four magnetrons of 1.5 kW capacities each and has a convective heating system also. 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. In Bamboo drying results suggest that it took 10 days in an electrical heated whereas, in MWV dryer it took 12 h (3 cycles) + 2 h pre-heating to bring initial moisture content 67.1% to final 14.5% moisture content. Defect score of convective dried bamboo was 64, whereas, for MWV dried, it was 53. In another component fabrication, testing, integration and calibration of Microwave based moisture meter system for wood is completed. Validation of the moisture measurement system with industrial trial and demonstration. Based upon the experimental results it was decided to design the system configuration based on wood density class (0.3-0.4; 0.5-0.6; 0.7-0.8 and > 0.9 g/cm^3) rather than based on timber species. The moisture measurement system was found to be very accurate with a variation ± 0.5%.

Under study on green dimensional aspect in wood turning of plantation grown timber conventional kiln drying of Eucalyptus and melia completed. **A patent was filed on "End grain drying of green turned wood.** For optimizing MW treatment for improving treatability of wood microwave pre-treatment of *E.hybrid* and *M. dubia* samples at 360, 480, 600, 720, 840 and 960 MJ/m3 MW Intensity carried out. 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/m3) with different preservatives is obtained in samples pretreated at 720 MJ/m3 and 840 MJ/m3 MW intensity followed by pressure treatment at 150 lbs/in2 pressure. Where as in Eucalyptus hybrid maximum retention (8-10 kg/m3) with different preservatives was obtained in samples pretreated at 960 MJ/m3 MW intensity**.**

AICRP-6: Value addition of wood and wood-based composites using nonmaterial

Zinc oxide (ZnO) and cerium oxide (CeO_2) nanoparticles embedded linseed oil emulsion developed as **ecofriendly wood preservatives/coating.** Study established potential use of nano emulsions of vegetable oils as environment friendly coating materials. **Nano-filler blended resins were used for improvement of quality of low-density woods by impregnating with.** *Melia dubia* and Poplar wood were impregnated with PVAc, FA and PVAc-nano ZnO and FA-nano ZnO blends. Nano-wood composites (NWC) were characterized with SEM. Thermal stability was determined using thermogravimetric analysis (TGA). Fire resistance test on NWC were performed, which showed improved fire resistance property compared to control. Nano-particles were used for **improving properties of Medium density fiber boards.** Mycological testing of 1% and 2% nano-SiO_2 loaded boards indicated that nano-SiO_2 had a positive effect in improving the efficacy of boards against fungal attacks. Formaldehyde emissions testing of 1% and 2% nano-SiO2 loaded samples were conducted. It was observed that addition of nano-SiO_2 reduced the amount of formaldehyde emissions from the boards.

Fig. 9 Wood without coating

Fig. 10 Coated with PVA/ 0.7%E/ 3%CNC

Nano cellulosic fibre filled composites were prepared using Cellulose nano fibrils (CNF) synthesized from bamboo and Eucalyptus pulp with TEMPO mediated oxidation process. Plyboards were prepared by using CNFs obtained from bamboo and Eucalyptus and mixed with PVAc. TSS results showed increase in shear strength on addition of CNFs as compared to PVAc alone. After the addition of Bamboo and Eucalyptus CNFs, the TSS was increased by 68.9% and 69.59% respectively. **To develop Nano cellulosic fibres /particles fruit** and dry waste of leaves of fig tree species was collected. Methanolic extract of *Ficus auriculata* fruit was extracted and CNCs from leaves were synthesized coating material of polyvinyl alcohol with fruit extract and CNCs with different concentrations and found that 3% CNC with 0.7% extract concentration was synthesized and found best for wood coating. Patent for same has been filed.

AICRP 7: 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

Information on the invasion of *Prosopis juliflora, Lantana camara, Acacia mearnsii and Mikania micrantha* have been collected in (about 60% different areas) of Gujarat, Rajasthan, Himachal Pradesh, Uttarakhand, Uttar Pradesh, Assam, Bihar, Jharkhand, West Bengal, Chhattisgarh, Madhya Pradesh, Assam, Kerala and Tamil Nadu states. Spatial mapping of *P. juliflora* invasion using satellite images in twenty-five Districts of Tamil Nadu has been completed. The overall habitat suitability for *P. juliflora* has been predicted to increase under the future climate change scenario (RCP 2.6 and RCP 8.5 for 2050 and 2070). The habitat suitability mapping of *L. camara and C. odorata* in the parts of central and eastern India has been completed.

The impact of selected IAPS on the native plant diversity, regeneration and soil physico-chemical properties in different habitats have been assessed. The native plant species diversity associated with IAPS have been recorded. The preliminary results showed that soil nitrogen and phosphorus content was high in the Prosopis invaded sites than the uninvaded sites. However, the quantity of other nutrients was more in the uninvaded sites than the invaded sites. The eco-physiological traits of Lantana such as leaf area, specific leaf area, tissue density, leaf thickness and chlorophyll content were recorded. The allelopathic effect of Lantana on *Pyrus pashia*, *Berberis lycium* and *Punica granatum* was assessed.

Fig. 11 Photographs from Field

Studies on Bioprospecting of Prosopis was initiated. Calorific value, ash content and fixed carbon content of different biomass samples of Prosopis was determined and Briquetting of biomass was carried out at moisture content between 6 to 8% and it was observed that briquettes crumbled and dust came out at the time of abrasion.

Isolation of Bio-control agents under *in-vitro* condition infecting *Mikania micrantha* was done. Till now, 3 different fungal colony were observed which are yet to be identified. Release of bioagent *Teleonemia scrupolosa* for biological control of Lantana under net house conditions

did not cause any damage during October to March. Manual removal of *M. micrantha* after germination was found effective to check its climbing on the trees. Pods of *P. juliflora* have been collected from six districts of Rajasthan and four districts of Gujarat for assessing the potential of seed bruchids as biocontrol agents.

AICRP 8: Conservation and productivity improvement of Red Sanders

To establish base population-cum-provenance trials to assess genetic variability in Redsanders, GIS based spatial analysis was done to understand geographical and climatic variation in the natural Red sanders zone and delineate provenances. The provenances were surveyed by the component collaborators and seeds were collected from 145 trees during 2022. The seeds have been put for germination at IFB Hyderabad and BIOTRIM, for raising progenies for provenance trials. To map natural distribution of Red sanders Maxent modelling was take to identify potentially suitable habitats for Red sanders. The consolidated GPS coordinates representing species presence were plotted and a distribution map generated.

Fig. 12 Rhizobium inoculated Red sander seedlings showing root nodule formation

62 candidates plus trees have been identified and scored using the grading criteria developed for Red sanders. Seeds were collected from 31 plus trees for raising half sib progenies. To refine vegetative propagation technique for Red sanders about 55% rooting success was observed in softwood cuttings kept inside poly tunnels and treated with 2000 ppm of IBA. Two strains of Rhizobium, three species of AM fungi (*Glomus geosporum, G. fasciculatum, G. aggregatm)* and one species of Phosphobacteria (*Bacillus megaterium)* have been identified for redsanders. Analysis of soil samples collected from natural Red sanders zone showed healthier AM fungal populations. To develop species-specific markers for Red sanders so far, DNA extraction protocol has been optimized; 42 RAPD primers have been screened and seven highly polymorphic/informative primers have been identified; 33 ISSR primers have been screened and twenty polymorphic primers have been identified. DNA extractions have been completed for 32 of 69 accessions and 31 plus trees for genetic diversity analysis and molecular characterization, respectively. Electric resistance tomography (ERT) to predict heart wood

formation in Red sanders was from 48 plantations in Karnataka and Tamil nadu and a tomogram library prepared. Heartwood prediction with ERT was found to be 85-90% accurate. 506 Red sanders heart wood cores have been analysed for stable carbon isotope composition ($^{13}C/^{12}C$). Stable carbon isotope composition ($^{13}C/^{12}C$) of for α-cellulose was explored to further refine the process.

The second sub-component aims to develop chemical markers for identification of Red sanders wood. Chromatographic (HPLC) analysis of methanolic extract of Red sanders heartwood collected from different locations was carried out. HPLC analysis indicated at least 11 common peaks at retention time (tR) 3.1, 3.5, 8.9, 11.1, 12.8, 13.5, 14.9, 15.7, 17.9, 18.3 and 26.5 (minutes). Similarities in chromatographic pattern between the samples from different locations were evaluated using the principal component analysis (PCA). The developed fingerprint may serve as supplementing tools for identification and evaluation of heartwood of *P. santalinus*. Isolation protocol has been standardized for polar phytochemicals and altogether 4 compounds have been isolated from heartwood extract of Red sanders.

AICRP 9- Quality teak production: capitalizing on cloning

Quality planting stock production of teak through tissue culture has become a popular method for raising clonal plantations of teak throughout the world. In India few farmers and other planters purchase such planting stock of unknown origin from various commercial sources. Hence, under this project efforts are made to assess the performance of teak clonal plantations raised in the past and introduce/multiply pedigree known improved planting stock for raising demonstration plantations for popularisation among farmers. One of the objectives of this project is to assess various aged plantations raised through commercial sources, and hence plantations from states like Kerala, Karnataka, Tamil Nadu, Chattisgargh, Maharashtra etc and found the growth at the age of 5 years was adequate with average height and girth of 9.0 m and 35.0cm respectively. Memorandum of agreement signed by IFGTB with 3 commercial tissue culture labs for large scale production and one of the laboratory HU Gugle Biotech private limited, Bengaluru initiated the supply of plants. In the project IFGTB provided start up cultures to all participating institutes (TFRI, FRI, IFP) for mass multiplication and plant production. In addition all the institutes initiated local clones for mass production. Field demonstration trials of about 55 ha in blocks and bunds were established in Punjab, Uttar Pradesh, Uttrakhand, Haryana, Gujarat, Tamil Nadu, Kerala, Karnataka, West Bengal, Jharkhand Maharashtra and Madhya Pradesh. Some of the state forest departments (Chhattisgarh, Madhya Pradesh, Maharashtra and Kerala) and forest development corporations are interested in taking up large scale plantations of teak and this project supports in the form of supply of plants, production of propagules in the state's laboratories and hands on training to forest department staff. The following are the details provided on the activities carried out by each participating institute:

Following are the location details on plantations raised by tissue culture produced teak by IFGTB

S. No.	Locations	Latitude	Longitude	Elevation	Area in ha	Type of Plantation
	Maharashtra					
1.	Compartment No 457, Hirva Range, Nagpur Division	21°33’17.1” N	079°21’47.2” E	360m	1.62	Block

2.	Compartment No 596, Deori Range, Gondia Division	21°01’03.4”N	080º21’04.7’’E	340 m	4.5	Block
3.	Compartment No 57, Balapur, Bhramhapuri Division	20º33’25.9”N	079º51’34.5’’ E	226 m	2.14	Block
4.	Compartment No 530, Markhanda Division	19º45’15.2”N	079º33’15.6’’ E	237 m	4	Block
5.	Mosum beat, Aheri Range, Allappalli Range	19º19’24.6”N	080º00’49.7’’E	139 m	2	Block
	Tamil Nadu					
6.	Namakkal	11º11’50.73”N	78º08’40.302’’E	194 m	0.5	Block
7.	Ariyalur	10º57’14.166”N	78º59’47.83’’E	41 m	0.5	Block
8.	Kandiyur	10º51’48.88”N	79º06’22.662’’E	38 m	0.5	Block
9.	RS Mathur	11º18’48.066”N	79º13’33.096’’E	77 m	1.0	Block
10.	Pudukkotai	10º28’32.394”N	78º47’45.582’’E	115 m	0.3	Block
11.	Keeranur	10º36’19.878”N	78º48’19.02”E	131 m	0.5	Block
12.	Tindivanam	12º11’12.192”N	79º40’39.852”E	58 m	0.75	Block
13.	Myladuthurai	11º06’55.2”N	79º42’05.6”E	54 m	0.75	Block
14.	Pondicherry	11º51’35.04”N	79º38’12.054”E	25 m	1.0	Block
	Chaattisgarh					
15.	Narharpur	20°27’11.3’’N	081°38’17.2’’E	416 m	4.5	Block
16.	Sarki	21°03’46.5’’N	081°39’45.7’’E	410 m	2	Block
17.	Kesda	21°36’03.2’’N	081°47’43.9’’E	402 m	1	Block
	Karnataka					
18.	Kollegal	12°04'18.0"N	77°09'26.2"E	587 m	4	Block
19.	Kollegal	12°4'38.87"N	77°8'8.41"E	573 m	2	Block
20.	Iruvakki	14°1'50.07"N	75°11'26.4"E	580 m	1	Block
	Kerala					
21.	Konnappara	9°15'27"N	76°52'17"E	130 m	1	Block
22.	Thavalappara	9°13'58"N	76°52'54”E	160 m	1	Block
23.	Adikuzhi	8°43'15.22"N	77°3'15.67	100 m	1	Block
24.	Nilambur	11°16'10.12"	76°12'21.99"E	400 m	2.5	Block
25.	Chuzhali	12° 4' 35N	75° 28' 15E	62	2	Block

The details on the field trials established by TFRI are as under

S. No.	Locations	Latitude	Longitude	Elevation (m)	Area (in ha)	Type of plantation
	Madhya Pradesh					
1.	Bargi-I, Jabalpur	22^0 58′ 26″ N	79^0 52′ 30″ E	411	0.51	Block
2.	Banjar, Jabalpur	$23^0$33′82.37″ N	$80^0$22′87.96″ E	133	1 .0	Bund / Agroforestry
3.	Durganagar, Jabalpur	22^0 58’40” N	79^0 58’54”E	468	0.20	Block
4.	Bargi-II, Jabalpur	$22^0$58′ 23″ N	79^0 52′ 26″ E	390	0.50	Block
	Maharashtra					

5.	Range: Arjuni, Beat: Morgaon, Comp. 249	20^0 43' 55" N	80^0 10' 32" E	245	1 .0	Block
6.	Range: Chichgarh, Beat: Magardoh, Comp. 807	$20^0$48'32.04" N	80^0 15' 33" E	273	1 .0	Block
7.	Range: Jamdi 1:, Comp.: 401; Beat-Bagadbandh	$21^0$21' 18" N	80^0 04' 35"E	415	1 .0	Block
8.	Range: Salekasa, Comp.: 434; Beat-Jamdi	$21^0$17' 54" N	80^0 32' 39"E	409	1 .0	Block
9.	Range: Salekasa, Comp.: 435; Beat-Bakalsara	$21^0$18' 45" N	80^0 32' 27"E	345	1 .0	Block

In the teak trial at Bargi 55-60% survival was observed and in bund plantation at Baghraji 80% survival was recorded. Survival in the FDCM plantations in Maharashtra is in the range of 71 to 97 %.

The details of established plantations by IFP ,Ranchi are as under:

Sl. No.	Location	Latitude	Longitude	Area (ha)	Type of plantation
1	Kashinagar, South 24 Paraganas, West Bengal	21.916811 E	88.200348 N	0.2	Block
2	Thakurpukur, Kolkata, West Bengal	22.463182 E	88.309845 N	0.05	Block
3	IFP Campus, Lalgutwa, Ranchi	23.35866 E	85.24677 N	0.1	Block
4	Jari, Gumla, Jharkhand	23.09924 E	84.18325 N	0.5	Agroforestry

The details on the field trials by FRI are as below:

Sl no	Location	Latitude	Longitude	**Area (Ha)**	Type of plantation
1	Haridwar, Uttarakhand	30°03'16" N	77°50'17" E	1 .0	Bund / Agroforestry
2	Haridwar, Uttarakhand	30°05'27.8" N	77°54'08" E	0.75	Bund / Agroforestry
3	Bajpur, Uttarakhand			1 .0	Bund / Agroforestry
4	Jayantipur, Biharigarh, Saharanpur, UP			0.5	Row - 3 m Plant – 3 m *Most of the plant died due to flash flood in river
5	Nagal Rodan Shamli, UP	29.625686 N	77.477508 E	1.75	Bund / Agroforestry
6	SSBS Nagar, Punjab	31° 01'14.5" N	76°22'23.1" E	2.0	Bund / Agroforestry
7	Haryana Forest	29.53414 N	75.914396 E	2 .0	Bund /

	Corporation Bithmera, Haryana				Agroforestry
8	FRI Campus			0.5	Block

The details on the field trials established by AFRI,Jodhpur are as under:

S. No.	Locations	Latitude	Longitude	Elevation	Area (in ha)	Type of plantation
1.	Chitroda, Teh. – Idar Dist. - Sabarkantha	23° 45' 3.6576"N	73° 4' 22.9692"E	200.73	0.97	Bund / Agroforestry
2.	Chitroda, Teh. – Idar Dist. - Sabarkantha	23° 44' 59.766"N	73° 4' 26.184"E	177.79	0.97	Bund / Agroforestry
3.	Village – Chitroda, Teh. – Idar Dist. - Sabarkantha	23° 45' 2.826"N	73° 4' 22.4796"E	190.59	0.97	Bund / Agroforestry
4..	Chitroda, Teh. – Idar Dist. - Sabarkantha	23° 45' 2.826"N	73° 4' 22.4796"E	190.59	0.45	Block
5.	Mandal, Songarh, Vyara, Dist - Tapi	21° 9' 34.4736" N	73° 27' 57.1752"E	129.18	2.00	Block

Fig. 13 Teak tissue culture & field trails by IFGTB

AICRP-10: Developing seed testing and seed storage protocols of selected forestry species from diverse forest types

In Fruit/Seed maturity and seed collection, processing and handling field survey done for demarcation of populations and fruit maturity assessment for *Acer pictum, Albizia julibrissin, Albizia odoratissima, Alnus nitida, Erythrina suberosa*, *Kydia calycina, Litsea chinensis, Premna latifolia, Pterospermum acerifolium, Quercus glauca, Sterculia villosa, Stereospermum suaveolens*, *Toona serrata, Diospyrous tomentosa*, *Heteropanax fragrans, Machillus odoratissima* and *Tsuga dumosa* in different forest divisions of Uttarakhand, Uttar Pradesh and Haryana **(FRI).** Field survey and seed maturation studies completed in ten species: *Semacarpus anacardium, Sterculia villosa, Buchnania lanzan, Butea monosperma, Stereospermum*

chelonoides, Kydia calycina, Hymenodictyon excelsum, Nyctanthes arbortristis, Putranjiva roxburghii and *Mallotus philippensis* and continued in 2 species: *Feronia limonia,* and *Pterospermum acerifolium* **(TFRI)**. Perambulated different forest areas (in Tamil Nadu and Kerala) and identified seed sources of *Elaeocarpus serratus, Maesa indica, Cipadesa baccifera, Murraya paniculata, Bischofia javanica, Symplocos cochinchinensis, Cullenia exarillata, Leea indica, Aphanamixis polystachya* and *Memecylon umbellatum*. Conducted flowering and fruit maturation studies in these species. Collected fruits and standardized seed processing and extraction. Seed germination studies also conducted in the species **(IFGTB)**.

Fig. 14 Mature Fruits of *Schima wallichii & Murraya paniculata*

Distribution and location of the populations of *Dipterocarpus indicus, Knema atteneuata* in Agumbe, Makutta and Gorusoppa, Honnavara (Karnataka) *Garcinia indica, Garcinia gummigutta, Kingiodendron pinnatum, Mammea suriga, Dimocarpus longan, Hopea parviflora, Diospyros ebenum, Lophopetallum wightianum* and *Schleichera oleosa* identified for observations on initiation of flowering, fruit maturity and to study suitable optimum period for fruit collection **(IWST)**. Flower anthesis and seed maturation studies on *Schima wallichii* and *Morus laevigata* (in Nagaland and Assam) *Strereospermum tetragonum, Mesua ferrea, Magnolia champaca*, *Pinus kesiya* (in Manipur) *Shorea robusta, Phoebe goaparensis*, *Dipterocarpus retusus, Chukrasia tabularis*. *Magnolia champaca* & *Mesua ferrea* (in Assam and Arunachal Pradesh) **(RFRI).** Field survey of natural populations of *Prunus cerasoides, Sorbus lanata*, *Betula utilis, B. alnoides* and *Rhododendron campanulatum* in various forest divisions of Himachal Pradesh **(HFRI)**, Selection of seed sources of *Anogeissus latifolia, Capparis decidua* and *Salvadora persica* in region of Nagaur, Balotra and Jodhpur (Rajasthan) **(AFRI) For investigating seed germination behaviour of forestry species from various forest types** seed quality evaluation through indirect tests, seed germination and dormancy pretreatments (if any) done in *Acer pictum, Albizia julibrissin, Albizia odoratissima, Alnus nitida, Dioppyros tomemtosa, Erythrina suberosa, Heteropanax fragrans, Kydia calycina, Pterospermum acerifolium, Premna latifolia, Sterculia villosa, Litsea glutinosa, Quercus glauca, Tsuga dumosa* and *Toona serrata; Semacarpus anacardium, Sterculia villosa, Buchnania lanzan, Butea monosperma, Stereospermum chelonoides, Kydia calycina, Hymenodictyon excelsum, Nyctanthes arbortristis, Putranjiva roxburghii*, *Mallotus philippensis, Feronia limonia,* and *Pterospermum acerifolium; Aphanamixis polystachya, Symplocos cochinchinensis , Elaeocarpus serratus, Memecylon umbellatum, Bischofia javanica,indica, Cullenia exarillata, Cipadesa baccifera, Maesa indica,* and *Murraya paniculata; Schleichera oleosa, Garcinia indica, Garcinia gummiguta* and *Dimocarpus longan; Mesua ferrea, Magnolia champaca var. pubinervia, Dipterocarpus macrocarpus*, *Elaeocarpus serratus, Shorea robusta*, *Duabanga grandiflora*, *Morus laevigata, Phoebe goalparensis, Pinus kesiya*; *Chukrasia tabularis*

and *Schima wallichi; Prunus cerasoides, Sorbus lanata*, *Betula utilis, Betula alnoides,* and *Rhododendron campanulatum; Anogeissus latifolia, Salvadora persica* and *Capparis decidua.*

Seed desiccation sensitivity and storage studies being conducted in *Albizia odoratissima,, Albizia julibrissin, Alnus nitida, Litsea glutinosa, Sterculia villosa, Pterospermum acerifolium, Quercus glauca, Kydia calycina, Toona serrata; Hymenodictyon excelsum, Kydia calycina, Putranjiva roxburghii, Semecarpus anacardium, Sterculia villosa, Nyctanthys arbortristis* and *Buchanania lanzan; Cipadessa baccifera, Maesa indica, Cullenia exarillata, Leea indica, Bischofia javanca , Aphanamixis polystachya, Elaeocarpus serratus* and *Memecylon umbellatum; Chukrasia tabularis, Phoebe goalparensis, Dipterocarpus macrocarpus, Mesua ferrea, Schima wallichii, Pinus kesia* and *Magnolia champaca,* Antioxidant activity (Ascorbate Peroxidase) was conducted in *Schima wallichii* and *Magnolia champaca; Betula utilis, Betula alnoides, Rhododendron campanulatum, Prunus cerasoides* and *Sorbuslanat*a .

Image analysis for fruit and seed morphology was done for ten species. Determined the respective weights. Seed shape, size, mass and moisture content of seeds of *Garcinia indica, Garcinia gummi-gutta Schleichera oleosa, Vateria indica* and *Dimocarpus longan* collected from various sources were studied. Ecological parameters such as rainfall, relative humidity, temperature recorded for each study location. Nursery trials wrt. effect of depth of sowing, potting media, container and time of sowing of *Prunus cerasoides, Betula utilis* and *Sorbus lanata* laid out in the nursery. Vegetative propagation trial of *Betula utilis* and *Sorbus lanata* also laid out in the nursery. Regular observations on their growth being recorded.

AICRP -11: All India coordinated research project on *Dalbergia sissoo*

In recovery of existing sick Shisham plantations by *Trichoderma* sp application 954 soil samples from 301 locations collected. 161 *Trichoderma* spp isolated. In isolation of pathogen isolates 77 isolates of Wilt pathogen: *Fusarium* sp & 56 isolates of Root rot pathogen: *Ganoderma* sp were isolated. DNA fingerprinting protocol for both pathogens (ITS1 & 2 of nrDNA) standardized. Barcode region amplification & sequencing is in progress. In dual culture tests for biocontrol antagonism 71 pathogen isolates

Fig. 15 (a) Pure cultures of *Fusarium* isolate, (b)*Fusarium* inoculated (left) and uninoculated (Right) on sorghum-chaff substrate, c) Mixing of Trichoderma-colonoized sorghum-chaff substrate (d) Sterile potting mixture (e) Addition of inoculated sorghum chaff substrate to potting mixture (f &g) Transfer of healthy shisham plants in polybag containing inoculated sorghum chaff substrate (h) Mass multiplication of *Fusarium* isolates

screened against 111 *Trichoderma* isolates. Mass inoculum of high performing isolates in dual culture tests have been prepared for field testing in affected plantations.

***Trichoderma* spp. cultivation protocol on waste biomass,** 18 agriculture waste and other organic substrates tested. 5 have shown promising results and are being used for mass production. Mortality sites identified for biocontrol application. In the study of **effect of *Trichoderma* on Shisham plant growth in nurseries** 85 per cent germination in treated seeds recorded. Growth parameters are being recorded. Survey of 60% mandated study area of has been completed. The download and pre-processing of models IPSL-CM6A-LR & MIROC6 (SSP pathway GCM models) and IPSL-CM5A-LR & MIROC-5 (RCP pathway GCM models) has been done. The data sorting and cleaning for other regions is ongoing. **To identify wilt and root rot resistant *Dalbergia sissoo* germplasm through *in vitro* screening and proteomic evaluations,** Callus induced for **18 genotypes** on MS medium using **nodal** explant. More than **400 calli cultures** are available for **18 genotypes**.71 Plus trees and 179 CPTs identified; 11000 seedlings of superior genotypes raised; Vegetative Multiplication Garden (VMG) was established using the selected clones. Screening for resistant germplasm by artificial inoculations is in progress.

AICRP-12: Assessment of demand and supply of timber, fuel-wood and fodder in India

Review of literature is being carried out pertaining to timber, fuel Wood and Fodder. The questionnaire for the survey of households to assess their demand for timber, fuel-wood and fodder was modified and finalized. Questionnaire and data entry excel sheet for cremation; unrecorded removal of timber, fuel-wood and fodder; and hotel/dhabha were finalized. Total number of households surveyed for the period April, 2022 to September 2022 was 4,544. Data collection pertaining to unrecorded removal of timber, fuel-wood and fodder by using Randomized Response Technique were 1412. Data collection pertaining to use of fuel-wood for burning of dead body in cremation place were 24. Cross verification of export and import of wood-based product in term of quantity (CUM/KGS/No) and Value (INR/US$) for the period 2000-21 through DGCIS, Kolkata. Conversion factor of export and import of wood-based product has been developed through mutual consultation with industries expert, industrial layman and through literature. Quantity of export and import of wood-based product having unit in CUM/KGS/No has been converted into CUM round wood equivalent. Data entry of collected data pertaining to household, industries, cremation and unrecorded removal of timber, fuel-wood and fodder survey data has been completed. A mid-term project workshop of the project was held in Tropical Forest Research Institute, Jabalpur.

Fig. 16 Collection of Alternate Sources of Fuel wood (Coconut shell and sheath) in Villages of Udupi district

AICRP-13: Valuation of forests for GDP, green GDP and payment of eco-system goods and services

A mid-term workshop was organized in TFRI, Jabalpur for reviewing project activities. Literature on relevant topics is under progress. The required data for various tangible and intangible services are being collected through either Census or Sample-based approach depending upon the availability of the information. The timber and employability data is being collected through all SFDs. The collected data would be used for GDP estimation. Questionnaire for the same for census based on sample based has been developed and pre-tested and a total of 6282 number of household were surveyed across country from 645 villages and remaining household survey is still in progress. The survey data of 2735 household were digitised. In Forest Group Type 5; a survey of 39 villages and 390 Households were made for objective 3. A total of 600 households survey in forest type FT02 (400) and FT06 (200) was completed covering Sindhudurg and Kolhapur districts of Maharashtra were completed. Besides a survey of 502 tourist has been made in Bhagwan Birsa Biological Park, Ormanjhi and 505 surveys of tourist has been made in Biodiversity Park, Lalkhatanga. A 600 tourists were surveyed at Dumna nature reserve, Jabalpur for recreation service estimation. List of Ecotourism spots located in Karnataka was identified. The pollution abetment services for the forests of the India has been estimated. The soil erosion abetment services of the forest has been estimated for three forest types.

Fig. 17 data collection as per Questionnaire

AICRP-14: Forest Fire Research and Knowledge Management

FRI, Dehradun: The burnt area information till March 2022 has been received from Uttarakhand State Forest Department from time to time and based on the information received field visits are being conducted. Sample tool kits (Kit-1 hand tools (15 sets) and Kit-2 safety clothing (06 sets) has been received from UPES, Dehradun in the month of March 2022 and the same has been sent to Uttarakhand, Odisha and Kerala State Forest Department for testing in actual field

conditions. Feedback form for providing feedback on suitability and efficiency of kit-1 and kit-2 has also been shared with SFDs. Design and development of Kit-3 (advance tools including leaf litter blower) from UPES, Dehradun is under progress. Proposal for design and development of fire-fighting tool kit from IIT, Roorkee has been invited. Meeting with IDTR, Jamshedpur has been conducted for designing and development offire-fighting tool kit.

RFRI, Jorhat: The baseline information about burnt and unburnt is being collected with active cooperation from the SFDs.

IFGTB, Coimbatore: The baseline information about burnt and unburnt is being collected with active cooperation from the SFDs.

HFRI, Shimla: The baseline information about burnt and unburnt is being collected.

IFB, Hyderabad: Data has been collected from burnt and unburnt areas and collection of data on anthropogenic, socioeconomic, preventive interventions & fuel characteristics from Telangana and Andhra Pradesh States are in progress.

AICRP-15: Tamarind (*Tamarindus indica* Linn.): Domestication, conservation and deployment of genetic resources for sustenance and livelihood amelioration

A preliminary study on the morphological characterization of the tamarind genetic resources available at Tamil Nadu, Telangana, Andhra Pradesh and Gujarat was conducted. Data collected on vegetative and reproductive Phenophases of different tamarind geneticresources.

The descriptors were developed as per the guidelines of PPVFRA. Passport data was collected from 55 tamarind clones for developing National Tamarind Registry. Fruit morphometric characterization in 55 clones was done using an image analyzer. Data was recorded on fruit length, width, fruit thickness, shell weight, vein weight, pulp weight, seed weight and the number of seeds per fruit.

Assessed gum recovery percentage from 22 different sources of Tamil Nadu to develop tamarind genotypes with high TSG value. Analyzed proximate and ultimate properties of tamarind seed gum. Seed morphometric traits such as seed brightness, roughness, shape and colour were assessed. Physicochemical properties such as pH, ash content, volatile matter, cold water solubility, viscosity, bulk density, particle density and moisture content was estimated. Biochemical characterization of seed kernel for carbohydrates, proteins, fiber and oil was conducted. Bio-chemicalcharacterization of tamarind seed polysaccharides was also done.

Biometric characteristics of tamarind clones available at Achuthapuram, Telangana were documented. Received permission from the Karnataka Forest Department for accessing Tamarind Genetic Resources. Categorized 55 Tamarind clones based on flowering behaviour and fruit setting pattern. Studied the phenological and reproductive variations for the tamarind genetic resources. The variations in fruiting behaviour were also assessed. A preliminary study was carried out on time of anthesis, floral visitor, pollen biology and breeding systems. Studied leaf anatomical variation to understand the foliar morphology among the red, sour and sweet variants.

Assessed variations in the clone banks of tamarind in Mulugu in Telangana and based on the

calculated data of Mulugu Plantation shortlisted 5 clones. Fruits have been collected from Rajahmundry and Tirupati, and measurement of the characteristics are under process. The floral biology study of the already assembled clones in FC&RI, Mettupalayam is in progress. Flowering and potential pollinator studies of 5 different tamarind germplasm (Hasanur 06, Hasanur 09, PKM 1, Mullampadi and Urigam) at Forest College and Research Institute, Mettupalayam were done. Data were collected on vegetative and reproductive phases to develop descriptors. Assessing the gum recovery percentage from different sources of Tamil Nadu to develop tamarind genotypes with high TSG value. The flowering- related traits and fruit development was observed in the tamarind genotypes for variations. The variations are being collected and these data will be used for preparing tamarind data registry. Identification and marking of 4 heritage Tamarind trees in Coimbatore District. Maintenance of VMG of Tamarind through regular watering, weeding and fertilizer application for higher production of scion shoots. Raised about 3000 tamarind seedlings for rootstock purpose. Optimized grafting season for large scale multiplication of tamarind genetic resources. Shortlisted 10 high productive clones at VMG, Forest Campus; Red and sweet Tamarind germplasm bank. Attempted 3500 grafts in 10 high productive clones. Established and maintained three multi-location clonal trail of tamarind at IFGTB field research station, Neyveli, Cuddalore Dt., Kangeyam Tirupur Dt., and Melur Madurai Dt. with 25 shortlisted high productive clone of Red, Sweet and Sour tamarind genetic resources through presicion silvicultural techniques. Data on growth traits were recorded from the different clones.

Established Tamarind clonal trials at Bayala, Thumkkuru; and Naickenpalayam, Coimbatore. Seeds were collected from the high-yielding tamarind trees from the National Germplasm Bank of Red and Sweet Tamarind at Salem. The seeds were subjected to pre-treatments with biofertilizers to test the resistance of seedlings towards diseases and the biometric characteristics were recorded. Seeds were collected from the Urigam trees for restocking and replanting of the trees. Established Tamarind plantations with 5000 seedlings at selected lands at panchayat, temples, schools, avenues and village roads for the restocking of TGRs towards the livelihood improvement of the rural population. Maintained the Tamarind plantations established in Bhodakaadu and Mullainagar panchayats, Dharmapuri district; Pallipatti, Krishnagiri Dt; Kallimandhayam, Ottanchatram with people participation.

Collected baseline data on Tamarind processing Industries in Dindigul and Theni Dt. Three farmer's producer organizations were identified and each FPO is having beneficiaries of more than 1000 farmers each. Communications made to farmers producer company for developing tamarind consortiums. Preliminary arrangements are made for forming a consortium of tamarind primary processing, secondary processing and value addition with FPOs, Industries, Machinery Manufacturers and Exporters.

The formation of tamarind consortium for enabling value chain of tamarind seed gum is initiated. The tamarind growing farmers who have FPO were identified in Dharmapuri regions. Trainings will be arranged for primary and secondary processing to different stakeholders to build a complete value chain on tamarind seed gum. Recovering percentage of gum solution with different micron size of filter cloth. Value added product from tender tamarind and tamarind flower gulkand were prepared.

AICRP 16: Bioprospecting for industrial utilization of lesser known forest plants

Documentation and analysis of current knowledge/information of 60 lesser known forest plants (LKFPs) were completed, and a structured format for prioritization of the LKFPs was developed. Scoring of the institute-wise selected 60 LKFPs was done in the format, and the following 28 LKFPs were prioritized for their intended investigations:

AFRI	*Balanites aegyptiaca, Citrullus colocynthis, Xanthium strumarium, Sterculia urens*
FRCER	*Vitex negundo, Pithecellobium dulce, Mallotus philippensis*
FRI/ HFRI	*Neolitsea pallens, Cupressus torulosa, Punica granatum, Prinsepia utilis*
IFB	*Soymida febrifuga, Buchanania axillaris, Gardenia gummifera*
IFGTB	*Balanites aegyptiaca, Careya arborea, Cassine glauca, Vitex altissima*
IFP	*Cinnamomum cecidodaphne, Pithecellobium dulce, Schima wallichi*
RFRI:	*Litsea cubeba, Mallotus nudiflorus, Carallia brachiata*
TFRI:	*Anogeissus pendula, Careya arborea, Cyperus rotundus, Woodfordia fruticosa*

Fig. 18 Shade drying of *C. arborea* bark

Surveys were conducted, 379 populations of 27 LKFPs were identified, and their geocoordinates were recorded. Chemical screening of the identified populations was undertaken to determine their chemical variability and to identify chemically superior genotypes. Fatty oils of the seeds collected from 6,15,6,3,17,1,14 populations of *Balanites aegyptiaca, Citrullus colocynthis, Xanthium strumarium, Pithecellobium dulce, Prinsepia utilis, Vitex altissima* and *Mallotus nudiflorus*; and essential oils of the leaves collected from 6, 13,14, 7 populations of *Vitex negundo, Neolitsea pallens, Cupressus torulosa* (needles), and *Cinnamomum cecidodaphne*; of the seeds collected from 12 populations of *Litsea cubeba*; of the rhizomes collected from 7 populations of *Cyperus rotundus,* respectively were isolated and their contents were determined. Statistical analysis of the contents of the essential oils isolated from 13 and 14 populations of *Neolitsea pallens* and *Cupressus torulosa* led to the identification of 3 populations of *C. torulosa* located in Oogla, Bhatwari and Gopeshwar of Uttarakhand and 3 populations of *N. pallens* located in Dalhousie, Jahal-Devidarh Road and Khajjiar of Himachal Pradesh as chemically superior populations for further investigations. GC-FID and GC-MS assisted chemical composition of the chemically superior populations of *C. torulosa* was established. Needles and leaves collected from 14, 13 and 14 populations of *C. torulosa, N. pallens* and *P. utilis* were lyophilized, defatted and their extractives for their chemical profiling were prepared using chloroform and 25% aqueous methanol, separately. LCQTOFMS assisted examination of the chloroform extract isolated from the leaves of *P. utilis* revealed the presence of triterpenoids, alkaloids, steroids, fatty acids, carotenoids, aliphatic oxygenated compounds, and amino acids. Protocols for recovery of natural dye in the yield of 28.1%, 19.7%, 24.6%, 12.83%, 3.75%, and 13. 47% from the peels of *Punica granatum*, barks of *Soymida febrifuga, Buchanania axillaris*, *Careya arborea*, and *Schima wallichi,* and fruits of *Mallotus philippensis,*

respectively were optimized. Using the optimized protocol, chemical screening of 10,10,1 and 3 populations of *S. febrifuga, S.wallichi, C. arborea*, and *M. philippensis,* respectively for dye content was completed. A process in collaboration with the R&D Global Consultant Pvt. Ltd, Thane, Mumbai, has been developed to use *S. febrifuga*-derived dye as hair colorant gel which has been tested and found comparable with the marketed hair colorant samples.

AICRP-17: Enhancement of fodder availability and quality to reduce unsustainable grazing in the forest

The major focus of the project is on field trials at the nine institutes of ICFRE in their mandate regions. Tree species are planned to be planted in different spacings in high density and managed with different frequencies of coppicing. Grass species are also planned to be planted. Same set of experiments is being 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.

The target no. of sites where field trials are to be established is 2 each for HFRI, IFB and RFRI, and 3 each for FRI, AFRI, IFP, TFRI, IFGTB and IWST. Planting has been done at the following no. of sites: AFRI 1, FRI 3, HFRI 1, IFB 1, IFGTB 1, IFP 3 and TFRI 1. Institutes are in process of finalising sites, fencing the areas and will raise the left-over plantations in the next monsoon season. The field trials are being maintained.

Experiments were initiated on silage making at FRI and HFRI. FRI collected literature on natural repellents to herbivory, prepared three repellents. Due to problems in testing of the repellents it is planned to drop the study on repellents.

AICRP-18: Silvicultural interventions for productivity enhancement and carbon sequestration in plantations of important tree species

At IFGTB, completed assessment on growth in 42 boundary planting and 13 block planting of Teak. Completed assessment on growth in 25 *Gmelina arborea* plantations. Collected data in seven Pongamia boundary plantations. Collected data from nine boundary plantations and three block plantations of Neem. Assessed growth in 11 block plantations and 6 boundary plantations of Ailanthus. Completed mixed planting of teak & casuarina in boundary plantation is completed in all the three locations – Kanchipuram, Tiruppur and Dindigul. Block plantation of mixed planting of Teak & casuarina was completed in three locations viz., Kangeyam, Kundadam and KVK-Myrada. Block plantation of mixed planting of teak & Acacia auriculiformis was completed in three locations viz. Kundadam, Kangeyam and Dindigul.

At TFRI, completed assessment on growth in 15 Gmelina plantations & in 8 Haldina plantations. Further, surveyed and identified 5-year, 10 year and 26 year old block and boundary plantations of Gmelina at farmers fields. Observation of growth recorded from the different block plantations of Gmelina under different irrigation methods like Flood irrigation(traditional method), Drip irrigation and sprinkler system. Explored and identified some new teak plantation in farmer's field only in single row and or on bunds of agriculture field. Surveyed and identified 2 block plantations of Haldu under government platations at Balod, Chhattisgarh and Kawardha, Chhattisgarh. Observation of growth recorded from the different block plantations of Haldu

under different irrigation methods like Flood irrigation (traditional method), Drip irrigation and sprinkler system. Carried out maintenance of Field Trials of *H. cordifolia* under block plantation spacing -3m x 3m and pit size- 30cm established at Farmers field in village- Dheemerkheda, Katni (MP). Observation of growth recorded from the established field Trials.During the period under report, established and maintained Haldina plantation at TFRI as per plan. Established and maintained field trials under mixed block plantation of Teak and Casuarina in two ratios viz, 1:1 ratio and 1: 8 ratio under irrigated condition. Established and maintained field trial under mixed block plantation of Teak and Acacia auriculiformis in two ratios viz, 1:1 ratio and 1: 8 ratio under rainfed condition at Farmers field in Village- Parasi, Dheemerkheda, Katni

Fig. 19 Mixed boundary plantation of Teak with *Acacia auriculiformis* established at Dheemarkheda village, Katni district (MP)

At AFRI, Jodhpur 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 pinnata*. Mostly Ailanthus, neem and *Pongamia pinnata* are scattered distribution.

At IWST, survey of 15 block plantations and 15 boundary plantations of teak were completed. Documented the data of teak plantations and calculated the biomass value of block and boundary plantation of teak. Completed assessment on growth in 5 teak plantations. Communicated with farmers and they are agreed to establish boundary plantation of teak and casuarina in their 7.5 Acres land. The farmers were signed the Undertaking form for establishment of boundary plantation. For Teak and Casuraina boundary plantation, procured seedlings of Teak (600) and Casuarina (2100) clone variety for boundary plantation.

FCRI analysed and documented growth biometry of 45 Block Plantations of farm grown teak under 3 age class (5-10 , 10-15 ,15-20 years) in North Eastern, North Western and Cauvery delta zones of Tamil Nadu. Analysed and documented growth biometry of 44 Boundary Plantations of farm grown teak under 3 age class (5-10 , 10-15 ,15-20 years) in North Eastern, North Western and Cauvery delta zones of Tamil Nadu. Estimated tree volume of 89 farm grown teak plantations (45 Block Plantations, 44 Boundary Plantations) under 3 age class (5-10 , 10-15 ,15-20 years) in North Eastern, North Western and Cauvery delta zones of Tamil Nadu. Assessed a total of 21 teak plantations (of which 12 are Block Plantations and 9 are Boundary Plantations) for biometric parameters. Yield model construction and validation was developed for Teak in all three age classes (5-10 years, 10-15 years and 15-20 years) under four agro-climatic zones viz.,

North eastern zone (NEZ), North western zone (NWZ), Cauvery delta zone (CDZ) and Western zone (WZ) of Tamil Nadu. Metabolic profiling of teak heartwood samples collected from different agroclimatic zones was conducted by Gas chromatography–mass spectrometry (GC-MS).

AICRP-19: Assessment of water requirement of different forest tree species and its impact on subsoil moisture

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. Total water requirement for transpiration of selected tree species are being measured with the help of sap flow monitoring systems. Protocol for instrumentation, data recording, and design of the experiment finalized. Sites for the study selected. The major equipment, 144 sap flow monitoring systems procured (36 for each participating institute). Analysed the DBH distribution pattern in the selected species trees to select candidate trees for installation of sap flow monitoring systems. Installation of sap flow monitoring systems completed by all the participating institutions, except for two species of FRI, Dehradun.

Fig. 20 Soil moisture sensor installation at Sanjay Van experimental site, New Delhi

Soil profiling with analysis of physical and chemical properties (texture, bulk density, porosity, hydraulic conductivity, organic carbon content, infiltration rate, and depth) has been completed by all the institutions. The soil moisture variation is being measured by multi-profile soil moister and temperature sensor (Make Odyssey) installed at the study sites within observation trees. The soil moisture sensor is located at different soil depths (0-20cm, 20-40cm, 40-60cm, 60-80cm, and 80-100cm) and measures the soil moisture at 15-minute intervals. The soil moisture sensors were calibrated as per the conventional soil moisture measurement at saturation. Sapwood thickness of over 200 trees of different species has been studied to facilitate proper installation of sap velocity measuring probe. Core samples were also analysed using tree ring analyzer –wind Dendron software to estimate age of the tree. The age of a sample tree of *Prosopis juliflora* at Sanjay Van experimental site was estimated at 89 years. Tree and wood parameters required for the analysis of sap flow velocity have been recorded and entered in the software. Weather parameters are being recorded at the experimental sites through automatic weather stations. Sap flow rate and cumulative sap flow in *Prosopis juliflora* and *Shorea robusta* trees have been estimated for the period May-September and April-September, 2022, respectively. Initial data suggest that the sap flow velocity varied between 1.2 to 7.2 lpd (liter per day) in *Prosopis*

juliflora during this period varying widely in days and months. In Sal (*Shorea robusta*) the sapflow was 0-6.7 lpd.

AICRP-20: Development of Biopesticide products/formulations from extracts of tree borne oil seeds and tissues of wild plants for management of insect pests

Production and supply of biopesticide preformulation Tree PAL^{H} and Crawl clean to ICFRE institute viz., FRI, Dehradun; TFRI, Jabalpur; HFRI, Shimla; AFRI, Jodhpur, IFB, Hyderabadand IWST, Bangalore: Tree PAL^{H} and Crawl clean were supplied to participating ICFRE institutes by IFGTB. Half litre of Tree PAL^{H} and 250 gm of Crawl clean were supplied to AFRI, Jodhpur on demand.

Lab and field evaluation of Tree PAL^{H} and Crawl clean at the prescribed dosages carried out at different jurisdiction areas of respective institutes and recorded the phytotoxicity parameters. Mortality rate of insect pest of the *D. sissoo* plantation was observed at 1st, 3rd and 5th day after treatment at Himachal Pradesh. Mortality rate of larva differed significantly among the treatments.

Efficacy of Tree PAL^{H}and Crawl clean was evaluated at TFRI, jurisdiction against *H. puera* and *E. machaeralis* in Jabalpur and recorded 93.93%, 67.64%; 87.87% and 84.37 % mortality respectively after 72 hours @1.5% concentration. Mortality of the defoliators of poplar and Shisham was observed at 24, 48 and 72 hrs after treatment at Punjab and recorded the data. Phytotoxicity trials have been carried out in the state of Uttarakhand.

The efficiency of biopesticide Tree PAL^{H} was tested under IFGTB jurisdiction against *ailanthus* defoliators *Eligma narcissus* and *Atteva fabriciella* in Tamil Nadu at Salem, Aliyar Dam and Poolavadi (Dharapuram) with different concentration ranging from 0.1%, 0.5%, 1.0%, 1.5% and 2.0% along with control and observed 75 to 85% larval mortality @ 1.5 % concentration with 24 hrs of treatment. Efficacy of plant extracts in controlling Gmelina insect pest on nursery and field under IFB jurisdiction was evaluated and observed after three days of treatment, Tree PAL^{H}, Profenophos and neem were equally effective (91.75%) followed by Crawl clean (83.25%) and *Sphereanthus indicus* and *Chloroxylon swietenia* (75.00%). The order of efficacy against gmelina larvae was Profenophos> Neem>Tree PAL^{H}> Crawl clean >*S indicus*>*C swietenia.* Potential sources of target plant sample with biopesticidal properties were collected and bioassay directed characterization of active principles is being studied. Surveys were conducted in the forest area of Nirsu, Nogli, Singhapur, Patakhra and Ogli in Himachal Pradesh, under HFRI jurisdiction for the collection of plant samples (roots, stem and leaves) of *B. albiflora*. Survey and collection of *B. aegyptiaca*fruits and stems of *C. decidua* were carried out at Fitkasni, Rudakli, Dangiyawas, Kokunta, Aakshali, MograKalla, Pali, Kharda and Rani villages under AFRI jurisdictions. Regular survey and seasonal collection of seeds of *Madhuca indica* and *Jatropha curcas* from nearby places under TFRI jurisdictions were carried out.

Bioassay directed isolation, identification of active compounds of potential sources of target plant sample with insecticidal properties has been carried out. The extracts of the targeted biopesticide plant samples were submitted to chemistry division FRI for chromatographic characterization through HPLC and GC-MS analysis. TLC analysis of *B. aegyptiaca* oil and *C. deciduas* stem extract showed the presence of secondary metabolites. HPLC analysis of Mahua

oil major fatty acids reported were oleic acid, palmitic acid, stearic acid and linolenic acid and in Jatropha oil, Palmitic, oleic and linolenic acid and minor compound as saponins, terpenoids and alkaloids. Samples were sent to IICT Hyderabad for identification of secondary metabolites. Evaluation of the insecticidal property of the active compounds for determination of LC 50 & LD 50 was carried out. Bioassay of botanicals extracts of *B. aegyptiaca* and *C. decidua* tested on target insect pests showed significant mortality. *J. curcas* seed oil 66.67% & 60.0% larval mortality and *M. indica* seed oil showed 53.33 & 60.0 per cent @ 1% concentration against Teak defoliator (*Hyblaea puera*) and skeletonizer (*Eutectona machaeralis*) respectively. Under nursery condition 55.6 and 56.67% larval mortality were observed in Jatropha seed oil whereas 51.72 and 53.33 % in Mahua seed oil tested against larvae of *H. puera* and *E. machaeralis.* Field evaluation @ 1% concentration revealed 49.06 % and 50.88% larval mortality in Mahua seed oil and in Jatropha seed oil showed 52.05 and 54.24 per cent larval mortality against teak defoliator (*Hyblaea puera*) and teak skeletonizer *(Eutectona machaeralis*) respectively. LD 50 (%W/V) and LC 50 values of methanol extract of *B. albiflora* plant was recorded as 1, 1.05 @ 24 hrs, 0.79, 4.76 @ 48hrs and 0.79, 4.76 @ 72 hrs) and in *Plecoptera reflexa* as 0.76, 1.01 @ 24hrs, 0.76,3.44 @ 48 hrs) and 0.76, 2.99 @ 72 hrs. LC_{50} values of 0.399 ml and 0.65 ml were obtained for the *S. glauca* seed oil against *E*. *narcissus* and *H*. *puera* respectively, 72 h after application. LC_{90} values of 0.72 ml and 1.35 ml were obtained against *E*. *narcissus* and *H*. *puera* respectively, 72 h after application.

AICRP-21: Development of superior bio-fertilizer products for enhanced plants productivity

Institute of Forest Genetics and Tree Breeding (IFGTB) has developed biofertilizers such as Vesicular arbuscular mycorrhizal fungi (VAM), *Azospirillum*, Phosphobacterium and Potassium mobilizer. These biofertilizers were mass multiplied and issued the partner institute of the project (FRI, AFRI, TFRI, RFRI, IWST) for further multiplication and inoculation in to the following tree species.

Institute	**Tree species selected for the study**
FRI, Dehra Dun	*Dalbergia sissoo, Gmelina arborea, Melia dubia* and *Santalum album*
TFRI, Jabalpur	*Dalbergia sissoo*, *Gmelina arborea* and *Santalum album*
AFRI, Jodhpur	*Capparis decidua*, *Dalbergia sissoo* and *Santalum album*
RFRI, Jorhat	*Dalbergia sissoo, Gmelina arborea* and *Santalum album*
IWST, Bangalore	*Gmelina arborea, Melia dubia* and *Santalum album*
IFGTB, Coimbatore	*Gmelina arborea, Melia dubia* and *Santalum album*

These species were propagated in the nursery and planted in the field inoculated with biofertilizers. The inoculated biofertilizers in the field showed better performance than the commercial biofertilizers application.

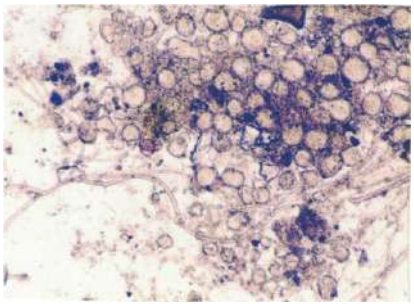

Fig. 21 Multiplied VAM Biofertilizer *Glomus fasciculatum*

The bio-fertilizer products (Commercial and IFGTB biofertilizer) such as *Azospirillum lipoferum* (10 ml) *Azotobacter* (10 ml), Phosphobacteria (10 ml) AM fungi (20 gm) and Potash Mobilizer (10 ml) used for bio-inoculation experiments. In-*vitro* detection of siderophore formation in

Azospirillum, *Azotobacter*, Phosphobacteria and Potash mobilizer IFGTB was observed. Siderophore formation is confirmed that the biofertilizers capable to control the pathogen as well as supply the nutrient from soil. Dry weight of shoot and root of *Melia dubia* species was taken for 180 days of experiment that the improved growth two times higher than the control and commercial inoculated biofertilizers. The seedlings of *Santalum album* is inoculated with biofertilizers showed improved growth. These seedlings were planted similarly the *Melia dubia* seedlings have also planted with biofertilizers. Growth parameters of planted *S. album, G. arborea* and *M.dubia* have been recorded after 6 months of planting. Pure culturing and mass multiplication of pathogenic cultures under *in vitro* have made also for tested the efficacy to control the pathogens (*Fusarium oxyporum, Alternaria solani, Diploidia*)

AICRP-22 Preparation of Forest Soil Health Cards under different Forest Vegetation in all the Forest Divisions of India

All the nine participating institutes collected total 15408 samples and undertaken 131423 analysis for 12 comprehensive parameters. Overall, 27% sample have been collected and 21% samples were analysed so far. Forest Soil Health Cards of Jharkhand state have been prepared for all the 31 forest divisions. Soil sampling and analysis was completed in Ladakh (UT) and more than 85% sampling was completed in West Bengal, Haryana and Chandigarh. Institute wise progress is described below. Under HFRI jurisdiction states total 1086 soil samples were collected from the various sampling points. The sample collection and analysis were completed for Ladakh and collection and analysis of remaining soil samples for various parameters is under progress. **FRI team took** total of 20385 analysis for 12 parameters were undrtaken. In Haryana and Delhi more than 85% soil sampling and analysis has been done. In Uttarakhand, 969 samples were collected and 9252 analysis were undertaken i.e. 56% of the total assigned samples. **IFGTB, Coimbatore team collected** total 976 soil samples were collected from sampling points and total 9768 analysis were undertaken i.e., 27% of the total assigned analysis. Soil sampling and analysis in Kerala, Lakshadeep and Tamil Nadu is yet to begin. **At TFRI** Soil samples from 65 forest divisions and 1048 FIDs (50 forest divisions; 776 FIDs of MP and 06 forest divisions; 131 FIDs of Maharashtra and 09 forest divisions; 140 FIDs of Chhattisgarh) were collected. The analysis was conducted for 2400 samples of pH & EC and 2397 samples of Organic Carbon. Analysis for macro elements of conducted for 2395 samples of Av. N, 2356 of Av. P, 2347 of Sulphur and 2570 of Ex. K. A total of 1541 soil samples micronutrients were also estimated. **IFB team took** soil samples from 1167 sampling points and 9783 analysis were undertaken from Telangana state.

FSHC of Jharkhand state have been developed. **At AFRI** total 860 samples were collected and 6460 analysis undertaken so far. **At RFRI** for the preparation of forest soil health card a total of 6279 soil sampling locations were assigned. Total 16183 samples have been analysed for these states. Sampling is yet to begin in Sikkim, Nagaland and Manipur State. A total of

FOREST SOIL HEALTH CARD (BOKARO FOREST DIVISION, JHARKHAND)

Institute of Forest Productivity
Indian Council of Forestry Research & Education
Ministry of Environment, Forest and Climate Change
Lalgutua, Ranchi-835 303

PHYSIOGRAPHIC DETAILS

Geo coordinates (Extent)	23.4348-23.9340N 85.4449-8636245E
Sampling Period	November, 2020
Altitude (m)	269-707
Aspect (Degree)	10.04-334.37
Slope (Degree)	1.90-49.85
Hillshade (Degree)	142-251
Forest Group Type	5-Tropical Dry Deciduous
Forest Class	MDF,OF

SOIL TEST RESULTS

SL	Parameters	Standard Value (Average)	Test Value
1	pH	5.47	5.17
2	EC	0.06	0.02
3	Organic Carbon (%)	0.81	1.18
4	Available Nitrogen (kg/ha)	258.32	326.57
5	Available Phosphorus (kg/ha)	17.39	9.47
6	Exchangeable Potassium (kg/ha)	179.55	142.28
7	Available Sulphur (ppm)	1.2	0.33
8	Available Zinc (ppm)	1.82	1.29
9	Available Boron (ppm)	1.25	1.51
10	Available Iron (ppm)	12.91	14.65
11	Available Manganese (ppm)	9.43	8.37
12	Available Copper (ppm)	1.08	0.36

FOREST COVER CLASSWISE SPECIES / RECOMMENDATIONS (ORGANIC) / RECOMMENDATION (INORGANIC)

Forest Class	Common Species	Parameters	Source	FYM Nutrients (kg)	Vermicompost Nutrients (kg)	Source	Soil Application (kg/ha)	(OR) Spray (ppm)
VDF	—	N	FYM (1.950 t/ha) or Vermicompost (0.56 t/ha)	9.75	8.91	Urea	–	–
MDF	Sal, Rohan, Giin, Amaltas, Palas	P		3.9	3.9	SSP	49.5	–
OF	Chiroanji, Bakera, Sal, Mahua	K		9.75	4.40	K_2O	62.4	–
SF	—	S		0.006	1.96	$(NH_4)_2SO_4$	8.12	3.63
NF	—	Zn		0.028	0.013	$ZnSO_4$	3.3	1.45
		B		0.028	0.01	Borax	–	–
Amelioration		Fe		2.86	0.098	$FeSO_4$	–	–
1. Lime (t/ha)	—	Mn		0.004	0.053	$MnSO_4$	7.78	3.48
2. Gypsum (t/ha)	—	Cu		8.19	0.003	$CuSO_4$	6.5	2.88

Abbreviation- VDF- Very dense forest, MDF- Moderate dense forest, OF- Open Forest, SF-Shrub Forest, NF-Non Forest

The (—) sign denotes sampling location does not fall in a particular forest class so species was not recorded for that particular class.

"Protect our forests before it's too late"

Fig. 22 FSHC of Bokaro Forest Division, Jharkhand

1332 soil samples were collected from forest divisions of Karnataka. 7956 analysis for soil macro and micronutrients has been undertaken.

AICRP 23: Genetic improvement and value addition of *Madhuca longifolia*

TFRI: Total 460 phenotypically superior trees were selected on the basis of criteria of flower yield from 23 different locations of Chhattisgarh, Madhya Pradesh and Maharashtra. Morphometric data of all 460 trees. Sugar, carbohydrate, phenol and protein contents were estimated in the flowers from 23 locations and oil content in seeds from twelve locations was done. Studies on natural regeneration were carried out at Chhatarpur, Umaria, Mandla, Dhar, Khandwa and Dindori in Madhya Pradesh, Surajpur in Chhattisgarh and Nashik, Shahapur, and Raigad in Maharashtra. Surveys were conducted at 8 locations of Madhya Pradesh and Chhattisgarh, and the insects pests recorded on Mahua were *Hieroglyphus banian*, Tussok caterpillar, termite- *Odentotermus obesus*, *Indarbela quadrinota*, *Bactocera zonata* and *Paracococus margintus*. During the month of July – September leaf webber *Hymenia recurvalis* affected Mahua seriously. In nursery trial, Spinosad 45% (0.0125%), Azadiractin 10000 PPM (0.02%), NSKE (5%) registered highest mortality with 69.69%, 65.71% and 63.63% larval mortality of *H. recurvalis* at 72 HAT respectively DNA extraction and quantification was done from the leaves of 123 selected trees. Seedlings (1200) were raised from 200 selected trees. Scions were collected from 200 selected phenotypically superior trees from 18 locations and cleft grafting was carried out in 600 root stocks. Grafting success of 50 % was achieved. Vegetative Multiplication Garden has been successfully established with grafted plants of 34 genotypes of selected superior trees from Madhya Pradesh, Chhatisgarh and Maharashtra at TFRI campus. Different ITK practices viz., for storage of flowers, processing of flowers and seeds, traditional uses, etc. were documented through questionnaire, videos and photos from 17 locations.

IFGTB: Total 100 phenotypically superior trees were selected on the basis of criteria of flower yield from 17 different locations viz., Coimbatore, Madurai, Thiruvannamalai, Salem, Tiruppur, Dharmapur, Dindigul, Theni, Viruthunagar, Tirunelveli, Kanyakumari, Cuddalore, Erode, Namakkal and Pondicherry (15 districts) of Tamil Nadu, two locations in Pathanamthitta in Kerala. Estimation of oil percentage was carried out from seeds collected from 10 different locations. DNA isolation and quantification work has been carried out in leaves collected from 25 selected trees. *In- silico* research is in progress. 700 seedlings were raised to carry out grafting. Cleft grafting was carried out and 100 grafted plants were raised. VMG has been established with 49 genotypes of Tamil Nadu at KVK, Myrada, Thalamalai. ITK has been collected and documented from 8 locations of Tamil Nadu through questionnaire, photos and videos.

IFP: Total 150 phenotypically superior trees were selected on the basis of criteria of flower yield from 38 different locations of Jharkhand, Bihar and West Bengal. Estimation of sugar was carried out in flowers of 8 locations. Fruits and seeds were collected and oil percentage was estimated from seeds of 10 locations. Scions were collected from 42 phenotypically superior trees and 350 grafts were made. Success of 53.2% has been achieved for 30 selected trees. Seedlings from selected phenotypically superior trees were raised and are being maintained. One VMG has been established with 20 genotypes at IFP Campus (23.35866 E; 85.24677 N).

IFB: Total 239 phenotypically superior trees were selected on the basis of criteria of flower yield. Nursery was renovated and 500 root stocks for grafting were maintained. 1200 rootstocks will be procured from Telangana State Forest Department. A total of 180 air layers were made through Air layering and only callus formation was observed in 17.7% of the air layers made. Scions were collected from 15 trees of Kamareddy (9) and Banswada (6) and 75 grafted plants were produced with success rate was 20%. ITKs related to post-harvest processing of mahua flowers and fruits and the utility of products obtained post-processing were documented in 10 locations.

FRC-ER: Total 160 phenotypically superior trees were selected on the basis of criteria of flower yield. Morphometric data of all 160 trees was recorded along with GPS.

FRC-SD: Experiments were conducted for formulation of energy bars/chocolates using dried mahua flowers and Mahua Energy Bars were developed. Mahua Herbal Toothpaste was developed from the leaves extract of mahua. Mahua Herbal cream was developed from oil of mahua seeds. Mahua Herbal hair conditioner was formulated by using oil of mahua seeds. Antibacterial activity of the herbal handwash developed with leaves and bark methanolic extract is being assessed. Survey was conducted in tribal areas of Madhya Pradesh and Maharashtra for documentation of ITK on processing of mahua oil for removal of bitterness, unpleasant odour removal from mahua flowers, traditional dishes viz. sattu, latto, laddus, bhondi, koya, domri, use of mahua flowers /seed cake for swelling removal and reptile repellent purposes and ethnnomedicinal purposes. Self help groups were identified for imparting training for dissemination of developed value added products. Application for obtaining FSSAI license for state level for the developed mahua chocolates is under process.

Fig. 23 Cuttings and seedlings of Mahua

AICRP 24: Combating desertification by enhancing vegetation cover and people livelihoods in degraded dry lands and deserts of India

Fig. 24 live hedge fencing at Khet Singh Nagar (26.63372 N and 72.319355 E in Tehsil - Setrawa, District – Jodhpur)

Live fencing around a cluster of farmer's fields has been done at selected sites of Rajasthan, Madhya Pradesh, Himachal Pradesh and Tamilnadu. Total 3640 seedlings *of A. senegal* were planted as live hedge fencing on boundary of two group of farmer's land at Chouradia (seven farmer's land of 4.50 ha) and Khet Singh Nagar (three farmer's land of 25.00 ha), Jodhpur. Total three clusters of farmers (Cluster 1: Three farmers - 7.70 ha, Cluster 2: Two farmers – 2.50 ha, Cluster 3: 0.80 ha) were selected (Nayapura Useth, Bheelpur, Esah Haveli) for erecting live fencing around clusters of farms and1900 seedlings of *Carissa carandas* with a spacing of 1m were planted on farmers' field boundaries of 2 villages/ clusters ie. Bheelpur and Esah Haveli with the cluster size of 3.30ha in Madhya Pradesh. 400 Neem seedlings planted as boundary plantations in cluster of farmers' field in the Cauvery delta zone at Kammanallur village in 0.5 ha in Tamilnadu. The plantation of Seabuckthorn (150), Salix (100) and Poplar (100) was carried out along the field boundaries of two villages in Himachal Pradesh for soil and water conservation and enhance farm production and people livelihoods. Various types of degraded areas have been targeted under this project for restoration like degraded hills, hillslopes, sand dunes, ravines and saline in hot and cold desert and other parts of country and field trials/plantation established in total 74.68 ha area. For restoration of degraded hillslopes in cold arid region plantation of *Juniperus polycarpos* in 1 ha area has been done at Badami Bag, Leh. The plantation of *Populus nigra, Salix alba, Juniperus polycarpos, Hippophae rhamnoides* and *Elaeagnus angustifolia* has been carried out in 5.0 ha area in 3mx3m spacing at Sushna, Spiti area of Himachal Pradesh (HFRI). For restoration of ravines plantation has been done at two sites Morena and Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya (RVSKVV), Gwalior. Plantation of five trees species, *Acacia catechu* (Khair), *Acacia tortilis* (Tortilis), *Azadirachtaindica* (Neem), *Anogeissuspendula* (Kardhai) and *Commiphorawightii* (Guggal) in an area of 16.20 ha near Ambah in Morena range of Morena forest division has been done. Second plantation has been done on RVSKVV land covering an area of 6.48 ha. Seedlings of *Aeglemarmelos* (Bael) and *Emblicaofficinalis* (Aonla) were planted. For rehabilitation of degraded hill in hot arid region an area of about 12 ha has been selected at Lunawas, Jodhpur. Plantation of six species has been done with three types of soil amendments (Farmyard manure, Sewage sludge and Hydrogel). Trenches were made to harvest rainwater in the area. Tree species planted were *Anogiessus sericea, Cordia gharaff*, *Azadirachta indica*, *Holoptelia integrifolia*, *Moringa concanensis*, *Ziziphus mauritiana* and *Commiphora wighttii*. To identify best species for restoration of salt-affected lands in Tamil Nadu areas field trial was established in 2 ha of salt affected farmer's field in the Cauvery delta zone at Rathinampillai Pudur village, Karur. 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. For effectively 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 in Bikaner district. Six shrub species were planted at 3 m × 3 m spacing. Seed of *Cassia aungustifolia* and *Lasiurus sindicus* were also sown as cover species. Total 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)*. For restoration of degraded sandy plain plantation has been done at Karah Jod, Jaisalmer in 15 ha area. Five tree species *A. indica, P. cineraria, S. oleoides*, *Z. mauritiana, A. nilotica* and five shrub species like *Mytenus emarginata Vachellia jacqumontii*, *Calligonum polygonoides*, *Cordia gharaf, Z. nummularia* were planted Different soil amendments treatment like biochar, hydrogel, neempati, Sewage sludge biofertilizers has been applied in planted tree and shrub species. For restoration of saline site superior populations have been identified from the native range of distribution of *Salvadora oleoides* and *Salvadora persica*. The fruits of 30 accessions (mother trees) of *S.persica*and *S. oleoides* have been collection from Rajasthan and Gujarat. Their de-pulping, drying, and then raising of the nursery beds has been conducted at four sites, namely Site 1: Babina Forest Range, Jhansi Forest Division (Uttar Pradesh Forest Department), Site 2: Central University of Punjab (CUP), Bhatinda and Site 3: Chaksarker, Ferozepur (Punjab Forest Department) and Site 4: FRI, Dehradun. For rehabilitation of mine overburden area, plantation of screened species with recommended soil amendment was done in 7 hectare of area at kiriburu site. On the slopes of the selected site, continuous contour trenches and staggered contour trenches were prepared to check the water flow and hence the soil erosion. Plantation on contour trenches has been carried out with grasses, bushy species, bamboo and *Delonix regia*.

AICRP 25: Domestication, genetic characterization, improvement and diversified utilization of poplars

Field trials of 16 clones of *P deltoides* have been laid out at FRI (4 sites), HFRI (1site) and IFP (1 site). Cuttings of *P. alba* ,*P. ciliata, P. nigra and Salix alba* from HFRI have been planted in nursery by FRI and RFRI. Cuttings of *P. alba* have been raised in the nursery by HFRI for setting up field trials on spacing, soil working technique and hydrogel dose. Experiment has been concluded on vegetative propagation of *P. gamblei* through branch cuttings. Seedlings of *P. gamblei* have been raised in the nursery by RFRI for supply to FRI and IFP for conducting introduction trials. Studies on DNA extraction and standardisation of DNA markers are underway in FRI, HFRI and RFRI. Surveillance of insect pests and diseases is in progress at HFRI, IFP and RFRI.

Fig. 25 *P. deltoides* trial in Saharanpur district (Uttar Pradesh) after 7 months

AICRP-26: All India Coordinated Research Project Genetic Improvement of *Azadirachta indica* A. Juss. (Neem)

At AFRI, survey and selection of 100 Candidate plus trees (CPT) of Neem from Gujarat (agro-climatic zone-13) and 137 CPT from Rajasthan (agro-climatic zone-14) was completed. Neem fruits were collected from marked 100 CPTs from agro-climatic zone 13 and 14 respectively. 100 seed samples from both the agro climatic zones were de-pulped, dried, packed and sent to Amity University, Noida for Azadirachtin content estimation. Passport data was recorded for all the CPTs. Oil extraction and estimation work was started from the seeds at AFRI. For phenological and morphological studies were carried out on neem trees marked at AFRI, Jodhpur and data was recorded. *Agrobacteriun* suspension cultures of strains LBA4404, GV3101 and EHA105 were maintained as stocks as well as live cultures. Transformed cell lines were further sub-cultured as callus. Co-cultivation experiments were conducted for double gene transformation which was achieved by the re-transformation approach, in which previously transformed and confirmed *glyIII* calli was retransformed by co cultivation with *CDH* gene. Putative double gene transformed cultures are growing well and are being maintained by regular sub culturing.

At TFRI, survey were carried out in the states of Madhya Pradesh and Uttar Pradesh, 100 CPTs of Neem were selected. Neem fruits (approx. 1.5 Kg fruits per tree) were collected from each selected tree. Morphometric characterization of trees, fruits, and seeds was done. Fruits were de-pulped, cleaned, and shade dried, for the purpose of total oil extraction. Seeds were extracted from fruits and oil extraction from kernels is being done. So far, total oil from the 50 samples of Neem seeds has been extracted. The range of total oil % is Min.18.38 to Max. 49.07. The seeds were also processed, packed in cloth bags with proper coding, and outsourced to Amity University, Noida for estimation of azadirachtin.

In IFGTB, intensive survey was carried out in six different agro climatic zones of Tamil Nadu, parts of Pudhucherry and Andhra Pradesh (ACZ 10 & 11). Selected 220 CPTs based on superiority in fruit yield, tree form and tolerance to pest and diseases. Collected fruits from the 220 selected CPTs and the seeds were processed as per common methodology in proposal for further estimation. 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. Collected information on flowering and fruiting phases in different accessions of 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. Data collected on different pheno-phases such as leaf fall, leaf fleshing, initiation of flowering, peak flowering and initiation of fruit shell. Repeated the breeding experiment such as autogamy, allogamy, geitogamy. Studied variations in the flowering and fruit setting pattern in different populations. Data was collected on the status of recovery of Neem decline. Recorded level of Tea Mosquito bug infection and different district of Tamil Nadu and found that western zones had heavily infested than the coastal region and younger tress are more susceptible than the older trees. Around 80 percentage of trees infected were recovered back and initiated new leaves and flowering. Identified accessions based on earlier works on Neem improvement conducted at IFGTB. Initiated callus induction using flowers, leaf

explants and immature embryos in ten different media combinations. Leaf and embryo explants inoculated for callus induction was very minimal. Initiated flower callus were transferred to suspension culture and are maintained. We estimated the Aza content by colorimetric method and through HPLC. The flower callus yields highest Aza in compared with leaf, embryo callus.

In IFP survey was conducted in three agroclimatic zones 3, 4 and 7. A total of 349 CPTs were selected. Data on tree height, GBH, crown diameter, number of branches etc were recorded for each selected trees. GPS data of each location were also recorded. Collected fruits from the 100 selected trees of each agroclimatic zones 3, 4 and 7 and the seeds were processed. Total 300 seed samples were dispatched to Amity University, Noida for estimation of azadirachtin content. Quantified variations among seed lots in the fruit and seed traits such as fruit length, fruit breadth, seed length, seed breadth and 100 seed weight.

At IWST survey was carried out in the allotted ACZ 10 covering Karnataka only. 100 CPTs were selected. Seeds were collected from the selected CPTs. These were depulped, dried, packed and sent to Amity University, Noida for AZA quantification.

At IFB survey was carried out in the allotted ACZ 9. 100 CPTs were finalized for seed collection. Seeds were collected from the selected CPTs. These were depulped, dried, packed and sent to Amity University, Noida for AZA quantification.

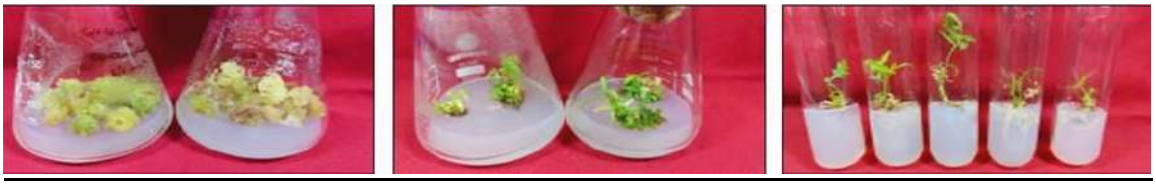

Fig. 26 A- Double Gene (GlyIII + CDH) transformed callus cultures; B- Shoot Induction cultures; C- Root Induction Cultures.

AICRP-27: Conservation and sustainable management of wild edible fruiting species

At TFRI, surveyed 14 districts: Jabalpur, Mandla, Chindwara, Betul, Dhar, Jhabua, Khargone, Barwani, Dewas, Ujjain District of Madhya Pradesh and Dhamteri, Gariaband, Mahasumund district of Chattisgarh and Raigad of Maharashtra for finding the distribution of *Flacourtia indica* and *Semecarpus anacardium.* Identified 60 superior plants of *Semecarpus anacardium* and 46 plants of *Flacourtia indica* on the basis of fruit and/or plant characteristics. Seeds were sown on different media (paper, soil and cocopeat) for germination test. Best media was found mixed soil for *Semecarpus anacardium* and coco peat for *Flacourtia indica.* Clayey and sandy soil was found best germination media for *Semecarpus anacardium* and Flacourtia *indica* seedlingsrespectively. When assessing sowing depth, 4cm in clayey soil under sun and 2 cm in sandy soil under shade was found best for Semecarpus *anacardium.* Polythene bags were found best for vegetative propagation. No root was produced in any treatment on shoot cuttings on *Semecarpus anacardium.* But 1000 ppm IBA in basal cutting produced maximum shoot and root in *Flacourtia indica.* Girth size of cuttings of *Flacourtia indica* for better propagation had been standardised (0.4-0.5cm). Feb-March was observed best season for vegetative propagation for *Semecarpus anacardium.* But in *Flacourtia indica* February to August was found best. Initiation of shooting was found in *Semecarpus anacardium,* but no rooting was observed in cuttings. Different ratio of sand, fertilizer and soil were used for germination and growth of seedlings of

Semecarpus anacardium. 1:2:1 ratio was found best for seedlings of *Semecarpus anacardium.* In combined experiment of weed, light and soil, weed-free plot was best for under sun, but weed didn't affect much when planted under shade. Under sun, each day irrigation is necessary, but under shade alternate day irrigation gave better result. One layer of green agroshade net was best in comparison of other conditions. Desiccation and freezing sensitivity of seeds of *Flacourtia indica and Semecarpus anacardium* was done. On the basis of different trials, the seeds of *Flacourtia indica and Semecarpus anacardium* can be considered as orthodox seed. Seeds of *Flacourtia indica* are adjusted to 3.43%, 8.4% and 11% moisture content at ambient, 15°C and 5°C to test its storability. Stored seeds were sampled after 3, 6 and 12 months of storage Seeds of *Flacourtia indica* stored at 3-8% moisture content were viable after one year of storage. Fruit maturity studies in Flacourtia indica has been completed. Biscuits are prepared from fruits of *Semecarpus anacardium. S*helf life of 'Karonda chips' and 'Energy drink' were determined. New products 'Karonda Powder',"Khatmithgoli", "Karonda Candey"and Cherry karonda prepared during the period. Nutritional analysis of all three value added products was done. New variety and collection area identified in Manendragarh C.G., Preparation of field for cafeteria in NWFP nursery also done during this period. Prepared karonda pickle and cherry karonda. Estimation of nutritive value of value-added products by AOAC International, (2016).

FRI surveyed twelve forest Divisions (Mussoorie, Chakrata, Pauri, Lansdowne of Uttarakhand, Pathankot, Hoshiyarpur and Jalandhar of Punjab, Ambala, Kurkshetra, Karnal, Sonipat & panipat of Haryana). Selected trees (Pyrus: 31, Ficus:17). No. of Quadrats laid (Uttarakhand (140) + Punjab (40) + Haryana (70)). No. of promising trees used for seedling production (Mussoorie-1 Chakrata-03, Tehri-03 and Pauri-01(150 Seeds of *Pyrus pashia*from each locationwere sown). No. of trials for vegetative propogation (Approx 1000 Cuttings were planted from different forest Divisions). Three potting mixtures and three net shades have been tried. Three treatment 1. Without hormone, 2. With IBA 3000ppm 3. With IBA 6000ppm have been tried. Natural regeneration data analysis for Pyrus pashia in Lansdwone and Pauri Forest div from 60 quadrats and 40 quadrats *Ficus palmata* from Lansdwone and Pauri Forest division was done. Data analysis for Punjab and Haryana is under progress. Nutritional Analysis of fruits: TSS, Moisture %, Total Ash %, crude fibre and crude fat, vitamin-C for *Pyrus pashia* and *Ficus palmata* fruits samples from Chakrata, Mussorie, Pauri, Punajab forest Divisions has been determined.

HFRI, consulted literature w.r.t. botanical description, habitat, ecological factors for their growth, phenology, reproductive system and fruit maturation and importance and use of the species. Surveyed natural population of species in Kullu, Mandi, Chamba and Shimla districts of Himachal Pradesh and Kathua district of Jammu. After the survey, 24 sites were selected for *M. esculenta* and 14 sites for *P. cornuta* in Himachal Pradesh. Seeds/fruits were collected from 12 sites for *M.esculenta* and 13 sites for *P.cornuta*. Kothi (Kullu), Narkanda and Kufri (Shimla), Katgoan (Kinnaur) of *P.cornuta* and *M. esculenta* vegetative propagules were collected from Baragaon (Shimla), Shilly (Solan), Majgaon, Sangrah and Lajwa (Sirmaur) and Panjiyara and Kathal (Chamba) and Siara and Kardoh (Jammu). Morphological and physical characteristics of the tree were recorded and superior trees were marked. Collected fruits were processed in the laboratory to record physical parameters. Weight and diameter of fruits (*M. esculenta* 28kg and *P. cornuta* 47.582 kg) and seeds (*M. esculenta* 8.630kg and*P.cornuta*21.980kg) were recorded. Nutritional analysis of fruits of *P. cornuta* was done for Carbohydrate by Anthrone method, Protein by Lowry's method and Crude fat was done. Moisture content of the seeds was

analysed. Phyto-sociological studies were carried out in sample plots following quadrate methods in Burata, Chailchowk, Kotmoras, Moviseri, Chandeh, Shakryala, and Algan-DPF of Mandi district for *M.esculenta* and Kothi (Kullu) for *P.cornuta* and planted after treatment in fabrication boxes and nurseries and data was recorded periodically.*M. esculenta*seeds were sown at Model Nursery Baragaon (Shimla) in open nursery bed ($70m^2$), in polyhouse bed ($15m^2$) and stem planting in polyhouse beds ($6m^2$) and at Shilly (Solan) seeds were sown in $30m^2$ in open nursery bed, $5m^2$ polyhouse bed and $5m^2$ in fabrication box. Seeds of *P. cornuta* were sown at Shillaru in open nursery bed $30m^2$ and $5m^2$ in Fabrication box and at Brundhar (Manali) seeds sown in $30m^2$ open nursery bed and $5m^2$in fabrication box and planted after treatment in fabrication boxes and nurseries and data was recorded periodically. Air layering in the branch of *M. esculenta* was done in Shilly (Solan) and Baragaon (Shimla). Ethno-botanical data on *M. esculenta* was collected from Shimla and Chamba district. Source wise seed germination in polyhouse nursery bed recorded maximum in Chailchowk (70%) and minimum in Kotmoras (28%). Treatment wise maximum germination was recorded in Cow dung (98%) and Hot water (96%) while minimum recorded in 100 ppm GA_3 (42%) and 1000 ppm GA_3 (42%). Maximum germination in *P. cornuta* in polyhouse bed Brundhar recorded 76% (Winter sowing). Equipments like electronic balance, fabrication boxes, grafting kits and nursery tools were procured during the period under report.

IFGTB surveyed and identified populations of *L. acidissima* in Erode, Coimbatore, Tiruppur, Salem, Karur, Trichy, Tiruvannamalai, Tirunelveli, Dharmapuri, Madurai, Dindigual and Palakkad (12 areas). Recorded flowering and fruit collection time in Limonia and Pithecellobium at different areas. Regeneration studies were done in Coimbatore (Anaikatty, Siruvani), Tirvannamalai, Pudhukottai, Trichy (Pachamalai), Palakkad (Menonpara, Kozhipara, Kollamadachalla) (8 areas). Sampled using stratified random design method. Developed a questionnaire for Ethnobotanicalsurvey.Conducted the studies at forest fringe villages of Coimbatore (Anaikatty and Siruvani) , Thiruvannamalai (Thumbakkadu &Vilankuppam), Trichy (Sengattupatti, Perumparappu & Sittur), Nilgiri (Thekkupadi, Lightpadi, Yanaipadi) for Tamilnadu and Palakkad (Nadupathy, Chavadipara&Vathyarchalla) (13 forest fringe villages)Arrived at CPT selection criteria for *Limoniaacidissima* and *Pithecellobium dulce* CPTs based on fruit yield.Selected 100 CPTs of *Limoniaacidissima*and recorded tree passport data, geo-coordinates of the CPTs. Selected 57 CPTs of *Pithecellobium dulce* and recorded tree passport data, geo-coordinates of the CPTs. Standardized fruit and seed morphometric characterization through image analysis. Fruit quality for taste, sweetness, colour, aroma, nutrients such as total fibre, total Carbohydrates, ascorbic acid and Total Soluble Solids for *Limoniaacidissima* and *Pithecellobium dulce*.Collected fruits, processed and analyzed Fruit and seed morphometric characterization through image analysis for 8 various CPTs.. Analysis of Nutritional parameters were done for 4 of the selected CPT's of *Limoniaacidissima* CPT-wise, germination studies in seeds of Limonia has been initiated. Carried out seed germination studies in *Limoniaacidissima*on fresh seeds at 5.7% moisture content and recorded 93% germination. Pretreatments failed to improve germination and seedling vigour index compared to control. *Limonia acidissima*-350seedlings and *Pithecellobium dulce*-420 seedlings have been transplanted for hardening*Various experiments to induce rooting in Limonia*stem cuttings using growth regulators and grafting showed nil result. Hence seed propagation has been concluded to be the suitable method. Rooting studies on *Pithecellobium dulce* slowed that 5-7mm

diameter thick stem cuttings are suitable for vegetative propagation than 8-10 mm of stem cuttings. However root induction by growth regulator (IBA) at different concentrations was not significant. Rooting experiments with various IBA compositions are being tested. Experiments to study the effect of potting mixture composition for *Limoniaacidissima* and *Pithecellobium dulce* have with initiated and studies are in progress. Experiment on effect of shade (temperature) and effect of direct sowing and transplanting on germination of *Limoniaacidissima*is continued. Studies on effect of temperature on germination of *Limoniaacidissima* seeds for various temperatures at 8 °C, 15°C, 20°C,-20°C,-80 °C, and room temperature is under progress. At the different study areas recorded factors such as temperature, rainfall, anthropogenic activities, other biotic and abiotic factors on sustenance of the study speciesInitiated fruit maturity studies in Pithecellobium dulce. Studies are in progress.

RFRI consulted available literature on the target species (*Spondias pinnata* and *Prunus jenkinsii*) and collected distribution of the species in different districts of Assam and Mizoram. Fruit pulps of *Spondius pinnata* and *Prunus jenkinsii* are edible. Ripe fruits of *Spondius pinnata* are made pickles. Decoration of fruit pulp is taken orally against stomach disease (diarrhoea, dysentery etc). Fruit pulp of *Prunus jenkinsii* is used for preparation of jam in Assam.Explored the distribution of *Prunus jenkinsii* in community forests of Hmuifang, ReiekTlang, Saitual and *Spondias pinnata* in Sairang, Selesi, Mizoram and collected the ethno-botanical information.Explored distribution of *Spondias pinnata* and *Prunus jenkinsii* in different RFs/WLS (Gibbon WLS, Jorhat and Nambor-Doigrung WLS, Golaghat, DihingPatkai National Park, Dibrugarh, and Poba RF, Dhemeji, Kakoi RF, Lakhimpur, and Sonai-Rupai WLS, Sonitpur district and different areas of Majuli district, Assam and recorded the regeneration status of the species. Maximum regeneration potentials -19 ± 9 per hectare of *S. pinnata* at Nambor-Doigrung WLS, Golaght, maximum saplings (< 10 cm dbh) -15±5 and tree > 10 cm dbh - 13±4 per hectare was recorded in Abhaypur RF, Charaideo. Recorded 50 genetic resources of *Spondias pinnata* in homestead gardens/ reserved forests of Jorhat, Sibsagar, Charaideo, Karbi-Anglong, Lakhimpur, Dhemaji, Tezpur district, Assam and made pass port data; selected 10 CPTs of *Spondias pinnata* and collected seeds 1.0 – 1.5 Kg from each of CPT and put in nursery for further studies. Being conserved 20 different genetic resources of *Spondias pinnata* and 3 of *Prunus jenkinsi*i which collected from different areas of Golaghat, Karbi-Anglong, Jorhat, Sibsagar, Charaideo districts, Lakhimpur, Sonitpur, Dhemaji and Majuli districts, Assam. Able to develop of 300 seedlings of *Spondias pinnata* and 150 seedlings of *Prunus jenkinsii,* conservingat RFRI nursery.

At IFB, survey and documentation of wild edible fruit species in forest areas and village markets of Ranchi, Dumka, Simdega, Ramgarh, West Singhbhum, Hazaribagh, Khunti, Deoghar, and Gumla districts in Jharkhand have been done. Identification of 44 wild edible fruit species 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. Dominant species found in forest areas are *Diospyros melanoxylon*, *BuchnaniaLanzan*, Schleichera*oleosa*, *Semecarpus anacardium*, *Aegle marmelos*, *Solanum torvum*, *Artocarpus heterophyllus*, *Syzygiumcumini*, *Madhuca indica*, *Zizyphusmauritiana*, *Tamarindus indica*, *Solanum nigrum*, *Mangifera indica*, *Coccinia grandis*, *Momordica charantia*, *Phoenix sylvestris, Woodfordiafruticosa.* Presence of 8 wild edible fruits are found less in the forests. Wild edible

fruits found in village markets are *Tamarindus indica, Solanum torvum, Coccinia grandis, Semecarpus anacardium, Mangifera indica, Aegle marmelos, Artocarpus heterophyllus, Momordica charantia etc.* Continuous literature review. Geotagged information has been documented.

Fig. 27 Value added products

AICRP-28: Population status, collection, characterization and evaluation of genetic resources of Indian Rosewood, *Dalbergia latifolia*

Field surveys has been conducted in Karnataka; Tamil Nadu, Kerala, MP, Jharkhand, Uttarakhand, Uttar Pradesh and Punjab. Studied population structure, natural regeneration, phenology, associated species, forest types etc. and recorded lat-long information.

Altogether 532 superior trees (IFP-174, TFRI- 160, IFGTB 173, IWST 25) were selected from these forest areas and marked geo-coordinates, Morphometric parameters and other baseline information on these selected trees were recorded. Collected information on silviculture and management practices from working plans of Karnataka and Kerala Forest Department, literature, and on receipt and sale of rosewood timber from Forest Timber Depots.

FRI has established field gene bank of CPTs at FRI campus and monitored for further biotic incidences. IFGTB has established field gene bank of *D. latifolia* and *D. sissoides* in 3 locations: i) Varavoor (Thrissur District, Kerala) in 1.1 hectare area with 68 accessions (290 individuals) and established during Sep, 2019 to Jan, 2021. The average height and girth of clones are 160 cm and 5 cm respectively; ii) Panampally (Palakkad District, Kerala) in 0.03 hectare area with 12 accessions (50 individuals) and established in Dec, 2020. The average height and girth of clones are 90 cm and 2 cm respectively; iii) Vanavarayar Institute of Agriculture, (Coimbatore District, Tamil Nadu) - under NFRP-166 project and being maintained under AICRP-28 project; 0.4 hectare area with 61 accessions (270 individuals) and established in the period of Jan, 2021 to Sep, 2021. The average height and girth of clones are 80 cm and 2 cm respectively. IFP has established progeny field trial cum germplasm bank of 7 accessions in RBD fashion with 5 replications and 6 plants/progeny/replication at NB farm Chandwa village, Latehar District (Jharkhand) in 0.5 Ha. DNA isolation protocol was standardized at IFP and IFGTB. IFP has isolated genomic DNA from 173 accessions, FRI from 73 accessions; IFGTB from 56 accessions of *Dalbergia latifolia* and DNA has been extracted and quantified. IFGTB has designed 30 sets of SSR primers using DNA sequences of *D. odorifera, D. sissoo, D. frutescence.* 56 accessions of *Dalbergia latifolia* were analysed with 30 sets of SSR primers and monomorphic bands were

obtained. Whole genome sequencing is in progress to get polymorphic bands giving SSR primer sets.

TFRI has studied the tannins, total phenolic and alkaloid contents of selected superior trees using bark and leaf samples. IFGTB has carried out Phytochemical analysis of 36 accessions of *D. latifolia* leaf and hard wood (root) samples for flavonoids (anti cancerous). Qualitative and quantitative analyses show good amount flavonoids in bark and leaf. FRI has carried out survey in a progeny trial established by SFD at Lal Kuan, Haldwani, FRI and recorded disease incidence and collected samples. The fungal pathogens found to cause yellowing spot and blight, and were identified as *Neopestalotiopsis* spp. and *Colletotrichum* spp. Survey of insect-pest of *D. latifolia* was made from Lalkuan, Fatehpur, Pantnagar and New Forest. A total of 12 insect species were recorded from young leaves. Seventeen insect-pest categorised as **defoliators** (*Apoderus* sp., *Ectropis bhurmitra, Hyposidra talaca, Plecoptera reflexa, Gastrophysaviridula, Chrysochuscobaltinus, Olene inclusa,* Himalayan Sailor); **Sap-sucker** (*Drosicha stebbingi, Leptocentrus taurus, Leptocorisa sp., Ricania speculum,* Leaf footed bug, *Halyomorpha halys*); Leaf-folder and leaf weevils were recorded from the region. Vegetative propagation of the selected superior trees by treating sprouts developed from the root cuttings with IBA and clonal plants raised at TFRI, IFGTB and IWST. Vegetative propagation using stem cutting does not yield result. Pods and seeds subjected to morphometry analyses. Seeds were stored at -4^{o} C and -20^{o}C for viability studies. The seeds show 50-80% germination (freshly collected). A total of 4500 seedlings were raised in IWST nursery and 8000 seedlings at IFP Ranchi. IFGTB has collected seeds from Tiruvannamalai, Pudukottai, Salem & Coimbatore and collected seeds of 6 Karnataka and one Kerala populations. 600 seedlings were maintained for progeny trial establishment. Studies on pollinators on rosewood in a agroforestry plantation revealed Honey bees *Apis dorsata* and *Apis cerena* were the major pollinators. From breeding experiments with controlled pollination revealed that, *D. latifolia* is cross pollinated.

AICRP-29: Sustainable management of NTFP's through conservation and value addition

Conducted extensive survey for collection of germplasm of *T. wallichiana*, *T. serpyllum*, *A. heterophyllum* and *R. australe* in different geographical locations of Himachal Pradesh. Collected germplasm of *T. wallichiana* from 28 different sites, *T. serpyllum* from 39 different sites, *R. australe* from 22 different sites and *A. heterophyllum* from 18 different sites. Established field gene bank of *T. wallichiana* (21 sources) and *A. heterophyllum* (15 sources) at FRS Brundhar (Kullu) and *T. serpyllum* (36 sources) & *Rheum australe* (20 Sources) at FRS Shillaru (Shimla). Recorded morphological parameters of *A. heterophyllum, T. serpyllum, Taxus wallichiana* and *Rheum australe* from established trialsat FRS Brundhar and FRS Shillaru.

Documented the harvesting methods of NTFP's from around 57 villages of Himachal Pradesh. Studied the effect of harvesting methods using quadrate method in *Viola* sp. and *Ajuga bracteosa* through different grades of harvesting i.e., 20-25%, 35-40%, 50-60%,80-90%harvesting etc. Analysis of alkaloids content in *T. wallichiana* (bark from 20 sources and leaves from 15 sources), *T. serpyllum* from 12 sources, *R. australe* from 17 sources and *A. heterophyllum* from 10 sources done. Analysis of saponin content in *T. wallichiana* bark from 20 sources, leaf from 15 sources, *T. serpyllum* from 12 sources and *R. australe* from 16 sources done. Documented the ethno-botanical information from local people of around 69 different

villages of Himachal Pradesh. Documented the methods of processing and value addition of NTFP's from 27 villages of Himachal Pradesh. Procured NTFP species from Markets of four districts of Himachal Pradesh for quality assessment. Collected the information about gaps from NTFP's collection to the market level from markets of 6 districts. Developed market linkage for NTFPs from 6 districts of Himachal Pradesh.

Populations for *Mesua ferrea*, 12 populations each for *Oroxylum indicum* and *Paederia scandens* and 14 population for *Dellinia indica* has been surveyed in North West Bengal. Collection of germplasms (seeds) of candidate plus trees of *Mesua ferrea, oroxylum indicum* and *Dillinia indica* was done. On the basis of phenotypic characters 20 CPTs of *Mesuaferrea*, 61 of *Oroxylum indicum,* 30 of *Paederia scandens*and 45 of *Dellinia indica* were selected. 17 forest fringe villages from Jharkhand, 3 from Bihar and 7 from West Bengal has been surveyed and required data on harvesting practice and traditional knowledge of ethno-medicinal plants was collected. Seedlings of *Oroxylum indicum* and *Mesua ferrae* for germplasm evaluation trial has been raised and field preparartion for the same for 2 species has been completed.

Surveyed 68 sites, identified the plants, and collected root bark/ pods of *Oroxylum indicum* from 60 locations of 31 forest divisions (19 locations of MP, 17 of CG and 24 of Maharashtra states). Survey and collection of *O. indicum* from all three states completed. Surveyed 56 sites, identified the plants, and collected root bark/ pods of *D. gangeticum* from 33 locations of 28 forest divisions (19 locations of MP, 11 of CG and 03 of Maharashtra states). Surveyed 59 sites, identified the plants, and collected root bark/ pods of *U. picta* from 12 locations of 12 forest divisions(08 locations of MP, 02 of CG and 02 of Maharashtra states). Surveyed 51 sites, identified the plants, and collected root bark/ pods of *Embeliatsjeriam – cottam* from 15 locations of 13 forest divisions (12 locations of MP, 03 of CG states). Visited 07 locations of 07 forest divisions of MH state but *E.tsjeriam– cottam*was not found.Quantified flavonoid, alkaloid, phenolic and terpenoid contents in *Oroxylum indicum*, *Desmodium gangeticum, Embeliatsjeriam – cottam*and *U. picta* respectively.

Assemblage and establishment of *Desmodium gangeticum*of 33. Domesticated 300 seedlings of *U. picta* in Farmer's field. Present prevailing and traditional harvesting practices of economically important species in central India viz. *Terminalia arjuna, Terminalia chebula, Oroxylum indicum, Curculigo orchioides, Butea monosperma* have been documented in the field.Germplasm of *Sapindus laurifolius* (ritha) was collected from 5 locations –M.P. and 04 of MH. GPS coordinates were taken and assembled in FRC-SD campus. Value addition of selected species viz. *Moringa oleifera* and *Cassia tora* was done for nutraceutical chocolates, handwash, cream, polyherbal biscuits and complementary food.

FSSAI registration is under progress for herbal chocolates to develop market linkages. Processed and developed edible product of fresh *Phyllanthus acidus* fruits and assessed nutrional value. Prepared herbal soap utilizing natural colour of extract of *Butea monosperma* flowers. The nutritional evaluation of *Phyllanthus acidus* fruits was carried out and per 100g of edible fresh fruit contains moisture: 84.5±1.9, protein: 0.24±0.97 and Carbohydrate: 4.7 ± 0.68. Value addition of *P. acidus* fruits (Pickle) was carried out and it contains Moisture: 9.15 ± 1.8; Protein: 0.19 ±1.78 and Carbohydrate: 3.6 ± 1.30. Prepared different valueadded product from *Diploknema butyrecea* - Chura Butter, Chura Soap, Lip Balm, Crack Cream, Candles etc. Collected marketed sample of NTFP Species from Munsyari, Ramnagar, Tanakpur Mana, Niti

Village of Uttarakhand and Jhansi, Mahoba, Banda, Chitrakut, Renukut and assessed the quality of samples (28).

6 villages have been surveyed for ITK and information have been recorded related to plants and formulations of 4 chronic diseases. Survey and collection of samples was completed for 25 populations of *Schumannianthus dichotomus* (Roxb.) Salisb, 3 population of *Tacca integrifolia* Ker-Gawl, 6 population of *Aporosa octendra* (Buch-Hum) ex D. Don, 5 populations of *Hydocarpus kurzii* (King) Warb., and 18 population of *Costus speciosus* (J. Koenig) Sm. Established germplasm bank for *S. dichotomus*, *T integrifolia* and *C. speciosus*. Propagation experiments were laid out for all above 5 species either through seeds of through cuttings at RFRI campus Jorhat. Surveyed literature for documentation of ITKs for *Mangifera sylvatica* Roxb., *Phoebe cooperiana* U.N kanjilal ex A. Das, *Dillenia indica* L., *Garcinia pedunculata* Roxb.

Fig. 28 Value added products from NTFPs

AICRP-30: All India coordinated research project on *Gmeilna arborea* Roxb.

Genetic trials

A total of 210 CPTs in Jharkhand & Bihar, 130 in Chattisgarh & Madhya Pradesh have been selected for the study (after extensive survey in the Eastern region (Bihar, Jharkhand) Northern region (Haryana, Punjab, UP & Uttarakhand) Central region (Maharashtra, Madhya Pradesh & Chhattisgarh) Southern region (Tamilnadu). Progeny field trials has been established at NB farm Chandwa(41), Ukdimadi village, Torpa, Khunti (58), Seothi and Bithmera in the Districts of Kurukshetra and Hisar Haryana (14), Madhya Pradesh & Chhattisgarh (4), Goalghat (Assam) (4) and 16 (Tamilnadu) for genetic evaluation.Seeds of 16 different progenies were shared by IFGTB, Coimbatore among the project partners and raised nursery and seedlings are being maintained in the nursery to establish field trials. A total of 41 trees have been screened based on the index value of 90The index value of selected trees has varied from 91 to 100. Raised 500 Seedling and 700 Grafts of *G. Arborea* clones by RFRI.

DNA Marker study

Genomic DNA isolation protocol has been standardized and genomic DNA of 135 CPTs, IFP and 30 (IFGTB) has been isolated by using the developed protocol. Twelve number of microsatellite markers (SSR primers) and have been synthesized by IFP & IFGTB for molecular characterization of selected CPTs.The twenty newly developed SSR primer sequences have been shared by IFGTB with other ICFRE partners of the project.

These twenty primers were optimized for PCR amplification. Half sibs progeny trial has been established by IFGTB at Kurumbampatti, Salem and also at Neyveli. Leaves samples were collected from progeny trials and 40trees from Dapoli (MS), Balaghat, M.P.; and Godhi, Baktara, Mura, Pacheda, Chhattisgarh and DNA was isolated from **Sixty-Eight** families by IFGTB and 40 by TFRI for SSR profiling. Microsatellite profiling of progenies were completed for fifteen polymorphic primers. Bark samples of were collected from 9 selected trees of Salitekri (Balaghat), 12 selected trees of Chhindwara and 14 selected trees of North Seoni, M.P. for biochemical estimation. Fruits from 54 trees were selected from different locations of M.P., Chhattisgarh and Maharashtra. Pre-treated seeds were sown in soil mixture-filled polybags after depulping of fruits. 68% germination was observed within 10-15 days and 3000 seedlings have been prepared so far. Established vegetative multiplication garden of *Gmelina arborea* with **10 shortlisted clones** based on the yearly growth performance. Maintained the VMG for higher cuttings production. Produced **500** cuttings from shortlisted clones. Vegetative multiplication of high productive of Gmelina clones through mini cutting is under progress. Established one each Clonal Seed Orchard at Horticultural Research Station, Kahikuchi and at Regional Research Station, Diphu respectively.

Agroforestry Trials

Maintained Gmelina based agro forestry models - Gmelina + Banana at Vadakadu, Pudhukottai and Gmelina + Papaya at Kangeyam, Thiruppur. Established mulit-tree agroforestry models- Gmelina + Casuarina + Ground nut at Soolakal, Pollachi (IFGTB) Gmelina+ Maize at Jabalpur (TFRI) and Gmelina+ Chilly (IFB) and data collected on different growth parameters on Gmelina arborea. (The agro-forestry model of Gmelina + Papaya was devastated due to heavy rain and water logging conditions) Applied intensive silvicultural inputs of regular irrigations and fertigations to the agro-forestry trial to obtain higher productivity.

Insect pests documented on *Gmelina arborea* Viz., *Calopeplaleayana*, *Phyllocnistisamydropha*, Soldier beetle- *Cordyloceralivida*m, Snail, *Galeurucellabirmanica*, *Indarbellaqudrinotata*, coreid bug, *Oxianitidula*, *Alcidodesludificator*and *Pygida* spp. The recorded insect pest was categorized into major and minor pests.

Table.1. Succession of different insect pests associated with *Gmelina arborea* during the observation period

Common Name	Scientific Name	Family	Order	Pest Category	Status
Khamer defoliator	*Calopeplaleayana*	Chrysomelidae	Coleoptera	Foliage feeder	Major in seedlings and pole sized plants
Shoot weevil	*Alcidodesludificat*	Curculionidae	Coleoptera	Shoot	Major in

	or			borer	seedlings and pole sized plants
Brown winged grass hopper	*Arphiaconspersa*	Acrididae	Orthoptera	Foliage feeder	Major in seedlings
Leaf miner	*Phyllocnistis amydropha*	Gracillaridae	Lepidoptera	Eat leaf tissues by mining	Attack on leaves
Looper	*Ectophisbhurmita*	Geometridae	Lepidoptera	Foliage feeders	Attack on leaves
Bark borer	*Indarbelaquadrinota*	Metarbellidae	Lepidoptera	Bark borer	Major in trees
Leaf folder	*PygidaSpp*	Crambidae	Lepidoptera	Foliage feeders	Major but seasonal
Defoliating caterpillar	*Eupterotegeminata*	Eupterotidae	Lepidoptera	Foliage feeders	Major in rainy seasons
Coreid bug	*Homeocerus inornatus*	Coreidae	Hemiptera	Sap sucker	Major in seedlings
Defoliator beetle	*Galeurucella birmanica*	Chrysomelidae	Coleoptera	Foliage feeders	Major in young trees

Defoliation intensity was rated through index method of insect infestation in all the genotypes. Defoliation percentage was calculated and found that site-1 ranges from 0.52 % to 42.58%, among which, clone number 14 shows the highest defoliation percentage and clone number 22 shows the lowest defoliation percentage. Visited *G. arborea* plantation site under TFRI campus and collected leaves to perform the leaf morphological studies. The parameters which have been taken for study were leaf size, shape, colour, thickness, surface area, trichomes. For determination of parameters, graph paper is used along with instrument like verniercaliper, microscope and Digital leaf area meter was used.

Trichomes arrangements were studied in all clones as minute microscopic hairy texture under microscope and stellate type of hairs was seen beneath the leaves. Thickness of site-1 and site-2 was recorded using vernier calliper which ranges from 1mm to 2mm.and 0.25mm-.9mm respectively. Surface area of the leaves of site-1 and site-2 was taken and recorded manually by using graph paper and Digital leaf Area meter. Among plant products, mineral oil and entomopathogens studied against *C. leayana* through contact method. Maximum mortality of grub was noted in spinosad 45% (0.0125%) 54.4 and 75.5 per cent at 24 and 48 HAT, whereas in leaf dip method spinosad 45% SC (0.0125%) registered 44.4 and 64.4 per cent mortality of grubs respectively during 24, 48 hours of treatment. This was followed by neem seed kernel extract 5% caused 33.3 and 56.6 per cent mortality of grub at 24 and 48hours after treatment respectively.

Fig. 29 Value added products made from gmelina wood

Value chain study

An extensive survey was carriedout in Tamilnadu, Chhattisgarh, and Madhya Pradesh to assess the market of wood products of *Gmelina arborea*. Tamilnadu has potential and people are engaged in manufacturing vale added products.

AICRP-31: Study of climate driven effects on Indian forests through long term monitoring

ICFRE has established permanent research plots (Eleven 10 ha plots; one 4ha plot; two 3ha plots; twenty-three 1ha plots) in different forest types with an area of 143 ha, to monitor the impact of climate change on Indian forests 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 equipments have been procured and installed. Layout and gridding of the experimental plots have been completed by most of the institutes and enumeration is in progress. HFRI, Shimla has completed the enumeration of all woody individuals above 1 cm diameter (DBH) in 10 ha plot following the common protocol. Enumeration is in progress in all the institutes. A total of 56,000 individuals have been measured and tagged so far. 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.

Observations on flowering host plants, their pollinators, and the frequency of insect pollinators are being recorded. 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. 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. The phenological study is being conducted on 2921geo-tagged individuals belonging to 264 species in different forest types. Soil samples are being collected 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.

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.

Fig. 30 *Marasmius capillaries* recorded in Dihing Patkai National Park, Assam

Fig. 31 *Entoloma hochstetter recorded* from Harbul plot, Jharkhand

Fig. 32 *Oudemansiella australis*, DihingPatkai National Park

Component II:
Programme for Conservation and Development of Forest Genetic Resources (FGR)
Part-1
(FRI, AFRI, RFRI, IFP & HFRI)

FRI Dehradun

FGR Documentation

Different forest sites of Uttar Pradesh (Chitrakoot Forest Division and Lalitpur Forest Division) and Punjab (Hoshiarpur Forest Division) were surveyed for ground truthing of distribution of target FGR species. Regeneration status survey of selected FGR species were conducted in following Forest Divisions of Punjab and Uttar Pradesh:

Chitrakoot Forest Division (*Diospyrus melanoxylon, Acacia catechu, Flacourtia jangomas, Lannea coromendelica, Azadirachta indica, Buchanania cochinchinensis, Terminalia bellirica, Pterocarpus marsupium, Helicteres isora and Ficus microcarpa*),

Lalitpur Forest Division (*Anogeissus latifolia, Aegle marmelos, Bauhinia racemosa, Bridelia retusa, Buchanania cochinchinensis, Butea monosperma, Diospyros melanoxylon, Ficus arnottiana, Lannea coromandelica, Lagerstroemia parviflora, Mitragyna parviflora, Madhuca longifolia* var. *latifolia, Pterocarpus marsupium, Schrebera swieteniodes and Wrightia arborea*),

Hoshiarpur Forest Division (*Holoptelea integrifolia, Grewia asiatica* and *Ehretia laevis*).

Eco-distribution mapping

Conducted field surveys in the various forest areas of Uttar Pradesh and Punjab. The GPS locations from Amritshar forest area has been recorded for a total of 25 FGR species viz. *Acacia catechu, Acacia nilotica, Adina cordifolia, Aegel marmelos, Albizia odoratissima, Albizia procera, Azadirachta indica, Bauhinia variegate, Bombax ceiba, Butea monosperma, Cordia dichotoma, Dalbergia sissoo, Ficus racemose, Holoptelea integrifolia, Melia azedarach, Moringa oleifera, Phyllanthus emblica, Prosopis cineraria, Syzygium cumini, Terminalia arjuna, Terminalia bellirica* and *Ziziphus mauritiana*. From Jhansi and Laltipur forest area, Uttar Pradesh, the GPS locations has been recorded for a total of 20 species viz. *Acacia catechu, Acacia nilotica, Aegelmarmelos, Anogeissus pendula, Albiziaprocera, Albizia lebbeck, Azadirachtaindica, Buchanania lanzan, Butea monosperma, Cassia fistula, Diospyrosmelanoxylon, Diospyrosmelanoxylon, Dalbergiasissoo, Ficusbenghalensis, Holoptelea integrifolia, Madhucalongifolia, Lagerstroemia parviflora, Phyllanthus emblica, Terminalia arjuna, Terminalia bellirica, Terminalia elliptica.* Further, satellite data has been downloaded for different states and data processing of the scenes will be processed further for different districts. The LULC map of Punjab has been done with 90.2% accuracy. The LULC map was completed with 88.53% accuracy for the districts of Jhajjar, Mahendragarh, Rewari, Gurgaon, and Faridabad in Haryana.

FGR Seed and Germplasm storage

Extensive Field tours were conducted in different forest divisions of Haryana and Uttar Pradesh for population survey and seed collection of prioritized FGR species. Mature fruits and seeds of

Acacia catechu, Aegle marmelos, Bauhinia racemosa, Calotropis procera, Cassia fistula, Diospyros montana, Ehretia laevis, Emblica officinalis, Ficus benghalensis, Flacourtia indica, Holoptelea integrifolia, Nyctanthes arbor-tristis, Pterospermum acerifolium, Sapindus mukorossi, Terminalia bellirica and *Ziziphus mauritiana* were collected.

Collected seeds were extracted and processed using suitable methods and subjected to moisture and germination tests. The germination test was conducted in seed germinator at 25±1ºC. The germination percentage calculated as per ISTA (2010). Seeds of following species were desiccated, packed, vacuum sealed and stored at -18℃ - *Albizia lebbeck, Acacia catechu, Aegle marmelos, Calotropis procera, Holoptelea integrifolia and Nyctanthes arbor-tristis* in FRI Seed testing laboratory. Total 15 Seed samples of 12 different FGR species have been deposited at seed gene bank of ICAR-NBPGR, New Delhi till September 2022. Total 21 seed samples of 16 different FGR species have been packed and kept for long term storage in FRI Seed testing laboratory and Seeds of 14 forestry species were kept for medium term storage.

Development protocols for in vitro storage of FGR

Phlogacanthus thyrsiflorus*:** Multiplication and *in vitro* rooting has been optimized and plantlets are being hardened in greenhouse. For storage, Synthetic seed formation also optimized and storage under different temperatures is being tested by regrowth at regular intervals. Also, experiments for slow growth through culture medium modifications have been established. Culture initiation and shoot multiplication is under progress for *Litsea glutinosa, Zanthoxylum armatum, Celastrus paniculatus, Pterocarpus marsupium, Rauwolfia serpentine* ***Catamixisis baccharoides: Synthetic seed formation has been optimized and stored under 4ºC, 15ºC and 25ºC. Regrowth being monitored at regular intervals. To raise seedling explants, seed germination both *in vitro* as well as *ex vitro* being tested in *Withania somnifera* and *Gloriosa superba*

FGR Characterization

Genomic DNA was extracted from 3 populations (20-30 individuals in each population) of *Pterocarpus marsupium*, and 2 populations of *Terminalia arjuna.*

SSR primers development process of *Pterocarpus marsupium and Acacia catechu* for their genotyping has been completed. Primer screening work in *Pterocarpus marsupium* and *Acacia catechu is in progress.* In *Shorea robusta*, genotyping of 10 populations with 11 selected highly polymorphic primers completed.Collected 3 populations of *Madhuca longifolia* from U.P.In *Terminalia bellirica*, 10 polymorphic primers have been found. Genotyping work of collected populations of *Terminalia bellirica* with 10 selected highly polymorphic SSR primers is in progress.

Disease survey:

Surveys were conducted to Mandwara, Barwara and Goan range (Lalitpur Forest Division) and Babina range (Jhansi Forest Division) for the identification of fungal diseases and insect pest infestation in the leaves of *Madhuca longifolia* and *Terminalia bellirica.* Leaves of *T. bellirica* (Barwara range) were found to be infected with *Colletotrichum gloeosporioides* and *Bipolaris maydis* causing leaf spots. Leaves of *M. longifolia* were found infected with *Pestalotiopsis* sp. causing leaf spots. Heavy infestation (100%) of leaf gall insect (*Eulophid* sp.) in *M. longifolia* was recorded in all the sites visited (Mandwara, Goan and Babina range of Lalitpur and Jhansi).

Surveys were conducted to Badkala range, Sahranpur Forest Division for the identification of fungal diseases and insect pest infestation in the leaves of *Madhuca longifolia.* Up to 60% leaf gall infestation on the leaves caused by *Eulophid* sp. and termite infestation on the tree trunk was recorded. Leaf blight symptoms were also recorded. Identification of causal fungal species is under progress.

Biochemical characterization

Marker compound arjunic acid (yield 0.17%) from the bark of *T. arjuna* using flash chromatography was isolated and its identity was confirmed by co-TLC and NMR (^{1}H and ^{13}C) spectroscopy data. Bark samples from 2 populations of *T. arjuna* growing at Manipur Range (20 accessions) and Bargarh Range (20 accessions) in Chitrakoot forest division (FD), Chitrakoot were oven dried, milled and extracted with methanol (1:10) using ultrasonication separately. Extracts were concentrated in vacuum till dryness and dark brown colored extracts in the yield of 11.12 ±0.24% and 10.20 ±0.54%, respectively were obtained. Total tannin contents (TTCs, (mg Tannic acid equivalent /gm of bark) in the populations of *T. arjuna* growing in Lalitpur (Jhansi FD), Farinda and Banki (Gorakhpur FD), Etawa (Etawa FD), Manikpur and Bargarh range (Chitrakoot FD) were determined in their bark samples (138 accessions) according to Folin Ciocalteu procedure using tannic acid as standard and found to be 0.128±0.11, 0.109±0.23, 0.145±0.19, 0.176±0.022, 0.154±0.096, 0.131±0.15, respectively. A population of T.arjuna growing in Etawa (Bijnor FD) was characterized by the highest TTCs (0.176±0.022). Marker compound arjungenin assisted chemical screening of aforesaid populations of *T. arjuna* using HPLC was initiated. 22 samples of extracts isolated from the bark of 2 populations of *T. arjuna* growing in FRI, Dehradun (02 accessions) and Farinda (20 accessions) were analyzed on a HPLC system (WATERS). Content of arjungenin in the population of Farinda was 1.06% while Dehradun population was not found to contain arjungenin.

FGR Conservation

Collected Seeds of different accession of *T. bellirica*, *A. catechu* and *B. lanzan* were grown in the nursery. Initially two species showed very good germination whereas later on i.e. *B. lanzan* had very poor germination in FRI Nursery Dehradun. Seeds of 9 accessions of *B. lanzan* were collected from Mirzapur, Varanasi of Uttar Pradesh and Madhya Pradesh and allowed to germinate in nursery conditions but no germination was recorded. A field gene bank of 21 germplasm of *T. arjuna* have been established at Bithmara, Hisar (Haryana). Presently about 250 seedlings of 4 accession of *T. bellirica* and 350 seedlings of 9 accessions of *A. catechu* are being maintained in the nursery for establishment of field gene bank.

RFRI Jorhat

FGR Documentation

Document FGR diversity & their population status

- Surveys conducted in Karbi Anglong East FD (Dollamora range, Northern range Dollamora), Kaziranga NP; Arunachal Pradesh (Nampong FD, Namdapha NP and Namsai FD) and total **25 points** have been covered. Regeneration analysis has been completed for *Shorearobusta, Schimawallichii, Mesua ferrea, Lagerstroemia speciosa and Dipterocarpus retusus.*

Eco-distribution mapping

- For development of Eco-distribution maps, total **228 GPS** points has been collected from Karbi Anglong East FD (Dollamora range, Northern range Dollamora), Kaziranga NP, Arunachal Pradesh (Nampong FD, Namdapha NP and Namsai FD), East Khasi and East Jayantia Hills (Meghalaya), Lakhimpur and Dhemaji District, Thenzawl FD (Mizoram), Dhalai and Unokoti district (Tripura) during this period. Prediction map of 3 species (*Shorea robusta, Magnolia champaca and Duabanga grandiflora*) has been done.

FGR Seed collection & processing

- Seeds of the following species collected from various seed zones:
  - **Assam*:*** *Tectona grandis, Toona ciliata, Schima wallichii, Morus laevigata, Albizia lebbeck, Terminalia bellerica, Emblica officinalis, Haldina cordifolia, Canarium strictum* were collected from Maibang range, Langting rage, Hatikhali range, Manderdisha range of Dimahasao east dist. of Assam.
  - **Lakhimpur, Arunachal Pradesh**: *Mesua ferrea, Kayea assamica, Magnolia hodgsonii* (Joyhing Forest Reserve), *Canarium strictum, Lagestromia speciosa, Ziziphus rugosa* (Bogoli Forest Reserve) of (Lakhimpur), *Spondis pinnata*
  - **Manipur**: *Mesua ferrea*, *Magnolia champaca, Anthocephalus cadamba, Amoora rohituka*
  - **Mizoram**: *Gmelina arborea, Tectona grandis* and *Litsea cubeba*

FGR Seed and Germplasm storage

- Moisture content, viability and germination percentage in freshly collected seeds and stored seed of above mentionedwere carried out. Further Seeds of above-mentioned species were kept for germination and germination status will be taken soon.
- Seeds of 24 FGR sp. Collected from different locations of northeast India has been sent to FRI, Dehradun till date.

Development protocols for in vitro storage of FGR

- For *in vitro* mediumterm storage protocols (those having recalcitrant seeds) work on development of in-vitro cultures started on *Litsea cubeba, Magnolia gustavii, Shorea assamica, Magnolia punduana and Illicium grafithii*.

FGR Characterization

- Leaf samples of *Magnolia champaca* collected from Karbi Anglong and Kaziranga NP(Assam) for population genetic analysis. Designed 9958 primers for the predicted SSRsand purchase order has been placed for 150 sets of primers.

FGR Conservation

- Experiments for the development of propagation protocols for *Cinnamomum tamala, Shorea assamica, Litsea cubeba,* carried out using branch cuttings and different concentrations of IBA.
- *Shorea assamica* seeds were collected from Joypore RF and also recorded rooting percentage of cutting of S. assamica
- *Phoebe goalparensis* and *Morus lavigata* location were identified in various location of Assam

- *Litsea cubaba* seeds were collected from Assam, Nagaland and East & West Jayantia Hills of Meghalaya. Germination of seeds started.

AFRI Jodhpur

FGR Documentation

Document FGR diversity & their population status

Total districts surveyed 1 Churu, Rajasthan

Total sites visited 35

Total FGR species documented-19

Documented two threatened species (*Ephedra foliata*and *Moringa concanensis)*

Regeneration recorded at 2 sites (*Balanites aegyptiaca, Tecomella undulata*)

Prepared Land Use Land Cover (LULC) map of Rajasthan state

Entered district wise GPS locations of 80 species for mapping

Herbarium label writing of 47 species completed

Downloaded bioclimatic data (BIOCLIM) and processed for species distribution modeling (SDM)

FGR Seed and Germplasm storage

FGR Seed Collection & processing

Seeds of different FGR species (20 in number) were collected from different geographical region of Rajasthan as per the detail given below:

From Jodhpur: *Albizia lebbeck* (280g) *Cassia fistula* (612 g)*, Holoptelea integrifolia* (420g)*, Tecomella undulata* (200g) and *Terminalia arjuna* (1610 g), *Capparis decidua* (350g).

Balotraand Barmer region: Seeds of *Capparis decidua* (1439 g), *Prosopis cineraria* (1262g)*, Salvadoraoleoides* (1500g)*, Salvadora persica*(1356g) and *Tecomellaundulata*(2540g)

Bilara and Borunda region: *Cardia grafa*(87g)*, Cardia dichotoma*(236g)*, Prosopis cineraria* (785g)*, Salvadora persica* (750g) *and Salvadoraoleoides*(650g).

Churu, Naguar, Sikar and Jhunjhunu: Seeds of *Acacia nilotica*(3760g)*, Acacia Senegal* (430 g)*, Albizia lebback* (430 g)*, Anogeissus pendula* (330 g)*, Bauhinia racemose* (820 g)*, Butea monosperma* (470 g)*, Capparis deciduas* (150g)*, Cassia fistula* (1200 g)*, Dalbergia sissoo* (200 g)*, Holoptelia integrifolia* (870 g)*, Tecomellaundulata* (3519 g) and *Terminalia arjuna* (490 g)

Seeds of *Acacia leucopholea*wascollected from Sawai Madhopur (920g). *Acacia nilotica* from Bundi (3000g); Ajmer (1500g); Kota (780g); Tonk (1100g); Sawai Madhopur (1900g) andJaipur (3000g).

Acacia senegal from Bundi (3000g) and Kota (1200g). *Aegle marmelos* from Bundi (80g). *Albizia lebback* from Sawai Madhopur (320g). *Boswellia serrata* fromShahbad (670g). *Butea monospema* Shahbad (520g). *Cassia fistula* from Tonk (310g) and Bundi (790g). *Dalbergia sissoo* Bundi (220g); Kota (1400g) and Sawai Madhopur (1200g). *Holoptelia integrifolia* from Bundi (2800g); Jaipur (1200g), Tonk (1000g); Sawai Madhopur (3000g) *Terminalia arjuna* from Tonk (2000g) and Kota (1500g).

Seed Cleaning and storage:

Seeds of 72 accessions of 20 FGR species wascollected from different forest area of Rajasthan. These seeds were cleaned and stored in the seed walk-in chamber and in cold storage chamber as well as in seed bank of AFRI.

Seed Germination test:

Seed germination test of 17 FGR species (*Acacia leucophloea, Acacia nilotica, Acacia Senegal, Albizalebbeck, Anogeissus latifolia, Anogeissus pendula, Capparis deciduas, Cassia fistula, Dalbergia sisso, Holoptelea integrifolia, Maeruaoblongifolia, Prosopis cineraria, Salvadora oleoides, Salvadora persica, Tecomella undulata, Terminalia arjuna* and *Terminalia bellirica*) was conducted in germination trays and Petri plates.

Development protocols for in vitro storage of FGR:

- Callus Cultures of *Leptadenia reticulata* have been inoculated on MS with BAP & NAA for somatic embryogenisis.
- Callus of *Commiphora wightii* from leaves have been inoculated on hormone free Gamborg B5 media and have been kept on 5 different temperatures (i.e. 4°, 10°, 20°, 30° and 40°) to study the effect of temperature on growth of somatic embryos.
- Callus was not obtained from leaves of *Salvadora persica* on media containing 2,4D, now immature fruits and leaves have beeninoculated on media containing different concentration of 2, 4D and BAP
  Callus Cultures of *Ziziphus nummularia* have been inoculated on hormone free, BAP & BAP+IBA for somatic embrogenisis.
- Seeds of *Anogeisus pendula* was inoculated on MS with PGR BAP and NAA. Internodal segments of *Capparis decidua* was inoculated on MS with BAP NAA callus was obtained.
- Internodal segments & leaves of *Salvadoraoleoides*was inoculated on MS with 2,4D & BAP to initiate callus.

FGR Characterization

Molecular characterization of FGRs

Tour was conducted for collection of leaf samples and passport data of

1) *Prosopis cineraria*
2) *Tecomellaundulata*

Total 30 samples of both the selected species were collected from Pali district (Rajasthan) and 30 samples for *Prosopis cineraria* from Sirohi district (Rajasthan). DNA of the both the species was extracted and PCR amplification for SSR markers was initiated. Total 56 Primers were screened.

Chemical characterization of FGRs

Tours were conducted for collection of samples and passport data of the following species:

- *Salvadora persica* from Pali and Sirohi district of Rajasthan
- *Commiphora wightii* from Pali district (Rajasthan)
- *Caparris decidua* from Jodhpur, Pali, Sirohi, Barmer and Jaisalmer district of Rajasthan

- *Boswellia serrata* from Pali district (Rajasthan).

FGR Conservation

- For establishment of field gene banks, the germplasm of the following species was collected from different geographical region:
- Seeds of *Tecomella undulata* was collected from Jodhpur, Jalore, Jaisalmer, Barmer and Pali. Total 2000 seeds were sown in root trainers for each location
- *Commiphora wightii*w as collected from Jodhpur (800 seeds), Jaisalmer (350 seeds), Barmer (400 seeds) and Nagaur (800 seeds) and were sown in root trainers. Germination was recorded
- *Caparris decidua* was collected from Barmer (1200 seeds), Nagaur (1500 seeds) and Gujarat (1650 seeds) and were sown in root trainers. Germination was recorded
- *Salvadora persica decidua was* collected from Jalore (3000 seeds) and Pali (2500 seeds) and were sown in root trainers. Germination was recorded.
- Seeds of *Boswellia serrata* was collected from Pali, Kota and Pratapgarh Total 550 seeds were sown in root trainers for each location
- *Butea monosperma*was collected from Sirohi (400 seeds), Pali (300 seeds) and Pratapgarh (400 seeds) and were sown in root trainers.

IFP Ranchi

FGR Documentation

Document FGR diversity & their population status

- GPS Field survey work was done. Laid out quadrates of 10×10m (trees), 3×3m (Shurbs), 1×1m (Herbs) (Mishra,1968) in different territorial division Jhakhand, Bihar and West Bengal.
- Field surveyed was conducted in different areas of Jharkhand: Dumka, pakur, Shahibganj, palamu, daltanganj, garhwa, betla national park with GPS referencing of trees (40-50 species), Shrubs (10-20 species), Climber (10-15 species).
- Other Morphological data of the species have also been recorded along with GPS data with a stipulated format.
- Out of 100 enlisted species for FGR documentation; 93 species have been identified from all over the surveys and GPS co-ordinates of these species have been recorded.

Preparation of eco-distribution Maps

- Pre-field visit point generation using random sampling in ArcGIS and verified point from Forest Type Map of FSI and Google earth.
- Satellite image processing is going on for Bihar and West Bengal state.
- Other topographical data such as DEM data and soil data are processed through ArcGIS.
- The creation of the occurrences database of species along with other phonological data has been going on simultaneously with the field visit.
- Occurrence database generation with comma separate value (.csv) through Excel for EDM.
- Eco-distribution mapping of *Madhuca longifolia* has been done for the Jharkhand state.

Collection of seeds of FGRs for long-term storage: Seeds of 20 species were collected from different states

FGR Seed and Germplasm

FGR Seed collection and processing,

- Collected seeds of different species were taken to IFP, Ranchi.
- The seeds were sorted and graded properly.
- True seeds were extracted from different collected species
- Seeds were preserved in the walk-in seed's storage at IFP, Ranchi

Periodic seed viability and vigour trials on stored seed

- Fresh and dry weight of collected seeds were taken to estimate the moisture percentage
- Seeds stored in walk-in seed storage is checked for its viability on regular basis
- Sample amount of seeds of different species were taken and germinated in Petri dish under controlled conditions
- The germination tests were conducted to estimate the viability and vigour of collected seeds which are kept in the walk-in seed storage.

Development protocols for in vitro storage of FGR

- Experiment started for three species viz. *i) Tinospora cordifolia ii) Litseaglutinosa iii) Vitex peduncularis*; so far we could establish aseptic culture of one species.
- Shoot multiplication is being carried out for the established culture of *E. ribes, E. tsjerium-cottam*
- Ethylene inhibitor (AgNO3) has been used for slow growth culture in *E. ribes, E. tsjerium-cottam*.
- The cultures have been stored in different temperature and light condition.
- After 6th months of slow growth culture, the plantlets have transferred into shoot proliferation media for regeneration and multiplication.

FGR Characterization

Molecular characterization of FGRs

- Surveying and sampling of populations: Collected samples of 20 populations of *Buchanania cochinchinensis* and *Shorea robusta* from Jharkhand and Bihar
- Standardized genomic DNA isolation protocol for *Buchanania cochinchinensis* and *Shorea robusta*
- Genomic DNA isolated from 16 population of *Shorea robusta* and 14 population of *Buchanania cochinchinensis.*
- Molecular markers procured for *Shorea robusta*
- PCR condition for SSR marker has been optimized.
- Amplification template DNA through PCR reaction using SSR primers is going on.

FGR Conservation

Establishment of Field Gene Banks

- Seeds of 4 species viz. *Buchanania cochinchinensis*, *Sterculia urens, Litsea glutinosa* and Pterocarpus *marsupium,* have been sown in nursery for raising seedlings.
- Air layering carried out in *Adina cordifolia* and *Buchanania cochinchinensis* with different media (Soil, FYM and moss) and IBA Concentration.

- For development of propagation protocols, branch cuttings of *Boswellia serrata*, *Adina cordifolia* and *Litsea glutinosa* have been treated with different concentration of rooting hormone and established in nursery.

HFRI Shimla

FGR Documentation

Document FGR diversity & their population status

- Field surveys were conducted in different forest sites of Himachal Pradesh (Chail Wildlife Sanctuary, Nalagarh Forest Division, Rohru Forest Division, and Rajgarh Forest Division) & Kargil Forest Division, Ladakh UT for ground verification of 109 FGR species (64 tree species, 26 shrub species, 6 climber species, 13 RET species).
- Recorded regeneration status of 16 FGR species (*Acacia catechu, Anogeissus latifolia, Butea monosperma, Cornus capitata, Dalbergia sissoo, Lannea coromandelica, Mallotus philippensis, Myrica esculenta, Pinus roxburghii, Rhododendron arboreum* and*Quercus oblongata,* etc*.)* with the quadrate method in Forest divisions across H.P.

Eco-distribution mapping

- The upgrading of Eco-distribution maps of 12 FGR species i.e., (*Cedrus deodara, Taxus wallichiana, Rhododendron arboreum, Betula utilis, Quercus semecarpifolia, Myrica esculenta, Berberis aristata, Zanthoxylum armatum, Abies pindrow*, *A. spectabilis*, *Neolitsea pallens,* and *Juglans regia*) were prepared on ARC GIS software in .shp format.
- The Supervised Classification method (Landsat-8 OLI) with a Support Vector Machine (SVM) algorithm was used to generate the Land Use Land Cover (LULC) map. Ten LULC categories were identified and utilized. At present, the final LULC categories map is in progress, because that will be required more Ground Control Point (GCP) from the various sites.

FGR seed collection & processing

- The seeds of *Rubus ellipticus* were collected from three populations i.e. Darlaghat, Joharji and Bharan.
- The seeds of *Berberis aristata* were collected from two population i.e., Larot and Baghi.

FGR Seed and Germplasm storage

- Seeds of *Rubus ellipticus* collected from three different sites, processed and dried in the laboratory.
- Passport data of 4 species viz., *Albizia chinensis, Oroxylum indicum, Acacia catechu* and *Rubus ellipticus* prepared.
- Seeds of *Alnus nitida, Sapindus mukorossi, Albizia chinensis, Oroxylum indicum, Acacia catechu* and *Rubus ellipticus* kept for storage trials in the laboratory and previous trials were maintained.
- Moisture content of *Sapindus mukorossi, Albizia chinensis, Oroxylum indicum, Acacia catechu* and *Rubus ellipticus* estimated in the laboratory.
- Initial viability of *Sapindus mukorossi, Albizia chinensis, Oroxylum indicum, Alnus nitida, Acacia catechu* and *Rubus ellipticus* seeds tested in laboratory.

- Periodic viability testing of stored seeds of *Hippophae rhamnoides, Rosa webbiana, Rubus ellipticus, Betula utilis, Picea smithiana*, *Pinus wallichiana, Cedrus deodara*, *Fraxinus floribunda, Betula alnoides, Berberis lycium, Acacia catechu***,** *Fraxinus xanthoxyloides, Juniperus polycarpos, Zanthoxylum armatum* and *Morus alba* carried out in the laboratory.
- Seeds of 42 accessions of 13 species viz., *Cedrus deodara, Fraxinus xanthoxyloides, Fraxinus floribunda, Rhododendron campanulatum, Betula utilis, Hippophae rhamnoides, Rosa webbiana, Zanthoxylum armatum, Juniperus polycarpos, Pinus wallichiana, Picea smithiana, Alnus nitida* and *Oroxylum indicum* vacuum sealed and kept in seed storage chamber.

FGR Characterization

Molecular characterization of FGRs

- Amplified DNA sequences of 4 *Rhododendron arboreum* populations (120 DNA samples) using selected 10 SSR primers.
- Standardized and started finger printing using Polyacrylamide Gel Electrophoresis (PAGE) technique and run amplified products of 1st *Rhododendron arboreum* population.
- PCR protocols for 10 SSR primers of *Quercus semecarpifolia* were standardized using BSA in the PCR reaction mixture to enhance the amplification efficiency.
- Completed the amplification and testing of DNA samples of one *Quercus semecarpifolia* populationusing 7 SSR primers.

FGR Conservation

- Cuttings of *C. jacquemontii* were collected from shilly forest area. Prepared the nursery beds for planting the cuttings. Cuttings were pre-treated with different rooting hormones IBA and IAA at different concentrations.
- Seeds of *F. xanthoxyloides* collected from different locations and treated with GA_3 of concentration 1500 ppm for 24 hours and were sown in polybags in FRS Shillaru.
- Selected new site for *C. jacquemontii* in Chitkul, Rakccham, Sangla, Shigrala and Kafnoo in Kinnaur.
- Marked new site for *A. pictum* in Holi forest, Chamba and Gulaba forest Manali and GPS coordinates were recorded.
- Germplasm of *Q. semecarpifolia* were collected from Chanshal, Hatu Forest, Shimla and were planted in FRS Shillaru.
- Collected germplasm of *Q. semecarpifolia* from Gulaba forest Manali and were planted in Jagatsukh nursery.

Fig 33 Seed collection: (A) *Cassia fistula*, (B) *Pterospermum acerifolium*

Part-2 -FGR

(IFGTB, TFRI, IWST, IFB)

Component A-Documentation of FGR

IFGTB

- Collected species distribution data from secondary literature and herbariums for 36 FGR species.
- Distribution map preparation was completed for 36 FGR species.
- Based on field survey the ground data collected were also mapped for 25 FGR species.
- Data compilation of collected germplasm for 69 FGR species was carried out.

TFRI

- Distribution maps are under progress based on the ground survey.
- Based on forest divisions survey in 3 states the ground data was collected and mapped for 30 FGR species.
- Compiled data on germplasm for targeted
  20 species were carried out and the Excel database was updated.

IWST

- Distribution maps were created for the study species based on the ground data.
- Documentation of existing improved germplasm was completed.
- Cataloguing of individual tree data was performed for trees selected.

IFB

- Preliminary distribution maps were updated with GPS locations for 19 species based on field survey data.
- Information on improved germplasm with Odisha Forest Department was obtained from State Silviculturist, Rayagada, and recorded.
- Species density was recorded for 18 prioritized species and the Excel database was updated.

Component B- FGR Collection

IFGTB

- Field surveys were conducted to carry out population density studies and seed sources selection at,
  Tamil Nadu: Madurai, Kanyakumari, Kolli hills, Tiruvannamalai, Siruvani, Thanjavur, Ramanathapuram, Pudukottai, Thuthukudi, Mundanthurai Tiger Reserve, Sivaganagi, Megamalai, Sathyamangalam, Anamalai Tiger Reserve, Sirumalai, Kolli Hills, Nilgiris forest areas
  Kerala: Wayanad forest area and Periyar Tiger Reserve
- Selected seed sources for 32 FGR species in the various forest areas surveyed. Recorded field details and individual tree passport data for 32 study species. Photographs of individual parts of the seed source were taken and recorded.
- Collected fruits of 11 species such as, *Terminalia eliptica, Swietenia mahagoni, Albizia amara, Sapindus emarginatus, Aegle marmelos, Limonia acidissima, Macranga peltata,*

Albizia lebbeck, Cassia fistula, Artocarpus heterophyllus, Artocarpus hirsutus from identified seed sources

- Carried out regeneration studies for *in-situ* species: *Vitex altissima* at Sathyamangalam

TFRI

- Field surveys were conducted and seed sources were selected at- Madhya Pradesh: Narsinghpur, Hoshangabad, Bhind, Morena, Gwalior, Shivpuri, Datia, Guna, Harda, Chhindwara, Seoni, Manpur, Mandla, Betul, Balaghat, Khandwa and Baihar. Chhattisgarh: Bilaspur, Pratappur, Jashpur, Marwahi, Katghora, Korba, and Balodabazar. Maharashtra: Allapalli.
- Selected seed sources for 8 FGR species were identified at different forest areas viz., *Pterocarpus marsupium*, *Bridelia retusa, Haldina cordifolia, Mitragyna parvifolia, Buchnania cochinchinesis, Careya arborea, Litsea glutinosa, Ailanthus excelsa* and *Saraca asoca*. Field data and passport data of all the selected seed sources were recorded along with biotagging in the form of GPS location.
- Collected fruits of 6 species namely*, Pterocarpus marsupium*, *Bridelia retusa, Haldina cordifolia, Mitragyna parvifolia, Buchnania cochinchinesis* and *Ailanthus excelsa* from 24 populations of identified seed sources.
- Tours were conducted and identified populations of *Hardwickia binata, Dillenia pentagyna, Cordia macleodii*, *Oroxylum indicum, Sterculia urens, Semecarpus anacardium, Boswellia serrata* and *Commiphora wightii* at 7 forest areas. Identified populations were surveyed and marked with random sample plots by laying different sized quadrates viz. 10m x10m, 5m x5m and 1m x 1m beneath trees.

IWST

- Georeferenced 16 Speices viz. *Canarium strictum, Dillenia indica, Garcinia gummigutta, G. indica, Gmelina arborea, Holoptelia integrifolia, Knemaattenuata, Lagerstomiamicrocarpa, Mammeasuriga, Pongamia pinnata, Santalum album, Shorearoxburghii, Strychnosnux-vomica, Terminalia arujuna, T. Bellirica* and *T. paniculata* identified from the survey in the natural population of evergreen and semi-evergreen forests under Sirsi, Yellapura and Karwar Forest Divisions was continued.
- Completed data collection for economic importance of the 30 prioritised species.
- Survey was made in evergreen and semi evergreen forest types of Karnataka. The population density study of 16 species was carried out from Sirsi, Yellapur and Karwar forest divisions.
- Preparation of Species-Specific Conservation Strategy forms was initiated.

IFB

- Natural populations of eleven prioritized species identified in Rayagada division of Odisha.
- The document on economic importance was updated.
- Species density information was recorded from quadrat surveys in Telangana and Odisha to identify populations with above average density.
- Individual tree passport data was collected for 1034 trees in 18 species.
- Seed germplasm was collected in four species, viz., *Pterocapus marsupium, Soymida febrifuga, Bombax ceiba, Dalbergia latifolia*

Component C- Seed Germplasm Storage

IFGTB

- Seed germination and pretreatment studies were carried out for 13 species: Studies are in progress-*Aegle marmelos, Bauhinia racemosa, Albizzia lebbeck, Albizia odorotissima, Wrightia tinctoria, Acacia ferruginea, Macranga peltata, Sapindus emarginatus, Sapindus laurifolius, Strychnos nux vomica, Swietenia mahagoni, Limonia acidissima, Terminalia paniculata*
- Seed storage studies after 3 months storage at -20ºC was completed for 5 species namely, *Zizyphus mauritiana, Chukrasia tabularis, Wrightia tinctoria, Aegle marmelos, Bauhinia racemosa*

TFRI

- Seed germination and pretreatment studies was completed on 30 species: *Acacia catechu, Boswellia serrata, Dalbergia latifolia, Flacourtia indica, Gmelina arborea, Haldina cordifolia, Lannea coromandelica, Litsea glutinosa, Mitragyna parvifolia, Schleichera oleosa, Semecarpus anacardium, Sapindus mukrossi, Sterculia urens*, *Terminalia chebula*, *Bridelia retusa, Desmodium oojeinense, Hardwickia binata, Holoptelia integrifolia, Phyllanthus emblica*, *Pterocarpus marsupium, Oroxylum indicum, Chloroxylon swietenia, Cordia myxa, Stereospermum cheonoides, Wrightia arborea, Buchanania lanzan, Gardenia latifolia, Sapindus mukorossi, Carossa carandus, Dilenia pentagyna.*
- Studies on seed storage behavior was completed on 28 species: *Acacia catechu, Boswellia serrata, Dalbergia latifolia, Flacourtia indica, Gmelina arborea, Haldina cordifolia, Lannea coromandelica, Litsea glutinosa, Mitragyna parvifolia, Schleichera oleosa, Semecarpus anacardium, Sapindus mukrossi, Sterculia urens*, *Terminalia chebula*, *Bridelia retusa, Desmodium oojeinense, Hardwickia binata, Holoptelia integrifolia, Phyllanthus emblica*, *Pterocarpus marsupium, Oroxylum indicum, Chloroxylon swietenia, Cordia myxa, Stereospermum cheonoides, Wrightia arborea, Buchanania lanzan, Gardenia latifolia, Sapindus mukorossi.*
- Seeds of *Buchanania lanzan and Haldina cordifolia* from different sources were stored at -20ºC.

IWST

- Completed seed germination studies in *Albizia amara, Anogeissus latifolia, Lagerstroemia microcarpa, Terminalia bellirica, Terminalia chebula, Terminalia paniculata* and *Wrightia tinctoria.* The germination of seeds was very poor in *Terminalia chebula, Terminalia paniculata, T. bellirica, Anogeissus latifolia* and *Lagerstroemia macrocarpa.* The seeds were not kept for storage. Seeds of *Albizia amara, Terminalia bellirica* and *Wrightia tinctoria* showed good germination and kept for storage in lower temperature. Germination study is continued at intervals.
- Collected seeds of 9 species namely, *Albizia amara, Anogeissus latifolia, Garcinia gummigutta, Knema attanuata, Lagerstroemia microcarpa, Terminalia bellirica, Terminalia chebula, Terminalia paniculata* and *Wrightia tinctoria*
- Seeds of 4 species *Knema attenuata, Garcinia gummigutta, Strychnos nux-vomica* and *Terminalia arjuna* are being tested for seed handling and germination studies.
- *Albizia amara, Garcinia gummigutta and Wrightia tinctoria* and *Terminalia arjuna* was subjected for seed storage studies.

IFB

- Moisture content of seed germplasm in four species that are collected during the current six months was estimated to plan for its reduction to suitable moisture content for storage at (-)20 C degrees.
- Seed of five species were studied for germination.

Component D- FGR Characterization

IFGTB

- Morphological parameters of fruits and seeds were measured using Image analysis for 20 species namely, *Acacia ferrugenia, Aegle marmelos, Albizia lebbeck, Artocarpus heterophyllus, Bischofia javanica, Cassia fistula, Chukrasia tabularis, Limonia acidissima, Macaranga peltata, Phyllanthus emblica, Pterocarpus marsupium, Sapindus emarginatus, Sapindus laurifolius, Strychnos nux-vomica, Sweitenia mahagoni, Terminalia arjuna*, *T. chebula, T. bellerica, T. elliptica & Zizyphus mauritiana*
- The DNA extraction protocol was standardized for the leaves sample *of Mesua ferrea*.
- Standardization of DNA extraction from softwood of 5 selected *in-situ* species (*Kingiodendron pinnatum, Mesua ferrea, Dysoxylum malabaricum, Myristica malabarica & Cullenia exarillata*) is under progress to obtain fine quality of DNA.
- Secondary metabolite screening of *Myristica malabarica* seed kernel has been initiated.

TFRI

- Data was recorded on morphological parameters of fruits and seeds viz., weight, length and width of fruits and seeds were noted down. Number of seeds in fruits was also counted of 6 species from 24 different populations: 19 trees of *Pterocarpus marsupium*, 10 trees of *Bridelia retusa,* 59 trees of *Haldina cordifolia,* 23 trees of *Mitragyna parvifolia,* 91 trees of *Buchnania cochinchinesis* and 10 trees of *Ailanthus excelsa.*
- Genomic DNA were extracted and purified from 20 samples of *Hardwickia binata,* 20 samples of *Dillenia pentagyna*, 39 samples of *Cordia macleodii* and 33 samples of *Oroxylum indicum*. Quantification of DNA is being carried out.
- SSR primers for *Oroxylum indicum* has been developed through transcriptome sequencing.

IWST

- Capturing images of leaf/ bark/ fruit/seed samples for morphological characterisation was initiated.
- Standardisation of DNA extraction procedure from leaf samples was continued.

IFB

- Seed images were captured for four species for characterization using image analysis

Component E- FGR Conservation (Field Gene bank)

IFGTB

- Communicated with MYRADA research station (Thalavadi) and submitted estimate for fencing and water facility for FGR field Gene Bank.
- Communicated with TNFD for demarcation and clearing 40 ha at Thiruvannamalai. Submitted estimate for fencing for Tiruvannamalai field gene bank.

- Raised nursery and hardened seedlings of species such as *Aegle marmelos- 3* sources*, Macranga peltata- 1* source*, Strychnos nux vomica- 9* sources*, Oroxylum inidicum- 2* sources*, Artocarpus heterophyllus- 2* sources*, Swietenia mahagoni- 2* sources

TFRI

- In the nursery, seedlings were raised of 5 species viz., *Pterocarpus marsupium*, *Bridelia retusa, Haldina cordifolia, Mitragyna parvifolia, Buchnania cochinchinesis* and *Ailanthus excelsa* for establishment of field gene bank.
- Communicated the Work Plan of Field Gene Bank to Amravati Forest department, Maharashtra.

IWST

- Upgradation of nursery in IWST was continued.
- The germplasm bank of *Santalum album* at Gottipura is maintained.

IFB

- Provision of electric connection to Mulugu field station is under process. Other activities not due.

Component F- Establishment of Centre of Excellence

IFGTB

- Indented, followed up and procured various equipments sanctioned under the program.
- Communicated with networking institutes about the progress and sorted out issues.
- Conducted a quarterly review meeting of the programme with networking partner institutes on 22.07.2022
- Coordinated with FRI and participated in an online training on Eco-distribution Mapping of National Forest Genetic Resources conducted for the 4 networking institutes during 27th-29th July 2022

Component G- Creation of National Forestry Seed Centre

IFGTB

- Procured office equipments
- Initiated setting up of carpellarium.

Fig. 34 Seed germination of a) *Haldina cordifolia*, b) *Buchnania cochinchinensis* and c) *Ailanthus excelsa*

Component-III:

Policy studies under Centre for Forest Policy Research

Total 4 Policy Research Studies are under progress. The details of the same are as given below:

PR Study: Study of Grazing Policies in different States and Formulation of Grazing Policy Guidelines for States.

Policy research study was allotted to **Society for Resource Planning, Development and Research,34, Aranya Vihar, Chuna Bhatti, Kolar Road, Bhopal** on 24th May, 2022 with total budget of Rs. 8,03,000/- for the period of 10 months by the Director General, ICFRE on the recommendation of Expert Committee of Centre for Forest Policy Research (CFPR) of ICFRE with the following ToRs**.**

- 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.

A MoA was signed between **ICFRE** and **Society for Resource Planning, Development and Research, Bhopal.**The inception report of Policy Research Study was submitted by the PI which was sent to the members of Working Group constituted by the Director General ICFRE for vetting/ finalization of Policy Research Study.After incorporation of comments of the members of Working Group in the inception report, Ist Installment of Rs.2,40,900/- i.e. 30% of total budget was released to **Society for Resource Planning, Development and Research, Bhopal**

PR Study: Issues in Forest Certification and Certifying Agencies.

Policy research study was allotted to **GICIA India Pvt. Ltd., 2nd Rear Office, 3rd Floor, Images Towers, B-27, Sector 132, Noida, Uttar Pradesh** on 13th June, 2022 with total budget of Rs. **Rs. 7,98,875/-**for the period of 6 months by the Director General, ICFRE on the recommendation of Expert Committee of Centre for Forest Policy Research (CFPR) of ICFRE with the following ToRs**.**

- 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.

A MoA was signed between **ICFRE** and **GICIA India Pvt. Ltd, Noida, UP.**

The inception report of Policy Research Study was submitted by the PI which was sent to the members of Working Group constituted by the Director General ICFRE for vetting/ finalization of Policy Research Study.

After incorporation of comments of the members of Working Group in the inception report, Ist Installment of Rs.2,82,802/- i.e. 30% of total budget has been released to **GICIA India Pvt. Ltd. Noida, UP.**

PR Study: Functioning of Forest Development Corporations and their role in the present scenario.

Policy research study was allotted to **IUCN (International Union for conservation of Nature) H-4, 3rd Floor, Green Park Extension New Delhi and IORA Ecological Trust, 635-636, GF, Lane No.3 West Marg, Garden of Five Senses Road, Saidulajab Village, Saket, New Delhi** 16th February,2022 with total budget of Rs. **Rs. 11,90,000/=** for the period of 10 months by the Director General, ICFRE on the recommendation of Expert Committee of Centre for Forest Policy Research (CFPR) of ICFRE with the following ToRs

- 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.

PI of the study has submitted the progress as follows:
Output-1: Identification of States with FDC/FC

Output – 2: Literature Review on Existing roles, Historical roles, Evolution of FDC/FC with Policy Change, Current Issues

Output – 3: Data gathering and Analysis on Financial data for studying economic viability, Recent Initiatives and Pilots Study, Diversification Potential and Options, Annual Plan of operation etc: By end of one Sixth Month i.e., August 2022: Ongoing

The second installment of Rs. 5,61,680/- i.e. 40% of total budget has been released after submission of progress report, utilization certificate and mid-term review.

PR Study: Popularization of the use of Wood and Wood Substitutes as per the National Forest Policy and Modalities for Facilitating Industries for its Optimum Utilization.

Policy research study was allotted to **Network for Certification and Conservation of Forests (NCCF), EPCH House, Pocket 6, Sector C, Vasant Kunj, New Delhi** on 24th January, 2022 with total budget of **Rs.9,95,160/- (Excluding GST)** for the period of 6 months by the Director General, ICFRE on the recommendation of Expert Committee of Centre for Forest Policy Research (CFPR) of ICFRE with the following ToRs

- 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.

PI of the project submitted the progress as follows:
Questionnaire based survey of stakeholders were carried out. The specific progress of questionnaire-based survey of following stakeholders was submitted.

- Wood-based industries:
- Government departments:
- Research institutions and universities:
- Farmer Federation/FPOs
- Architects and builders:
- NGOs/CBOs

A Focused Group Discussions was organized for seeking views of practicing experts representing various stakeholder categories through open discussion based on some lead questions and mostly open-ended questions.

Key outcomes of the Focused Group Discussions were as follows

- Need for cradle-to-grave LCA of wood products versus alternates (metals/plastics etc).
- Performance standard of various furniture components and other such products to ensure optimum utilisation wood in different sub-sectors.
- Financial services such as capital funding and insurance mechanism for tree crops
- Ease of felling and transit regulations for timber originating in agricultural/cultivable lands.
- Certification of plantations to enhance the availability of certified timber in India
- Facilitating/encouraging import timber substitution by Indian tree species
- Encouragement of ease of doing business by removing restrictions of Govt. Depts.
- Encouraging seasoning and treatment of timber
- Provisions for grading of timber
- Development of performance standards for high density wood panels and other such new products to encourage their use.

- Ad campaign for public awareness regarding benefits for usage of wood and wood products.
- Industry and farmer collaborations through contract farming, buy-back agreement etc.
- Emphasis on reduction of the price of wood product keeping in consideration of dollar exchange rate.
- Comprehensive periodic assessments of timber consumption, wood products production and consumption

Time line of the study has been extended up to November, 2022.

The second installment of Rs. 4,69,716/- i.e. 40% of total budget has been released after submission of progress report, utilization certificate and mid-term review.

Component IV:

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

A. Resource manual for capacity building of State Forest Departments: A resource manual for capacity building of State Forest Departments for developing State REDD+ Action Plan (SRAP) in Hindi has been published and copies of the Resource Manual in Hindi will be distributed to all the State Forest Departments of Hindi speaking states. The manual has been written in a simple and easy to understand manner so that State Forest Departments can easily follow the methodology and process for developing their SRAP.

B. Methodology and Process followed in Organisation of the Capacity Building Programmes: The methodology and process followed for organizing the training workshops were based on the Resource Manual: Capacity Building of State Forest Departments for Developing State REDD+ Action Plan (2020) developed by ICFRE under the project component. Following the introductory and contextual background on REDD+ mechanism and overview of preparation process of State REDD+ Action Plan, the workshop participants were divided into three working groups (1. Deforestation, 2. Forest Degradation and 3. Forest carbon Enhancement) in order to analyze and prioritize the most important drivers of deforestation and forest degradation, as well as the main barriers forest carbon enhancement activities in the state. The process involved firstly prioritization (e.g., of deforestation drivers) within each Working Group, secondly a plenary presentation of the higher priorities by each Working Group, and thirdly an overall scoring by all workshop participants of all the prioritized by the three Working Groups.

C. Organization of the Capacity Building Programmes of the State Forest Departments for developing State REDD+ Action Plan: Organized the 02 capacity building programmes for State Forest Departments of Goa and Telangana for developing State REDD+ Action Plans as per following details:

S. No.	Dates and Venue	SFD participated	No. of the Participants	ICFRE Institutes Involved in Organisation of the capacity building programme	Remarks
1.	23-24 August 2022 at Goa	Goa	24	IWST, Bengaluru	
2.	05-06 September 2022 at Hyderabad	Telangana	13	IFB, Hyderabad	Researchers of IFB, Hyderabad also participated

Component V:

Operationalization of Human Resource Development Plan of ICFRE

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. During the period following trainings have been organized by different ICFRE and non-ICFRE institutes: A total of 160 participants participated in the trainings. The trainings conducted are listed below:

As per the approved HRD plan of council total 54 scheduled trainings have been conducted for 1316 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	10	1	180
2023-24	21	-	-	-
Total	113	47	7	1316

S. N	**Trainings Name**	**Institute's**	**Number of Participants**	**Beneficiaries**
01	New Analytical Methods in Soil Research (12-16 Sept, 2022)	CAFRI, Jhansi	05	**Scientist**
02	STQC Certified Information Security Professional- ISO 27001 implementation & Information security management system lead auditor as per ISO 27001 (NABED Accredited) (19-23 Sept, 2022)	IIQM, Jaipur	06	
03	Invasive Weed Management (26-30 Sept, 2022)	DWR, Jabalpur	15	
Total			**26**	

S. N	**Trainings Name**	**Institute's**	**Number of Participants**	**Beneficiaries**
01	Advance Techniques in Soil, Plant and Water Analysis (19-23	IISS, Bhopal	25	**Technical Staff**

	Sept, 2022)			
02	Computer and Internet Application (19-23 Sept, 2022)	IFP, Ranchi	15	
03	General Forestry (26-30 Sept, 2022)	FRI, Dehradun	25	
Total			**65**	

S. N	**Trainings Name**	**Institute's**	**Number of Participants**	**Beneficiaries**
01	Ethics & value in public governance/good governance/Right to information/ gender sensitization/ Sexual Harassment for Administrative staff (29-31 Aug, 2022)	IFP, Ranchi	26	**Administrative Staff**
02	Administrative Vigilance Disciplinary Proceedings (12-14 Sept, 2022)	IIPA, New Delhi	25	
Total			**51**	

S. N	**Trainings Name**	**Institute's**	**Number of Participants**	**Beneficiaries**
01	Induction Training for newly Recruited LDCs, Steno Gr-II, LIA (01-03 June, 2022)	FRI, Dehradun	**18**	**Induction Training for Administrative Staff**

Fig. 35 Glimpse of trainings

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

- **Establishment of Technology Demonstration Centre**

  Established Technology Demonstration Centres at IFP, FRI HFRI, RFRI and Marine Interpretation Unit at FRC-CE and Photogallery at FRI

  In process: Technology Demonstration Centre being established at IWST, TFRI and IFGTB.

- **Establishment of New VVKs**

  Established VVKs at Gottipura (Karnataka); Umium, Barapani (Meghalaya); Gorakhpur (Uttar Pradesh); Longani, Mandi (Himachal Pradesh); Gobichettipalayam (Tamil Nadu); Salem (Tamil Nadu); Sukna (West Bengal); Jagadapur (Chhattisgarh); Udaipur (Rajasthan) and Mulugu (Telangana)

  In process: VVKs being established at Banka (Bihar) and FRC-SD, Chhindwara (Madhya Pradesh)

- **Nurseries Established at** Shivdhwala (Himachal Pradesh); Metaguda, Jagdalpur (Chhattisgarh); Meghalaya; Kalka Mata Nursery, Udaipur (Rajasthan)**;** Mulugu (Telangana) and Gorakhpur (Uttar Pradesh)

- **Establishment of New DVs**

  Established DVs at Baragaon, Shimla (Himachal Pradesh); Mohangarh, Jaisalmer (Rajasthan); Topra, Khunti (Jharkhand) and Attivata, Bangalore Rural (Karnataka)

  In process: DVs being established at Surandi, Coimbatore (Tamil Nadu) and Site being selected by TFRI, FRI, FRC-ER and RFRI.

- **Demo Trails:** Established demonstration plot of Guggal in 1 ha at Mohangarh, Jaisalmer (Rajasthan); *Melia dubia* in 2 ha at Khunti and Ranchi (Jharkhand) Mahogany in 1 ha at Ramgarh (Jharkhand) *Neolamarckia Cadamba* at Arepalayam, ICAR-KVK (MYRADA), Tamil Nadu; windbreak clonal plants in Narasipuram village in Coimbatore District of Tamil Nadu; Sandalwood based agroforestry model at Attivatta (Karnataka) and *Calophyllum inophyllum, Gmelina arborea,* Tamarind, Teak (T.C), Cadamba, Pricision Silvicultural Technique with Teak and Casuarina, Tree fodder species, Medicinal Plants, etc. under 5.20 ha (each 0.5 ha) at ICAR KVK MYRADA, Talamalai.

- **Trainings:** 54 Trainings/Workshops organized for 2100 stakeholders including farmers, SFDs, SHGs etc. under VVKs, DVs and MDTC etc.

- **Documentaries**

  Prepared 36 documentaries/short films viz. Walking Tall with Trees (English, Hindi and Tamil), Rendezvous with Natural History, Cold Desert of North West Himalayas, Cultivation of Medicinal Plants and Hill Bamboo, Agroforestry, Research, Extension and Education Activities of FRC-ER, Prayagraj, Identification of Bamboos, Tissue Culture, Lac Cultivation and Uses, A Tour of IFP, Techniques of Bamboo Propagation, Bamboosetum in IFP, Documentary on AFRI, Jodhpur, Biodiversity of New Forest Campus, Eco Rehabilitation of Coalmine Areas Overburden Dumps, Fungal Biodiversity, Insect Biodiversity, Forest Genetic Resource Conservation, Floral Diversity

of Bihar, Documentary on IWST, Sandalwood Cultivation, Sandalwood ERT, Sandalwood Oil, Micropropagation of Bamboo, Wood Preservative Treatment, Thermal Modification of Wood, Wood Polymer Composite, Transparent Wood Composite, Bamboo Lumber-An Alternative to Timber, Advanced Woodworking Training Centre (AWTC), Preserving Pollinators, Agro and Farm Forestry, Sandal Spike Disease and Documentary on TFRI, Jabalpur (English and Hindi).

In process: 27 documentaries.

❖ **Tree Growers Melas/Kisan Melas/Workshops**

- Tree Growers Mela at at Coimbatore, Erode, Sivagangai, Hazipur and Jorhat.
- Kisan Mela at Prayagraj, Dehradun, Jabalpur and Mandi.
- Stakeholders Workshop on "Forestry research prioritization with special emphasis on Agro forestry" at Coimbatore.
- Workshop on Bamboo Growers and Bamboo Entrepreneurs at Ranchi.

❖ **Extension Normal/Other Activities**

Publications: HFRI-07 pamphlets on medicinal plants; TFRI-10 Technical bulletins, 02 brochures and 01 leaflet; IWST- 07 technical bulletins and 03 leaflet/brochure/poplar article; FRC-ER – 01 training manual; IFGTB – 01 brochure and 01 proceeding

Participation in Exhibitions: Shining Uttar Pradesh at Varanasi by FRC-ER; Agro-vision at Nagpur by TFRI, Jabalpur; International Herbal Fair at Bhopal by TFRI, Jabalpur; Vigyan Sarvathra Pujyate– A Mega Science and Technology Expo at New Delhi by ICFRE and its Institutes; India Wood Exhibition at Bengaluru by IWST Bangalore and 5thAadiUtsav (Tribal Fair) at Jabalpur by TFRI and FRC-SD

Prakriti: Over 12000 Students were sensitized through 152 awareness programmes, Trainings, Competitions etc. under Prakriti

Celebration of Days: Constitution Day, Earth Day, Good Governance Day, International Day of Forests, International Museum Day, Parthenium Awareness Day, Van Mahotsav, World Biodiversity Day and other days of environmental importance.

❖ **Modified Direct to Consumer Scheme**

- Manufacture of ArborEasy DNA isolation kit: A total of 430 reactions were sold.
- Improvement of VAM Production unit extended for producing 2000 kg of VAM/year.
- QPM of various forestry species have been raised by HFRI – 14260, IFGTB – 3000, AFRI – 485000, IFP – 1925, RFRI – 25000 and FRI - 50000 for distribution to various stakeholders.
- Mass production of mycorrhizal (VAM=AM Fungi) inoculums (consortium) has been initiated in the laboratory, for field application by FRI, Dehradun.

Fig. 36 Four days training programme on bamboo handicraft by TFRI, Jabalpur

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

Research papers presented in conferences, seminars, symposia etc.

- 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 indica*). In: Virtual Workshop on Clonal Propagation of Tree Species. Organized by: Institute of Wood Science and Technology, Bengaluru, 7th October 2020, pp. 18.
- Phytochemical screening of red tamarind clones in Tamil Nadu. 2021. Mayavel, A., Chitra, P., Senthil Kumar, N., Nagarajan, B. presented at IHC- NEXT Generation Horticulture 2021 Tamil Nadu Agricultural University
- 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
- Paper presented on "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).
- A paper titled "Chemi-mechanical processing of cellulose nanofibers from bamboo and development of natural fiber-based nanocomposites" was presented in an International e-Conference on "Nanomaterials & Nanoengineering" held during February 24-26, 2022 at National Physical Laboratory, New Delhi (India)
- Dr Rekha R Warrier 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" held on 21st and 22nd March 2022 (online mode) at IWST, Bengaluru.
- K Chandraprakash, Pankaj Singh, MSagar and G Sandeep. 2021. A Study of Important Medicinal Plants of Kowdipally Forest Area Medak Telangana in Abstarct book of NATIONAL CONFERENCE- "VALUE ADDITION AND MARKETING OF NTFPs", TFRI, Jabalpur Pp. 87.
- One paper has been 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 -a potential Non-Timber Forest Product of North East India prepared and sent during Jan, 2022
- Sreenivasan, K. Krishnan, S. Soosai Raj, J. and Mayavel, A. Quality Planting Stock Production of *Gmelina arborea* Roxb. Virtual Workshop on "Clonal Propagation of Tree Species" 7th October 2020, organized by Institute of Wood Science and Technology (IWST), Bangalore. Pp.3.
- 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

- Menon, D., Behera, D., Ayyappan, N. & Aravajy, S. (2021). Understanding tropical phenology of the Western Ghats: Combining citizen science and expert based approach. *In*: 11th International Conference on Ecological Informatics (ICEI 2020+1) Online, Thiruvananthapuram, India, 9-13 November 2021.
- Behera, D., Menon, D., Wilson, V., Das, P., & Ayyappan, N. (2021). Integration of Sentinel-1 and Sentinel 2 for the estimation of biomass in a tropical wet evergreen forest. *In*: 11th International Conference on Ecological Informatics (ICEI 2020+1). pp. Online, Thiruvananthapuram, India, 9-13 November 2021.
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- Madhuvanthi K.C, Muthulakshmi E., Suma Arun Dev, Ulaganathan, K. and Ghosh Dasgupta, M. (2022). MicroRNA-mediated post-transcriptional regulation of sesquiterpene pathway genes in Santalum album. Poster presented in 20th IUFRO Tree Biotech & 2nd Forest Tree Molecular Biology and Biotechnology Conference 7-9 July, 2022, Harbin, China.
- Sandhya M. C., Manoj Kumar R., Balasubramanian, A., Shamili K., Sreeja S., Sivakumar V., Kumar K.K., and Nambiar- Veetil, M. 2022. Evaluation of MsPRP2 promoter for root preferential and salt inducible expression in *Eucalyptus camaldulensis*. 20th IUFRO Tree Biotech & 2nd Forest Tree Molecular Biology and Biotechnology Conference 7-9th July, 2022,

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- A paper titled “Chemi-mechanical processing of cellulose nanofibers from bamboo and development of natural fiber-based nanocomposites” was presented in an International e-Conference on “Nanomaterials & Nanoengineering” held during February 24-26, 2022 at National Physical Laboratory, New Delhi (India)
- Richa Bansal 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, Chitme H.R., Lal Mohan, Tripathi Y.C., and Varshney V.K. (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 was also awarded 'Young Scientist Fellowship' for registration fee to attend the symposium.
- Research paper on" 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. Authors were Dr. Vishakha Kumbhare, Smruti Shukla and Revanth V.
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- Paper entitled "Screening the Biometabolites of *Pterocarpus santalinus* L.F. - An Endemic, Threatened, Medicinal and Multipurpose Plant Taxon." is accepted for publication in the *International Journal of Pharmacy and Biological sciences* ISSN: 2230 7605.
- Desv. ex DC. – A dashmool species.*Acta Chromatographica*. Impact factor (1.64, Nass rating: 7.64)
- Microwave processing of bamboo, Wood is Good, 1(2): 73-75, 2021
- Published one article titled "UV resistant wood coating based on zinc oxide and cerium oxide dispersed linseed oil nano-emulsion", Materials Today Communications, 103177 (online).
- Submitted a manuscript entitled "Wood modification with nanoparticles fortified polymeric resins for producing nano-wood composites: A review" in a journal "Bulletin of materials science".
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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 for reduction 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.

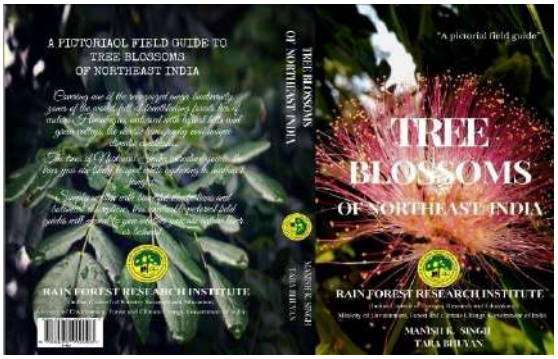

Fig. 37 Book on "Tree Blossoms of northeast India"

Fig 38 Technical bulletin on *Dendrocalamus stocksii*

- 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.
- 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)

Videography

- 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-23, Indigenous Traditional Knowledge were collected and documented from different locations in Tamil Nadu and Kerala through questionnaire, photos and videos.

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 for the synthesized coating material by IIT-Roorkee under AICRP-6.
- Invention Disclosure Forms for following two innovations were prepared and submitted to the Patent Attorney for filing of patent applications 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.
- 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


Selected CPCs of *Bambusa balcooa* in Chhattisgarh

Germination and planting stock production of Eucalyptus species

Germinating seeds of *Butea monosperma*

Inoculation of biofertilizers

Inauguration of VVK-Longani, Dharmpur, Mandi (Himachal Pradesh) in presence of Shri Arun Singh Rawat, Director General, ICFRE

Kisan Mela at FRI, Dehradun

Kisan Mela at Mandi, Himachal Pradesh by HFRI, Shimla

Inauguration of Technology Demonstration Centre at Forest Research Institute, Dehradun inaugurated by Shri C.P. Goyal, DGF&SS, MOEF&CC, New Delhi

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
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
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
GBH	Girth at Breast height
GC-MS	Gas chromatography–mass spectrometry
GCP	Ground Control Point
GDP	Gross Domestic Product
GFM	Gass Forest Museum
GPR	Ground-penetrating radar
HFRI	Himalayan Forest Research Institute
HRM	Heat Ratio Method
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
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
NBRI	National Botanical Research Institute
NCCF	Network for Certification and Conservation of Forests
NIH	National Institute of Hydrology
NPC	National Project Coordinator
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
QPM	Quality Planting Material
RFRI	Rain Forest Research Institute
SAMEER	Society for Applied Microwave Electronics, Engineering and Research
SAW	Simple Additive Weighting
SDAU	Sardar KrushinagarDantiwada, 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
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