PHYSICAL PROGRESS REPORT
OF SCHEME

"STRENGTHENING FORESTRY RESEARCH FOR ECOLOGICAL SUSTAINABILITY AND PRODUCTIVITY ENHANCEMENT"

(as on 30-9-2021)

Submitted by
Indian Council of Forestry Research and Education, Dehradun.

(Progress Report as on 30-9-2021 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 scheme

"Strengthening Forestry Research for Ecological sustainability and Productivity Enhancement"

(1st April 2021 to 30th September 2021)

Introduction of the scheme : To fulfill national commitments, ICFRE proposed a dedicated scheme entitled "Strengthening Forestry Research for Ecological sustainability and Productivity Enhancement" under the 'Compensatory Afforestation Fund Act, 2018, towards addressing the requirements of conserving the Forest Genetic Resources, enhancing forest productivity, strengthening of ecosystem services, and sustainable use of resources, strengthening the extension of Forestry research through various scientific and technological interventions and capacity building of ICFRE personnel. The intervention of ICFRE is proposed in diverse disciplines of forestry research, policy and extension. The scheme is for 5 years starting from January 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:

a) Compilation of existing knowledge/ data for all the projects completed. Recruitment of project staff, purchase of equipments and other material completed. MOUs with non-ICFRE project partners signed.

b) Methodologies developed and finalized for each project. Work plan/time line of projects finalized. Coordination meetings of the projects conducted. Two Project Expert Group (PEG) meeting involving external experts for monitoring of project conducted.

c) Identied land/sites for trials and field experiments in AICRPs where production of planations has to be increased by selection of site and end use-specific planting material. Sites were prepared by cleaning of bushes, levelling of field (Through JCB), digging of pits and application of compost in the pits. Need based irrigation, plant protection measure (Against termites) and weeding were carried out in the established trial.

d) Institute wise work elements of each projects finalized. Priority list of species including bamboo for various components were finalized. The criteria for selecting experimental sites for laying trials either based on potential of species for cultivation or on contrast environments finalized.

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 will be taken up in the project:

(i) Clonal trials with the accessions already released by ICFRE in new areas and for new end uses

(ii) Family trials with a broad genetic base which will function as a source of next generation clones and also as a seed orchard

The planting material required for establishing the trials were produced in IFGTB, Coimbatore and supplied to different Institutes. Fifteen trials have so far been planted in the States of Andhra Pradesh, Karnataka, Gujarat, Haryana, Jharkhand, Madhya Pradesh, Tamil Nadu, Telangana and Uttar Pradesh. Surivival and growth data have been recorded for the trials established during 2020. Current status of establishment of clonal trials by the participating Institutes is given below in Table 1:-

Table 1: Establishment of clonal trials by participating institutes:

Institute	No. of trials	Location of areas identified for planting	Current status	Remarks
IFGTB	2	Ariyalur Palapattu, Tamil Nadu	Planted; First year data recorded	Two additional trials planted with indigenous timber trees
FRI	2	Shajanpur, UP Fethabad, Haryana	Planted	Nil
AFRI	2	Mahuva, Gujarat Navsari AU, Gujarat	Planted	Nil
TFRI	3	TFRI Campus, MP	Planted	Nil

		CoA, Balaghat, MP KVK, Umaria, MP		
IFP	2	Arid, Jharkhand Chandwa, Jharkhand	Planted	Nil
IWST	2	Battemallapa Chamrajnagar Karnataka	One trial planted in Battemallapa with sandal trees	One trial to be planted during October / November.
IFB	2	Vokadu, Nellore, AP Dulapally, Telangana	Planted	Nil
Total	**15**	**Planted: 14**		

Fig. 1 Clonal trial of Casuarina at Arid, Jharkhand

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. So far established five progeny trials in the states of Haryana, Madhya Pradesh, Tamil Nadu, Telangana and Uttar Pradesh each with 80-100 families. Current status of establishment of progeny trials by the participating Institutes is given below in Table 2:-

Table 2: Progeny Trials by participating institutes:

Institute	No. of trials	Location of areas identified for planting	Month & year of planting	Remarks
IFGTB	1	Chettinadu, TN	September 2021	112 families
FRI	2	1. Shajanpur, UP 2. Fethabad, Haryana	July 2021 September 2021	96 families
TFRI	1	Umaria, MP	September 2021	80 families
IWST	1	Chikamagaluru, Karnataka	October 2021	To be planted
IFB	1	Mulugu, Telangana	September 2021	80 families
Total	**6**			

Request was made to organizations in different countries involved in Casuarina improvement to provide germplasm of *Casuarina equisetifolia* for inclusion in progeny trials to be established during 2022-23. Import permits were obtained from ICAR-NBPGR to procure seeds from China, Kenya, Malaysia and Solomon Island. Seeds have been received from Kenya Forestry Research Institute, Nairobi and Research Institute for Tropical Forestry, Guangzhou, China. A hybrid clonal trial was established with 32 clonal and control seedlot accessions to select new high-yielding clones. Growth data has been recorded from the hybrid progeny and clonal trials.

Fig. 2 Seedlings of Casuarina junghuhniana families in AFRI nursery to be planted in a progeny trial

AICRP -2: All India Coordinated project on Bamboos

Field survey was conducted in Munsyari and Rudraprayag region of Uttarakhand for selection of candidate clupms of hill bamboos (*Himalayacalamus falconeri* i.e Dev ringal and *Drepanostachyum falcatum* i.e. Gol ringal). The rhizomes of hill bamboos were also collected and kept. Further form region of Uttarakhand rhizomes from selected superior clumps of three species, *Bambusa tulda*, *Bambusa nutans* and *Bambusa balcooa* were collected and planted in Germplasm bank. Ten plus clumps of *Bambusa tulda,* 15 plus clumps of *Bambusa balcooa* and 2 plus clumps of *Bambusa nutans* were selected from NE region. D.*stocksii* clumps were evaluated for their growth characteristics.

Fig 3. Candidate clumps of Dev ringal

Plants of *Bambusa vulgaris* var. green (BV-SL-05, BV-RAI-02, BV-SL-02, BV-RAI-01) *Bambusa tulda* (BT-NWFP-04) and *Bambusa nutans* (BN-DEM-09) were produced after treatment with 200 ppm IBA. Vegetative propagation trial of *Dendrocalamus strictus* was conducted at different concentration of IBA, NAA and IAA at Bir pallasi nursery, Nalagarh. Vegetative propagation trial of *Dendrocalamus strictus* was conducted at different concentration of IBA, NAA and IAA at Bir pallasi nursery, Nalagarh. Initiated standardization of propagation through culm cutting in *Schizostschyum. dullooa* and *Bambusa cacharensis.* Performed shoot multiplication for established cultures of six genotypes (*B. nutans* CPC-648, *B. tulda* CPC- 494 & 489, *D. stocksii* CPC-15 & 58, *D. strictus* CPC- 3). *Dendrocalamus hamiltonii* culture has been successfully established.

For developing improved silvicultural practices for increased productivity stand management and harvesting, thinning operation in selected matured bamboo clumps of *Dendrocalamus strictus* has been started. Developed demonstration cum experimental plot in gram panchyat office campus, Messamora, Golaghat, Assam. Developed demonstration cum experimental plot in gram panchyat office campus, Messamora, Golaghat, Assam. For evaluation of Bamboo species for reclamation of coal mined/salt affected lands, 25000 seedlings of the species identified for evaluation *viz*., *Bambusa bambos, B. tulda, Dendrocalamus strictus, D. longispathus* and *Schizostachyum dullooa* have been raised in the nursery. Land has been identified for trials at two sites in Pratapgarh and Raibareilly districts. A Multipurpose Windbreak Model plantation has been raised using *Thyrsostachys oliveri* and *Bambusa polymorpha* at Experimental plot (Area 1 acre), College of Agriculture, Tripura.

Fig 4. Cuttings from different clones of Dendrocalamus strictus planted in nursery beds and Cuttings of Dendrocalamus strictus planted in trays

New pest affecting bamboo collected from bamboo nursery. Different characteristics of life stages of the collected pest studied thoroughly for identification. Disease survey was conducted in nurseries (Pariyat nursery, Darauli nursery, Katni; Katanga nursery Mandla) plantation at Moeyanala, Jabalpur; and state forest nurseries at Korba, Ambikapur, Haritima nursery Rajpur, Bhoolatola nursery Khairagad, and plantations at Katghora, Rajnangaon, Chhattisgarh and TFRI, campus against insect pests of different Bamboo species.

For population genetic analysis of important bamboo species, SSR marker in *D. longispathus* was developed. Genotyping of 14 samples each of *B. tulda, B. vulgaris* collected from various

localities of central Indian states was completed using 14 SSR primers. Collected morphological data of bamboo culm and culm sheath of different bamboo species for their characterization. For population genetic study, genomic DNA was isolated from different Bamboo species. SSR markers are being tested and selected for genotyping work. DNA bar-coding in ten bamboo species initiated. For developing management strategies for pre and post flowered bamboo resource, seeds are being collected, processed and tested for various parameters. Bambusetums have been established at PAU Ludhiana, one site at Assam, TFRI Jabalpur. Two Technical Bulletins on Propagation and Management of different species of Bamboos were published in English and Hindi language.

AICRP-3: Conservation, improvement, management and promotion of Sandalwood (*Santalum album* Linn.) cultivation in India

Guidelines for collection and evaluation of sandal germplasm, establishment of sandal-based agroforestry system and collection of wood core sample for estimation of oil and chemical profiling have been finalized. Populations of sandalwood were identified from Rajasthan (2), Tamil Nadu (6) and Karnataka (7). Identified trees were marked for seed collection. Seeds were collected from two seed sources in Rajasthan and nursery was raised.Production method for mass multiplication of sandal genotypes through root suckers have been optimized.The first Methylated cytosine map of *S. album* generated. Short-listed 40 polymorphic SSRs including 8 EST SSRs for genotyping of base population.

Fig 5. Establishment of sandal-based agroforestry trials

Established sandal nursery with known seed source and five agroforestry trials have been raised. Information on existing agronomic and silvicultural practices followed and its effects on sandal growth was documented from 31 plantations in Karnataka.Field survey conducted in farmer's fields in Andhra Pradesh, Telangana and Karnataka and assessed the incidence of red stem borer on sandal. Survey was conducted in Chamundi hills, Yelwala, Chikmagalur, MM hills and Marayoor sandalwood reserves and assessed the incidence of sandal spike disease. Molecular diagnostic assay for SSD detection completed in two seed sources to ascertain the transmission of the phytoplasma through seeds. Collected ERT data from different plantations and optimized the linear regression model using actual and ERT heartwood data and documented 90% similarity with R2 = 0.95. Carbon isotope composition (13C/12C) analysis of 60 wood samples using IRMS completed. Estimation of the oil content and alpha and beta santalol content completed in 25 samples. Prepared a video on estimation of heartwood using ERT in standing trees of sandalwood.

Fig 6. Sandal-based agroforestry trials at Ludhiana and Bhatinda

AICRP-4: Eucalyptus improvement

In Component-1 on "Selection of superior Eucalyptus clones" at IFGTB multiplication of 41500 clonal plants. About 24200 clonal plants were individually numbers and transported to IFB, IFP, TFRI, CSFER, FRI, AFRI. Established germplasm bank with 285 clones. **In IFB, Hyderadabd out** of the three planned adoptive multilocational trials of *Eucalyptus camaldulensis,* two trials have been established. Besides the 142 IFGTB clones, 20 local clones from SK Biotech were included in the MLT. **At FRI Dehradun** plants received from IFGTB in year 2020 were maintained in nursery. On the basis of land requisition sent to Forest departments for land and one location finalised in Punjab by forest department. **At TFRI** one clonal trial consisting of 151 clones with six replications was established in August, 2020. Despite best efforts, mortality was high and 30% survival was recorded. **At IFP, Ranchi** based on survival and availability of plants, a clonal field trial of 143 clones of eucalyptus has been established at NB Farm Chandwa, Latehar (Jharkhand) in RBD fashion with five replications and one plant per clone per replication.

Fig. 7 Establishment of MLT at Mulakalapally, Paloncha, Telangana

In Component 2, it is envisaged to produce novel combinations of hybrid individualsin eucalyptus. Best performing clones were selected as seed (15) and pollen (7) parents respectively. Branch cuttings were grafted on seedling root stock and established the grafts successfully. Pollen collection, viability testing and storage carried out to use in controlled pollination. Each capsule yielded 12-17 hybrid seeds and the entire process of pollination to seed harvest takes about 90-95 days. Hybrid seeds were germinated, seedlings produced and 1000 plants will be sent for field planting. **In Component 3 to** improve the germplasm available

for future tree improvement of the species the previous introductions of this species were reviewed for their ecological requirement and appropriately reintroduced depending of the ecological requirement of the specific species. About 45 plus trees have been identified from the base populations present in Karunya and Panampally. Further, efforts have been taken to import seeds of *E. urophylla* and *E. pellita* from CSIRO. Shortlisted *E. cloeziana, E. sideroxylon, E. moluccana* and *E. longirostrata* for import of seeds from CSIRO as timber yielding species. **In component 4** on "Establishment of progeny tested clonal seed orchard" shortlisted and selected 25 clones of *Eucalyptus camaldulensis* for raising the seed orchard. Collected seeds of Eucalyptus from CSO Karunya and raised seedlings for grafting purpose. **In Component 5 on "**Development of transgenics/ transgrafts" **Agrobacterium** mediated transformation experiments were initiated using existing CaMV promoter driven *EcHKT1;1* hpRNA construct. Generated 8 plantlets under hygromycin selection from callusing explants co-cultivated with AGL1 strain harbouring pCAMBIA1305.1:CaMV:*EcHKT1;1*hpRNA construct. Developed five transformation constructs

a) pCAMBIA1305.1 -MsPRP2 *EcHKT1;1* hpRNA

b) pHKN29: MsPRP2-*EcHKT1;1* hpRNA-Hsp

c) pCAMBIA1305.1- MsPRP2 GUS,

d) pHKN29: MsPRP2-*GUS* –Hsp

e) pCAMBIA1305.1: MsPRP2-*GFP* –Hsp.

Generated Eucalyptus composite plants using A4RS pCAMBIA1305.1:MsPRP2 –GUS-Hsp. An average of 1.4 GUS spots was observed in 14.5 % of the NaCl treated hypocotyl explants, while an average of 1 GUS spot was observed in 1.6 % of untreated explants indicating that MsPRP2 promoter is salt inducible. Existing *Li* hpRNA transgenics were PCR confirmed using CaMV and *Li* hpRNA primers. **In Component 8 on** "Popularize new clonal varieties and impact of introduced clones" assessing popularization and economic benefits of introduced Eucalyptus clones of IFGTB baseline data has been collected on the spread of Eucalyptus clones of IFGTB along with other varieties with TNPL and TAFCORN completed and baseline data for three districts viz., Ariyalur, Cudalore and Pudukotai. A total of 2100 plants are propagated with the available base

material in the nursery.A stakeholder Webinar (Series I) on the theme "*Popularization of Eucalyptus Clones of IFGTB*" exclusively for the tree growers/farmers was organised on 11.06.21.

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

In Component on Design and development of RF based wood processing system sepcifications have been finalized.The technical specifications are given in table- 1 :

Table-1 : Technical Specifications: -

Radio Frequency Dryer for IWST,Bangalore	
RF Power	20 kW
Frequency	27.12 MHz
Electrical Supply	415V ± 1% 50 Hz; 3 Phase
Overall length	4500 mm
Overall height	3000 mm
Overall width	2000 mm
Max electrical mains supply	50 KVA

Further a lab scale model of MW vacuum dryer was fabricated. A pair of vacuum desiccators was placed in a MW oven and vacuum pipes were connected to the desiccators by making hole in the side wall of the MW oven. The lab scale MW vacuum drying showed that efficiency of MW energy utilisation was around 55-62 %. The distribution of the MW energy was highly un-uniform in the oven. Wood layers have ability to block the MW radiation. **Further for developing protocols for bamboo straightening and/or bending using microwaves** carried out initial experiments on bending of green and dry bamboo strips (8-10 mm thick) using domestic microwave. In green condition, bamboo strips (300 mm long) could be bending after 90 sec of microwave treatment at 900 W power levels. *Dendrocalamus strictus* samples of around 1 m

length were harvested from field station. These samples were continuously kept submerged in water. The water saturated samples were used for different experiments. The samples were MW irradiated at different intensities (1200 watts, 1600 watts and 1800 watts) and the conveyor belt speed was kept constant i.e., 60 mm/sec. Drying was done in a 20 minute cyclic manner where samples were exposed to the MW for 20 minutes and then left out to cool for 20 minutes duration consecutively. The loss in weight after each cycle was recorded. It was observed that the drying rates depend on the intensity of microwave. Samples exposed to higher intensity dried faster as compared samples irradiated at lower intensity (1800w> 1600w > 1200w). **For green dimensional aspect in wood turning of plantation grown timber** wood of Eucalyptus and *Melia dubia* was procured. The surface roughness of fifteen eucalyptus samples is determined from both finished and unfinished surfaces.The average surface roughness of finished surface comes out as 7.601 micro meter.Immersed 20 prepared samples of eucalyptus and *melia dubia* species in to the water to get uniform moisture and other set for drying. The moisture content and specific gravity of unturned sample is 59.18% and 0.705 respectively whereas of turned sample is 71.5% and 0.529. Out of these twenty samples two samples was turned one of which consume power of 6.9 KWH for 17 minutes and other consume 6.4 KWh for 11 minutes. The average surface roughness of unfinished surface comes out as 8.26 micro meter. After sanding the surface of eucalyptus samples with 60 mm sand paper the smoothness of eighteen samples were determined and the average was 3.82 micro meter. Then sanding the samples with 80 mm sand paper the average surface roughness of unfinished surface comes out as 3.59 micro meter. After Turning and sanding with 60 mm sand paper the average surface roughness of Eighteen eucalyptus finished surface comes out as 4.83 Micro meter.Then sanding with 80 mm sand paper The average surface roughness of finished surface comes out as 3.797 micro meter.The eighteen immersed samples were turned,which consumed average power of 7.00 kwh for 12 minutes.The moisture content and specific gravity of three unturned, *Melia dubia* samples were 0.154 and 0.497.The surface roughness of 20 *Melia dubia* unturned samples were determined from unfinished surfaces.The average surface roughness of *Melia dubia* unfinished surface after slight sanding comes out, as 9.171 micro meter. For **optimizing MW treatment for improving treatability of wood,** microwave

pretreatment of *E.*hybrid and *M. dubia* samples at 360, 480, 600, 720, 840 and 960 MJ/m^3 MW Intensity. Preservative treatment of Microwave treated samples with ZiBOC, CCB, CCA and Borax-boric preservatives at 6% concentration by diffusion method (treatment-1), Pressure method at 100 lbs/$1n^2$ pressure with initial and final vacuum of 50 cm of Hg (treatment-2) and at 150 lbs/$1n^2$ pressure with initial and final vacuum of 50 cm of Hg for *M. dubia* and at 150 lbs/$1n^2$ pressure followed by dipping in preservative solution for 24 hours for E. hybrid (treatment-3). Anatomical studies to see the effect of MW irradiation on *Eucalyptus* hybrid and *M. dubia* samples pre-treated at 360, 480, 600, 720, 840 and 960 MJ/m^3 MW intensity carried out and results shows increase in vessel diameter with the increase in MW intensity. Determination of MoE and MoR of the samples of *E.* hybrid and *M. dubia* exposed to 360, 480, 600, 720, 840 and 960 MJ/m^3 MW Intensity carried out results shows upto 15% decrease in MoR and upto 20 % decrease in MoE in case of Eucalyptus hybrid and upto 14.81% decrease in MoR and upto 17.73% decrease in MoE in case of *M. dubia*. Retention studies shows in *M. dubia* optimum retention (12-16 kg/m^3) with different preservatives is obtained in samples pretreated at 720 MJ/m^3 and 840 MJ/m^3 MW intensity followed by pressure treatment (150 lbs/in^2). Where as in Eucalyptus hybrid maximum retention (8-10 kg/m^3) with different preservatives was obtained in samples pretreated at 840 MJ/m^3 and 960 MJ/m^3 MW intensity followed by pressure treatment at 150 lbs and dipping for 24 hrs in preservative solution.

Fig. 8 Removal of samples from Termite mound after 1st termite season

Fig. 9 *M. dubia* CCB treated samples after 1st termite season in TMT

Fig 10 *M. dubia* control samples after 1st termite season in TMT

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

Component 1: Nano-material embedded ecofriendly wood preservatives/coatings

- Preparation of nanoparticle dispersed linseed oil nanoemulsion with tween 80 as a surfactant was carried out using homogenization and ultrasonication techniques. Zinc oxide and cerium dioxide nanoparticles were incorporated in the nanoemulsions. Nanoemulsions were characterized on the basis of particle size and polydispersity index measured using dynamic light scattering technique. Morphology of nanoemulsions was examined using optical and scanning electron microscopy. Storage stability of nano emulsion was evaluated by measuring effective particle size and zeta potential over a period one month.
- Wood specimens of *Pinus radiata* were coated with zinc oxide and cerium dioxide nanoparticles (concentration 0.5-2% w/v) dispersed linseed oil-water nanoemulsions and UV stability of coated wood was accessed in an accelerated weathering tester by evaluating color changes on wood surfaces using CIE color parameters. Fourier transform infrared spectroscopy was used to elucidate the chemical changes on the irradiated surfaces. The results (color changes and chemical degradation) indicate significant improvement in UV shielding of wood surfaces coated with oil nanoemulsion with nano particle dispersion.

Component 2: Improvement of quality of low-density woods by impregnating with nano-filler blended resins

- Dispersions of nanoparticles with PVAc (10-30%) and Furfuryl alcohol were prepared using high speed homogeniser and ultrasonicator. Viscosity of PVAc (50% solid content) was 50640 mPa while 10% and 20% PVA cexhibited 9.62 and 24.2 mPa.s. Viscosity of 98% Furfuryl alcohol was 12.05cP which reduced to 7.6cP at 30%. Nano-resin dispersions were analysed using DLS for particle size and dispersion stability by measuring zeta potential. Higher zeta potential of nano-particle resin blends (-20-30 mV) were found indicating stable dispersions.

- Poplar wood was impregnated with PVAc and PVAc-nanoZnO blend and *Melia dubia* wood with PVAc. PVAc-nanoparticle dispersions were impregnated into wood samples using vacuum and pressure technique. WPG was found to increase by 26.7% and wood density was increased by 27.3%, when impregnated with 30% resin. Tangential swelling of wood was found to decrease by 35.7% when impregnated with 30% PVAc compared to control samples. Impregnated *Melia dubia* wood with different concentrations of furfuryl alcohol (30%, 40% and 50%) and cured in a vacuum oven.
- Impregnated nano-wood composites were evaluated for different physical and mechanical properties as per IS standards. After treatment with PVAc, hardness (end surface) of Poplar wood was increased by 30% from 3.94 kN of control to 5.13 kN of 25% PVAc treated wood. Compared to control, MOR was increased by 7% at 20% PVAc. However, PVAc did not affect the MOE and compressive strength. Higher concentration (>25%) did not improve the mechanical properties of impregnated wood. Significant improvement in water absorption was observed in Poplar and Melia wood treated with PAVc and nano ZnO blend. After adding the nano ZnO to PVAc, MOR of Poplar wood was significantly increased as compared to PVAc impregnated wood.
- Resin impregnated wooden stakes and control samples have been installed in field and durability studies against termite activities. Installed Poplar (control, PVAc and PVAc-nanoZnO impregnated) and Melia wood (control and PVAc impregnated) in a graveyard test field to determine its durability against termites.

Component 3: Improving properties of wood composites using nano materials

- Based on the observations from the preliminary studies done on boards loaded with nanoclay-resin formulations as noted in table 1, a method incorporating sonication and homogenization for varying durations was incorporated.

Table 1:Mean data for physical and mechanical properties of prepared boards

SAMPLE	Density (g/cc)	MC (%)	Swelling (%)				MOR (N/mm^2)	MOE (N/mm^2)
			GA			SA		
			L	B	T			
CONTROL	0.75	12.46	0.45	0.50	32.02	5.74	10.86	576.61
NC-1/10/10/10	0.8	9.91	0.60	0.77	40.70	17.93	-	-
NC-1/10/10/15	0.73	9.26	0.52	-	33.50	23.58	10.58	658.41
NC-1/10/10/20	0.67	11.1	0.53	0.53	31.87	10.89	12.20	746.03

The resin-nanoclay formulations were crafted in the following manner:

Table 2: Sonication and Homogenization time for preparation of nanoclay-UF formulations

S_1	**H_1**
5 min	5 min

(a)

Samples to be prepared with and without hardener.	**C/S_2**	**10 min**	**20 min**	**30 min**
	1%	NC-1/5/10	NC-1/5/20	NC-1/5/30
	2%	NC-2/5/10	NC-2/5/20	NC-2/5/30
	3%	NC-3/5/10	NC-3/5/20	NC-3/5/30
				H_2 = 5 min

(b)

- UF resin was used to prepare resin-nanoclay formulations using the sonication times in table 2. Samples for all the formulations as well as a control set were prepared for characterization. The techniques for characterization adopted were SEM, XRD, TGA, and DSC. The objective of these characterization techniques was to understand the degree of dispersion of resin in the formulations as well as to analyse their behaviour in presence of heat.

Component: 4 Nano cellulosic fibre filled composites

- Estimated holo-cellulose and lignin contents of bamboo and eucalyptus wood. Cellulose content of bamboo and Eucalyptus was 50% and 47%, respectively. Nanocellulose was synthesized from bamboo, Eucalyptus and waste paper pulp by using chemi-mechanical process, TEMPO mediated oxidation process followed by high speed homogenizing and ultra- sonication. Solid content of nanocellulose suspension was calculated and it was about 3% for both the species.
- Various physical properties of nanocellulose prepared from bamboo pulp and waste paper pulp were evaluated. Particle size and zeta potential of bamboo nanocellulose was 187.2nm and zeta potential was found to be -27.87 mV. Zeta potential was analyzed using DLS and it was -77 mV for bamboo and -30.3 mV for Eucalyptus. Particle size was analyzed using Dynamic Light Scattering (DLS) and it was 162.7nm and 341.3nm for bamboo and Eucalyptus respectively.

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

At regions covered by AFRI, Jodhpur list of 80 exotic species was documented of which 50 were invasive including trees, shrubs and herbs from Rajasthan. The most important invasive species were *Prosopis juliflora*, *Lantana camara, Leucaena leucocephala* and *Parthenium* sp. Infloresence and pod/fruits samples of *Prosopis juliflora* (Sw.) DC and *Lantana camara* L. were collected and various parameters recorded and insects collected from 8 districts. Two species of seed bruchids emerged from pods of *Prosopis juliflora* collected from 6 districts. The experiments were laid for evaluation of host range for the two species of seed bruchids initially on seeds of eight tree species *viz*. *Acacia tortilis* (exotic), *Prosopis cineraria*, *Tamarandus indica, Cassia fistula, Dalbergia sissoo* (indeginous species), *Prosopis juliflora, Lantana camara* and *Leucaena leucocephala* (invasive species). Out of the two species of seed bruchids *Caredon serratus* was found to infested seeds of five tree species in storage conditions *viz*. *Prosopis cineraria*, *Acacia tortilis*, *Tamarindus indica* and *Cassia fistula* whereas *Algarobius prosopis*

(LeConte, 1858) was recorded only from *Prosopis juliflora and Prosopis cineraria* species. No infestation of the two species of seed bruchids was recorded from seeds of *Leucaena leucocephala*. Further experiments are in progress for evaluating the seed bruchid *Algarobius prosopisis* host range and identification of other seed bruchids. Other two important insect pests recorded were defoliator *Schistocerca gregaria* Forsskal, 1775 (Desert Locust) belonging to family Acrididae of Order Orthoptera swarms recorded perching and feeding on *Prosopis juliflora* from Jodhpur, Barmer and Churu districts and Leaf infestation of white flies (Sap sucker) *Acaudaleyrodes rachipora* (Singh, 1931) (Aleyrodidae: Homoptera) was also recorded on *P. juliflora* from Jodhpur, Pali, Nagaur and Barmer districts. *Streblote siva* a major defoliator of *Prosopis juliflora* was recorded from Jodhpur district only. 5 species of butterflies and five species of hymenoptera were recorded as beneficial pollinators associated with the important invasive species of which the bees were the most important. Data on biological control agents in association to *P. juliflora* is being recorded for further studies. Data collected on soil and physico-chemical properties from secondary sources and soil samples were collected for analysis from Jodhpur, Rajasthan from *Prosopis juliflora* habitat to study the impact. Data on spread of 50 invasive species in Rajasthan collected from secondary sources and data on spread of *Prosopis juliflora* and *Lantana camara* in different districts of Rajasthan recorded and list of 80 exotic species prepared. **At HFRI, Shimla** reconnaissance survey was done for the selection of sites invaded with *Lantana camara* in Sabathu and Oachghat Block in Solan Forest Division and Sunni block in Shimla Rural Forest Division; Bharoli, Dehra and Jawalmukhi Blocks in Dehra Rural Forest Division and Jowar Block in Una Forest Division. The reconnaissance survey was done for the selection of sites invaded with *Lantana camara*; in Dharampur and Parwanoo blocks in Solan forest division; and Kansar, Banethi and Khojjar blocks in Poanta Sahib and Nahan Forest Division**.** Field surveys for occurrence data collection was conducted in Jharkhand, CG, Bihar and West Bengal. The occurrence data for *Lantana camara and Mikania mikrantha* was collected from 172 sample locations from close to 60 grids have been collected.The climate models IPSL-CM5A-LR and NIMR_HADGEM2_AO for the year 2050 under different RCP scenarios i.e. 2.6, 4.5, 6.0 and 8.5 have been downloaded from CCAFS site and digitised from the study area.In Tamil Nadu and Kerala to map the spatial extent of *P.juliflora* invasion, data

collected from about 450 points in various districts. Satellite images for Viruthunagar, Ramanathapuram, Coimbatore, Kanyakumari, Tirunelveli, Villupuram Pudukkottai, Thoothukudi, Sivagangai, Dindigul, Karur, Trichy, Thanjavur and Theni have been downloaded and being processed. Accuracy assessment of classification of satellite images of Tirunelveli, Pudukkottai, Thoothukudi and Sivagangai districts has been completed. To predict the future spread of *P.juliflora*, occurrence points (450 locations) have been collected and bioclimatic data have been downloaded.

Fig.11 Sites invaded by Lantana camara in Kansar and Banethi Block

In RFRI, Jorhat to map the spatial extent of selected IAPS (*Mikania micrantha*) some of the old satellite images of Assam downloaded/ collected. Some of the preliminary GIS layers created/ updated. A format for collection of presence/absence data of invasive species from selected grids was designed and tested on field. Data from a total of 93 grids was collected for presence/absence information of invasive species, covering Jorhat, Sibasagar, Golaghat and Dhemaji district. The centre points of each of the grids were demarcated in high resolution images and land use characteristics of each of the point was noted. Later, based on the land use/cover type, each of the points was re-classified in terms of potential presence of selected invasive species. Data collection of 2158 grid was completed so far based on high resolution open source images.

In the regions covered by BU restoration of *Prosopis juliflora* Invaded lands using desired native tree species in Udayalipatti Village Pudhukottai was done. In Kolunji farm the desired plant saplings are raised which are as follows, *Azardiracta indica, Ficus benghalensis, Borassus flabellifer, Thespesia populnea, Syzygium cumini, Lannea coromandelica, Tamarindus indica, Millettia pinnata, Wrightia Tinctoria, Albizia amara, Albizia lebbeck, Holoptelea integrifolia, Cassia fistula, Dalbergia sissoo, Dalbergia latifolia, Saraca asoca.* New experimental plot in

Kovilveerakudi: This study plot is a seasonal wetland (about 500 acres), currently under the maintenance of PWD (TN Govt); the local panchayat and the village community has been endowed with the privilege to access the wetland resources for fuel and fodder. A sizable portion of the wetland (about 100 acres) has been invaded by *P.julifolra*. In this wetland, we envisage a participatory (community) approach in the eco-restoration of wetland. *P.julifolra* is currently being removed mechanically with active participation of the village community. At **DWR, Jabalpur** surveys were made in Jabalpur, Hoshangabad and Betul districts of Madhya Pradesh for the infestation of Lantana, *Prosopis juliflora* and other weed species targeted under the AICRP-7 along with insect species for their biological control. Severe Lantana infestation was found on the road side in Kundam, Barela and Padaria locality of Jabalpur. High level infestation of Lantana was recorded in the forest area of Satpura National Park which fall under the ambit of the Pachmarhi Biosphere. In Sarni area of Betul district Lantana infestation was mild. Severe *Mikania micrantha* infestation was found in Sarni locality of Betul district of Mdhya Pradesh. This is a new occurrence of this weed in the central region indicating it's spared from its known area to other area. Particularly, this weed was found in the area where ashes from the MP Electric Power Generating company is disposed. Survey in other adjoining forest area did not reveal the occurrence of this weed. This may be considered a new record of this weed from Madhya Pradesh. *Prosopis juliflora* infestation was not found in surveyed area of these districts. Many insect species collected from the Lantana during the survey, but most prominent species was *Teleonemia scrupulosa*, Drying of leaves of Lantana was observed during rainy season (August September 2021) with the increase of population of the insect.

Fig 12 Severe infestation of Lantana in Pachmarhi
(Hosangabad district of MP) forest area

AICRP 8: Conservation and productivity improvement of Red sanders

While achiving the aim of component "Establishment of base populations" the entire natural range was delineated into six provenances using GIS**.** This was communicated to the component collaborator (BIOTRIM) for field surveys and seed germplasm collection during the current fruiting season.GPS coordinates collected during field surveys were plotted on a GIS map. Global bioclimatic environmental layers were collected and clipped for use in niche modelling. Candidate plus trees were identified and scored using the grading criteria developed for Red sanders. Seeds of 31 plus trees were collected and shared among the five collaborators. Seeds of these selected plus trees were put for germination in nursery at five respective places. Vegetative propagation trials were laid using different rooting media, hormone concentrations, and cuttings from different Candidate Plus Trees at IFGTB. Similarly, three sets of trials were laid at IFB Hyderabad to standardize diameter of coppice shoot, hormone concentration and method of hormone application. Rooting/callus response of air layers was recorded two months after treatment**.** Axillary buds were collected from one CPT (BIOTRIM 1) and used in culture establishment**.** AM fungi, PSB and Rhizobium inoculated seedlings of *Pterocarpus santalinus* were analysed for the growth and biomass. The combination of PSB with AM fungi and PSB with *Rhizobium* inoculated seedlings showed significantly higher growth improvement (49.7 cm), biomass (424.4 g plant^{-1}), leaves number (15.3 plant^{-1}) and number of nodules (18.6 plant^{-1}) over control**.**

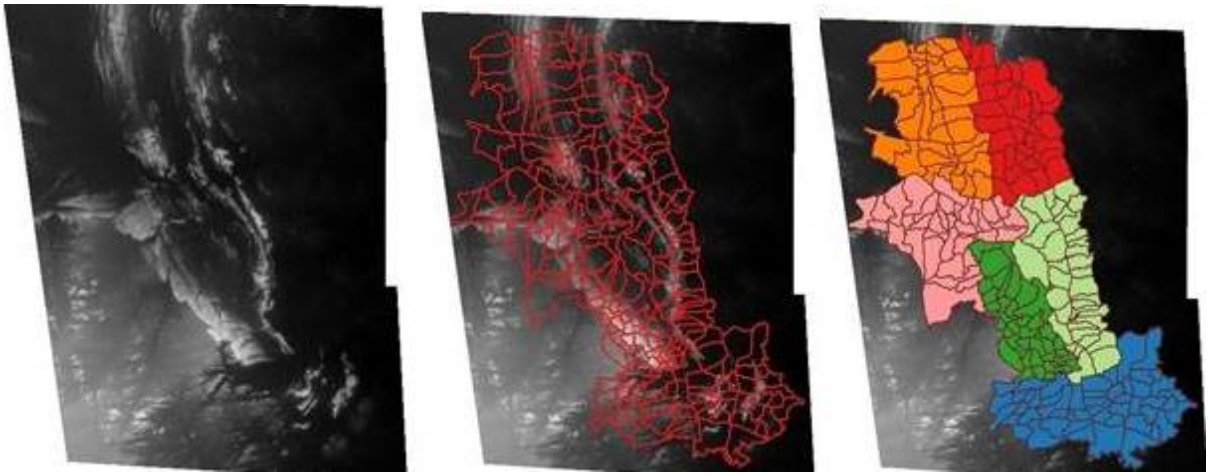


Fig. 13 GIS based provenance delineation in Red sanders and nursery raising

Three ISSR primers *viz*., UBC-811, UBC-825 and UBC-864 were screened on 40 accessions of *P. santalinus* which detected polymorphism of 50%, 87.5% and 66.7%, respectively**.** PCR conditions were optimized and four cross-species SSR primers were screened on 10 accessions of *P. santalinus.* Among the polymorphic primers, the primer-mPeCIR-D14 produced polymorphic bands when screened on 40 different accessions**.** Further, RNA was isolated from two diverse accessions (Rudravaram, Andhra Pradesh and Nayapakkam, Tamil Nadu) of *P. santalinus* and sent for *de novo* transcriptome analysis.

Fig. 14 Biofertilizer inoculated stem cuttings of *P. santalinus.* T1-AM fungi, T2-Phosphobacteria, T3-Rhizobium and T4-combination of all three biofertilizers

One more site was identified at Hoskote, trees were marked and ERT readings recorded. The ERT equipment was standardised for Red sanders by developing a linear regression model using actual and ERT heartwood data. About 91 % (R^2 = 0.98) similarity was observed.

AICRP 9- Quality teak production: capitalizing on cloning

All the participating institutions are in the position to mass multiply the five teak clones initially supplied by IFGTB. Shoot multiplication performance of these cultures varies across the institutes. Currently each institute has about 300 -1000 culture bottles for five clones. IFP Ranchi has made significant progress in production of palnts an about 1000 plants were already hardened. IFGTB has signed an MoU with three commercial tissue culture lab for large scale production and distribution. Existing clonal trials of tissue culture raised (TC) teak were evaluated and initial analysis reveal their better performance. However, the cost of planting stock is prohibitory for farmers and source of planting stock is unknown. Local clones were introduced into culture by the institutes with partial success. Field trials (~12 ha in bund and block plantations) have been established as block or bund plantations by all the participating institutes except IFP, Ranchi. Continuous multiplication, production of plantlets and new clonal

accession will be carried out. Efforts will be made to identify planting sites for the next planting season.

Fig. 15 Plantation of tissue culture raised *Tectona grandis* (teak) at Banjar, Bagraji, Jabalpur (A-B-C-D-E) Preparation of bunds at planting site, (F-G-H) Plantation activities on bund in farmer's field

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

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, Erythrina suberosa, Kydia calycina, Litsea glutinosa, Premna latifolia, Pterospermum acerifolium, Quercus glauca, Sterculia villosa, Stereospermum suaveolens* and *Toona serrata*. Seed maturation studies and germination done on *Butea monosperma, Buchnania lanzan, Putranjiva roxburghii, Mallotus philippensis, Semacarpus anacardium, Sterculia villosa* and *Stereospermum chelonoides*. Perambulated different forest areas and identified seed sources of *Elaeocarpus serratus, Maesa indica, Cipadesa baccifera, Murraya paniculata, Bischofia javanica, Symplocos cochinsinensis, Cullenia exarillata, Leea indica,*

Aphanamixis polystachya and *Memecylon umbellatum*. Distribution and location of the populations of *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. Field survey, flower anthesis and seed maturation studies on *Dipterocarpus retusus, Chukrasia tabularis*. *Magnolia champaca, Mesua ferrea, Shorea robusta, Duabanga grandiflora, Morus laevigata* and *Phoebe goalparensis*. Survey of natural populations of *Prunus cerasoides, Sorbus lanata, Betula utilis, B. alnoides* and *Rhododendron campanulatum* done. In **Component 2 on** investigating seed germination behavior of forestry species from various forest types after seed collection, quality evaluation done through indirect tests and seed germination in *Acer pictum, Albizia julibrissin, Albizia odoratissima, Erythrina suberosa, Kydia calycina, Premna latifolia, Pterospermum acerifolium, Quercus glauca, Sterculia villosa, Stereospermum suaveolens* and *Toona serrata*. Seed germination studies conducted on *Semacarpus anacardium, Sterculia villosa, Putranjiva roxburghii, Mallotus philippensis, Buchnania lanzan, Butea monosperma, Stereospermum chelonoides* Seed germination in progress in *Elaeocarpus serratus, Maesa indica, Cipadesa baccifera, Murraya paniculata, Bischofia javanica, Cullenia exarillata, Leea indica,* and *Memecylon umbellatum*. Germination studies conducted in *Semacarpus anacardium, Buchanania lanzan, Putranjiva roxburghii*, and pretreatments to overcome dormancy devised. Seed germination studies being conducted in *Memecylon umbellatum, Bischofia javanica, Leea indica, Cipadesa baccifera, Maesa indica* and *Murraya paniculata*. Seed germination conducted in *Garcinia indica* and *Garcinia gummi-gutta*. Seeds of former germinated while no germination recorded in latter. Seed germination and pre-sowing treatments on *Chukrasia tabularis*. *Magnolia champaca, Elaeocarpus serratus, Mesua ferrea* and *Magnolia champaca* were conducted. Morpho-physiological studies (i.e. viability test, desiccation studies through EC meter, germination studies) at different stages in *Mesua ferrea, Dipterocarpus retusus, Chukrasia tabularis*. *Magnolia champaca*. Seed germination trials of *Prunus cerasoides, Sorbus lanata, Betula utilis, B. alnoides* and *Rhododendron* -26- *campanulatum, Anogeissus latifolia* conducted in the laboratory. In **Component 3 on** Seed Storage physiology Seed desiccation and

storage trials were conducted on various species. Viability of the desiccated seeds of various species stored under different conditions was evaluated periodically, which is as follows *Quercus glauca acorns* (86% - 15°C), *Toona serrata* (43% - at 5°C), *Albizia odoratissima*(46% - at 5°C), *Albizia julibrissin*(74% - at 5°C), *Sterculia villosa* (80% - at 5°C). Seeds of *Putranjiva roxburghii, Semecarpus anacardium, Mallotus philippensis, Buchanania lanzan, Butea monosperma* and *Stereospermum chelonoides* were desiccated to different moisture content and viability was assessed. Seeds were put in different storage conditions and viability evaluated at 3 months interval. Initiated seed storage study to analyse the effect of storage temperature on germination in *Cipadessa baciferra, Bischofia javanica* and *Leea indica*. Seeds of *Garcinia indica* and *Vateria indica* were kept at various storage temperatures for the viability studies. Seed desiccation studies for storage trials conducted in *Mesua ferrea, Dipterocarpus retusus, Shorea robusta, Chukrasia tabularis* and *Magnolia champaca*. Seed storage trials of *Betula utilis, B.alnoides, Rhododendron campanulatum* and *Sorbus lanata* laid out in the laboratory. **In Component 4 on** correlating seed storage category with ecological parameters Rainfall, temperature and RH data collected from the seed sources identified for different species. Seed shape, size, mass and moisture content of *Garcinia indica* and *Garcinia gummi-gutta* were studied from one location each. Fruits of Vateria indica were collected from two sources to study the impact of environment and vegetative type.

Nursery techniques for production of quality seedlings Nursery trials of Prunus cerasoides, Betula utilis and Sorbus lanata laid out. Germination and growth data recorded. Nursery experiments initiated for *Anogeissus latifolia*.

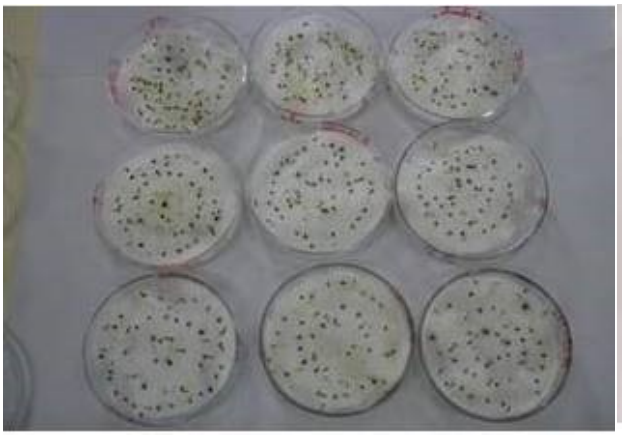


Fig. 16 Germinated seeds of *Betula alnoides*

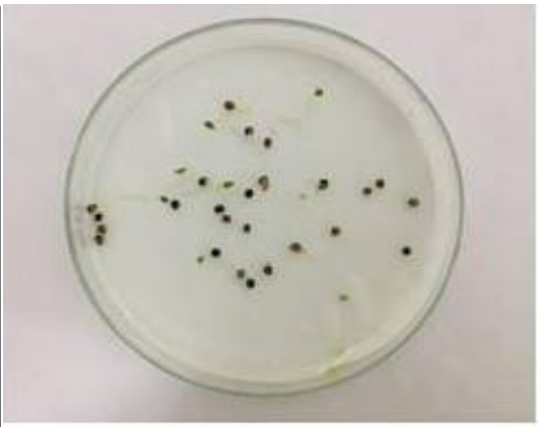


Fig. 17 Germinating seeds of *Premna latifolia*

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

Disease surveys were conducted in seven different sites at Forest Research Institute, Dehradun. Sporophores of *G. lucidum*, oozing wood, yellowish drooping leaves and stag head symptoms were observed. Fungi isolated from the oozing wood samples were identified as *F. solani* and *Verticillium* sp. based on morphological features. Pure cultures of *G. lucidum* and *Trichoderma* spp. were obtained. In addition, foliar pathogens, namely *Alternaria* sp., *Cladosporium* sp., and *Colletotrichum* sp. were isolated from the leaf samples with spot symptoms. Three *F. solani* samples were obtained from National Type Culture Collection of Forest Pathology Discipline, FRI, Dehradun. Eight *Trichoderma* species isolates were tested against all the isolated pathogens in dual culture assay. Maximum (96.5 %) mycelia growth inhibition (MGI) was observed against *F. solani* isolate and minimum MGI (76.7 %) against *G. lucidum*. Pathogenicity test conducted for one *F. solani* isolate was successful as wilt symptom appeared 14-days after inoculation in a glasshouse. Although, soil nutrient analysis results did not show any correlation with wilt and dieback but low organic carbon content and comparatively high nitrogen percentage was observed in two diseased sites. Twenty genotypes cultures initiated and multiplied using this protocol standardized for culture intiation was carried out on full strength Murashige and Skoog (MS) medium supplemented with 4.53 µM *2,4-dichlorophenoxyacetic acid* (2, 4-D) and 4.44 µM 6-benzylaminopurine (BAP) as respective sources of auxins and cytokinins and multiplication was carried out on MS medium supplemented with BAP and α-naphthaleneacetic acid (NAA) at 4.44 µM and 2.9 µM respectively. This conjugation has resulted in production of compact, green and non-friable calli and regular cycles of sub-culture are maintained for multiplying callus. A local survey was completed in a pure uniform age stand of *Dalbergia sissoo*. A point based score method based on growth, stem form, vigour and apparent absence of disease and insect absence was developed for selection of suitable phenotype as candidate plus trees (CPT). This methodology will be used for selection of phenotypes in field. Two CPTs qualified after scoring. These CPTs again visited and marked as plus tree and passport data for these trees was compiled. The mass-propagation of various genotypes was carried out. Currently 57 genotypes have been subjected to micropropagation and cuttings were transferred to bags and are being maintained. Six-month-old Shisham plants

were procured from Genetics and Tree Improvement Division, FRI, Dehradun. The pathogenicity tests were conducted using two methods. (1) Conidial suspension (10^6 conidia/ml) of one *F. solani*isolate was prepared from 14-day-old culture grown on PDA. Healthy plants were first uprooted, then washed twice with sterile water. Finally, the plants were dipped in the conidial suspension and planted in polybags containing potting mixture (sand+soil+FYM in ratio 1:3:1). (2) Fungal mycelium was obtained from 14-day-old culture grown on PDB. Five gram dried mycelia was inoculated in sterile potting mixture (Sand+Soil+FYM in ratio 1:3:1) and healthy plants were planted. The experiment was conducted in a completely randomized design with five replications in a glass house. Seedlings treated with sterile distilled water and grown in the potting mixture served as controls. Wilt symptoms were observed 14 days post inoculation. Controls remained symptomless. In the third half year of the project four *Trichoderma* species were isolated from soil samples and sporophores collected from diseased shisham trees. Seven *Fusarium* and one *Ganoderma* isolates were recovered from ooze, root and soil samples collected from diseased shisham trees in areas of Asan Barrage near Dehradun.

Morphological identification of isolates was done. Molecular identification of isolates is in progress. Dual culture assay of nine *Trichoderma* isolates against six *Fusarium* and one *Ganoderma* isolates was done. *Trichoderma* isolates (T1-T9) inhibited growth of *Fusarium* and *Ganoderma* isolates in the range of 56-94 and 54-61 per cent, respectively. The process of induction on standardized medium (MS supplemented with BAP and 2, 4-D) in ongoing. Of the 25 genotypes, induction was carried out for 15 genotypes. Post induction, the cultures are being maintained by simultaneous sub culturing on MS medium supplemented with NAA and BAP (standardized previously). Calli induced during this time, have shown variation in terms of growth time, health and characteristic (friable /compact) with respect to genotypes. Protocol for organogenesis is under progress as of now. Success has been achieved in certain genotypes. Regeneration frequency studies are under process.Cultures are being tested for pathogenesis. For proteomic studies suspension culture protocol is being standardized. Calli post induction was sub-cultured on certain compositions to obtain friable calli, desirable for cell-suspension culture. These cultures were further subjected to various liquid media with different

concentrations of supplements. The parameters for recording growth and viability are being studied to get conclusive results for an optimum medium. Natural and artificial plantation sites of shisham were surveyed. Uttarakhand: Areas covered were Asan Barrage Raipur, Dehradun and Eastern Punjab region- Ludhiana, Jagraon, Amritsar, Garhshankar, Hoshiarpur, Dasuya, Pindori Mindo- mind, Nangal, Ropar and Anandpur Saheb. Symptoms (wilting, oozing and stag head appearance) and signs (sporophore) were recorded. GPS coordinates of the locationswere also noted down Surveys were conducted in Uttarakhand, Haryana, UP, MP and Punjab. Sites contained a high disease/mortality rate. Data pertaining to Height, Girth, D.B.H. (Diameter at breast height) was recorded and score assigned to each tree on the basis of the above mentioned parameters in form of Stem Character, Clear bole and vigour. The best suited individuals, with score at par with the surveyed population, were selected as candidate plus trees and marked. The passport data for these trees was compiled. The Survey area included Aasan Barrage (Dehradun), Ludhiana, Amritsar, Hoshiarpur, Roopnagar and Anandpur Saheb of Punjab. Yamunagar, Budelkhand region of UP an MP. The selection was carried out from the natural sites and plantations by the local Forest departments. Data pertaining to Height, Girth, D.B.H. (Diameter at breast height) was recorded and score assigned to each tree on the basis of the above mentioned parameters in form of Stem Character, Clear bole and vigour. In Arcadia, Uttrakhand: There were massive infection found. Four CPT selected using a prescribed method (without disease and also good stem characters) and out of which 3 were finally selected as Plus trees. Vegetative materials collected for cloning of those individual plus trees. In Punjab from disease infested areas, total of 7 CPTs have been selected through survey and also included 4 (marked as CPTs by forest department) as well. Vegetative propagules for cloning and also seed will be collected in coming season. A preliminary survey was carried out in Bundelkhand regions of UP and MP to monitor the disease incidence and selection of healthy and superior trees. In this area disease incidence was not observed in months of March April. Total 40 CPTs were selected. Seed collection was done for about 40 individuals (CPTs) along with their geospatial and growth characteristics. All the seeds were sown. Seedlings have been raised and maintained in nursery Some potential genotypes (six in numbers) tested in earlier experiments have been assessed in nursery. Survival rate after one year is more than 85 % in

these potential genotypes against less than 40 % survival in susceptible genotypes. More than 70 genotypes (from earlier collection are being) are being multiplied and presently their availability from 15 to 100 ramets from the respective genotypes. A hedge garden of seven potential resistant genotypes has been raised. Samples of bark, ooze, sporophores, roots and soil were collected from diseased shisham trees. For pathogenicity testing healthy six-month shisham seedlings were taken from Central Nursery, FRI. Inoculum made in Sorghum chaff was used for pathogenicity testing. Five mm mycelium discs of *Fusarium* isolates were inoculated in sorghum chaff substrate (5:1) and incubated at 30°C for 15-20 days. After full colonization of the substrate by fungus, the substrate was crushed and filled between two layers of sterilized potting mixture (sand + soil + FYM) in polybags. Healthy seedlings were uprooted and transferred to the polybags. Control plants were transferred to polybags with uninoculated sorghum chaff substrate.

Fig. 18 Microconidia and Macroconidia of Fusarium isolates

Twelve shisham populations in Himachal Pradesh were surveyed for selection of disease resistant genotypes and sample collection. Geo coordinates and weather parameters (temperature and humidity) of visited sites were recorded. Soil, disease plant samples and fruiting bodies of *Ganoderma lucidum* were collected. Five isolates of *Trichoderma* spp. were isolated by serial dilution method. Pure culture of *G. lucidum* was raised from fruiting body. Macroscopic and microscopic characteristicsof *G. lucidum* and *Trichoderma* spp. were recorded.

Pure cultures are being maintained on PDA.Ten superior trees were marked at two sites (Singhapur and Nirsu) of Rampur Bushahr, Shimla.Twenty-eight superior trees were marked at two sites (Plasi and Aaduwal) of Nalagarh, Solan. Fruiting bodies of *G. lucidum* were collected from dead Shisham tree andpure culture of *G. lucidum* was raised. In the third half year of the project 9 isolates of *Trichoderma* spp. were isolated and being maintained on PDA. Isolation of more *Trichoderma* species/ isolates is under progress. Soil samples were collected from 5 sites in Sirmaur and 12 sites in Una, Himachal Pradesh.Soil samples were collected from 15 sites of Jammu, Samba and Kathua districts of union territory of Jammu and Kashmir. 3isolates of *Trichoderma* spp. were screened against *G.lucidum* and *Fusarium solani* by dual culture method. The growth inhibition was recorded in the range of 10-32%.17CPTs were selected from Sirmaur (10), Kangra (4) and Una (3) districts of Himachal Pradesh. 7 CPT were selected from Jammu, samba and Kathua districts of Jammu & Kashmir (HFRI). Sugar bagasse, wheat bran, wheat straw and needles of *Cedrus deodara*, *Pinus roxburghii*, *P. wallichiana*, and *Abies pindrow* were screened to find suitable substrate for mass multiplication of *Trichoderma* spp. Maximum 5.71×10^6 spores/mg were recorded on the needle powder of *Pinus roxburghii* supplemented with potato dextrose broth and yeast extract. Shisham populations of 5 sites in Sirmaur and twelve sites in Una, Himachal Pradesh were surveyed. Total 12 (4+8) sites in both places were reported healthy. One site in Sirmaur district was reported to have 22% severity of disease and 4 sites in Una with infection range from 11- 21% was recorded. 15 sites in Jammu, Samba and Kathua districts of Jammu and Kashmir, UT were surveyed. Infection in the range of 12-17% was recorded in 3 sites Morphological characteristics (stem, length, girth, flowering and fruiting) of Candate plus trees (CPTs) were recorded The soil samples collected from surveyed sites (Bilaspur, Solan, Kangra and Sirmaur) were processed for analysis of texture, pH, moisture etc. and data was recorded accordingly. Fruiting bodies of *Ganoderma lucidum* and bark samples of stemwere collected from dead and diseased trees of visited sites. 6 isolates of *G. lucidum* and 2 isolates of *F. solani* were isolated and maintained on PDA. 2 sample plots (one each at Ponta Sahib, district Sirmour and Dharmpur, Dist. Mandi) were selected for the establishment of VMG/CMA of resistant genotypes in Himachal Pradesh. Site selection in Jammu and Kashmir is under progress. Seeds were treated with 5 mL suspension of *Trichoderma* sp. containing 10^3

mg/mL spores. Trials conducted in Petri plates under laboratory conditions. The seeds inoculated with *Trichoderma* sp. Exhibited 90% seed germination while the untreated seeds had only 55% germination. Shisham populations in 5 sites in Sirmaur and 12 sites in Una, Himachal Pradesh were visited and disease incidence and geo coordinates were recorded. Shisham populations in 15 sites of Jammu, Samba and Kathua districts of Jammu and Kashmir, UT were surveyed and geo coordinates were recorded.

At IFP, Ranchi the SRTM DEM data set for India has been downloaded and created data sampling grid for the study area. The other environmental layers like Hillshade, aspect, slope and elevation shall be derived from this DEM data. Data format for field data collection has been designed. Downloading of Landsat 8OLI satellite imagery. Satellite imagery based AOI (Area of Interest) layer clipped and prepared. Derived Hillshade, Aspect, Elevation and slope layers from SRTM-DEM by IFP. Bioclimatic layers downloaded and prepared for the study area. The LULC map of India for 2015-16 downloaded from Bhuvan portal. Field survey for occurrence data collection initiated. Jharkhand: Surveyed the field areas in parts of Ranchi, Khunti, Pakur, Hajaribagh covering 25 no of sample grids. CG: Surveyed the field areas in parts of Bilaspur, Raipur, Durg, Bhilai covering 30 no of sample grids. Bihar: Surveyed the field areas in parts of Araria, Purnia, Darbhanga covering 26 sample grid points. WB: Surveyed the field areas in parts of Kahragpur area covering 15 no of sample grids. In the third half year of the project Field surveys for occurrence data collection initiated. Jharkhand: Surveyed the field areas in parts of Ranchi, Khunti, Lohardaga, Gumla and Latehar covering 35 no of sample grids. Ganoderma samples was collected from these sites. WB: Surveyed the field areas in parts of Bantala, Amtala, Malancha, Usthi, Gangapur, Bhojerhat, Ghunimeghi area covering 15 no of sample grids. Ganoderma samples was collected from these sites Field survey for observing Hazzard issues in Jharkhand and WB as per following details: Jharkhand: Surveyed the field areas in parts of Hutar, Khunti, Inta, Sarenghatu, Bandra covering 35 no of sample grids. Ganoderma samples was collected from these sites. WB: Surveyed the field areas in parts of Bantala, Amtala, Malancha, Usthi,Gangapur, Bhojerhat, Ghunimeghiarea covering 15 no of sample grids The Future (2050) Climate model IPSL_CM5A_LR and IMR_HADGEM2_AO have been downloaded and digitised for the study area. Downloading soil layers data from FAO data portal

and digitize as per the study area. Digitisation of LULC map of study area based on ESRI LULC data 2020.

Surveys were conducted in Sagar, Datiya, Gwalior and Mourena. Soil samples collected from *D. sissoo* trees. *Trichoderma* sp. was isolated from local soil samples were multiplied in broth culture.*Fusarium*sp. isolated using serial dilution techniques. *Ganoderma* sp. collected from trees of *D.sissoo* and culture madefrom fruit body.Dual culture tests of *Trichoderma* isolates against *F. solani*and *G. lucidum* being done. Raisingplanting stock of selected genotypes in the nursery is ongoing. In the third half year of the project Multiplication of *Trichoderma sp.*on wheat straw and sugar cane waste was done. 03 site were visited. Soil samples were collected from 12 locations. 05 *Trichoderma sp*- isolates (T*richoderma harzanium*-3, *T.viride*-02) were isolated. 03*Fusarium solani* isolates and 2 *Ganoderma sp* samples collected.

At AFRI, Jodhpur 39 rhizospheric soil samples were collected from different locations. Trichoderma has been grown on leaf litter, coco-peat, saw dust, compost. 20 disease samples were collected from different locations. Preliminary survey to identify wilt and root rot resistant *D.Sissoo* plus trees were conducted at Khandwa, and Bargi. At Bargi plus trees were identified 10 CPTs selected from different locations.

Soil collection was done nearby diseased Shisham tree from Jorhat, Golaghat and Sivasagar districts of Assam.*Trichodermaharzianum* and *T.viride* were isolated from collected soil samples using Trichoderma Special Media (TSM). Fruiting body of *Ganoderma lucidum* was collected from diseased tree and pure culture was isolated.Setup experimental trial to develop *Trichoderma* spp. cultivation protocol using Agricultural waste materials. Field surveys were conducted at Jorhat, Golaghat and Sivasagar districts of Assam for ground verification and occurrence of data recording by GPS. A total number of 48 trees data was recorded. Four trees were found infected by *Ganoderma* sp. Survey of Shisham populations and areas for incidences of Shisham mortality was recorded in large plantation at Gomari in Golaghat and Horaguri Chapori in Sivasagar districtsof Assam. Four trees were found infected by *Ganoderma* sp.Seed collection was done from Shisham plus trees from Jorhat, Golaghat, Sivasagar, Dhola and Majuli of Assam.Established a *D. sissoo* nursery with seeds of *D. sissoo* collected from plus trees. In the third half year of the project serial dilution, PDA plating and Isolation of

Trichoderma from soil has been done. Seeds of *D. sissoo* collected from plus trees of different plantations/natural areas were raised with their GPS location in the nursery. Setup experimental trial to develop *Trichoderma* spp. cultivation protocol using Agricultural waste materials such as Paddy straw, Weed, Vermicompost, Cowdung, Weed+ Vermicompost + Cowdung, Cowdung + vermicompost. Experiment results revealed that weed is the best substrate for multiplication of *Trichoderma viride.*

Fig. 19 Candidate plus trees selected during surveys based on DBH, Height, Stem Character etc.

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

Literature survey is being carried out for demand and supply of Timber, Fuel wood and Fodder.The work on three manuals as per the action plan is under progress. The broad sources for demand and supply of timber, fuelwood and fodder was identified.The questionnaires was prepared for the primary survey from industries, households and SFDS. The pilot survey for each of the category was conducted and the questionnaires was improved. The year and month wise import and export data regarding on wood and wood products from 2010 to 2020 was compiled. Obtained the list of wood based industries from ASI. The same lists from the respected states are also obtained from some of the states. Based upon the manpower engages, the stratification of industries was completed. The industries were classified in the five

categories i.e. Pulp and Paper, Panel, Saw mill, Solid Wood and others. Received the data from SFDs of some of the states. Coordination with SFDs are in progress for obtaining the required data. The sampling method for industry and household was finalized. The estimators are almost finalized. Collected village level details, locations and other secondary information required for the survey as per the distance from the forests. The CAPI based survey format is finalized and is in process to be implemented. Conducted quarterly review progress of the project. Organized one day workshop on "Demand and Supply of Timber" on 13.09.2021 and the suggestion of the experts are being implemented.

Fig. 20 Collection of village level details, locations and other secondary information

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

AFRI, Jodhpur consulted literature on NPV by IIFM entitled, "Forest Resource accounting and valuation of economic contribution of Forests and Protected areas in Rajasthan and capacity building on environmental statistics and green accounting" by Verma et al 2017. Collected information of Forest types of Rajasthan and Gujarat on various aspects viz. name of FT, location (Division and Range), altitude (m), area (In sq km), forest density (In sq km), geo-coordinates, annual temperature range, annual precipitation range, soil type, dominant trees, dominant shrubs and major species, fuelwood collection, fodder collection, grazing, debris collection, grass collection, NTFPs collection and major NTFPs of each district in every Forest Type and submitted to NPC in prescribed format. By **HFRI, Shimla** pilot testing of revised questionnaire was done in villages Deothi, Mathan, Chawal, Bergaon, Rundhan-ghoron, Unchagaon, Baroh and Kasol valley in Solan district adjoining to chir pine forests and 70

households were surveyed. Literature was also searched on tangible and intangible benefits derived from various ecosystems. Pratap *et al*. (2012) conducted a study on economic valuation of pollination in Himachal Pradesh for 32 crops, EVIP was USD 365 million and EVIP for 28 crops in Kashmir was USD 426.8 million. Hipolito *et al*. (2019) conducted a study in Serra da Bocaina estimated the total annual monetary value of the pollination services performed by bee species was 564,000 dollars and 246,000 dollars in Mata do Jambreiro during the year 2016. Borges *et al*. (2020) estimated the crop production value (CPV) for Para state was US$ 2.95 billion and total pollination service value (PSV) was US$ 983.2 million, corresponding to 33% of CPV in Para. Knapp and Osborne 2017 conducted a study on production of Courgette (*Cucurbita pepo* L.) was estimated £6.7billion in United Kingdom. Monery *et al*. (2015) conducted a study in Satander, Columbia on economic value of pollination provided by honeybees (US$ 129.6/ha of coffee) was more than that of stingless bees (US$ 16.5/ha).

IFB, Hyderabad reviewed literature on relevant topics. Census and Sample-based secondary data has been collected. Literature reviewed on the total economic value of forest and Net Present Value (NPV) from similar studies is going on. Identification of forest class and physiographic zones and the corresponding eco-system goods has been going on. Literature reviewed on the replacement cost of the forests. Identification of site of non-forestry uses and the deliverables of the use is going on. **In TFRI, Jabalpur** the PI attended inception meeting of the project at Van Vigyan Bhawan, New Delhi. The project staff under the project has been appointed. According to the format provided by NPC, the data on households from 20 families belonging to 2 villages of Jabalpur district has been collected for quantification of forest resources by the households. A manual on “Valuation of Nutrient Cycling in Ecosystem Services” has been developed and submitted to NPC for further comments. The manual includes glimpse of nutrient cycling in forest, provides glance of important nutrient cycles (NPK), and format for Valuation of Nutrient Cycling in Ecosystem Services. A case study of Changbaishan Mountain Biosphere Reserve (CMBR) in Northeast China is also mentioned in the manual as an example to measure total nutrient accumulation. In **IFGTB, Coimbatore** literature on ecosystem goods and services of forests & plantations especially of bamboo plantations was collected. Details of tree plantations outside forests in Tamil Nadu were collected. Basic details

on forest areas in Tamil Nadu, Kerala, Andaman & Nicobar Islands were collected. Attended the inception workshop of the project conducted at New Delhi. Draft pilot survey formats have been received and Trial questionnaires were filled up. List of shortlisted villages for carrying out questionnaire survey was received.

Fig. 21 Piloting of house hold questionnaire at Kotiyal Village (Mand-Mulugu, Dist-Medak, Telangana

AICRP-14: Forest Fire Research and Knowledge Management

The project work is going as per the target given. The burnt area information for the current fire season has been received from Uttarakhand State Forest Department from time to time and based on the information received, field visitis are being conducted. Purchase of field equipment completed. The recruitment of manpower is also completed. Development of fire-fighting tools and equipment is under progress through collaboration with expert institutes like UPES, Dehradun and IIT, Roorkee. Work order for developiong sample too kit has been placed with UPES and proposal for developing sample tool kit has been invited from IIT, Roorkee.

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

Preliminary studies were conducted on morphological characterization of the tamarind genetic resources available at Tamil Nadu, Telangana, Andhra Pradesh and Gujarat. Studied

phenological and reproductive variations of the 45 tamarind genetic resources available at Tamil Nadu, Telangana and Gujarat. Descriptors were developed as per the guidelines of PPVFRA for collection of data for the National Tamarind Registry and passport data collected from 45 tamarind clones. Characterized 30 tamarind clones through quantitative and qualitative traits. Fruit morphometric characterization of 40 clones was done through image analyser. Data recorded on fruit length, width, fruit thickness, shell weight, vein weight, pulp weight, seed weight and number of seeds per fruit. Assessed the gum recovery percentage from 22 different sources of Tamil Nadu to develop tamarind genotypes with high TSG value. Studied leaf anatomical variation to understand the foliar micro-morphology among the red, sour and sweet tamarind. 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 was done.

Optimized cleft grafting season for large-scale multiplication of tamarind genetic resources. Shortlisted 25 high productive clones for sour, red and sweet tamarind in different clonal assemblages of Tamarind located at different parts of Tamil Nadu, Telangana and Gujarat. Seeds were collected from the high-yielding tamarind trees and raised 2000 tall tamarind seedlings for establishing avenue plantations. Raised about 3000 tamarind seedlings for root stock purpose. Attempted 1000 cleft grafts in 3 high productive clones assembled at vegetative multiplication garden. Mass multiplied 16 high productive clones of red, sweet and sour tamarind through approach grafting/cleft grafting. About 5000 grafts were attempted and 3000 grafts were produced for supplying clones to establish MLTs in AICRP partner institutions. IFB, Hyderabad has shortlisted 5 high productive clones from the tamarind clonal assemblage maintained by Andhra Pradesh Forest Department at Mulugu. Communication has been made with Chief General Manager, NHAI, Tamil Nadu for executing avenue plantation activities. Identified NH corridors Coimbatore - Salem and Coimbatore to Pollachi for establishing tamarind avenue plantation. Mass multiplications of selected high productive Tamarind genetic resources through approach grafting are in progress. Baseline data were collected for the creation of the Tamarind consortium for value addition and market linkages. Selected the lands under panchayats, temples, schools and village roads for restocking of TGRs towards the

livelihood improvement of rural population. Established Tamarind Plantations in Panchayat land, temple land and village roads with the participation of President, Panchayat, District Collector, State Minister and rural people. Survey was conducted in the National Highways between Salem to Ulunthulpettai and allotted land had the scope for extension of lanes. Hence, the establishment and restocking of TGRs have been shifted to village roads. Selected the lands along village roads for restocking of TGRs towards the creation of revenue from avenue. Established Tamarind Plantations in village roads with the participation of rural people. Established multi-location clonal trials in farmer's field located at Kangeyam, Tiruppur, Melur, Madurai and IFGTB-FRS, Neyveli, Cuddalore. The multi-location clonal trials were established with 25 clones planted in randomized block design with 4 replications and 3 ramets per replications were maintained.

Fig. 22 Stocking and numbering of Tamarind approach grafts at Salem FRS

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

Documentation and analysis of existing knowledge/information in respect of institute wise selected 60 LKFPs for their prioritization was completed. A structured format in consultation of the partner institutes for prioritization of the LKFPs was developed. Scoring of the institute wise selected 60 LKFPs was done in the format and following LKFPs were prioritized for their intended investigations.

AFRI: *Balanites aegyptiaca, Citrullus colocynthis, Xanthium strumarium, Sterculia urens*

FRCER: *Vitex negundo, Pithecellobium dulce, Mallotus philippinensis*

FRI/ HFRI: *Neolitsea pallens, Cupressus torulosa, Punica granatum*, *Prinsepia utilis*

IFB: *Soymida febrifuga, Buchnania axillaris, Gardenia gummifera*

IFGTB: *Balanites aegyptiaca, Careya arborea, Cassine glauca, Vitex altissima*

IFP: *Cinnamomum cecidodaphne, Pithecellobium dulce, Schima wallichi*

RFRI: *Litsea cubeba, Mallotus nudiflora Carallia brachiate*

TFRI: *Anogeissus pendula, Careya arborea, Cyprus rotundus, Woodfordia fruticosa*

Compilations of the reviews in respect of all the selected 60 LKFPs were completed. However, their examination and finalization in fulfillment of requirement of the technical database was continued.

Field survey, identification and authentication of population lines of the shortlisted plant species

AFRI: Surveys were conducted and populations of *Xanthium strumarium* in Abu Road block of Sirohi district, Desuri region of Pali district and Bandhiyagarh, Surpagla; *Citrullus colocynthis* in Phalodi/Pokaran, Jodhpur local and Jaisalmer areas and *Balanites aegyptiaca* in local areas of Jodhpur, Dangiawas, Kaparda, Pali district (Moriya, Bassi), Chotila and Parasaram Mahadev), Kambaleshwar Mahadev in Sirohi district (Rajasthan) and Khedbrahma and Himmmat nagar (Sabarkantha) in Gujarat were identified.

FRCER: Surveys were conducted and population lines of *Pithecellobium dulce* (Near Prayag station, Prayagraj, Phaphamau, Prayagraj, Medical chaurahe, Prayagraj, Chitrakoot , Pratapgarh , Mirjapur, Kunda, Jaunpur, Kaushambi, Jhusi, Kanpur, Badaun), *Vitex negundo*(Vishwanathganj , Shankargarh, Arail Ghat, Tharwai, Baluaghat, Hanuman dhara, Jankikund Marg in Prayagraj;. Satihara and Paina inDeoria, Arogyadham in Chitrakut) and *Mallotus phillepensis (*Gorakhpur, Mahrajganj Gonda Lakhimpur kheeri Pilibhit, Aurangabad, Biswan and Prayagraj) in Uttar Pradesh for the study were identified. Leaves of *Vitex negundo* from various populations identified in Prayagraj, Pratapgarh, and Chitrakoot districts were collected and their geocordinates were also recorded. The leaves collected from the populations of Prayagraj, and Chitrakoot were sent to the FRI, Dehradun for essential oil extraction. Seeds of *Pithecellobium*

dulce were collected from Phaphamau, Saraswati Ghat (Yamuna Bridge) and Medical College Campus (nearby site Athiti Grah Guest House and A.N.Jha Hostel), Prayagraj locations and sent to FRI, Dehradun for fatty oil extraction.

FRI: Surveys were conducted and 9, 7, 6, 2 population lines of *Cupressus torulosa, Neolitsea pallens, Prinsepia utilis,* and *Punica granatum*, respectively in Uttarakhand and Himachal Pradesh forest areas for the study were identified.

HFRI: Surveyed forests in Shimla (Theog, Kotgarh, Rampur and Kunihar, Dhami- Potter Hill-Ghanahatti, Basantpur-Sunni-Karyali), Solan (Arki, Shalaghat, Sabathu, Bathalang) also in Chamba (Dalhousie, Khajjiar, Tissa, Bairagarh) and Mandi (Devidadh, Janjheli, Shakardehra) districts for distribution/ of population lines of *Cupressus torulosa Neolitsea pallens, Prinsepia utilis* and *Punica granatuu.*

Fig. 23 *Punica granatum* (Daru) leaf and rind after extraction

IFGTB: Surveys have been made for identification of potential sources of selected LKFPs in Salem and Namakkal districts. Field survey and identification of population lines of *Balanites aegyptiaca, Careya arborea, Cassine glauca and Vitex altissima* was conducted in the Western Ghats.

IFB: Surveys were conducted and a total of sixteen population lines of *Soymida febrifuga,* nine population lines of *Buchnania axillaris,* and nine population lines of *Gardenia gummifera* in Telangana were identified.

IFP: Surveys were made and 23 population lines of *Schima wallichii,* 6 population lines of *Cinnamomum cecidodaphne* and 15 population lines of *Pithecellubium dulce* have been identified in the forest areas of Jharkhand and West Bengal.

RFRI: Surveys were conducted and 40 population lines of *M. nudiflorus* and five population lines of *Litsea cubeba* in Jalukonibari, Chenijan and Rangajan, of Jorhat, Digboi arboratum, Tinsukia district, and Galaki, Sivasagar district in lower Brahmaputra Valley, Upper Brahmaputra valley, Hill Zone and North Bank were identified.

TFRI: Surveys were conducted and population lines of *Cyprus rotandas* and *Woodfordia fruticosa* in 7 and 11 districts of Madhya Pradesh for the study were identified. Populations of *Careya arboreya* were also identified.

Chemical screening of the identified populations and determination of their chemical variability

AFRI: Collected fruit samples of *Citrullus colocynthis* from Phalodi/Pokaran, Jodhpur and Jaisalmer areas (3 population lines), and processed for recovery of seeds. Seeds were isolated and extracted with petroleum ether to yield fatty oils (16.87% to 21.06%).

Collected dried fruits of *Xanthium strumarium* from Pali/ Desuri area and processed for recovery of seeds. Seeds were isolated and extracted with petroleum ether to yield the fatty oil. Samples of *Xanthium strumarium* collected from Desuri and Pali region were processed for oil extraction. On an average 34.27% oil was extracted in samples collected from Jaiselmer (Nachna) and 30.30% oil was extracted in samples collected from Pali. Physical characters of fruits viz. diameter of seeds, no. of seeds in 100g etc. were also recorded.

Collected fruits of *Balanites aegyptiaca* from local area of Jodhpur, Dangiawas, Kaparda and two samples from Pali (Moriya & Bassi) and processed for recovery of seeds. Samples of *Balanites aegyptiaca* fruits collected from Pali district (Moriya and Bassi) were depulped and processed for oil extraction. Processing of seeds is very difficult as there is woody seed coat which is very hard. Seed coat was removed by holding of seeds with multiplier followed by beating of woody fruits by hammer. Seeds were ground into fine powder and processed for

oil extraction. On an average 48.4% oil was extracted in samples collected from Pali and 47.33% in samples collected from Jaiselmer. Physical characters of fruits viz. diameter of seeds, no. of seeds in 100g etc. were also recorded.

FRCER: Leaves of three populations of *Vitex negundo*, growing in Deoria, Prayagraj, and Chitrakoot, were collected, shade dried and stored for their essential oils examination.

FRI: Needles of *C. torulosa* were collected from the trees growing at nine locations including SuaKholi (Mussorrie), FRI Dehradun, Chakrata, Gopeshwar, Dungar, Chirbatya, Bhatwari, Jhala in Uttarakhand and Majhrana forest in Himachal Pradesh, hydrodistilled and their essential oil contents were determined. The yield of essential oil varied from 0.18% (Chakrata) to 0.76% (Dungar). The needles from the trees of *C. torulosa* growing at nine locations were lyophilized, defatted and their extractives were prepared using chloroform and 20% aqueous methanol, separately for their chemical Leaves of *N. pallens* were collected from the trees found in seven locations namely, Himri, Majhrana Forests, Bharana Link Road, Kotgarh, Nankhari Road, Gahan Forest Block and Taklech Forests of Himachal Pradesh and their essential oils were isolated, their contents were determined and found to be ranged from 0.1-1.1%.

Seeds of *P. utilis* collected from Chakrata, UK and Shilarru (Shimla), Rieya forest (Kullu) of HP were Soxhlet extracted with hexane and their fatty oils (43%, 36.13 to 43.88% and 35.06 to 40.17%, respectively) were isolated. Leaves of *P. utilis* from the trees occurring in Dungar, Chirbatya, Bhikhalpani, Ganglani, Jhala, and Chakrata locations of Uttarakahnd were collected, lyophilized, defatted and their extractives using chloroform and 20% aqueous methanol, separately for their chemical profiling were isolated. Process of optimization for production of dye from the peels of *Punica granatum* was continued. Seeds of *Pithecellobium dulce* collected and sent by FRCER from three locations were Soxhlet extracted with hexane and their fatty oils were isolated in the yield varied from 10.68% to 12.94%. Essential oil extraction of the *Vitex negundo* leaves was initiated and continued. Fatty oils from the seeds of 10 different populations of *Mallotus nudiflorus* collected Soxhlet extracted with hexane and their fatty oils were isolated in the yield varied from 2.86% to 18.45%. The yield data of the *Cupressus torulosa* needles essential oils of the

Suakholi, Tuneta, Chakrata, Gopeshwar, Dungar, Chirbatya, Bhatwari, Jhala of Uttarakhand and Majhrana were subjected to ANNOVA and Turkeys post hoc test analysis using SPSS version 23. ANNOVA showed that the yield of these essential oils varied significantally ($P<0.05$) while Post hoc analysis showed that the essential oils of Bhatwari and Gopeshwar locations did not differ significantly ($p>0.05$).

HFRI: Collected/harvested the leaves from *Cupressus torulosa* (from one population line, *Neolitsea pallens* (from eight population lines) , and *Prinsepia utilis* (from three population line) and the fruits / peels of *Punica granatum* (from nine population lines). and submitted to the NPC at Dehradun.

IFB: Bark samples of *S. Febrifuga* and *B. Axillaris* were collected from 15 and 7 populations, respectively. Gum resin from *G. gummifera* was collected from four populations. Bark samples of *S. febrifuga and B. axillaris* were dried, milled and packed in airtight plastic cover. Methods for extraction of dye from the barks of *S. febrifuga and B. axillaris* were standardized according to Box- Behnken design which showed that *S. febrifuga and B. axillaris* bark dye could be produced in yield of 19.66% and 24.6%, respectively using the MLR (6g:100 and 3g:100, respectively), pH 11.0 and duration 45 min.

IFP: Bark samples from 23 populations of *Schima wallichii*were collected and processed for their chemical screening. Standardization of method for extraction of dye from the bark of *Schima wallichii* was initiated and continued.

IFGTB: Ripened fruits of *Balanites aegyptiaca* (Nanjunda) were collected from Coimbatore and the fruits were processed. *B. aegyptiaca* seeds were subjected to fatty oil extraction using Petroleum ether, and n - Hexane. Yield of the oil was 10 % and 36%, respectively. n - Hexane was chosen for chemical screening of *B. aegyptiaca* populations. 2 kg leaves and 3 kg barks of *C. arborea* were collected. The samples were shade dried at room temperature, milled and stored for further chemical examination. Geo coordinates of the tree were also marked. Physical parameters of the collected bark samples were recorded. Standardized the conditions of MLR (17.5:100), time (55 min), and pH 8.0 which could produce natural dye form the bark of *Careya arborea* in yield of 1.24%.

RFRI: Fruits from populations of *Mallotus nudiflorus* were collected and depulped. The seeds were extracted and stored at -20°C. Fatty oil from the seeds of 14 populations *M. nudiflorus* was isolated.

TFRI: Isolation of essential oils from the rhizomes of *Cyprus rotandas* collected from 7 districts of Madhya Pradesh was completed. Standardization of the method for extraction of dye from the flowers of W*oodfordia fruticosa* was initiated and continued.

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

Literature on fodder trees and grasses was collected by all the nine participating institutes under ICFRE for different regions of India. Potential sites were identified by the institutes for respective regions. SFDs, other departments and farmers have been approached to provide land for field trials. To select the sites, the sites were visited during the period. Seed of the fodder trees was procured. Grass seed or plants were purchased. Sowing was done in the nursery.

The finalised sites were fenced and field trials were laid out as per design supplied by the NPC. The number of sites where field trials have been established by different institutes is: AFRI 1, FRI 3, HFRI 1, IFP 3 and TFRI 1. The target no. of sites is 2 each for HFRI, IFB and RFRI, and 3 each for FRI, AFRI, IFP, TFRI, IFGTB and IWST. Planting is in process at some institutes according to rainfall pattern and irrigation facility.

Baseline survey of fodder usage and storage practices in village around trial sites will be done after finalisation of sites. Collected literature on silage making, and initiated experiments on silage making at FRI and HFRI. FRI collected literature on natural repellents to herbivory, prepared three repellents.

Minor equipment that are proposed to be purchased under the project are in various stages of purchase. Project staff was appointed in March 2020 at all institutes; the staff worked till July 2020/August 2020 and was discontinued thereafter due to limited funds and limitations in

working due to COVID-19. The staff has been appointed again at institutes according to funds availability.

The major focus of the project is on field trials at all institutes. Each institute will lay out trials at 2-3 sites. In the field trials innovative studies are planned on:

a) High density plantation model of trees for fodder production under the project. The espacements to be tested are as under: 1m x 1m, 1.25m x 1.25m and 1.5m x 1.5m
b) Coppicing of trees to produce multiple shoots and explore fodder harvest at young age and multiple times per year. Fodder harvest frequency: Once/year, twice/year and thrice/year

Three grass species are also being tested at each site. The NPC obtained online training on fodder management at ICAR- Indian Grassland and Fodder Research Institute (IGFRI) Jhansi. The NPC is disseminating the knowledge and other directions to the PIs through guidelines for project implementation.

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

IFGTB Coimbatore conducted assessment on growth done in 5 block and 5 boundary teak plantations, 25 *Gmelina arborea* plantations. Procured 10,000 Casuarina hybrid clonal plants for establishing mixed planting with teak and established teak & Casuarina mixed boundary planting in 2 locations. Surveyed and identified block plantation of *Gmelina* at farmers fields viz. Greenwood Agro plantation, Village- Tewar, Jabalpur ,Village-Tinsi, near Bargi,Jabalpur, Phoenix Farm,Dehri-Kalan, Jabalpur and recorded data on growth recorded from the different block and Boundry plantations of *Gmelina* under different irrigation methods like Flood irrigation(traditional method). At TFRI, Jabalpur field trials established in 1 ha under mixed block plantation of Teak and Casuarina in two ratios viz, 1:1 ratio and 1: 8 ratio under irrigated condition. Established field trial of 1 ha of teak in **boundary** plantation at 2 m spacing under irrigated condition. Established field trials in 3 ha 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. Established Field trials of teak in **boundary** planting at **2 m spacing** for establishment in 3 ha *Acacia auriculiformis* on either side of the teak row (1 m away from teak row) under rainfed condition is established at Village-Hinautiya, Barela block, Jabalpur district. **IWST, Bangalore** carried out assessment of Teak plantations in Shimoga and Gulburga for availability of sites to carry out field experiments. Some more plantations of Teak in farmers field in Mysore, Mandya, Chamarajanagar and Kolar will be assessed for taking up of field experiments. Five plantations each of block plantation and boundary plantations of age above 10 years were surveyed. Girth at breast height and height of the trees are recorded for calculating the biomass of the plantation. **AFRI, 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. Growth assessment done in 4-year-old cadamba plantation and 3-year-old teak plantation raised with drip irrigation system at FCRI, Mettupalayam. Continued growth assessment in these two plantations during the current year as well. Recorded growth biometrics in four block plantations of teak at i) Alangombu, ii) Pungampalayam, iii) Sirumugai, and iv) Bagathur of Mettupalayam taluk, Coimbatore district.

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

This 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. Four ICFRE institutes (TFRI, Jabalpur; IFGTB, Coimbatore; AFRI, Jodhpur and FRI, Dehradun) are involved in the project.

Fig. 24 Weather station at AFRI, Jodhpur

Protocol for instrumentation and data recording has been finalized. Sites for the study have been selected and necessary approval obtained for establishing experimental setup by all the partner Institutes.

Purchase order has been placed for the Sap flow meters which are being procured centrally by FRI for all the partner institutes.

Core samples extracted to measure sapwood thickness were also analysed using tree ring analyzer –wind Dendron software to estimate age of the tree.

Hydraulic conductivity of soil was measured from 0-30 and 30-60 cm soil depths at Sal forest, Champion block of Forest Research Institute at different pressure head. Hydraulic conductivity k (h) at 0 cm pressure head ranged between 0.008 and 0.068 m/s^{-1}. It ranged between 0.006 and 0.086 m/s^{-1} at -1 cm pressure head and between 0.004 and 0.005 m/s^{-1} at -3 cm pressure head.

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 preformulation of **Tree PAL** and **Crawl clean** to ICFRE Institutions for nursery and field evaluation against key forest pests is done periodically. Collection of seeds and wild plant parts with potential insecticidal properties, processing and extraction of oil using different organic solvents in progress at different centers. Isolation and identification of effective biopesticide compounds using spectral analysis (UV, HPLC, GC MS, NMR etc.) in progress at different centers.

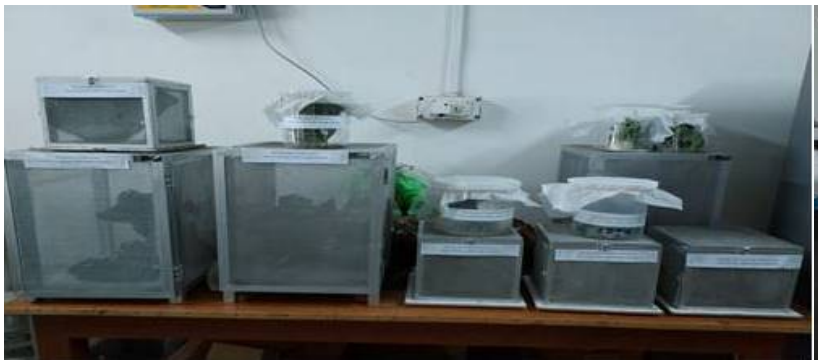


Fig. 25 Mass rearing of larval defoliator of teak

Fig. 26 Prepared stock solution of Mahua and Jatropa

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

At IFGTB, Coimbatore seedlings (5 replicates) dried in oven at 50°C for 48 hours to measure the biomass. Later 5 g dried root and shoot samples were digested with potassium sulphate and copper sulphate (5:1) + triple acid (nitric + sulphuric + perchloric at the ratio of 9:3:1. These samples were analysed for tissue nutrient contents of N, P and K in Skalar auto analyser. The results showed the biofertilizers inoculated seedlings showed more nutrient content (N 5.4 mg g^{-1}) , P (4.6 mg g^{-1}) and K 3.9 mg g^{-1}) than the un inoculated control seedlings. The seedlings of *Gmelina arborea* showed increased growth and biomass than the uninoculated control seedlings (Inoculated Height: 60.8 cm; stem girth 2.1 cm: Control Height;15.21 cm; Stem grith 0.84 cm) The anatagonistic activity of the biofertilizer *Azospirllum brasilense* was studied and showed that the biofertilizer suppressed the growth of *Fusarium oxysporum* in the laboratory conditions. Field trial of *G. arborea* in RBD was established inoculated with both IFGTB and Commercialbiofertilizers at Dharmapuri.

Fig. 27 Bio fertilizers inoculated seedlings of G. arborea

At FRI, Dehra Dun growth data collection of IFGTB developed bio-inoculants is under progress. Dry weights of shoot and root were taken after 180 days of inoculation. Standardized the optimum dosage of bio fertilizer inoculation for *D. sissoo*. Standardized dosage of inocula of IFGTB bio-fertilizers in *Santalum album* was done Mass multiplication of bio-fertilizers from taking strains of IFGTB developed bio-fertilizers was initiated.

At TFRI, Jabalpur soil physiochemical characteristics such as pH, EC, Nitrogen (N), Phosphorus (P), Potassium (K), Copper (Cu), Zink (Zn), Iron (Fe) and Manganese (Mn) was analysed by following standard procedures. Raising of seedling of selected commercially important forestry species (*Gmelina arborea*, *Dalbergia sissoo*). *Santalam album* again trying to raise.Growth data collection and identification of efficient bio-fertilizer is going on.Calculated the antagonistic effect of bio- control agents against pathogens by growth incidence.Isolate soil and root borne pathogens in tree nurseries.Mass cultivation of *Fusariumoxy sporum*.The efficacy of different bio-fertilizers against *Fuserium spp*. and *Thielaviopsis spp.* got good inhibition zone under in *vitro.* Isolates some pathogenic fungi from soil (*Penicillium Sp. Aspergilus sp. Alternaria sp. Fuseriumsp,* etc.) Visited Seoni, Balaghat, GondiyaRamtake and surrounding area for site selection and preparation for establishing field trials.

Fig. 28 Mass multiplication of bio-fertilizers

At RFRI, Jorhat as per methodology standard doses of each biofertilizer and consortia have applied in three months old seedling of *G. arborea* (AAU & IFGTB biofertilizer*)* and *S. album* (IFGTB biofertilizer) and *D. sissoo* (IFGTB biofertilizer) respectively. Growth data of *S. album* and *D. Sissoo* was recorded after 90 days and 180days of treatment interval. Initial growth data was recorded before biofertilizer treatment. At IWST, Bangaluru iIsolation and culturing of Fusarium and Pseudoidium pathogens was done and cultures are maintained at Microbiology /

Pathology laboratory, IWST. And before carrying out the field experiment, antagonistic activity test against the Fusarium oxysporum pathogen was done at laboratory conditions, after that, dual culture test with selected bio- fertilizer's versus fungal pathogen and analysis was done.

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

The soil sample collection strategy was derived with the help of GIS and remote sensing techniques. The stratification criterion based on forest types and forest cover, focusing on degraded forests in different forest divisions of India during the initial year of project. Accordingly, the digital maps from by FSI, FAO, and divisional boundaries of forest divisions from SFDs were used to derive the sampling locations. These geo-coordinates of sampling points in the different forest divisions of India were also statistically validated and communicated to all participating institutes for collecting the soil samples. From this, **HFRI** have collected 234 soil samples from two forest divisions, **FRI** collected 384 soil samples from 7 forest divisions, RFRI collected 402 soil samples from 7 forest divisions, **TFRI** collected 310 soil samples from 19 forest divisions, **IFGTB** collected 59 soil samples, **IFP** collected 900 samples from 20 forest divisions and **IWST** collected 232 soil samples. Institutes also worked out technical specifications of scientific equipment, procured and installed them to strengthen soil testing facilities in the previous year. Resultantly all the regional soil testing laboratories are fully functional except IWST Bangaluru. A manual for soil sample collection and testing was prepared and circulated to all participating institution for adhering to the prescribed procedures and uniform methodology to be followed in all the institutes.

IFP Ranchi (one of the participating institutes) organized training on soil survey to the nominated employees of all ICFRE institutes regarding soil testing methods for macro and micro nutrients, handling on soil testing equipment nutrient management and carbon sequestration. Accordingly, all the Institutes have started soil sampling from suggested locations and initiated soil testing as per the prescribed procedures. In total, ICFRE Institutes has collected about 2521 soil samples and are being processed and analyzed for the twelve parameters mentioned in the present project (pH, EC, OC, N, P, K, S, Zn, B, Mn, Fe and Cu). For

developing Soil Health Portal for forest soils, NIC Delhi was also visited and discussed about changes to be included in soil health card portal were also suggested.

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

At TFRI, Jabalpur surveys were carried out and tours were conducted to different locations in Maharashtra and Madhya Pradesh. Around 200 trees have been selected. Flowers, fruits, seeds, branch cuttings and leaf samples were collected from selected superior trees from - Kondagaon, Kanker, Dhamtri, Mahasamund, Balodabazar, Marwahi, Surajpur, in Chhattisgarh and Mandla, Balaghat, Guna, Chhatarpur, Jabalpur, Madhya Pradesh Narsinghpur and Hosangabad. Morphological characterization of flowers and seeds was done. Fresh flower weight (g), fresh flower length (cm) and fresh flower width (cm) was recorded. Drying and processing of flowers was carried out. Seeds were collected from the 200 selected trees and morphological characterization was done. Seedlings of selected trees were raised in the nursery. Soil samples were collected from each location.

The cuttings were collected from selected trees and planted in mistchamber after treatment with 1000 ppm IBA. Scions were collected from 10 phenotypically superior trees with diameter size of 0.5-1 cm and length of 12-20 cm. Cleft grafting was carried out in 50 root stocks. Studies on natural regeneration were carried out at three locations Chhatarpur, Umaria and Mandla in Madhya Pradesh and one location Surajpur in Chhattisgarh. Natural regeneration was recorded in these locations and morphological parameters of the regenerated seedlings, saplings and trees were noted down. DNA extraction work has been initiated from the leaves of *Madhuca longifolia* and DNA was extracted from 56 trees. ITKs were recorded through discussion with local people in villages of Mandla, Chhatarpur and Umaria, in Madhya Pradesh and Kanker, Kondagaon, Dhamtari and Mahasamund, in Chhattisgarh. Videographical and photoghrapical records of ITKs were observerd viz., for storage of flowers, processing of flowers and seeds, traditional uses, etc.

IFGTB, Coimbatore carried out survey in local areas of Coimbatore District, Madurai District, Thiruvannamalai District, Salem District, Tirupur District and Dharmapuri District. Totally 40 phenotypically superior trees were selected from different locations of Coimbatore District, Madurai District, Thiruvannamalai District, Salem District, Tirupur District and Dharmapuri

District. The stem cuttings, flowers, fruits, and seeds were collected. Stem cuttings were collected from selected superior trees and propagated with the applications of IBA 1000 and 2000ppm, shoot initiation was observed after 7 - 10 days, rooting was observed after 65 - 80 days. Plants raised through stem cuttings were transferred from the polytunnels to the outside shade house for hardening process. Phytochemical analysis of leaves has been carried out from 19 superior trees. Fruits and seeds were collected, various measurements such as length and width of fruits and seeds were carried out. Phytochemical analysis like sugar analysis has been carried out in flowers and leaves of *Madhuca longifolia* collected from different locations. Estimations of oil percentage from seeds have been initiated. Seeds were pretreated with water and H_2SO_4 and sown in sand bed for germinations. Water treatment of seed shows better results. Once seed germinated the seedlings were transferred into polybags. Grafting has been carried out to produce quality planting materials. Stem cuttings were collected from Dharapuram, Thirupur District were grafted with root stock. Molecular work has been initiated; DNA isolation and its optimization are in progress from selected trees. Regenerations study has been carried out in Coimbatore District in one location. Indigenous traditional knowledge was collected and documented from Dharapuram, Tirupur District and in Madurai District through photos and videos. **IFP, Ranchi** was carried out in three agroclimatic zones of Jharkhand and one zone of each of Bihar and West Bengal states. Survey was carried out in total 16 districts for selection of superior trees of Mahua (*Madhuca logifolia*). So far 65 phenotypically superior trees were selected from three states. Data on tree height, GBH, crown diameter, number of branches etc were recorded for each selected trees. The GBH of selected CPTs ranged from 1.09 m to 2.80 m. GPS data of each location were also recorded. Flowers and fruits of CPTs were collected and data were recorded. Seedlings are being raised in nursery Later on, these seedlings will be used as root stock for grafting. Scions were collected from six CPTs and more than 50 grafts were made. **FRC-ER, Prayagraj** carried out survey for selection of *Madhuca longifolia* trees in Meja, Pratapgarh and Prayagraj Forest Division. Total 110 phenotypically superior trees were selected in Vindhyan region, Gangetic plains and Bundelkhand region. Morphometric data of trees viz., Total tree height, Clear bole height, GBH, crown diameter and number of branches was recorded for each tree. Morphological characterization of seeds was

carried out and the parameters recorded were seed length, width and weight. Seed were collected from 46 CPTs. A nursery as also been raised from seed of Mahua collected from marked CPTs. Natural regeneration of Mahua was recorded in Multanipur, Pratapgarh, Gangetic plains region. Indigenous Traditional Knowledge has been recorded in Pratapgarh range in Gangatic plains. **IFB, Hyderabad** did survey in AP, Odisha, Telangana State Forest Departments to conduct the studies in the states. Tours were conducted to Kamareddy, Banswada, Manuguru, Paloncha and Yellandhu divisions in Telangana. A total of 81 phenotypically superior trees were selected and traits like GBH, crown diameter, height, etc. of the selected trees were recorded along with GPS coordinates while the flower traits were recorded for 31 selected superior trees. Finalization of a site for conducting regeneration study in Telangana. Observation of pest infestation in *Madhuca* in the surveyed regions. Few of the unrecorded pest infestations were noted. Renovation of nursery for maintenance of *Madhuca* seedlings and cuttings. Cuttings collected from 46 selected phenotypically superior trees. Rootstocks are being raised for grafting. Documentation of ITKs related to post-harvest processing of mahua flowers, fruits and the utility of products obtained post-processing were documented in Kamareddy, Banswada, Manuguru, Paloncha and Yellandhu ranges/divisions of Telangana through videos and photos.

Fig. 29 Mahua flowers collection, drying and processing done by improved method

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

AFRI, Jodhpur carried extensive survey was done in Bikaner, Jaisalmer and Jodhpur for site selection. Udasar site at Nokha, Bikaner was selected for plantation under sand drift control.

Seeds of *Ziziphus nummularia, Mytenus emarginata, Calligonum polygonoides* and *Cenchrus cilliaris* were collected and seedling raising is under progress. For models of degraded hills restoration a site in Lunawas Bhakhar was selected seedlings of *Anogiessus sericea* & *Ziziphus mauritiana* raised. Another site for restoration of degraded sandy area was selected at Karah Jod in Jaisalmer. Seeds of *Acacia senegal* collected and the seed sowing was done on bund of two cluster of farmers group at Chourdia and Khet Singh Nagar, Setrawa, Jodhpur.

Fig. 30 Preparation of seed ball of A. senegal

At **HFRI, Shimla** survey carried out in Cold Desert area at Tabo, Poh, Maine, Lalung and Gue areas of Himachal Pradesh and at Meru, Opasi and Shey area of Ladakh region for knowing tree, shrub and associate species. The dominant species found in Himachal Pradesh were *Juniperus polycarpos, Salix alba, Rosa webbiana, Colutea nepalensis, Hippophae rhamnoides*, *Populus ciliata, Salix fragalis, Myricaria squamosa, Artemisia sp, Lonicera sp, Cousinia thomsonii, Plantago sp.,* etc. Whereas, in Ladakh region, main species found were *Populus nigra, Salix alba, Salix fragilis, Rosa webbiana, Hippophae rhamnoides*, *Rosa webbiana, Artemesia sp., Plantago sp., Pedicularis sp.* etc. Survey was carried out in five villages, i.e. Tabo, Poh, Maine, Lalung and Gue for selection of cluster of farmers for live fencing and for establishing snow harvesting structures. The snow harvesting devices/ structure were constructed at Tabo, Lalung and Gue for augmenting water supply to the selected clusters of farmers. Collected seed and cutting of *Populus* sp, *Salix* sp, *Rosa webbiana, Coultea nepalensis*, *Juniperus polycarpos, Fraxinus xanthoxyloides, Elaegnus angustifolia* for raising nursery stock. The area of 1 ha. for plantation at Badami Bag, Leh and 8 ha at Sushna, Gue and Rama area in cold desert region of Himachal Pradesh has been selected. The plantation of *Juniperus polycarpos* in 1 ha area has been done at Badami Bag, Leh. **TFRI, Jabalpur** selected 20-ha plot in Morena district of M.P. for raising plantation of suitable tree species in consultation with SFD officers. Vegetation survey has been

conducted near the selected site to get a broad understanding of indigenous species of grass, herbs, shrubs and trees. Soil samples were collected from plantation site and processed and analyzed in laboratory for their physico-chemical characteristics and texture. In **FRI, Dehradun** samples were collected from eight accessions of *S. oleoides*. Overall, 200 cuttings from different accessions were treated with IBA at concentration of 2,000 ppm processed in April, 2021. Shoot outgrowth has been observed in the cuttings after 10-15 days of placement of the cuttings in the mist chambers. Root initiation were observed in 30% cuttings in 45-60 days. The rooted cuttings were transferred to the nursery in polybags containing steam autoclaved potting mixture in third week of June 2021.Tours for the site visit were conducted during August 2021 for Jhansi (UP) and September 2021 for districts of Punjab state. Total of 11 soil samples (6 of the Jhansi and 5 of the Punjab) were collected in different depths. All the collected soil samples were analysed for pH, EC, SOC, N, P, K, Na, porosity and texture. **IFGTB, Coimbatore** planting stock production of seedlings of Casuarina species (2000 nos.) for plantation of these species along the field boundaries was initiated. Identification of lands for establishment of field trials in the Southern and Western Agro climatic zone has been initiated.

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

Plants of 16 clones (15 clones produced by FRI and one control clone) have been planted in nurseries. The plants will be planted during late-January or early February 2022 in field trials at five sites by FRI (3 sites), IFP and HFRI (1 site each). One site for planting has been finalised and three sites are in advanced stage of selection. Seedlings of four provenances (in W. Bangal, Nagaland and Arunachal Pradesh) of *P. gamblei* have been raised by RFRI for establishing provenance trial during monsoon season of 2022. Experiment on vegetative propagation of *P. gamblei* through mini cuttings as well as branch cuttings is in progress and the rooting and survival of cuttings has so far been low (2-5%). For introduction trials of *Populus alba* and *P. gamblei,* cuttings were planted in the nursery by HFRI and RFRI respectively. Cuttings of *P. alba* rooted but sprouting did not take place and the cuttings failed to survive. In *P. gamblei,* rooting did not take place and only 2-5% cuttings survived. Fresh cuttings of the two species will be

collected and planted in nursery during spring 2022 for outplanting during 2022-23. Information was collected on natural population of *P. alba* in Distt. Kinnaur (Yangthang, Akpa, Pooh) and Kungri in Lahaul & Spiti from H.P. State Forest Department and also from published literature. Natural populations of *P. ciliata* were surveyed at Shillaroo, Narkanda, Batnal, Thandar, Oddi (Kotgarh Forest Division), Fagu (Theog Forest Division) and Shimla local. Recorded morphometric traits of *P. ciliata* and geo-coordinates of all the sites. DNA extraction protocols of *P. alba, P. gamblei, P. deltoides* have been completed and characterisation of DNA has been initiated. Surveys of disease and insect attack have been conducted by FRI in parts of Uttarakhand, Punjab and Haryana. Insect pest infestation was studied in populations of *P. ciliata* at Kotgarh and Theog Forest Divisions. Disease infestation of *P. deltoides* was also studied FRI and DNA was successfully isolated from four fungal isolates. Plantations of *P. deltoides* have been identified for collection of lops and tops and small wood. The wood material for making oriented strand board and glue lam will be harvested during leafless stage of trees during December 2021.An oriented strand board was made from wood of *P. gamblei.*

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

AFRI Jodhpur carried out survey and selection of 40 Candidate plus trees of Neem from Deesa and Gandhinagar Division of Gujarat (agro-climatic zone-13) and 74 Candidate plus trees from Nagaur, Jalore, Sikar and Jodhpur districts of Rajasthan (agro-climatic zone-14). Oil extraction and estimation was completed from the processed 46 seeds samples. For phenological study, Neem trees were marked at AFRI, Jodhpur. Morphological (tree height, diameter, health, crown) and phenological data (flowering, fruiting pattern) were recorded for each of the marked trees. Agrobacteriun suspension cultures of strains LBA4404, GV3101 and EHA105 were maintained as stocks as well as live cultures. Agrobacteriun with pCAMBIA vector used for cocultivation of neemcalli. Gus+ calli obtained confirming successful transient transformation event. Agrobacteriun elimination was pretty much achieved with antibiotic combinations. GusA expression after 12 weeks or later was achieved and Stable transformation achieved. More experiments on co-cultivation continued. Cdh (Choline dehydrogenase) was cloned at ICGEB

has been put in a plasmid vector. Co-cultivation experiments with cdh gene carried out. PCR based confirmation experiment was carried out for integration of gusA and hptII gene. Both genes bands were obtained and successful transformation event was achieved. Rooted plants however did not survive upon further subculturing. Transformed cell lines were further sub-cultured as callus. Hygromycin-B based selection did not work in neem. Alternative strategies are being looked into. GlyIII based gene construct has been procured and the Agrobacterium cells have been cultured. Co-cultivation experiments to begin shortly. GlyIII based gene construct was successfully transferred to Agrobacterium strains. Co-cultivation experiments optimized with pCAMBIA vectors in last year were used with GlyIII vector as well. Results are awaited. Putative transformant callus cultures are growing well. PCR based confirmation experiment was carried out for integration of gusA and hptII genes. Both genes bands were obtained and successful transformation confirmation of successful transformation event in neem cell lines. These experiments were mostly repeated for confirmation only and data collection.

Fig. 31 a-d) Fruits spread for drying after collection; e-f) Shade drying seeds after de-pulping; g) Phenological observation: Leaf initiation in Neem.

IFB Hyderabad conducted tour to six forest divisions of Yavatmal, Amravati, Buldhana and Akola districts. Selection of CPTs from different ranges and beats was initiated with the help of SFD officials 176 trees were selected. Amravati district exhibited maximum mean height (19.73m), followed by Akola (17.61m), Buldhana (16.17m) and Yavatmal (15.70m). The highest mean girth was exhibited in Akola district (2.22m), followed by Amravati (2.16m), Yavatmal (2.06m) and Buldhana (1.96m). The maximum mean crown diameter was exhibited in Amravati district (15.29 m), followed by Akola (14.56m), Yavatmal (14.11m) and Buldhana (12.80m). The highest average crown length was exhibited in Amravati district (16.38m), followed by Akola (14.60m), Buldhana (13.32m) and Yavatmal (12.81m). The maximum average number of primary branches was exhibited in Yavatmal district (2.64), followed by Buldhana (2.42), Akola (2.31) and Amravati (2.30).

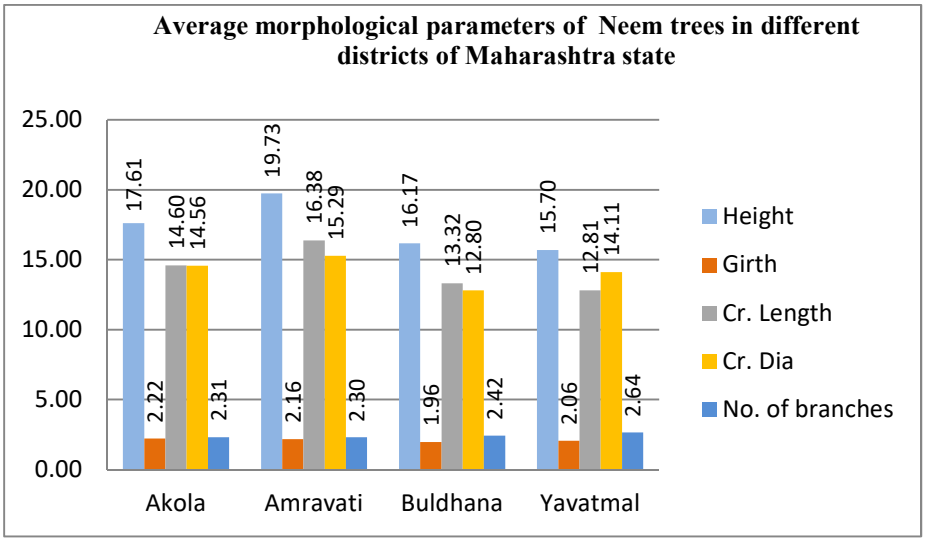


Fig. 32 Graph showing average morphological parameters of Neem trees in different districts of Maharashtra state

TFRI Jabalpur did in different locations of Madhya Pradesh in Agroclimatic zone 8.49 trees were selected from in and around Jabalpur, Shahpura, and Katni forest divisions. 28 trees were selected from Sohagpur (Narsinghpur Forest Division), Vikramnagar and Itarsi (Hoshangabad Forest Division). Geographical locations were noted using GPS. Soil samples were collected from six different locations in Madhya Pradesh (Sohagpur, Vikramnagar, Itarsi, Jabalpur, Shahpura and Katni) and soil analysis was performed to evaluate soil properties, viz., pH, EC, SOC and Total Nitrogen. For phenological studies, observations (Number of branches, leaf fall,

leaf initiation, and flowering initiation and peak flowering) were recorded from 30 trees of three different locations of Madhya Pradesh (Shahpura, Jabalpur and Katni). In total, so far **77** trees have been selected from six different locations of Madhya Pradesh.

IFP Ranchi conducted survey in three agroclimatic zones 3, 4 and 7 covering a total of 22 districts. So far 126 phenotypically superior trees were selected (Table 1). Data on tree height, GBH, crown diameter, number of branches etc were recorded for each selected trees. The mean of all parameters was higher in ACZ 7 than in ACZ 3 (Table 2). GPS data of each location were also recorded. Flowering and fruiting data were also recorded.

Table 1. Number of selected neem trees in different agroclimatic zones

Sl. No.	Agroclimatic zone	State surveyed	No. of trees selected
1	3 (Lower Gangetic Plains)	West Bengal	30
2	4 (Middle Gangetic Plains)	Bihar, U.P.	50
3	7 (Eastern Plateau and Hills)	Jharkhand, West Bengal, Chhattisgarh	46
	Total		126

Table 2. Mean of different traits of selected neem trees in different agroclimatic zones

ACZ	GBH	CBH	Height	E-W	N-S
3	1.21	3.32	9.81	10.85	11.22
4	1.54	3.07	10.53	12.19	12.09
7	1.62	3.35	12.36	13.75	13.47

IFGTB Coimbatore selected 120 CPTs based on superiority in fruit yield from 6 different agroclimatic zones. Collected fruits from the 120 selected CPTs and were processed for further estimation. Studying of variations in the flowering and fruit setting pattern is under progress in different populations of Neem located in Tamil Nadu. The neem oil have been extracted from 40 seed lots. Estimation of oil properties and Aza is under progress. 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. Under the Objective F, we identified accessions based on earlier works on neem improvement conducted at IFGTB. We initiated callus induction using flowers, leaf explants and immature embryos in ten different media combinations. The flowers produced callus weighing ~250mg,

while the cotyledon and leaf response was slow. The callus was transferred into suspension cultures. Since COVID travel restrictions prevailed, we could not collect neem samples with high aza. Instead, we estimated the aza content in the callus cultures obtained from the different plant parts. Flowers yielded highest aza, almost 50 percent observed in the seeds.

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

TFRI, Jabalpur surveyed Jabalpur, Mandla, Chindwara and Betul District of Madhya Pradesh and Dhamteri district of Chattisgarh for finding the distribution of *Flacourtia indica* and *Semecarpus anacardium.* Surveyed the villages of Jabalpur and Mandla District and observed that the fruits of *Flacourtia indica* and *Semecarpus anacardium a*re edible and collected by villagers from the nearby forests. Leaves of *Flacourtia indica* are used as fodder and branches are collected for fire-wood. Surveyed Dhamteri district of Chattisgarh and Chindwara and Betul district of Madhya Pradesh for finding local use and natural regeneration. Identified 18 superior plants of *Semecarpus anacardium* and 7 superior plants of *Flacourtia indica* on the basis of fruit and/or plant characteristics. The morphological data on the description of fruit and the plant and sugar content of the fruit of the selected trees were recorded. 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*. Nursery beds, polythene bags and root trainers are prepared for carrying out experiments on vegetative propagation. Polythene bags were found best for vegetative propagation. Cuttings of *Flacourtia indica* and *Semecarpus anacardium* were collected and experiments were initiated on effect of different doses of IBA and position of the cuttings on root generation. No root was produced in any treatment on *Semecarpus anacardium.* But 1000 ppm IBA in basal cuttings produced maximum shoot and root in *Flacourtia indica.* Different ratio of sand, fertilizer and soil were used for germination and growth of seedlings of *Semecarpus anacardium.* The experiment is going on. Desiccation and freezing sensitivity of seeds of *Flacourtia indica* had been done. On the basis of these trials the seeds of *Flacourtia indica* 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 and 6 months of storage. Determine shelf life time of 'Karonda chips' and 'Energy drink', new products 'Karonda Powder',"Khatmith goli", "Karonda Candey"and Cherry karonda prepared during the period. Nutritional analysis of all three value added products were done. New variety and collection area identified in Manendragarh C.G., Preparation of field for cafeteria in NWFP nursery also done during this period.

Fig. 33 Value added product 'Khat- Mith" goli & "Karonda Candy"

FRI, Dehradun tour was undertaken for survey and collection of fruit samples and cuttings of *Pyrus pashia* and *Ficus palmata* from Mussoorie forest Division (Mussoorie, Yamuna Bridge, Jaunpur Range, Dhanaulti, Part of Chamba), Kalsi and Chakrata Forest Division, Garhwal (Tehri dam 1, Tehri dam 2, Uttarkashi, Tons forest Divisions) and Kumaon (Chamoli,,Pithoragarh, Almora ,Champawat Forest Divisions) of Uttarakhand. Quadrats were laid down in selected locations in each Forest division of Garhwal and Kumaun region and data was recorded. Species density, frequency, abundance, relative density, relative frequency , relative dominance , and IVI values were calculated for all the species found in quadrats. Best trees bearing fruits were selected on the basis of their fruit size and their GPS location was recorded. Associated species were also recorded for both the species. To conserve the selected germplasm, seeds were extracted from the *Ficus palmata* fruits and their quality measurements viz. vigour index, seed weight were taken. Seed germination percentage was determined. **In IFP, Ranchi** survey in the villages and village markets of Hazaribagh, Deoghar, Dumka, Khunti and Gumla districts in

Jharkhand have been carried out for identification of wild edible fruit species and WEF species found in the regions have been documented. Identification of 15 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.

IFGTB, Coimbatore selected 91 CPTs of *Limoniaacidissia* and 45 CPTs of *Pithecellobiumdulce.* Collected the passport data, geo-coordinates of the CPTs. Initiated rooting of Pithecellobium stem cuttings and obtained 47.5% success. Studies are in progress. Pre-treatment requirement was not promising for Limonia as indicated by experiment to improve germination and seedling vigour index. Studies on effect of temperature on germination of *Limonia acidissima* and effect of direct sowing and transplanting effect have been initiated. Initiated studies to store *Limonia acidissima* seeds at sub zero temperature for long term**. HFRI, Shimla** after survey selected 17 sites were 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.*Morphological and physical characteristics of the tree were recorded. Collected fruits were processed in the laboratory to record physical parameters. 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.* Stem cuttings of *P. cornuta* were collected from Kothi (Manali) and Hatu (Narkanda, Shimla) and *M. esculenta* from Baragaon (Shimla) and planted after treatment in fabrication boxes and nurseries and data was recorded periodically.Seeds of *P. cornuta* were sown twice and monitored in open nursery beds area ($60m^2$ and $35m^2$) at FRS, Brundhar (Manali) and in $35m^2$ in FRS Shillaru (Shimla). Seeds of *M. esculenta* were sown in open nursery beds of 10 m^2 area and 13 m^2 area in poly house and $30m^2$ in open bed at Model Nursery Baragaon Shimla and trials were regularly monitored and maintained.

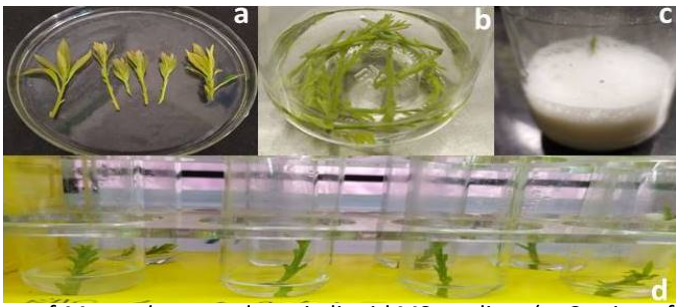


Fig. 34 Meristematic tissue culture of *M. esculenta* explants in liquid MS medium (a: Cutting of explants, b: Washing with Tween20, c: Fungicide treatment, d: Inoculation in liquid MS medium

RFRI, Jorhat found that, *Spondius pinnata* is called "Tei-taw" in mizo and "Amara" in Assamese.The distribution of the species was recorded in Sairang, Aizawl. *Prunus jenkinsii* is called "Kei-pui" in Mizo and "Thereju" in Assamese was explored from localities of Saitual area, Aizawl. No seedlings were recorded near by the mother plants. Fruit pulps of *Spondius pinnata* and *Prunus jenkinsii* are edible. Ripe fruits of *Spondius pinnata* are made pickle. 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* Hook. f. & Thompson in Saitual, Aizawl in between (N 23º42' 46.82" - E 092º57' 9.57") at altitude 887m and *Spondias pinnata* (L.f) Kurz in Sairang, Aizawl in between (N-23º 27' 06.8"-E 092º 45' 12.4" at altitude 119 m and collected the ethno-botanical information.Explored distribution of *Spondias pinnata* and *Prunus jenkinsii* from Gibbon WLS, Jorhat and Nambor-Doigrung WLS, Golaghat of 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. Survey was carried out in 31 different places (homestead gardens/ reserved forests) of Jorhat, Sibsagar, Charaideo, Karbi-Anglong district, Assam and selected 10 CPTs of *Spondias pinnata* and collected seeds 1.0 – 1.5 Kg each of 6 selected CPTs and put in nursery for further studies.Collected 10 different genetic resources of *Spondias pinnata* and 3 of *Prunus jenkinsii* from different areas of Golaghat, Karbi-Anglong, Jorhat, Sibsagar, Charaideo districts, Assam and being conserved at RFRI campus.

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

Data on the population structure, natural regeneration and phenological characteristics of the target species, *Dalbergia latifolia* was collected from the forest areas of Cauvery WLS, Bhadra Tiger Reserve, BR Hills Haliyal, Dandeli, Yellapur Madikeri, Virajpet, Kushalnagar and nearby areas in Karnataka (by IWST); Bastar and Dhamtari in Chhattisgarh, Akola and Yavatmal in Maharashtra and Tikariya, Bijadandi and Itarsi in Madhya Pradesh (by TFRI), Coimbatore, Tiruvannamalai, Pudukkottai forest divisions (Tamilnadu) by IFGTB; Ranchi, Ramgarh, Khunti,

Latehar, Garhwa, Hazaribagh and Bokaro Ramgarh, Khunti, Latehar, Garhwa, Chandil, Dalma, Hazaribagh and Bokaro areas (Jharkhand) by IFP Ranchi and Fatehpur, Haldwani, Nainital by FRI Dehradun were collected. Altogether 157 superior trees were selected from these forest areas and marked. Geo co-ordinates, mophometric parameters and other baseline information on these selected trees were recorded. Vegetative propagation of the selected superior trees by treating sprouts developed from the root cuttings with IBA and clonal plants raised at TFRI, IFGTB, IWST. Vegetative propagation using mature stem cuttings did not yield the desired results. Seed pods were collected from the selected superior trees and recorded morphometric characters. Germination test conducted in nursery by IWST showed 96.4 % germination. Seedlings were raised from the seeds of superior trees. IWST Bengaluru has raised 3500 seedlings and IFP, Ranchi 8000 seedlings. IFP Ranchi has raised a progeny trial of seven accessions in RBD design, having five replications and six plants/ progeny/ replication at NB Farm Chandwa, Latehar (Jharkhand). Land preparation for raising the second trial is underway. DNA isolation protocol was standardized at IFP for the isolation of genomic DNA and the DNA from the superior trees was isolated for molecular studies. The total phenolic and alkaloid contents of some of the superior trees were estimated in bark and leaf samples of selected trees at TFRI. Tannin content in leaves was in the range of 0.15%-0.51% and in bark samples in the range of 0.03%- 0.50%. Total phenol content observed in leaf samples was in the range of 2.39%-8% and in bark samples in the range of 0.77% -7.67 %. Alkaloid percent estimated in bark samples ranged between 3.49%-8.78% and highest average content was in trees located in Silewani. The fungal pathogens infecting leaves caused yellowing spot formation and blight. The pathogens were isolated from leaves and cultured in PDA medium and identified as Neopestalotiopsis sp. and Colletotrichum sp by FRI, Dehradun. Molecular characterization of the pathogen was carried out. Cultures of the antagonistic fungi (biocontrol

Fig. 35 *Dalbergia latifolia* Roxb. –Sandalwood-Mixed species agroforestry model

agent) Trichoderma spp. were developed and testing against the fungal pathogens causing various diseases in D. latifolia is in progress. Insect pest survey was initiated in the nurseries and different pests causing damage to seedlings and saplings recorded.

Fig. 36 A, Tea twig caterpillar; B, Black inch looper; C, Shisham defoliator; D, Black plant hopper; E, Rice ear bug

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

FRI Dehradun surveyed Nainital, Almora, Ramnagar, Bageshwar, Pithauragarh, Champawat, Chakrata, Forest Division, Niti, Malari, Mana village, of Badrinath forest Division, Sonparyag, Ukhimath, Mandal of Kedarnath wild life sanctuary, of Uttarakhand State and collected samples of *D. deltoidea, Gentiana kurroo, Diploknema butyreaceae* with GPS cordinates. *Diploknema butyreaceae, Dioscorea deltoidea* and *Gentiana kurroo* were assembled in NTFP nursery FRI and Chakrata Nursery. Collected data on harvesting techniques/methods of economically important NTFPs viz. *Arundanalia falcatta* (Ringal) from Mandal village Kedarnath

wild life sanctuary and Rudrapryag Forest Division of Uttarakhand. Surveyed Munsyari, Dharchulla of Pithauragarh forest Division, Mana, Niti- Malari Village of Badrinath Forest Division, Nainital Forest Division, and collected data on traditional knowledge of ethno-medicinal plants used by traditional healers to cure different chronic diseases (Cardiovascular, Diabetes, Bronchial and Arthritis). Collected the information of medicinal species from Chakrata, Badrinath, Nainital forest Divisions.Traditional methods of processing of Ringal (*Arundanalia falcata*) for making Daliya, Tokri etc., from Kedarnath wild life sanctuary, Processing Methods for Dhoop from different NTFP, in Niti- Malari Village from Badrinath Forest Division. Processing methods of Jam chatni from different NTFP fruits Nainital Forest Division were recorded. Collected marketed sample of NTFP Species from Munsyari, Ramnagar, Mana, Niti Village and Assessed the quality of Jatamanshi, Kutki, Aonla, Baheda, Harad, Balchad, Dolo, Jhulaghass, sphagnum moss, gandhrani, Timur, Kuth, Timur, Chitrak, Giloy, Punernava, Arjun bark, Satavar, Aswagandha, Chain patti, Ritha, and Tejpatta. Collected information from different forest Divisions and markets for documentation of gaps from NTFP's collection to market level.

Fig. 37 Value addition of *Arundanalia falacata* in different forest division of Uttarakhand

TFRI Jabalpur collected root samples and germplasm of *Uraria picta* from 8 locations; 07 locations of MP and 01 location of CG. Collected root samples and germplasm of *Desmodium gangeticum* from 22 locations of 12 forest divisions of MP and 04 forest divisions of CG. The root bark of *Oroxylum indicum* from 16 locations belonging to 08 forest divisions (North Seoni,

Khargone, West Mandla, East Chhindwara, West Chhindwara, North Betul, Jabalpur, South Balaghat) of Madhya Pradesh state was collected. Root bark of *Oroxylum indicum*from 13 locations of 09 forest divisions (Janjgir-Champa, DhamtariBalodabazar, Bilaspur, Korba, Bastar and Bijapur, Mahasamud, Manendragarh) of Chhattisgarh has been collected. Soil samples of 13 locations of MP and 11 locations of CG were analysed for organic carbon, organic matter, EC, $P^{H,}$ K and Phosphorus.Experiments for germination of seeds of *O. indicum* in different potting media were laid out. Potting mixture (Soil: Sand: FYM, ratio 1: 1: 1) seeds showed approx. 90% germination. More than 200 seedlings of *O. indicum* were prepared. Pods/ seeds of *Oroxylum indicum* were collected from 08 forest divisions of Madhya Pradesh and 09 forest divisions of Chhattisgarh states for preparing seedlings for assemblage. Assemblage and establishment of germplasm of *Uraria picta* from 8 locations and *Desmodium gangeticum* of 22 locations (19 of M.P. and 3 of CG) were carried out. Seed germination experiments were laid out for *Urariapicta, Desmodium gangeticum* and *Embeliatsjeriam – cottam* using different treatments i.e.$GA_{3,}$ Conc. $H_2SO_{4,}$ hot water, cold water and cow dung for different time intervals using different potting media. Preliminary results showed the 83% germination of *U. picta* seeds after pre-treatment with concentrated H_2SO_4 for 15 minutes. Standardization of HPTLC method for quantitative estimation of active marker compound lupeol in *U. picta* roots has been done and samples of 08 locations were evaluated for lupeol content. Standardization of HPTLC method for quantitative estimation of Baicalein in root bark of *O. indicum* has been done. Analysis is in progress. Present prevailing and traditional harvesting practices of economically important species in central India viz. *Curculigo orchioides, Oroxylum indicum, Terminalia arjuna* and *Terminalia chebula* have been documented in forest areas.

Forest Research Centre for Skill Development, Chhindwara availability of targeted species-*Curcuma angustifolia* (Tikhur) and *Sapindus laurifolius* (ritha) was identified through internet sources and also through visits done in Chhindwara, Betul Districts (Satpura plateau) and Seoni (Kymore Plateau) and locations were identified. *Sapindus laurifolius* (ritha) fruiting period is Feb-April. Best harvesting period is April. Documentation of harvesting techniques/methods of targeted species viz. *Curcuma angustifolia* was done. Documentation of harvesting techniques/methods of targeted /economically important NTFP species of Delakhari, Ghatlinga

and Tamia Range was done. *Curcuma angustifolia* (Tikhur) was found in all three areas. Germplasm of *Curcuma angustifolia* (Tikhur) were collected from 13 districts (07 from MP and 06 from CG states) and established at FRCSD, Chhindwara campus. Germplasm of *Sapindus laurifolius* (ritha) were collected from 5 locations of Chhindwara and seedlings raised in the nursery. Screening of best germplasm based on the saponin and starch content for both the species is under progress. Soil samples were also collected from all germplasm collection sites. Organic carbon content was estimated and further work is under progress. Documentation of harvesting methods of targeted species viz. *C. angustifolia* and other economically important species was done in CG districts.

Survey and documentation of traditional knowledge of ethno-medicinal plants used by tribes in different formulations to cure chronic diseases(cardiovascular, arthritis, bronchial, diabetes) was done in Delakhari, Tamia, Sangakheda, Srijot, Patalkot, Rated, Kukarpani and Ghatlinga, West Forest Division, Chhindwara (Satpura Plateau), Ranikheda village, Dori beat Bhimpur block, Chicholi range Betul District and Savangi and Mohgaon villages of West Khawasa Range, South Seoni (MP) and 06 districts of CG was done. Tribals of Delakhari use *C. angustifolia* tubers in cough and asthma, Uses of other economically important species found in the above areas were also recorded. Preparation of inventory and prioritization of region wise species / targeted species for development of post- harvest management of NTFPs was done for Chhindwara, Betul and Seoni Districts of Madhya Pradesh. Traders of Chhindwara, Betul and Seoni districts were visited and information received. Documentation of traditional methods of processing and value addition of NTFPs of targeted species viz. *Curcuma angustifolia* and other economically important species was done at MP & CG. Experiment was laid out for value addition of *Curcuma angustifolia* and *M. oleifera* for complementary food formulation. Work is under progress for consumer acceptability test and optimization of the product formulation. Market sample collected from local Chhindwara market of *Curcuma angustifolia* powder was analyzed for assessing its nutritional parameters viz. total carbohydrates, total fat, energy value, ash, moisture, iron, sodium, potassium, calcium, dietary fibre and ascorbic acid content. Market samples of *Curcuma angustifolia* starch powder were also collected from CG state from traders and SHGs. Work is under progress for assessing the quality of the collected tikhur starch

powder samples. Range wise NTFPs haat bazaars of Chhindwara District were identified and market samples were collected for their quality assessment. Identification of gaps from NTFPs collection to market level was identified for villages of Chhindwara, Betul and Seoni Districts of MP and Van Dhan Vikas Kendras of Dugli, Dhamtari, Kanker and Jagdalpur districts of CG were visited. Interaction with some SHGs of CG involved in tikhur processing was done. Equipments proposed under the project were procured and are being used. Further work is under progress as per annual action plan.

AFRI,Jodhpur carried out nutritional analysis of *Miliusa tomentosa* (fruits), *Emblica officinalis* (fruits), *Aegle marmelos* (fruits) and *Averrohea carambola* (pods) for moisture, protein, sugar, oil and ash. Physical parameters viz. Length, diameter, weight, weight of pulp etc. were also recorded. Preliminary phytochemical analysis for alkaloids (Wagner's test), phytosterol (Salkowski's test), saponin (froth test), tannin (alkaline reagent test), phenol ((Ferric Chloride Test) were conducted for *Miliusa tomentosa* (fruits), *Averrohea carambola* (pods), *Emblica officinalis* (fruits), *Eclipta alba* (seeds), *Cassia auriculata* (flowers), *Acacia concinna* (pods), *Butea monosperma (*flowers), *Sapindus trifoliatus* (fruits), *Aegle Marmelos* (fruits), *Cassia fistula* (seeds), *Annona squamosa* (fruits) and *Putranjiva roxburghii* (seeds).

Fig. 38 Seed germination of Miliusa tomentosa in AFRI, Nursery

Seed sowing of *Averrohea carambola, Eclipta alba, Acacia concinna and Miliusa tomentosa* was carried out in AFRI Model Nursery. Germination % obtained as: *Acacia concinna* Rajasthan: (79.50%), Gujarat (17.92%), *Averrohea carambola* (2.92%) and *Miliusa tomentosa* (61.64 %).

Species prioritized for development of Post Harvest Management includes *Averrohea carambola, Goruga pinnata, Pithocellobium dulce, Trigonella foenum, Feronia limonia, Tamarindus indica, Boswellia serrata, Manilkara hexandra, Butea monosperma and Madhuca indica*.

HFRI, Shimla conducted extensive survey for collection of germplasm of *Taxus wallichiana*, *Thymus serpyllum Aconitum heterophyllum* and *R. australe* in different geographical locations of Himachal Pradesh. Collected germplasm of *T. wallichiana* from 20 different sites, *T. serpyllum* from 22 different sites, *Rheum australe* from 16 different sites and *Aconitum heterophyllum* from 11 different sites. Established the vegetative propagation trial of *T. wallichaiana* (using different grades of IBA & GA_3), *T. serpyllum* and *R.australe* (using Bavistin fungicide) in Model nursery Baragaon, Shimla and FRS Bhrundhar, Manali (Himachal Pradesh). Documented the harvesting methods of NTFP's among the local people of village Mayar, Bairagad, Devikothi of Chamba; Chhoth, Rakchham and Chhitkul of Kinnaur district; Neri, Kukdi, Pulag, Flantu and Baga sarahn of Kullu district, Himacshal Pradesh. Also collected information for prioritizing the NTFP from above eleven villages for developing post-harvest management of selected species. Analysed the Phenol content of Leaves (10 sources) and Bark (15 sources) of Taxus wallichiana from different sources.

Fig. 39 Collection of Taxus wallichiana from Ranikot, Chamba (H.P.)

RFRI, Jorhat consulted district work plans of state Forest Departments of NE India for distribution of 9 target species i.e. *Schumannianthus dichotoma* (Roxb.) Salisb, *Tacca*

integrifolia Ker-Gawl, *Mangifera sylvatica* Roxb., *Aporosa octendra* (Buch-Hum) ex D.Don , *Hydocarpus kurzii* (King) Warb., *Phoebe cooperiana* U.N kanjilal ex A. Das, *Dillenia indica* L., *Garcinia pedunculata* Roxb. and *Costus speciosus* (J. Koenig) Sm. Field survey was done for Jorhat, Sivasagar, Golaghat Majuli districts of Assam and Namsai district of Arunachal Pradesh for identification of population sites of *S. dichotomus C. speciosus, H. kurzii* and *A. octandra.* Initiated works of establishment of germplasm bank and nursery work for standardization of propagation protocol at RFRI campus Jorhat with the population of collected species during field survey. Analysis of phyto-chemical of the species *C. speciosus* and A. octandra in laboratory has been initiated. Two value added products of *D. indica* has been prepared.

IFB, Hyderabad surveyed the forest divisions of Telangana State and locations were identified for *Costus speciosus* and *Gloriosa superb* with GPS coordinates. Rhizome of *Costus speciosus* from 12 locations and *Gloriosa* superba from 16 locations have been assembled and established in IFB, campus. Endemic *Terminalia pallida,* and *Shoreatumbuggaia* seeds from 4 and 3 location of Andhra Pradesh have been collected and are being germinated in IFB, Hyderabad campus while *Pimpinella* plants from one location in Andhra Pradesh have been collected and established. GPS coordinates of 30 trees (of each species) was recorded for mapping purpose.3 germplasm of Costus rhizomes (CS14 KMNPLY,CS1 KMNPLYCS3 KMNPLY,) were analyzed for total ash (18.25%, 18.25% & 11.40%) and water soluble (6.60%, 10.30%, 5.90%) ash as well as acid insoluble ash (7.20%, 4.70%, 1.30%). *Terminalia pallid* and *Shorea tumbuggaia* bark from 1 location have been tested for alkaloids (4.22% & 4.30%). HPTLC facility is not available in IFB, Hyderabad. So same may be out sourcing /involving from other organization in Hyderabad. Based on Mulugu GCC, GCC Mahadevpur GCC Adilabad, GCC Utnoor , GCC Kagaznagar, GCC Mahadevpur, on collection of NTFP's, 10 no species were prioritized *viz*. *Madhuca longifolia, Strychnosnux-vomica, Pongamia pinnata, Tamarindus indica, Decalepis hamiltonii, Terminalia chebula, Aristida adscensionis, Entada persuata and Sapindus emarginatus.* One PRA held on 21/09/2021 Tuniki village of Kowdipally mandal of Meadak district, Interviewed traditional knowledge holder Teegala. Shekhar aged about 38 years told us about usage of Local forest medicinal plants and their usage for curing various diseases as well as targeted four Chronic diseases. Earliar PRA meeting held on 24th June 2020 at Thoompally village, Sirikondamandal,

Nizamabaddist in the presence of Local healer, villagers, and District Biodiversity Coordinator regarding Ethno-botanical survey. Local healer Palle Bakkanna (50 years) told us about the local forest medicinal plants and their usages for curing various diseases. Traditional knowledge holder (Mr.Rameshchalla) in Tadvai forest division of Telangana for different chronic diseases was interviewed. Surveyed the traditional way of processing of Mahuva seeds in Armoor forest villages. Surveyed the traditional way of processing of nux vomica seeds and broom sticks in Mulugu forest.

In IFP, Ranchi 4 populations for *Mesua ferrea*, 12 populations each for *Oroxylum indicum* and *Paederia scandens* and 4 population for *Dellinia indica* has been surveyed in North West Bengal. Collection of germplasms (seeds) of plus trees of *Mesua ferrea* was done. On the basis of phenotypic characters 20 CPTs of *Mesua ferrea*, 34 of *Oroxylum indicum*, 30 of *Paederia scandens* and 8 of *Dellinia indica* were selected. Through village survey, the required information is being collected. 7 villages of Kalimpong and Darjeeling district have been covered. 15 villagers for each village i.e. 3 villages of district Gaya of Bihar and 12 villages of Girdih, Deoghar, Khunti and Ranchi (3 villages each) were surveyed and requisite data was collected. For documentation of traditional knowledge of ethno-medicinal plants, through sampling method and by taking into account the distance from forests, the villages in different agroclimatic zones in Jharkhand and West Bengal were listed out. 18 forest fringe villages from Jharkhand and 7 from West Bengal has been surveyed and required data has been collected. Inventory preparation has been prepared for post harvesting of medicinal plants.

AICRP-30: All India coordinated research project on *Gmeilna arborea* Roxb. (Khamer or Gamhar)

From the regions covered by FRI, Dehradun seedling of 18 progenies have been raised in the nursery and kept ready for field evaluation. Land for raising trials has been finalized. **Team of IFP, Ranchi conducted** survey at various places in Bihar (Madhubani, Darbhanga, Saharsha, Hajipur) and Jharkhand (Ranchi, Ramgarh, Khunti, Latehar, Garhwa, Hazaribagh, Bokaro, Saranda forest areas, Kamdara, Simdega etc.) for the identification and selection of CPTs of the species. Sixty-nine (69) number of CPTs was identified in Jharkhand and 20 numbers of CPTs in Bihar. Seeds were collected from 34 CPTs identified in Jharkhand and Bihar for raising

nursery.Seeds of 16 different progenies were collected from IFGTB, Coimbatore and raised nursery.Nursery has been raised from the collected seeds of identified CPTs and progenies collected from IFGTB, Coimbatore. **IFGTB, Coimbatore also** collected seed of *Gmelina arborea* from community seed orchards and selected CPTs. The seeds were depulped and processed. Maintained community seed orchards and progeny trials for higher seed production. The seeds of 20 open pollinated families were collected from the seed orchards and selected CPTs. Studied variation in seed morphometric traits. Established Gmelina based agro forestry models - Gmelina + Banana at Vadakadu, Pudhukottai, Gmelina + Papaya at Kangeyam, Thiruppur and Gmelina + Casuarina + Ground nut at Soolakal, Pollachi. Maintained agro forestry trials through intensive silviculture operation. **Further team IFGTB extracted** Genomic DNA from thirty individuals of *Gmelina arborea*. Twenty sets of new genome wide microsatellite primers were designed for synthesis. These twenty primers were optimized. Leaves samples were collected from progeny trial established by IFGTB at Salem. DNA was isolated from twenty nine families of *Gmelina arborea* for SSR profiling. Microsatellite profiling of progenies were completed for fifteen polymorphic primers. The twenty developed SSR primer sequences have been shared with other ICFRE institutes. **Team RFRI, Jorhat** conducted 10 tours for collection of seeds and scion cuttings from Naharoni, Golaghat, Assam and for collection of grating stocks for clonal seed germination and grafting trial. Fruits from 50 clones and scion cuttings of 26 clones were collected. Total 300 stocks were collected from Titabar Biodiversity Park, Lohpohia Forest Nursery and from Ruma Nursery, Hojai (Nagaon), Assam collected 600 nos. of planting stock. Further the collected stocks were raised under nursery condition at RFRI. Collected fruits from 50 clones were de-pulped and sown in polybags under green shed. Bud grafting was done and total seven hundred fifty two (752) grafts were prepared and regular sprouting data has been recorded. Thirty five (35) numbers of clones responded for germination. In **TFRI, Jabalpur (MP)** 26 CPTs were selected from Belgahna, Kendai, South Singpur and Kanan Pendari, Bilaspur Chhattisgarh. 21 CPTs were selected from Shahpura, Madhya Pradesh. Survey was conducted in nurseries and plantations at Jabalpur, Madhya Pradesh and Korba, Rajpur, Khairagad, Rajnangaon district of Chhattisgarh. against the insect pests of *Gmelina arborea*. The assessments of losses of key pests were recorded. Different life stages and morphometric

observations on the defoliator, *C. leayana* was recorded. Some of the insect recorded on *G. arborea* are *Tingis beesoni*, *Odontotermes* sp. *Trypanophora semihylina*, *Indarbela quadrinotata*.

Fig. 40 Stones of *Gmelina arborea* collected after depulping of fruits

Fig. 41 Gamhar seedlings at IFP, Nursery, Ready for transplanting

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

IFGTB Coimbatore conducted reconnaissance surveys in the selected plot area and nearby forest areas, Kurisimala, Pandipattu and Arappuchola for enumeration and documentation of species diversity. Nearly 368 plant specimens were collected and confirmed species identity for 160 plants species including 3-Endangered, 11-Endemic, 9-Invasive, 3 Near Threatened and 7 Vulnerable species in the Redlist category. Further identification of plant species is in progress. 23 Insect specimens were collected and preserved, 12 were identified. Common insects were only documented by photographs. Collected and identified 12 pollinators namely *Eureka hecaba, Hypolimnus misipolis, Ypthima baldus, Parantica aglea, Pachliopta pandiyana*, *Junonia iphita, Idea malabarica Abisava sp., Ypthima huebnori, Neptishylus cuphaerymanthis, Loxura atymnus, Kalidasa lantana*. Collected samples from the selected plot area and outside forest area for physico-chemical analysis. Soil pH ranged from 4.1 to 4.9. In two places $_{N2}$ content was high i.e. 473.2 and 472.2 kg/ha but in other areas it was in medium range between 280 to 450 kg/ha. K ranged from 130 to 280 kg/ha. P content varied from 24- 50 kg/ ha. The organic carbon also varied from 0.5 % to 0.75 %. Initiated recording of macro fungal diversity. Collected fourteen macro fungal fruiting bodies from the study area and preserved using Hot air oven

method at 48^{o}C. Identified twelve macro fungal fruiting bodies. Soil samples were analysed for Vesicular Arbuscular Mycorrhizae spore density (VAM) using wet sieving and decanting method and recorded spores of *Acaulospora* spp and *Glomus* spp.

Fig. 42 Project inception launch workshop was organized at Mudumalai

RFRI, Jorhat has conducted biodiversity survey, ecological studies, regeneration study in 24 transects. A total of 113 species were enumerated. Regeneration status of plants species falling within the sample plots was also studied. Seventy two representative and composite soil samples for physicochemical characterization and estimation of soil bulk density were collected so far. Phenological observations of 48 tree individuals (20 species) have been done so far. **IFP, Ranchi** has initiated data collection of biodiversity and invasive species for development of biodiversity. Monitoring disease, pest and status of pollinator's in the study plots has been started. Collected 117 insects [Lepidoptera (51), Odonata (10), Coleoptera (12), Isoptera (20), Moth (5), Mantis (3), Grass hopper (15)] and 27 species of fungus.

HFRI, Shimla recorded observation on phenological parameters like emerging needles/ leaves, young unfolded needles/ leaves, needle/ leaf stages, open pollen, full pollen release, open flower, full flowering etc. of selected tree species. Study for recording plant diversity, invasive species and natural regeneration during pre and post monsoon season has been done. Total 111 specimens of Lepidoptera from both sites i.e. Shimla Water catchment and Shikari Devi WLS were collected. Two insect species infesting the Oak (*Q. semecarpifolia*) at Shikari Devi were recorded. All the collected specimens were stretched, pinned and identified. Dissection of

butterflies was carried out to study the genitalic characters to update the taxonomy of the species. Pollinator's density and their host plant species were recorded. Total 20 species of butterflies were identified. Identification of other specimen is in process. Total 20 Macrofungi samples from Shimla water catchment and 41 wild Macrofungi samples from Shikari Devi Wild Life Sanctuary were collected. Twelve macrofungi samples were identified up to species level and 10 samples were identified up to genus level. Out of 20 identified macro fungi, 4 were mycorrhizal, 17 sparobic and 3 were parasitic in nature. Soil samples were collected during monsoon period and being analysed for microbial diversity by serial dilution method and recorded 2.5×103 fungal colonies in one gram of soil. The common fungi appeared on the culture plates includes the species of Penicillium, Rhizopus, Mucor, Aspergillus, Trichoderma etc. Soil samples were also analysed for the diversity of Arbuscular Mycorrhizal Fungi (AMF). The taxonomic characterization revealed 16 AMF species in 2 genera in the soil collected from of *Quercus semecarpifolia* forest and 13 AMF species in 2 genera from the soil of *Abies pindrow – Picea smithiana* forest.

In **French Institute, Pondichery** a total of 1861 individuals of trees belonging to 108 species, 86 genera and 41 families were inventoried. Foliar and reproductive phenological events of 600 individuals belonging to 93 species are being monitored. 41 out of 95 species were in the fruiting stage during the period April- September, out of which, 10 species had their fruiting period during August - September. Whereas, the flowering event was recorded only for 10 out of 95 species during April to September. Climate parameters such as temperature, humidity and rainfall are being monitored since April 2021 using hobo U23-001 pro V2 temp/humidity data logger and manual rain gauge established within the study area. Rainfall is being monitored in the plot using a manual rain gauge. **FRI, Dehradun** has initiated process of gridding and layout of the 10 ha experimental plot. Biodiversity study was conducted at Binog wildlife sanctuary. All woody individuals having >1cm BDH were recorded. Shrubs and herbaceous vegetation were recorded in sub-transects of 3 m x 3 m and 1m x1 m, respectively. A total 38 species of trees, 42 species of shurbs and 88 species of herbs were found in the area. The area was found to be primarily dominated by *Quercus leucotrichophora* (banj oak) species (150-300 in different transects). Various vegetation parameters and indices were calculated

such as density, frequency, abundance, IVI, basal area, dispersion pattern, species diversity, species richness, species dominance and species evenness were anlysed. Natural regeneration has been recorded from the 1m x 1m sub-quadrates.

A) Mature fruit of *Fahrenheitia zeylanica* B) fallen fruit of *Mesua ferrea* C) Mature flowers of *Baccaurea courtallensis* D) Fruit of *Dimorphocahx lawianus* E) Fallen fruit of *Vepris bilocularis* F) Fallen fruit of *Pterospermum diversifolium* G) Fallen fruit of *Diospyros sylvatica* H) Fallen fruit of *Mastixia arborea* I) Flower and fruit of *Dimorphocahx lawianus* J) Mature fruits of *Baccaurea courtallensis* K) Dehiscent fruit of *Euonymus indicus* L) Fallen fruit of *Diospyros buxifolia*

Fig. 43 Phenological study at Upangla

Fungal fruit bodies and their abundance, fruiting pattern and host preferences were recorded along with the geo-tagging. A total of 49 species belonging to 40 genera were recorded. Rhizospheric soil samples of different trees in different transects were examined for microfungi and mycorrhizal diversity. *Cladosporium sp*., *Penicillium sp*., *Curvularia sp*., *Fusarium* and *Aspergillus sp*. were found to be dominating species. Phenological study has been conducted for the month of June, July, August and September 2021 on 92 geo-tagged individuals of 10 selected species in the experimental area, Binog wildlife sanctuary. Leaf/ flower / fruiting phenophases were recorded on field data sheets and entered in the database.

Component II:

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

Part-1

(FRI, AFRI, RFRI, IFP)

A priority list of 750 FGR species was refined and vetted through expert consultation and brainstorming sessions. The work on the extraction of FGR distribution records from accredited national herbaria and from Forest Working Plans has been completed by FRI, AFRI, and IFP. Field surveys to document FGR diversity & their population status with GPS referencing has been started by most of the institutes. Regeneration status of selected FGR tree species was recorded in different Forest Divisions of Haryana and Uttar Pradesh. Preparation of eco-distribution maps of priority FGR species has been initiated and the Geo-coordinates of various FGR species are being collected for preparation of eco- distribution maps. Further, satellite data has been downloaded for different states and data processing is being done for different districts. Collection of seeds of more than 51 species and their populations has been achieved by the institutes FGRs for long-term storage. Seed extraction, cleaning, grading, data recording etc is being done by the institutes. Seed moisture content and germination percent of the collected species is being determined as per ISTA methods.

For development of protocols for in vitro medium term storage of germplasm of FGR species of very high conservation work on *Phlogacanthus thyrsiflorus, Litsea glutinous, Leptadenia reticulate, Commiphora wightii, Rhamnus triquetra, Aegle marmelos, Embelia ribes, Gmelina arborea*, *Vitex peduncularis* and *Tinospora cordifolia, Rowalfia serpentina , Litsea cubaba, Cinamomum tamala* has been started.

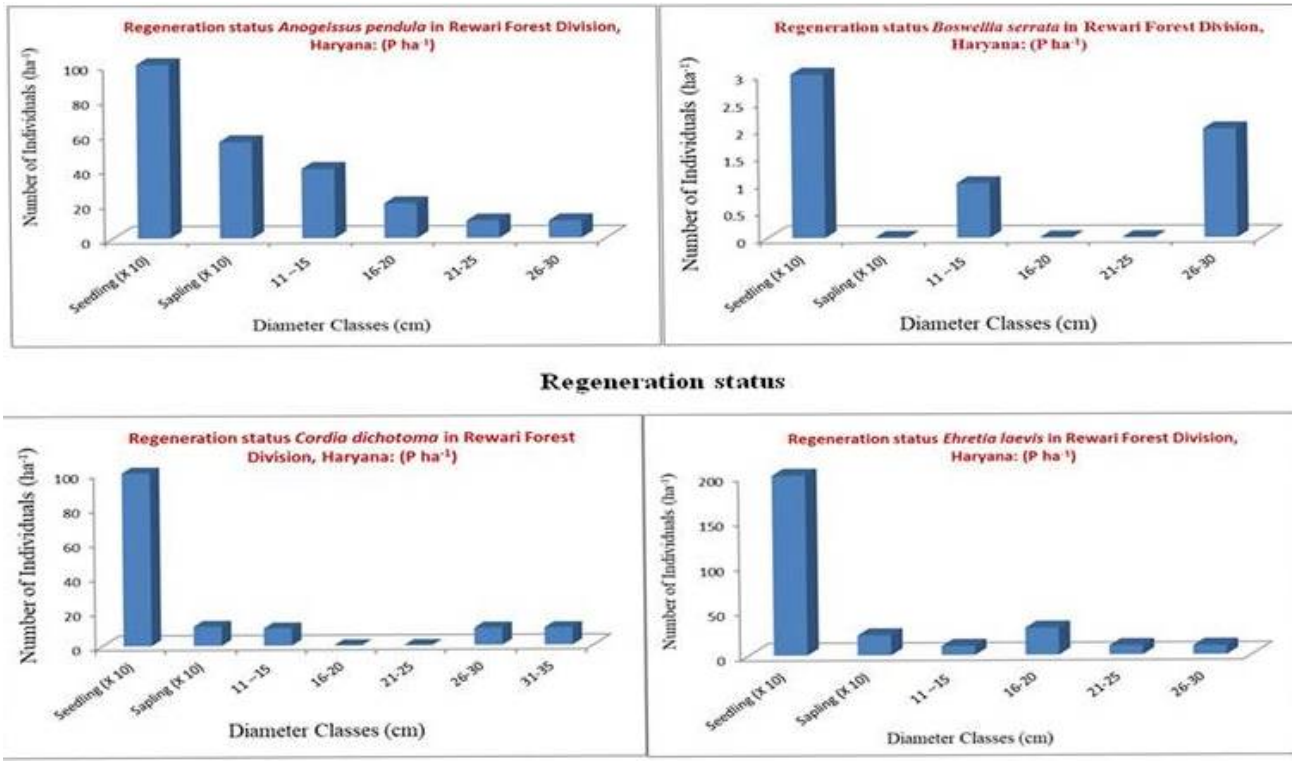


Fig. 44 Regeneration status of *Anogeissus pendula, Boswellia serrata, Cordia dichotoma* and *Ehretia laevis*

Survey and sampling was done for the collection of foliar, stem and root diseases and macrofungi (fungal fruiting bodies) on the diseased populations of A. catechu, A. nilotica, T. chebula, T. arjuna and S. robusta. All the required parameters (viz. tree health, infection, disease severity % etc.) were recorded. Isolation and identification of fungal species has been achieved. For biochemical characterization, sampling and standardization of secondary metabolite extraction from leaf samples from *Salvadora persica, Terminalia arjuna, Terminalia belerica* and *Commiphora wightii* is being carried out. For genetic diversity studies, sampling of the population of the selected species has been started. DNA extraction protocol for 10 selected FGR species have been standardized. Shallow genome sequencing of five species: *T. arjuna, T. chebula, Acacia catechu, Acacia nilotica* and *Pterocarpus marsupium* has been completed. SSR development from the sequenced data is in progress.

Fig. 45 Germination in *Acacia nilotica* and *Cassia fistula*

For development and standardization of nursery techniques and establishment of field gene banks of FGR species of very high conservation concern, field surveys has been conducted for identification of the populations, seed collection and nursery raising has been started by the partner institutes. For the establishment of National Forest Seed and Referral Centre at FRI, site has been identified, estimate for the renovation of the existing building has been prepared and approved by the competent authority and the contract is being awarded.Though the work has been initiated in all the components, but the pace of work is slow due to the corona pandemic leading to complete lockdown in various states and affecting the laboratory and field activities.

Part-2 -FGR

(IFGTB, TFRI, IWST, IFB)

Component A-Documentation of FGR

IFGTB Prepared scoring sheets for prioritizing FGR species. Documented and compiled the scoring sheets of the prioritized FGR species collected from different stakeholders, universities, experts for ranking. Prioritized 75 FGR species based on index scores calculated. Documented improved germplasm available at IFGTB for 5 species namely, *Calophyllum inophyllum, Pongamia pinnata*, *Neolamarckia cadamba, Azadirachta indica* and *Gmelina arborea.* Initiated distribution maps preparation with the available geocoordinates for five species worked at IFGTB to orient with the mapping. Prepared distribution maps for the 10 FGR species based on field survey conducted at 4 different locations upto September 2021. Initiated data compilation of collected germplasm for 30 FGR species. Technical inputs and specifications was sought from custom made database software service providers. **TFRI** prioritized 65 FGR species.Out of 65 species, initiated distribution map preparation or 10 species. Documentation of existing improved germplasm is under process for *Tectona grandis, Pterocarpus marsupium, Litsea glutinosa***.** 30 species were prioritised for FGR conservation at **IWST** after conducting a Stakeholders' meeting and by ranking of shortlisted species based on scores of experts. Thirty species were prioritized by **IFB, Hyderabad** for FGR conservation. Documentation of improved germplasm in Telangana and Odisha was carried out. Quadrat based field surveys initiated in Telangana. Population database created in Excel. Population density data computed for five species viz. *Soymida febrifuga, Bridelia retusa, Mitragyna parvifolia, Sterculia urens, Diospyros melanoxylon.*

Component B- FGR Collection

IFGTB screened for population of priority species. Conducted reconnaissance survey for populations of FGR species in Anamalai Tiger Reserve, Mudumalai Tiger Reserve, Nilgiri Biosphere Reserve, Sathyamangalam Tiger Reserve, Srivilliputtur Grizzled Squirrel Wildlife Sanctuary, Kolli Hills and Siruvani reserve forest. Identified populations of 10 species prioritized for *in-situ* conservation. Carried out regeneration studies for 4 species namely *Vitex altissima,*

Persea macrantha, Kingiodendron pinnatum, Cullenia exarillata. Economic importance for the species in priority list were collected inorder to strategise germplasm collection. Developed a field guide to facilitate planning and survey of 75 FGR species in different locations Developed and improvised population and tree selection, seed germplasm collection and conservation strategy, prepared and submitted the detailed documents. Selected seed sources for 30 FGR species in the various forest areas surveyed. Recorded field details and individual tree passport data for 30 study species which includes 11 field gene bank species, 9 seed gene bank species and 10 *in-situ* species. Collected tree parameters such as clear bole height, tree height, girth, phenological details, economic trait for 30 FGR species. Photographs of individual parts of the seed source were taken and recorded. Oriented the JPFs /PAs on germplasm collection and assemblage through a field visit to Panampally, IFGTB research station. Collected fruits of 9 seed gene bank species such as *Trewia nudiflora, Bauhinia racemosa, Phyllanthus emblica, Elaeocarpus tuberculatus, Cassia fistula, Terminalia arjuna, Caesalpinia bonduc, Limonia acidissima, Stereospermum chelonoides,* from identified seed sources. Collected fruits of 6 species *Artocarpus heterophyllus, Artocarpus hirsutus Aegle marmelos, Sapindus emarginatus, Vitex altissima, and Oroxylum indium* from identified seed sources for field gene bank. **TFRI ,Jabalpur** surveyed in the forest of Chhindwara, Betul, Mandla of Madhya Pradesh and Dhamtari and Rajnandgaon of Chhattisgarh states to verify natural population of 10 species. Tour was conducted in Gwalior, Sheopur, Bhind, Jhabua, Dhar, Betul and Khandwa forest division of Madhya Pradesh and collected data on selected species by conducting vegetation survey for *Sterculia urens, Terminilia tomentosa, Anogeissus latifolia , Hardwickia binata , Boswelia serrata Buchnania lanzan, Acacia catechu, Pterocarpus marsupium.* Economic importance for those species in priority list was collected in order to strategise germplasm collection. A broad strategy for selection of population and trees, germplasm collection has been finalized in consultation with the project coordinator. Contributed to the improvement of population and tree selection, seed germplasm collection and conservation strategy Selection of phenotypically superior trees of *Boswellia serrata* (20 trees) and *Haldina cordifolia* (20 trees) was carried out at Umaria, M.P. Distribution of prioritised species was documented through working plans, books and online sources. **IWST** collected data for natural distribution of the 30

prioritised species. A broad strategy for selection of population and trees, germplasm collection has been finalized in consultation with the project coordinator. Contributed to the improvement of population and tree selection, seed germplasm collection and conservation strategy**.** Natural populations of two species *viz., Dalbergia latifolia* and *Buchanania* sp. identified in Medak district of Telangana state. Natural populations of five species viz. *Soymida febrifuga, Bridelia retusa, Mitragyna parvifolia, Sterculia urens, Diospyros melanoxylon,* identified in Telangana. Economic importance of 30 prioritized species documented A broad strategy for selection of population and trees, germplasm collection has been finalized in consultation with the project co-ordinator. Population data of five prioritized species collected. Populations of five prioritized species identified. Seed germplasm will be collected following fruit/seed maturity.

Component C- Seed Germplasm Storage

IFGTB shortlisted 45 species from prioritized list for seed banking, seed handling and storage strategies . Standardised processing of fruits and seed extraction in 9 seed gene bank species such as *Trewia nudiflora, Bauhinia racemosa, Phyllanthus emblica, Elaeocarpus tuberculatus, Cassia fistula, Terminalia arjuna, Caesalpinia bonduc, Limonia acidissima, Stereospermum chelonoides*. Conducted germination test for the 9 species. Standardised processing and extraction of seeds of 5 field gene bank species such as *Artocarpus heterophyllus, Artocarpus hirsutus, Oroxylum indicum, Strychnos nux-vomica* and *Sapindus emarginatus* and conducted out germination test. Initiated effect of temperature (-20C) on storage of 4 species such as *Trewia nudiflora, Cassia fistula, Phyllanthus emblica* and *Limonia acidissima.***TFRI** shortlisted 45 species from prioritized list for seed banking. Compilation of data on Seed handling and storage techniques of target species is in progress. Procurement of equipments is continued. Purchase of cold room is under process. Identification of trees for seed collection is in progress. Compilation of data on seed storage behaviour of target species is in progress. **IWST**shortlisted 20 species from prioritized list for seed banking. Initiated experiments for seed handling and storage techniques for two prioritized species.

Component D- FGR Characterization

IFGTB identified characters such as growth parameters, leaf size, shape, venation, flower, fruit details to be recorded for 15 prioritised species, after establishing in the field gene bank.Recorded morphological parameters of the fruits/seeds collected from different seed sources of 13 species such as, *Trewia nudiflora, Bauhinia racemosa, Phyllanthus emblica, Elaeocarpus tuberculatus, Cassia fistula, Terminalia arjuna, Caesalpinia bonduc, Limonia acidissima, Stereospermum chelonoides*, A*rtocarpus heterophyllus, Sapindus emarginatus, Strychnos nux*-vomica and *Aegle marmelos,* using image analyser. *Insilico* research has been initiated for available molecular sequence data. Based on *in-silico* research shortlisted 5 species for Molecular/biochemical characterization. Worked out details for molecular/ biochemical characterization for 5 species under *in-situ* conservation. Leaf samples of *Kingiodendron pinnatum, Cullenia exarillata* and *Myristica malabarica* have been processed for optimization of DNA extraction. **At TFRI** four species were prioritised for molecular characterization. Distribution of prioritised species was documented through working plans, books and online sources. **IWST** prioritized three species for molecular characterization. Initiated standardization protocol for DNA extraction in *Barringtonia racemosa*

Component E- FGR Conservation (Field Gene bank)

IFGTB identified borewell point for FGR nursery through geological expert from TNAU. Strengthened FGR nursery infrastructure such as setting of poly tunnels and procurement of nursery tools. Sweet water supply facility for the nursery was obtained. Raised seedlings, transplanted and initiated hardening of *Artocarpus heterophyllus, Sapindus emarginatus, Oroxylum indicum* collected from different seed sources. Upgradation of Green shade net for FGR nursery was initiated. Constructed open nursery beds for raising seedlings of light demanding species. Indented and completed formalities for borewell and water facility provision in the FGR nursery. Indented and completed formalities for permanent motherbed construction in the FGR nursery under shade net. Visited and selected forest land of TNFD of 5.0 hecatare at Sarkarpathy. Selected land of TNFD at Panamarathupatti (Jarugumalai)-25.0 ha. Selected land at Gudalur near Chennai- TNFD- 10.0 ha. Requested Kerala Forest Department to allocate 10 ha land in Kerala for field gene bank. Identified land for field gene bank established

in TNFD land at Thuraiyur. Inspected the land, demarcated the area with the SFD staff. Inspected another TNFD land at Tiruvannamalai forest division, demarcated the area, obtained approval of DFO and submitted to TNFD headquarters for allocation of the same for field gene bank. Identified 4.0 ha area at KVK –MYRADA (ICAR), Thalavadi for establishing field gene bank. Existing germplasm of Teak and *Pongamia pinnata* were maintained by casuality replacement. **At IWST** maintained existing clonal germplasm bank of one species (*Santalum. album*) at Gottipura.

Component F- Establishment of Centre of Excellence

IFGTB organized a one day Seminar on Forest Genetic Resources Management inviting experts from NBPGR, Hyderabad and Directorate of Oilseeds Research, Hyderabad on 5th March 2020 to brief on the FGR concepts. On 6th March 2020, conducted the Interactive meeting and launched the program on NPFGR wherein the implementation strategies were presented and discussed with networking institutes. Developed FGR prioritization mechanism through scoring. Conducted the first in-house Workshop on Prioritization of FGRs for fine tuning the scoring process on 7th July 2020. Circulated the FGR prioritization scoring sheets to various stakeholders (SFDs, SAUs, research institutes, wood based industries, experts) along with relevant information for scoring. Made available the scoring procedure to the networking institutes for prioritization of species. Collected the species score information from various stakeholders for compilation. Placed requests for permission from SFDs for forest visits throughout the project period to carry out the field studies and collection of germplasm. Communicated the land requisition letter for field gene bank to PCCF TNFD. Followed up with the SFDs for getting approval for land for establishing field gene bank. Communicated the aims of the FGR program, its activities and outcome with SFDs seeking their support and co-operation. Organized II Workshop on Prioritization of FGRs and made presentation on 6th October 2020 at IFGTB. Conducted an online meeting in March 2021 with networking institutes of the FGR program for fine tuning the methodology. Sent reminders, communicated with SFD officials and successfully obtained forest permission from TNFD and KFD to carry out the FGR studies. Paid forest permission fee and caution deposit to TNFD and communicated the same to different forest divisions. Followed up with KVK-MYRADA through extension wing of IFGTB for land allocation

for field gene bank. Followed up with DFO, Tiruvannamalai for land demarcation for field gene bank and recommendation for allocation. Conducted an online meeting on 6th September 2021 with networking institutes of the FGR program to discuss the progress made and clarify doubts regarding methodology. Expert advice and guidance through a discussion meeting and field visit to Sathyamangalam forests was organized for population studies and tree identification for the FGR species. Approval for procuring field research vehicles was obtained. Carried out body modifications in the field truck to facilitate seed collection. Placed indents and procured field truck- 1no. and Field research vehicle-1 no. Back up batteries for various scientific equipments were repaired and upgraded. Indents were placed for various scientific and office equipments, processed, procured and installed. The procurement is in progress for balance items.

Comp. G- Creation of National Forestry Seed Centre

Seed indents received for supply of quality seeds of different species were processed and supplied 34.75 kg seeds. Ensured quality seed availability at nominal price. Maintained seed collection and supply data. Procured office equipment for seed centre.

Component-III:

Policy studies under Centre for Forest Policy Research

Under CFPR out of the total 11 studies, 4 studies have been allotted so far. Two studies were allotted in the last financial year (2020-21) and two recently in the current financial year. The details regarding these studies and progress achieved so far are given below:

SN	Name of study	Name of the executing Agency	Progress
1.	Institutions of community Participation including Joint Forest Management Committees (JFMs) and Eco-Development Committees (EDCs), linkages with Panchayati Raj Institutions, review of their working in various regions of the country and identification of successful models and shortcomings	TERI, New Delhi	Discussion meeting held with the agency for improvements in the report suggested by working group. A stakeholders meeting is to be organize to get the views on the identified suggestions for the incorporation in final report.
2.	Policy issues in agroforestry including market mechanism, forward and backward linkages, regional availability, transit of forest produce, linkages with NDC targets, choice of species and utilization	NCCF, Noida	The period of submission of report is extended till December, 2021 due to COVID-19 pandemic. Final report is awaited.
3.	Popularization of the use of Wood and Wood Substitutes as per the National Forest Policy and Modalities for Facilitating Industries for its Optimum Utilization	NCCF, Noida	New study allotted to NCCF, New Delhi and inception report is awaited.
4.	Functioning of Forest Development Corporations and their role in the present Scenario	IUCN and IORA, New Delhi	New study allotted collectively to IUCN and IORA, New Delhi.Inception report is awaited.

The Directorate of Education has been mandated to look into the policy issues for the better governance of forests, wildlife and other natural resources. In this endeavor, **Centre for Forest Policy Research** was establishment at ICFRE (HQ) and notified vide Secretary, ICFRE Notification No.58-21/55/2017-ICFRE dated 06.02.2018 to take up policy research studies exclusively

focused on forest and environment sector. The prime aim of the CFPR is to act as **"Policy Think Tank"** dedicated to undertake extensive and in-depth research on policy perspectives in the forestry and environment sector. The prime focus of CFPR is on research in contemporary policy issues for the better governance of natural resources in India and providing inputs to Government of India for policy decisions and appropriate interventions.

An Advisory Committee for CFPR was constituted under the Chairmanship of DG, ICFRE. Members of Advisory Committee are as follows:

i.	**Director General, ICFRE**	**-**	**Chairperson**
ii.	Full time members		
	a) IGF (Forest Policy), MoEF&CC	-	Member
	b) DIG (Forest Policy),MoEF&CC	-	Member
	c) DDG (Education), ICFRE	-	Member
	d) DDG (Research) , ICFRE	-	Member
	e) DDG (Administration) , ICFRE	-	Member
	f) DDG(Extension) , ICFRE	-	Member
	g) Directors from three ICFRE Institutes		Members (to be nominated by Chairperson)
	h) Director (IC), ICFRE	-	Member
	i) ADG (BCC), ICFRE	-	Member
	j) ADG(Education), ICFRE	-	Member Secretary
iii.	Experts and Specialists (2-5 Members) (with domain knowledge)	-	To be nominated by Chairperson
iv.	Practitioners (2-3 Members)	-	To be nominated by Chairperson

The terms of reference of Advisory Committee are as follows:

1. To identify the specific areas for policy research in the arena of forest and environment.
2. To review the existing legislations related to forest and environmental sector with the changing scenario at national and global level for undertaking policy research.
3. To advise the CFPR in formulation of proposals to initiate policy research indentified thrust areas.
4. To review the progress of work done by CFPR.

Director General, ICFRE also constituted thirteen members Expert Committee under the Chairmanship of DDG (Education), ICFRE vide Order no. 22-1/2006-Edu/CFPR/ICFRE (Part)/ 252 dated 2nd December, 2018.

The terms of reference of the Forest Policy Research Expert Committee are as follows:

1. To shortlist the proposals received for the forest policy research studies by scrutiny of the proposals received and evaluating the proposals/ presentations.
2. To suggest suitable modifications in the proposals in terms of the objectives, methodology, time lit, cost, etc., for achieving the objectives of the studies.
3. To negotiate with the applicants for incorporation of the suggested modifications and recommend the proposals for approval of DG, ICFRE.
4. To suggest changes in the eligibility criteria, conditions of engagement, etc., related to the award of the policy research studies.

CFPR aims to become "Center of Excellence for Public Policy Research" in the arena of forest, wildlife and natural resource management and governance by providing leadership, best practices, research and support. The center will serve as 'policy think tank' for Government of India and play policy advocacy role, provide inputs for policy formation, implementation and evaluation for ensuring optimal usage and conservation of natural resources in the country.

The CFPR conducts policy research in the arena of forest, wildlife natural resources management and provide inputs for the Government in the process of policy formulation, implementation and evaluation for management of forest & environment sectors. The CFPR's mission is:

1. To provide inputs to the Government for better policy formulation for the management of forest and natural resources in the country.
2. To undertake consultancy projects on policy advocacy and assignments related to evaluation of government policies/programmes /projects.
3. To strengthen the policy formulation for the better governance of forest and natural resources, making use of rich research experience and expertise available in the ICFRE in the forestry sector.

4. To augment the capacity building of public servants, researchers and executives with latest techniques and tools for better policy formulation, implementation and evaluation.

The main objectives of CFPR:

1. To identify the thrust areas where there is a need for policy interventions for better governance of forest, wildlife and other natural resources in the country and also conduct research on the same through collaborative research projects.
2. To undertake the policy analysis of governance of natural resources and also look into the relevant legislations in a changing socio-economic scenario.
3. To provide inputs to the Government on issues related to policy formulation & strategies for implementation.
4. To carryout evaluation of various Government programmes/projects/policies with respect to identification of gaps in policy perspective.
5. To provide policy advisory services to Government of India and State Government Organizations, on the matter related to sustainable management and Governance of natural resources.
6. To conduct capacity building programmes for the stakeholders involved in the management and governance of natural resources.
7. To organize seminars/workshops/conferences on public policy related to governance of natural resources.
8. To create a knowledge base on public policy issues related to the governance of natural resources.
9. To develop CFRP as 'State of the Art' resource center having repository of information on governance of natural resources and best practices adopted across the globe for the sustainable management of natural resources.

First meeting of the Advisory Committee was held on 23.04.2018 at ICFRE (H.Q.) under the chairmanship of D.G., ICFRE. After detailed deliberations in the meeting of Advisory Committee, the following topics of Research (ToR) have been prioritized for taking up the Policy Research Studies:

1. Policy issues in agro forestry including market mechanisms, forward and backward linkages, regional availability, transit of forest produce, linkages with NDC targets, choice of species and utilization aspects.
2. Institutions of community participation including Joint Forest Management Committees (JFMCs) and Eco-Development Committees (EDCs), linkages with panchayati Raj Institutions, review of their working in various regions of the country and identification of successful models and shortcomings.
3. Issues in forest certification and certifying agencies.
4. Study on grazing policies in different state and formulation of grazing guidelines for states.
5. Devising Methodologies for periodical valuation and payment of ecosystem services.
6. Analysis of policy perspectives for inter-sectoral synergy in achieving goals of National Forest Policy and other policies and implementation of National Action Plan for Climate Change and Green India Mission.
7. Popularization of the use of wood and wood based substitutes as per the National Forest Policy and modalities for facilitating industries for its optimal utilization.
8. Functioning of Forest Development Corporations and their role in the present scenario.
9. Guidelines under Forest (Conservation) Act, 1980 for diversion of privately owned forests and non-forestry uses.
10. Public Private Partnership in a broad perspective in forestry involving various sections of the society.
11. Augmenting resources including innovative means of fund raising for achieving the targets enshrined in various policy documents – Review of the existing schemes and formulation of new ones with self-financing capacity.

Presently following two policy research studies have been undertaken by CFPR.

1. **Institutions of community participation including Joint Forest Management Committees (JFMCs) and Eco-Development Committees (EDCs), linkages with panchayati Raj Institutions,**

review of their working in various regions of the country and identification of successful models and shortcomings.

The institutions like Joint Forest Management Committees (JFMCS) and the Eco Development Committees (EDCs) have been the important institutional arrangements for community participation in the conservation of forests. The implementations of the various schemes of the Government are being carried out through these institutions. However there are issues pertaining to the functionality and sustainability of these institutions, effectiveness in their roles and responsibilities, legal backing, integration of these institutions with the Gram Sabha etc.

Terms of Reference:

(1) To analyse the working of the institutional arrangements for community participation in environment, forest & wildlife sector, in terms of the roles and responsibility, functionality, sustainability, adequacy of benefits to the community etc.
(2) Recognition of these institutions by other departments/ministries in states/centre in implementation of their schemes.
(3) To study the self sustenance of these institutions and its role in empowerment of the community.
(4) To study the legal backing of these institutions in states/UTs and integration/coordination with the Panchayati Raj Institutions.
(5) To suggest ways to improve the functioning of these institutions.
(6) Review of working of these institutions in various regions of the country.
(7) Identification of successful model.

PI: Sh. Yogesh Gokhale, Senior Fellow, Centre for Forest Management & Governance, The Energy and Resources Institute (TERI), New Delhi

Co- PI(s)

1. Dr. J.V. Sharma, Director Land Resource Division, TERI, New Delhi
2. Dr. Aparna Tyagi

3. Ms. Priya Sharma
4. Ms. Priya Sharma
5. Ms. supriya Kumari
6. Ms. Malika Vashist
7.

Budget: 12.83 lakh

Duration: 7 months

Final Draft Report has been received from TERI, New Delhi which is under process of reviewing.

2. **Policy issues in agro forestry including market mechanisms, forward and backward linkages, regional availability, transit of forest produce, linkages with NDC targets, choice of species and utilization aspects**

Taking cognizance of the multiple benefits of agroforestry, an ambitious National Agroforestry Policy in 2014 was launched to mainstream trees growing on farms. Agroforestry is a useful strategy for farmers to increase the productivity from their lands as well as to increase the resilience to climate change impacts. The potential of agroforestry to contribute to sustainable development has been recognized internationally. The National Adaptation Plans of Action (NAPAs) and Nationally Appropriate Mitigation Actions (NAMAs) also talk of agroforestry as an important component in agricultural sector actions. Experience over the past few decades has shown that commercial agroforestry gained momentum in the regions, where it got support from industry and assured market facilities. Many studies have also indicated that still there are many policy and regulatory gaps which need to be addressed for wider adoption of the programme.

PI: Dr. Devendra Pandey, Ex- PCCF & HoFF, Arunachal Pradesh and Ex -DG, FSI

Co-PI:

1. Sh. A.K. Srivastava, DG, NCCF, Noida
2. Sh. Suneel Kumar Pandey
3. Sh. Sachin Jain
4. Dr. S.K. Dhyani

5. Ms. Sneha Sukare

Budget: 9.95 lakh

Duration: 6 months

Terms of References:

(1) Analyze the effectiveness of existing policy options, institutional mechanisms and financial incentives available in the country for promotion of agroforestry

(2) Recommend a framework for involvement of financial and insurance sector in promotion of agroforestry, similar to the facilities of insurance and credit for agriculture sector from the financial institutions and an organized marketing structure.

(3) Suggest the policy changes required in light of the impacts of climate change, REDD+, NDC targets and forest certification aspects on availability and price of timber and non-wood forest produce to bridge demand and supply gap.

(4) Suggest unified regulatory regimes for agro-forestry produce and also recommend relaxation/removal of restrictive prescriptions with respect to harvesting, transportation and marketing of agro-forestry produce.

(5) Develop a strategy and road-map for large-scale production and supply of genetically superior and/or certified quality planting material through collaboration between private sector (tree growers, nursery growers, and industry), research organizations and state forest departments. Also suggest a mechanism for certification of nurseries and planting material through laboratory and nursery accreditation.

(6) Suggest incentivizing mechanisms such as tree credits and Minimum Support Price (MSP) for extending area and productivity of trees outside forests (TOF) and also propose a detailed mechanism for fixation of MSP and its implementation.

(7) Impact of import/export policy and role of WBIs in the development of agro forestry sector in India.

(8) Scope of research for ICFRE in agro-forestry.

(9) Appropriate role of Forestry Institutions regarding progress in the Agro forestry sector.

(10) Market price analysis of agroforestry produce based on past trends, to identify the factors responsible for it and suggestions to bring in market stability.

The date of submission of Final draft report has been extended up to December, 2021.

Total Expenditure during 2021-22 quarter-wise

Ist Quarter	**IInd Installment to TERI, New Delhi Rs. 6,05,576/=**
IInd Quarter	**IInd Installment to NCCF, New Delhi Rs. 4,69,640/= -**

Meeting of the Expert Committee was held on 28-29 June, 2021 at ICFRE(HQ) for examining and finalizing the proposals received for 9 Forest Policy Research Study and recommending for approval of DG,ICFRE under the Chairmanship of Deputy Director General (Education), ICFRE

Out of 9 studies, two Policy Research Studies were awarded to the following organizations in the month of July, 2021.

1. **Popularization of the use of Wood and Wood Substitutes as per the National Forest Policy and Modalities for Facilitating Industries for its Optimum Utilization"**

Wood substitutes are building products that are not graded as lumber. Popularizing of the use of wood and wood substitutes positively contribute to encouraging increased wood production, carbon sequestration and increased area under forest cover. Although the majority of wood substitutes contain wood by products, other substitutes contain no wood whatsoever. Substitution becomes a universal and inevitable phenomenon as a result of technological advancement and ever growing societal needs. It is remarkable that the substitution is a positive process allowing saving of valuable natural raw materials and pressure on forests. Further the wood products also result in cost saving over the lumber without comprising on the wood properties.

Terms of Reference

1) To assess the present utilization and demand of wood and wood substitutes in the country including the analysis of earlier studies.
2) 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.
3) 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.

Organization: Network for Certification and Conservation of Forests (NCCF),

EPCH House, Pocket 6, Sector C, Vasant Kunj, New Delhi and IORA Ecological Trust, 635-636,GF, Lane No.3 West Marg, Garden of Five Senses Road, Saidulajab Village, Saket, New Delhi

Budget: **Rs. 9,95,160/-**

Duration: **6 months**

2. Functioning of Forest Development Corporations and their role in the present scenario"

The forest development corporations were established in most of the states and have been registered under the Companies Act. Their major role was, harvesting of timber and other forest produce, marketing, plantations, etc. However due to the policy changes in the forestry sector like ban on green felling, conservation oriented approach, etc., the role of these corporations have been restricted in their conventional sectors and their profitability has also been greatly reduced. Some of these corporations are diversifying into other activities like ecotourism, wood based industries, etc. The role of these forest development corporations is required to be revisited and remodeled to capitalize on the strengths of the existing institutions.

Terms of Reference

(1) To study the present role of Forest Development Corporations in the states/UTs and their economic viability.

(2) To study the recent initiatives taken by these FDCs in various states/UTs, in terms of success, sustainability and profitability.

(3) To recommend programmes/activities to be taken up by the FDCs in the current scenario.

(4) To study the existing structure of the FDCs and suggest revamping wherever necessary for execution of the roles proposed for the current scenario.

Organization: IUCN (International Union for conservation of Nature)

H-4, 3rd Floor, Green Park Extension, New Delhi

&

IORA Ecological Trust,

635-636,GF, Lane No.3, West Marg, Garden of Five Senses Road, Saidulajab Village, Saket, New Delhi.

Budget: **Rs. 11,90,000/-**

Duration: **10 Months**

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 Plans has been prepared and published. 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. The manual addresses five main stages for developing SRAP, i.e., prepare, analyse, plan, monitor and budget. The first stage: preparation is purely institutional and comprises of collection of preparatory data and analysis, the second stage: analysis involves identification and prioritization of drivers of deforestation and forest degradation through multi-stakeholder consultation processes. The rest of the three stages, i.e., planning, monitoring and budgeting deals with identification of intervention packages, safeguards analysis, monitoring activities and budget for identified activities along with operation plan. The 'Problem Analysis Workshop' and 'Solution Analysis Workshop' are the central group activities that give an outline towards and recognising the challenges faced by the respective areas and contributing necessary actions to improve the forest productivity. These contribute essential inputs in the whole process of developing SRAP. Copies of the resource manual has been shared with all the State Forest Departments.

B. **Capacity building of the Nodal Officers/ Trainers of ICFRE institutes for developing State REDD+ Action Plan:** 18 Nodal Officers/ trainers have been nominated by the ICFRE's institutes for building the capacity of the officials of the State Forest Departments for developing State REDD+ Action Plan. A four days stakeholder consultation workshop and expert consultation workshop for building the capacity of the State Forest Departments of Chhattisgarh was organized under the World Bank funded Ecosystem Services Improvement Project at Raipur, Chhattisgarh from 17 to 20

February 2021. This platform was also utilized for building the capacity of the 18 Nodal officers of ICFRE institutes (two from each institute).

C. **Organization of the capacity building programmes of the SFDs for developing State REDD+ Action Plans:** Following capacity building programmes have been organized:

S. No.	Dates	ICFRE Institute Involved	States covered for capacity building programmes
1.	15-16 March 2021	IWST Bengaluru	Karnataka and Andhra Pradesh
2.	10-11 August 2021	HFRI, Shimla	Ladakh UT
3.	30 Sept. to 01 Oct. 2021	IFP, Ranchi	West Bengal
4.	21-22 Oct. 2021	IFP, Ranchi	Jharkhand
5.	21-22 Oct. 2021	AFRI, Jodhpur	Rajasthan
6.	27-28 Oct. 2021	IFP, Ranchi	Bihar
7.	29-30 Oct. 2021	IFB, Hyderabad	Odisha
8.	26-27 October 2021	TFRI Jabalpur	Madhya Pradesh and Maharashtra

Organization of the training programmes for other states have been planned and will be completed by March 2021.

D. Hindi version of the Resource Manual for capacity building of the SFDs has been prepared and same is under finalization. This will be useful for the Hindi speaking states.

E. Documentary for developing state REDD+ action plan is also under preparation and finalization.

Component V:

Operationalization of Human Resource Development Plan of ICFRE

Under HRD activities total 9 trainings have been conducted out of which 2 are the induction trainings and 7 are regular trainings as per the approved HRD PLAN of the council. The trainings conducted are listed below:

SN	Name of Training	Institute	Participants	Date	Target Group
1.	Induction training for Scientist – B (First Phase)	FRIDU, Dehradun	30	01 Apr, 2021 to 25 Jun, 2021	Scientist
2.	Induction Training for Technician	FRI, Dehradun	15	05-09 Apr, 2021	Technical staff
3.	New approaches in Agroforestry and tree crop interaction	CAFRI, Jhansi	20	26-28 Jul, 2021	Technical staff
4.	Introduction to Remote sensing and GIS	IIRS, Dehradun	38	02-06 Aug, 2021	Scientist
5.	Analytical chemistry of NWFPs and Medicinal Plants	CIMAP, Lucknow	20	23-27 Aug, 2021	Technical staff
6.	Refresher training in statistical methods in forestry research (First Phase)	Statistics Division, ICFRE, Dehradun	14	20-24 Sep, 2021	Scientist
7.	Computer and internet application (First Phase)	IFP, Ranchi	39	20-24 Sep, 2021	Technical staff
8.	Forest Certification	FRI, Dehradun	20	27 Sep, 2021 to 01 Oct, 2021	Scientist
9.	Plus Tree selection	KFRI, Peechi	39	28-30 Sep, 2021	Technical staff
		Total	**235**		

Induction Training of Newly Recruited Scientists of ICFRE (*Batch I*)

The task for conducting the induction training for the newly recruited scientists of the ICFRE was assigned to FRI (Deemed to be University). Initially, the said training program was to be conducted in both online and offline mode, in which 10 weeks online and 02 weeks offline was scheduled. However,due to the increase outbreak of Covid-19 epidemic, the entire training program was conducted in online mode. Alsoit has not been possible to conduct the 02 weeks offline mode that covers the north India and South India tour.

The main objective of the induction course was to present the newly recruited scientists, an overview of forestry and forestry research and to acquaint them with the operational and professional culture of the council and to enhance their core competence in their areas of the specialization. It was also intended to provide them with crucial insights ofthe scientific mandate of the council and orient them towards forestry research, extension and education fields, which they will further, develop in due course. The ten week training program was organized between 15th March and 25th June, 2021. The inauguration of the Training Course was done by the Director General, ICFRE on 15th March 2021.A total of 95 sessions were conducted (schedule is appended in annexure-1) in online mode. Two week module on Project management and Research Methodology was conducted by NAARM, Hyderabad for the participants. The participants were also briefed about the use of Information and Communication technology in the field of research and were introduced to research and development activities undertaken by ICFRE. There were 30 participants in the batch. The participants were nominated by the ICFRE drawnfrom various Institutes of ICFRE. A list of the participants who attended the induction training course along with their respective Institutes has been given in the following table :

S. No.	Name of the Scientist	Name of the Nodal Institute
1.	Dr. Nibedita Guru	FRI, Dehradun
2.	Sh. Suryanarayan Murthy Midde	AFRI, Jodhpur
3.	Sh. KingshukModak	AFRI, Jodhpur
4.	Dr. Balkrishna Tiwari	HFRI, Shimla
5.	Sh. Deepak Kumar	AFRI, Jodhpur
6.	Dr. Mohan C.	TFRI, Jabalpur
7.	Ms. Anjali Joshi	AFRI, Jodhpur

8.	Mr. SumantraBasu	AFRI, Jodhpur
9.	Dr. Aditi Tailor	AFRI, Jodhpur
10.	Sh. Tanmaya Kumar Bhoi	AFRI, Jodhpur
11.	Sh. Dheeraj Kumar	FRI, Dehradun
12.	Mr. Anshuman Das	IFP, Ranchi
13.	Dr. Balaganesh G	FRI, Dehradun
14.	Sh. Mohit Husain	FRI, Dehradun
15.	Mr. Blessing Roy Suchiang	IFP, Ranchi
16.	Sh. Pravin Rawat	HFRI, Shimla
17.	Sh. Digvijaysinh Rathod	TFRI, Jabalpur
18.	Sh. Kaushal Tripathi	TFRI, Jabalpur
19.	Sh. Nikhil Verma	TFRI, Jabalpur
20.	Sh. Neeraj Prajapati	TFRI, Jabalpur
21.	Ms. Jangam Deepika	TFRI, Jabalpur
22.	Sh. Vinod Kumar	IFB, Hyderabad
23.	Sh. Ajin Sekhar	TFRI, Jabalpur
24.	Ms. Bharati Patel	IFB, Hyderabad
25.	Sh. Tatiparthi Srinivas	IFB, Hyderabad
26.	Sh. Kavi Sidharthan V.	IFB, Hyderabad
27.	Sh. Muhammad Ali Noushad	IFGTB, Coimbatore
28.	Sh. Sarath S.	IWST, Bangalore
29.	Sh. Veer Singh Gautam	IWST, Bangalore
30.	Sh. L.R. Lakshmikanta Panda	FRI, Dehradun

The course content as approved under the HRD programme of ICFRE was covered in the ten week duration. Due to the CORONA pandemic, the offline tour programme to North India and South India were not covered in the course. The brief course content of the induction training course has been presented here.

Week	**Module**	**Coordinating Institute**
Week-I &II	**Module-I. Forest Administration, Office Procedures & Administration**	**FRIDU**
	Forest Administration Overview of ICFRE and Institutes, Forest Administration in India, structure and function of various forestry organizations. Overview of forestry in India, Challenges and opportunities, forest policies and legislation (important acts), Overview of forestry Programmes (JFM, GIM, NAP etc.),forestry organizations (international and national), changes in forestry sector at global and national level,	

	international conventions. **Administration and Office Procedures** 1. General Management concepts and principles, Organizational behavior, leadership, motivation, Group dynamics and team building, conflict resolution, HRD and personnel management. Effective communication, presentation and soft skills for personality development, Career progression and planning. 2. Handling office correspondence, file management, Preparation of notes, drafts etc., Manual of office procedures., Service and establishment rules, accounting procedures, Procurement procedures and rules, Public services doctrine and conduct., Right to information and other aspects. **Research, Extension, Education** 1. Mission, goal, vision, thrust areas and themes, Research prioritization/NFRP, Institutional setup for research in ICFRE including RAG/RPCs, etc., Procedures/guidelines for the projects preparation and implementation, Monitoring and evaluation of research, Other activities of Directorate of Research. 2. Insight into activities of Directorate of Extension-Media and Publication, National Forestry Extension Plan, Forest database and EIA works. 3. Activities of Directorate of Education, Centre of Forest Policy Research, Forestry education system, networking with universities and Other activities of Directorate.	
Week-III &IV	**Module-III. Forestry overview**	**FRIDU**
	Forestry Overview 1. Silviculture Classifications, Forest Types, Important species, Forest management imperative and principles, Sustainable Forest Management, Mensuration, biometrics , growth modelling ,Forest Certification, forest Working Plans, Tree Improvement, productivity of forest and plantation, Joint and Participatory forest management. 2. Forest protection including forest fires, Non timber forest products. 3. Cultivation, harvesting, processing, storage, marketing of forest produce.	

	4. Wildlife Management. 5. Extension forestry and agroforestry 6. Wood Science and Technology 7. Forest ecology and biodiversity conservation 8. Soil and water conservation, approaches, tools and techniques, Watershed management and hydrology. 9. Environmental management, environmental impact assessment, forest carbon & climate change, carbon budgeting and trading, IPR/ bio safety issues.	
Week-V	**Module III :Forestry Overview (Status of Research)**	**FRIDU**
	Status of research in various subjects, knowledge gaps and current research, AICRPs, priority areas, etc.	
Week-VI&VII	**Module IV :Specialization Module**	**Respective ICFRE institutes in consultation with FRIDU**
	Attachment with an identified division preferably in the area of proposed specialization either in the institute of ICFRE or other organization for two weeks. The scientist will also be attached to a senior scientist (Scientist E or above) during which period the trainee scientist/researcher will develop a working paper on a pre-assigned topic and convert into a project. The topic will be decided by a panel of experts in the relevant field to the specialization branch of the trainee. Mentoring will also be in the form of a structured programme and will be monitored and evaluated.	
Week-VIII & IX	**Module II :Project Management & Research Methodology**	**NAARM, Hyderabad 03-14 May 2021**
	Project Management Propounding research Proposals, Scientific values and professional ethics in Research Proposal writing, Skills for scientific research paper and research report writing, Brainstorming techniques, Project Designing, Preparation on concept papers and technical notes, Project Management techniques, Funding agencies and approach, Periodical reporting. **Research Methodology Module** The module will comprise concepts and applications of statistics in forestry research with hands on workshops on statistical software with case-studies. 1. Observations, data and their measurement scales, Frequency distributions, Central Tendency,	

	Dispersion, skewness, kurtosis, influential point & outlier, Presentation of data: Graphical data analysis, Probability and its applications in data analysis, Binomial and Normal /Weibull and Johnson Distributions and their applications, Framing and Testing hypothesis for research: Parametric and Non-parametric tests, Bi-variate analysis-Correlations and regressions analysis of variance and covariance. 2. Designing lab and field experiments in forestry-CRD, RBD, LSD, Designs for optimization, alpha-designs, Factorial, split-plot, incomplete block design, Basic socio and economic tools and techniques, Planning sample surveys: development of questionnaires and data collection forms, Sampling techniques commonly used in forestry. 3. Basic Multivariate Analysis-Multivariate ANOVA, Cluster analysis, Principal Component Analysis, Factor analysis, Multiple Regression Analysis, Non linear regression, use of state space approach.	
Week-X	**Module V: ICT & GIS**	**FRIDU**
	1. ICT Application in ICFRE/research, computer application- Microsoft excel, access database and other application, Database Management system, IFIRIS and its various modules, Hands on working on IFIRIS system. 2. Remote Sensing and GIS application in forestry, handling GPS in surveys and data collection, Working with GPS data, sampling, trails etc, visit to FSI/IIRS. Experience sharing. Presentation of working papers and projects before a panel of experts.Valedictory and closure of the course.	

The course was run by taking the services of a galaxy of both in-house faculty and Forestry and Management experts from outside Institutions & Universities. The list of the resource persons who delivered lectures and practical training to the participants is given below:

S. No.	Session	Name	Designation & Organization
1.	• Overview of ICFRE and Institutes. • Mission goal, Thrust Areas and Themes. •	Dr. S.D. Sharma	Deputy Director General (Research) ICFRE
2.	• Status of Research in FGR research. • Evaluation of project presentation of newly recruited Scientist of ICFRE	Dr. H. S.Ginwal	Scientist-G and Dean FRIDU
3.	Forest policies and legislation (Important acts)	Sh. Kunal Satyarthi	Principal Central Academy of State Forest Services
4.	• Structure and function of various forestry organizations. • Changes in forestry sector at global and national level. • Forestry organization (National and International). • International Conventions. • Environmental Policies and Law	Sh. Ajay Kumar Lal	Retd. IFS
5.	• Overview of Forestry programmes, JFM, GIM, NAP etc. • Forest Types of India. • Silvicultural Classifications and Important Species. • Sustainable Forest Management	Sh. Sama Raghupati Reddy	Assistant Silva (G) FRI
6.	• Career Progression and Planning. • Group Dynamics and Team building	Sh. Chetan Sharma	Career Launcher
7.	• General Management Concepts and Principles. • Conflict Resolutionand management. • Motivation, Leadership	Smt. Shilpa Arora	Faculty, University of Petroleum and Energy Studies
8.	• HRD and Personnel Management. • Effective Communication, presentation and soft skills for personality development	Smt. Asha Rani Kapoor	Director Training , Global Solution India

9.	• RTI and other aspects • Growth modeling • Carbon budgeting and trading	Dr. Rajiv Pandey	Scientist-E, ICFRE
10.	• Accounts Procedures and Rules Part I. • Accounts Procedures and Rules Part II. • Wood Seasoning and Wood physics	Dr. N K Upreti	Scientist-G & Group Coordinator (Research), FRI
11.	• Manual of office procedures- Part I. • Manual of office procedures- Part II	Shri. Prem Lal	Under Secretary ICFRE
12.	• Services and Establishment Rule. • Handling office correspondence and file management, Preparation of Notes, drafts etc	Smt. Neelima Shah	Registrar, FRI
13.	• Research Prioritization/NFRP. • Institutional Set up for Research in ICFRE including RAG and RPC. • Procedures/ guidelines for the project preparation.	Dr. Vimal Kothiyal	Assistant Director General (RP), ICFRE
14.	Monitoring & Evaluation of Research & other activities of Directorate of Research.	Sh. E. Vikram	Assistant Director General(Monitoring & Evaluation) ICFRE
15.	Insight into activities of Directorate of Education.	Smt. Kanchan Devi	Deputy Director General (Edu) ICFRE
16.	• Overview of forestry in India, Challenges and opportunities. • Forest Administration in India. • Public Service Doctrine & conduct. • Forest management Imperatives and Principles.	Sh. Deepak Mishra	Head Forest Silviculture & Management, FRI
17.	Forestry education system	Dr. P.K. Pandey	Retd. Scientist
18.	Insight into activities of Directorate of International Cooperation	Sh. Anurag Bhardwaj	Director (IC) ICFRE
19.	• Insight into Activities of Directorate of	Dr. Geeta Joshi	Assistant Director

	Extension- Media and publication. • National Forestry Extension Plan		General (Media & Extension) ICFRE
20.	Procurement procedures and Rules	Dr. N.S.K. Harsh	Retd. Scientist
21.	Forest database and EIA works. Environmental Impact Assessment (EIA)	Dr. Amar Nath Singh	Assistant, Director General (EM) ICFRE
22.	• Forest Mensuration. • Status of Research in Silviculture	Dr. Dinesh Kumar	Scientist-G FRI
23.	Forest Working plans.	Sh. Sushant Kumar	Forest Silviculture and Management Division, FRI
24.	Biometrics	Dr. Manoj Kumar	Scientist-C, FRI
25.	Forest Certification.	Dr. Shailendra Kumar	Scientist-C, FRI
26.	Tree Improvement.	Dr. Ajay Thakur	Scientist-G and Head, FRI
27.	Productivity of forest and plantation.	Dr. A. Nicodemus	Scientist-G, IFGTB
28.	Forest Insects and their control.	Dr. R.S. Bhandari	Retd. Scientist-G, FRI
29.	• Forest Diseases and their control. • Status of Research in Forest Pathology	Dr. Amit Pandey	Scientist-G, FRI
30.	• Wildlife Management. • Biodiversity Conservation. • Evaluation of project presentation of newly recruited Scientist of ICFRE	Dr. Pradeep Kumar Mathur	Retd. Dean, Wildlife Institute of India
31.	Cultivation, harvesting, processing, storage and marketing of forest produce and composite wood.	Sh. Dwarika Prasad Khali	Scientist-G, FRI
32.	Forest fires and Protection.	Smt. Arti Chaudhary	Addl. Professor ,IGNFA
33.	Extension forestry.	Dr. Ashok Kumar Pandey	Retd. Scientist -G
34.	Natural Resource Conservation and Management	Smt. Nataliya Krishnambika	Faculty, FRIDU
35.	Overview of Wood Science and Technology.	Dr. K.K. Pandey	Scientist-G, IWST
36.	Soil Conservation approaches, tools and techniques.	Dr. Parul Bhatt Kothiyal	Scientist-E, FRI

37.	• Water Conservation approaches, tools and techniques. • Watershed management and hydrology	Dr. Parmanand Kumar	Scientist-C, FRI
38.	Environmental Pollution and Management.	Dr. Ananad Kumar Gupta	Scientist (Environmental Science) ICAR-Indian Institute of Soil and Water Conservation
39.	Forest Ecology basic Principle, Ecosystem Structure and Function	Dr. Sanjay Singh	Scientist, ICFRE
40.	Forest Carbon and climate change.	Dr. Vijay Raj Singh Rawat	Retd. Scientist,FRI
41.	Forest Soils	Sh. NirmalyaBala	Scientist-G ,FRI
42.	Agro forestry	Dr. Syam Viswanath	Director, KFRI, Peechi
43.	IPR. Status of Research in AICRP *Melia dubia*.	Dr. Ashok Kumar	Scientist-G , Forest Genetics and Tree Improvement
44.	Biosafety issues.	Dr. Shambhavi Yadav	Scientist-B, FRI
45.	Non timber forest products	Dr. Neelu Singh	Scientist-F, FRI
46.	Networking with Universities and Other activities of Directorate of Education. Centre of Forest Policy Research.	Dr. V.S. Senthilkumar	Assistant Director General (Edu & RB) ICFRE
47.	Status of Research in Bio-prospecting of Forest Products	Dr. Vinay Kumar Varshney	Scientist-G, FRI
48.	Status of Research in Restoration of Degraded Land.	Dr. G. Singh	Scientist-G, AFRI
49.	Status Research on Bamboo Improvement & propagation.	Dr. SantanBarthwal	Scientist-F, FRI
50.	Forest Soil Health Card Mapping.	Dr. Vijendra Pal Singh Panwar	Scientist-E, FRI
51.	Status of Research in Forest Seed Technology.	Dr. Manisha Thapliyal	Scientist-F , FRI
52.	Status of Research in Forest Biotechnology	Dr. R. Yashoda	Scientist-G ,IFGTB

53.	Status of Research in Forest Entomology	Dr. R. Sundararaj	Scientist-G, IWST
54.	Status of Research in NTFP Research	Dr. Sandeep Sharma	Scientist-G , HFRI
55.	Status of Research on Forest Biodiversity	Dr. C. Kunhikannan	Director , IFGTB
56.	• Research Proposal Writing for DBT & DST • Status of Research in Forest Genomics	Dr. Modhumita Dasgupta	Scientist-G, IFGTB
57.	IFIRIS and its various modules	Dr. Jatender Singh	Scientist-D , IT ICFRE
58.	• Computer Application- Excel, Access Database and other Application, Database Management System. • Hands on working on IFIRIS system.	Sh. Sudhir Kumar	IT Div.,ICFRE
59.	Evaluation of project presentation of newly recruited Scientist of ICFRE.	Dr. P.K. Mathur	Ex Dean WII
		Dr. Subhash Nautiyal	Retd Scientist-G and Head , Botany Division.
		Dr. H.S.Ginwal	Dean (A), FRIDU

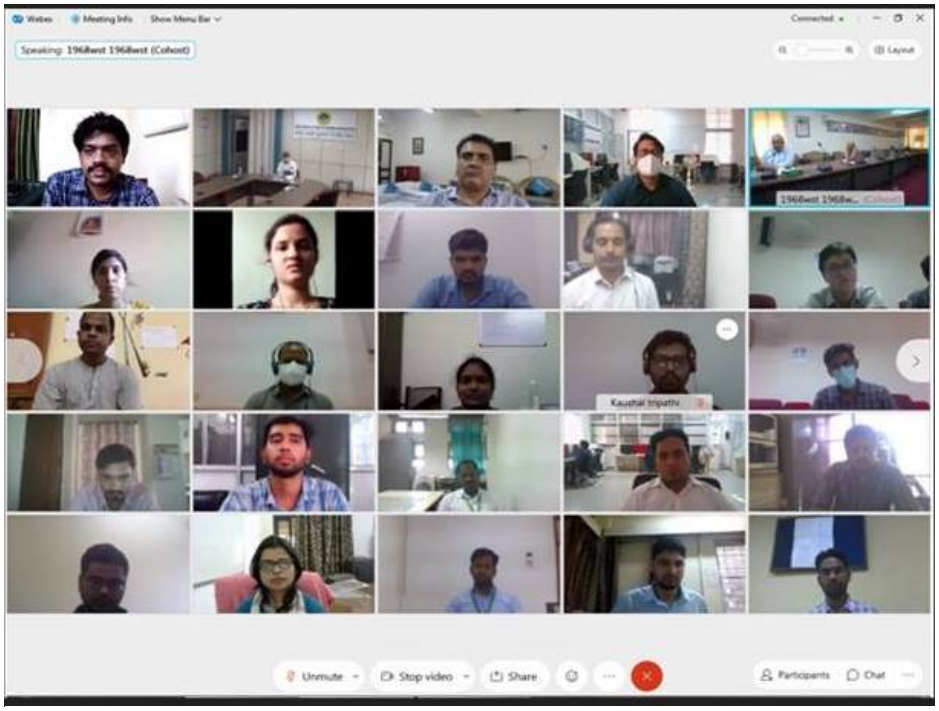


Fig. 46 Glimpses of the virtual induction training

NAARM, Hyderabad Sessions

Two modules of the Induction Training i.e. "Project Management and Research Methodology" for the Scientists of ICFRE, Dehradun, were organized and conducted by the ICAR-National Academy of Agricultural Research Management, Hyderabad from 3rd to 14th May, 2021 in virtual mode.The programme was organized as a part of the Memorandum of Understanding (MoU) signed between the ICAR and ICFRE.

The participants were introduced to the concept of Design Thinking (DT) and its use in the various aspects related to research management, with relevant illustrations and case studies. The innovative exercises were designed to instil DT perspectives among the participants in research problem identification, prioritization of research solutions, research concept development and project log frame construction.The various sessions conducted by the NAARM, Hyderabad has been summarized below:

Module 1: Project Management & Science Communication

Session	Resource Person
Inaugural Session & Programme Overview	Coordinators
Winning Type Research Project Proposals: Tips	Ch. Srinivasa Rao
Design Thinking (DT): Overview & DT - Research Management Interface	SK. Soam
DT Perspective in Problem Identification and Definition: Case Studies **[Gr. Ex: 1]**	P. Krishnan
Developing Rationale for Research Projects	SK. Soam
Building Research Concepts – Introduction to Terminologies	P. Krishnan
Building Research Concepts using Research Concept Writer **[Gr. Ex: 2]**	SK. Soam
(Contd) Conceptualization using Research Concept Writer **& Presentation**	P. Krishnan / SK. Soam
Hierarchy of Objectives **–** M&EConcepts	SK. Soam
Hierarchy of Objectives **[Gr. Ex: 4]**	P. Krishnan
Understanding M&E Terminologies: OVI, MoV, CA, R	P. Krishnan / SK. Soam
Prototyping and Visualization using PLW **[Gr. Ex: 5] & Presentation**	SK. Soam
Research Project Prioritization using AHP Analyzer – Concepts & Exercise **[Gr. Ex: 6]**	SK. Soam
Elements for Science Communication	Ch. Srinivasa Rao

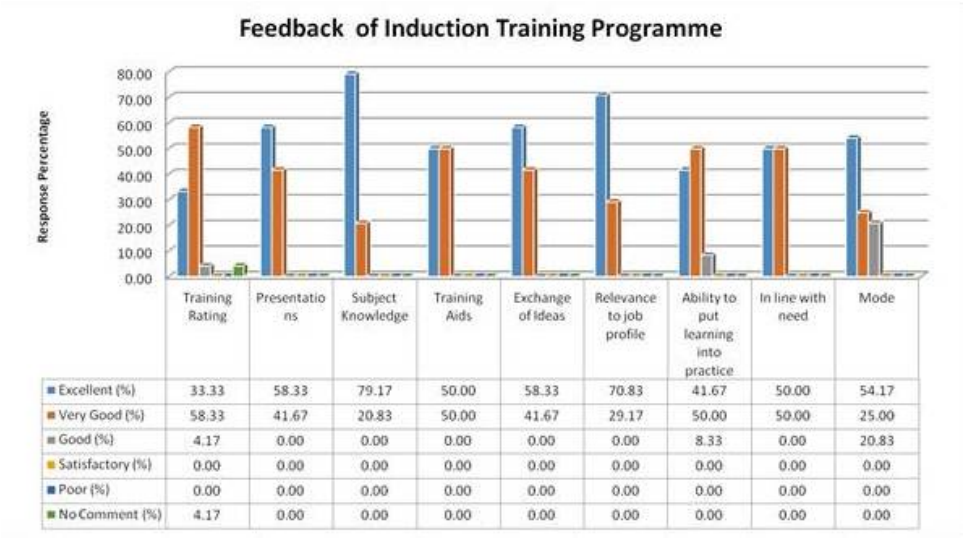
Online tools for Reviewing / Data Visualization / Science Communication **[Gr. Ex: 7]**	P. Krishnan
Tips for Poster Presentation	Bharat S Sontakki
Communication in Social Media	P. Venkatesan
Breaking Myths in Science Communication	P. Krishnan
Digital Tools for Communication **[Gr. Ex: 8]**	GF- UoH Madhavi Kumar

Module 2: Research Methodology

Session	Resource Person
Research Methodology: An Overview	A. Dhandapani
Descriptive Statistics	N. Sivaramane
Tests of Significance	A. Dhandapani
Descriptive Statistics & Tests of Significance (using BlueSky Statistics)**[Gr. Ex: 1]**	N. Sivaramane /BS.Yashawanth
Visualization of Data	A. Dhandapani
Visualization of Data**[Gr. Ex: 2]**	BS.Yashawanth
Correlation and Regression Analysis	S. Ravichandran
Regression Diagnostics	S. Ravichandran
Correlation and Regression Analysis**[Gr. Ex: 3]**	S. Ravichandran
Logistic Regression	N. Sivaramane
Logistic Regression**[Gr. Ex: 4]**	N.Sivarmanae
Principles of Experimentation	A. Dhandapani
Design of Experiments (DoE) – I: Simple Designs	A. Dhandapani
DoE – I**[Gr. Ex: 5]**	A. Dhandapani
DoE – I (Contd.)	A. Dhandapani
DoE – I**[Gr. Ex: 6]**	A. Dhandapani/BS.Yashawanth
Design of Experiments (DoE) – II: Factorial Experiments	A. Dhandapani
DoE- II (Contd.) – Special Designs	A. Dhandapani
DoE – II**[Gr. Ex: 7]**	A. Dhandapani
Multivariate Analysis – Introduction	A. Dhandapani
Cluster Analysis	A. Dhandapani
Cluster Analysis**[Gr. Ex: 8]**	A. Dhandapani/ BS.Yashawanth
Feedback, Online Examination	GRK. Murthy
Valediction	P. Krishnan

After the completion of the training, the feedback of the participants on various parameters viz. overall rating of training, rating of resource persons (on the aspects of presentation skills, knowledge and command of the subject, use of training aids andexchange of ideas), and rating of training (relevance to job profile, will participant be able to put learning into practice, conformity with the training needs, mode of training and duration of training) was obtained

through a standard format. The analysis of the feedback revealed that the induction course was rated in the category of Excellent (33.33 %), Very Good (58.33 %) and Good (4.17 %). The average response of the participants on various parameters viz. has been presented. In general 91.66 % participan rated it in the category of Excellent and Very Good. Participants found that the training was good and was placed in a very comfortable way.Their response to the training rating, presentation, training aids, ability to put learning into practice, mode of training, relevance to the job profile, subject knowledge, in line with need as well as exchange of ideas was totally positive. Some of the participants suggested to conduct offline mode of training which is very likely to provide greater oppourtunities and learning as the online mode sometimes adversely affected by internet connectivity. They also suggested that the demonstration of successfully completed project of ICFRE from formulation to implementation and writing of project completion report may give the idea about key points and challenges faced during the formulation of project. All the above suggestions will be taken into consideration while formulating the next training programme.



	Training Rating	Presentations	Subject Knowledge	Training Aids	Exchange of Ideas	Relevance to job profile	Ability to put learning into practice	In line with need	Mode
Excellent (%)	33.33	58.33	79.17	50.00	58.33	70.83	41.67	50.00	54.17
Very Good (%)	58.33	41.67	20.83	50.00	41.67	29.17	50.00	50.00	25.00
Good (%)	4.17	0.00	0.00	0.00	0.00	0.00	8.33	0.00	20.83
Satisfactory (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Poor (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No Comment (%)	4.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Fig. 47 Graphical Representation of Feedback Response Received from the Participants

The valediction of the first batch of induction coursewas held on 25th June 2021 in the presence of Director General, ICFRE. A short presentation on the 10 week induction training was given by Dr. H.S. Ginwal, Dean (A), FRI (Deemed to be University) who had coordinated and organized the programme for the newly recruited scientist of ICFRE. Words of encouragement and motivation to the young scientist were given by the chief guest Sh. A.S. Rawat, Director

General, ICFRE on this occasion. A number of research institutes and scientist of ICFRE and other organizations such as NAARM, Hyderabad were involved in conducting the training programme. The programmeended with a format vote of thanks to ICFRE Dehradun, NAARM Hyderabad and each and every one who was involved in the successful organisation of the 10 week induction course.

Programme Schedule

Programme Week - I

Module I -Forest Administration, Office Procedure and Administration

Date ▼	**I Lecture**	**II Lecture**	**III Lecture**	**IV Lecture**	**V Lecture**
Time ▶	**09:30-10:30**	**10:45-11:45**	**12:00-01:00**	**02:15-3:15**	**03:30-04:30**
15.03.2021	Inaugural Session		Course overview **(Dr. H. S. Ginwal)**	Overview of ICFRE and Institutes **(Dr. S.D Sharma)**	Overview of forestry in India, Challenges and opportunities **(Sh. Deepak Mishra)**
16.03.2021	Forest policies and legislation (Important acts), **(Sh. K. Satyarthi)**		Forest Administration in India **(Sh. Deepak Mishra)**	Structure and function of various forestry organizations **(Sh. A.K. Lal)**	
17.03.2021	Overview of Forestry programmes, JFM, GIM, NAP etc. **(Sh. S. R. Reddy)**		Changes in forestry sector at global and national level **(Sh. A.K. Lal)**	Forestry organization (National and International), **(Sh. A.K. Lal)**	Career Progression and Planning (**Sh. Chetan Shrama)**
18.03.2021	General Management Concepts and Principles **(Smt. Shilpa Arora)**	Conflict Resolution and management **(Smt. Shilpa Arora)**	Group Dynamics and Team building **(Sh. Chetan Sharma)**	International Conventions **(Sh. A.K. Lal)**	

19.03.2021	HRD and Personnel Management **(Smt. Asha Rani Kapoor)**	Motivation, Leadership **(Smt. Shilpa Arora)**	Effective Communication, presentation and soft skills for personality development **(Smt. Asha Rani Kapoor)**

Programme Week – II

Module I: Forest Administration, Office Procedure and Administration

Date ▼	**I Lecture**	**II Lecture**	**III Lecture**	**IV Lecture**	**V Lecture**
Time ▶	**09:30-10:30**	**10:45-11:45**	**12:00-01:00**	**02:15-3:15**	**03:30-04:30**
22.03.2021	RTI and other aspects. **(Dr. Rajeev Pandey)**	Accounts Procedures and Rules Part I **(Dr. N.K. Upreti)**	Manual of office procedures- Part I **(Sh. Prem Lal)**	Accounts Procedures and Rules Part II **(Dr. N.K. Upreti)**	Services and Establishment Rule **(Smt. Neelima Shah)**
23.03.2021	**Directorate of Research**		Public Service Doctrine & conduct **(Dr. Deepak Mishra)**		Manual of office procedures- Part II **(Sh. Prem Lal)**
	Mission goal, Thrust Areas and Themes (**Sh. S.D Sharma)**	Research Prioritization/ NFRP **(Dr. Vimal Kothiyal)**			
24.03.2021	Handling office correspondence and file management, Preparation of Notes, drafts etc. **(Smt. NeelimaShah)**		**Directorate of Research**		**Directorate of Research**
			Institutional Set up for Research in ICFRE including RAG and RPC **(Dr. Vimal Kothiyal)**	Monitoring & Evaluation of Research & other activities of Directorate of Research **(Sh. E. Vikram)**	Procedures/ guidelines for the project preparation (**Dr. Vimal Kothiyal)**
25.03.2021	**Directorate of Education**		**Directorate of Education**		**Directorate of Extension**
	Insight into activities of Directorate of Education **(Smt. Kanchan Devi)**		Forestry education system (**Dr. P.K Pandey)**		Forest database and EIA works. **(Dr. A.N Singh)**

26.03.2021	**Directorate of Extension**		**Directorate of Extension** National Forestry Extension Plan (**Dr. Geeta Joshi)**	Procurement procedures and Rules (**Dr. N.S.K. Harsh)**	**Directorate of Education** Insight into activities of Directorate of International Cooperation. (**Sh. Anurag Bhardwaj)**
	Insight into Activities of Directorate of Extension- Media and publication. **(Dr. Geeta Joshi)**	Insight into Activities of Directorate of Extension- Media and publication **(Dr. Geeta Joshi)**			

Programme Week – III

Module III: Forestry Overview

Date ▼	I Lecture	II Lecture	III Lecture	IV Lecture	V Lecture
Time ▶	**09:30-10:30**	**10:45-11:45**	**12:00-01:00**	**02:15-3:15**	**03:30-04:30**
29.03.2021	**Holi**				
30.03.2021	Forest Types of India **(Sh. S.R. Reddy)**		Silvicultural Classifications and Important Species (**Sh. S.R. Reddy)**		Forest management Imperatives and Principles **(Sh. Deepak Mishra)**
31.03.2021	Sustainable Forest Management **(Sh. S.R. Reddy)**	Forest Mensuration **(Dr. Dinesh Kumar)**	Biometrics (**Dr. Manoj Kumar)**	Growth modelling (**Dr. Rajeev Pandey)**	Forest Certification (**Dr. Shailendra Kumar)**
01.04.2021	Forest Working plans **(Sushant)**	Tree Improvement **(Dr. Ajay Thakur)**	Productivity of forest and plantation **(Dr. A. Nicodomus)**	Forest Insects and their control (**Dr. R.S Bhandari)**	Forest Diseases and their control **(Dr. Amit Pandey)**
02.04.2021	**Good Friday**				

Programme Week – IV

Module III: Forestry Overview

Date ▼	I Lecture	II Lecture	III Lecture	IV Lecture	V Lecture
Time ▶	**09:30-10:30**	**10:45-11:45**	**12:00-01:00**	**02:15-3:15**	**03:30-04:30**
05.04.2021	Wildlife Management **(Dr. P.K Mathur)**	Biodiversity Conservation **(Dr. P.K Mathur)**	Cultivation, harvesting, processing, storage and marketing of forest produce and composite wood (**Sh. D.P Khali)**		Forest fires and Protection **(Smt. Arti Choudhary)**
06.04.2021	Extension forestry (**Dr. A.K Pandey)**	Natural Resource Conservation and Management **(Smt. Nataliya Krishnambika)**	Overview of Wood Science and Technology **(Dr. K.K. Pandey)**	Wood Seasoning and Wood physics **(Dr. N.K Upreti)**	
07.04.2021	Soil Conservation approaches, tools and techniques (**Dr. Parul Bhatt)**	Water Conservation approaches, tools and techniques (**Dr. Parmanand Kumar)**	Watershed management and hydrology **(Dr. Parmanand Kumar)**	Environmental Pollution and Management (**Dr. Anand Gupta)**	Environmental Policies and Law (**Sh. A.K. Lal)**
08.04.2021	Environmental Impact Assessment (EIA) **(Dr. A.N. Singh)**	Forest Ecology basic Principle, Ecosystem Structure and Function (**Dr. Sanjay Singh)**	Forest Carbon and climate change (**Dr. V.R.S. Rawat)**		Carbon budgeting and trading (**Dr. Rajeev Pandey)**
09.04.2021	Forest Soils **(Sh. N. Bala)**	Agro forestry. (**Dr. Syam Viswanath)**	IPR **(Dr. Ashok Kumar)**	Bio-safety issues (**Dr. Sambhavi Yadav)**	Non timber forest products (**Dr. Neelu Singh)**

Programme Week – V

Module III: Forestry Overview (Status of Research)

Date ▼	**I Lecture**	**II Lecture**	**III Lecture**	**IV Lecture**	**V Lecture**
Time ▸	**09:30-10:30**	**10:45-11:45**	**12:00-01:00**	**02:15-3:15**	**03:30-04:30**
12.04.2021		Networking with Universities and Other activities of Directorate of Education (**Dr. V.S. Senthilkumar)**	Status of Research in Forest Pathology **(Dr. Amit Pandey)**		Status of Research in Bio-prospecting of Forest Products **(Dr. V.K**
13.04.2021	Status of Research in Restoration of Degraded Land **(Dr. G. Singh)**	Centre of Forest Policy Research (**Dr. V.S. Senthil kumar)**		Status Research on Bamboo Improvement & propagation (**Dr. SantanBathwal)**	Forest Soil Health Card Mapping (**Dr. Vijendra Pal Singh Panwar)**
14.04.2021	**HOLIDAY**				
15.04.2021	Status of Research in Forest Seed Technology (**Dr. Manisha Thapliyal)**	Status of Research in Forest Biotechnology (**Dr. R. Yashoda)**	Status of Research in AICRP Melia Composites (**Dr. Ashok Kumar)**	Status of Research in Forest Entomology (**Dr. R. sundararaja)**	Status of Research in NTFP Research (**Dr. Sandeep Sharma)**
16.04.2021	Status of Research in Silviculture **(Dr. Dinesh Kumar)**	Status of Research in FGR research. (**Dr. H.S. Ginwal)**	Status of Research on Forest Biodiversity (**Dr. C. Kunhikannan)**	Research Proposal Writing for DBT & DST **(Dr. Madhumita Das Gupta)**	Status of Research in Forest Genomics (**Dr. Madhumita Das Gupta)**

Programme Week - VI and VII

Module IV: Specialization Module

Date ▼	I Lecture	II Lecture	III Lecture	IV Lecture	V Lecture
19.04.2021 to 30.04.2021	Attachment with an identified division preferably in the area of proposed specialization either in the institute of ICFRE or other organization for two weeks. The scientist will also be attached to a senior scientist (Scientist E or above) during which period the trainee scientist/researcher will develop a working paper on a pre-assigned topic and convert into a project. The topic will be decided by a panel of experts in the relevant field to the specialization branch of the trainee. Mentoring will also be in the form of a structured programme and will be monitored and evaluated.				

Programme Week - VIII and IX

Module II: Project Management and Research Methodology

Date ▼	I Lecture	II Lecture	III Lecture	IV Lecture	V Lecture
03.05.2021 to 14.05.2021	**The above Induction Training of 2 weeks is to be held in NAARM, Hyderabad.**				

Programme Week – X

Module V :ICT&GIS

Date ▼	**I Lecture**	**II Lecture**	**III Lecture**	**IV Lecture**	**V Lecture**
Time ▶	**09:30-10:30**	**10:45-11:45**	**12:00-01:00**	**02:15-3:15**	**03:30-04:30**
21.06.2021	**-**			IFIRIS and its various modules **(Dr.Jatendra Singh)**	
22.06.2021	Computer Application- Excel, Access Database and other Application, Database Management System **(Sh. Sudhir Kumar)**				
	Hands on working on IFIRIS system. **(Sh. Sudhir Kumar)**				
23.06.2021	Remote Sensing in Forestry and GIS in Forestry, ICT Application **(Dr. Manoj Kumar)**				
24.06.2021	Evaluate project presentation of newly recruited Scientist of ICFRE **(Dr. P.K. Mathur/Dr. Subhash Nautiyal/Dr. H.S.Ginwal)**				

25.06.2021	Evaluate project presentation of newly recruited Scientist of ICFRE **(Dr. P.K. Mathur/Dr. Subhash Nautiyal/Dr. H.S.Ginwal)**

Progress Report for Induction training for Technicians

As per the HRD Plan (2018-2023) manual of ICFRE an induction Training for newly Incumbent Technician (Field/Lab Research) on the subject "Overview of ICFRE, administration, office Procedures and Computer Application" for one week was conducted on 05-04-2021 to 09-04-2021.

In this training following participants was participated:-

Shri Rahul Chamoli	Shri Abhishek Sani
Shri Atul Kumar Sani	Shri Sajan Kumar
Shri Amit Kumar	Shri Manoj Kumar
Shri Rajgopal Singh	Shri Sachin Kumar
Shri Ashish Singh	Shri Saptarshi Baruri
Shri Rajarshi Ghosh	Shri Gaurav Negi
Shri Sayed Doulat Hossain	Shri Pushpendra Singh
Shri Mandeep Kumar Fauji	

During this training following topics were discussed:-

1. Overview of ICFRE & Institutes
2. Service & Establishment Rules, ACR/APARs
3. Accounting Procedures, Procedures and rules (Pay & NPS)
4. Public Services doctrine and conduct
5. Preparation of Notes & Drafts, manual of Office procedures.
6. Computer Application
7. Overview of Genetics and Tree Improvement Division
8. Handling office correspondences, File management record keeping
9. Right to Information
10. HRD and personnel management, effective communication & presentation skills for personality development
11. Career progression and planning
12. Overview of Forest Products Division

13. Overview of Forest Protection Division
14. Overview of Forest Botany Division
15. Overview of Forest Ecology and Climate Change Division
16. Overview of Silviculture & Forest Management Division
17. Overview of Facilities and Services Division
18. Overview of Chemistry Bio-Prospecting Division

An amount of Rs 1,11,000/- was sanctioned, out of this amount Rs 1,06,821/- were incured during this training and remaining amount of Rs 4,179/- deposited in the head of HRD Training. The training was conduct sucessfully and the particepents requested that this type of training will also conduct in future regularly because it enhance the knowledge.

Component VI:

Operationalization of Forestry Extension Strategy and Action Plan of ICFRE

Technology Demonstration Centre

At IFP, Ranchi, the process of designing, preparation, fabrication of Technology Demonstration cum Interpretation Centre is in progress. Write up of 22 panels approved and sent to vendor, the work on preparation of panels is under progress and is expected to be completed in next quarter.

Fig. 48 Paneling work of TDC at IFP, Ranchi

At IWST, Bengaluru, building plan for display of technological advancement of wood as a building material finalized, approved and communicated to CCU for construction.

At FRI, Dehradun civil work and planning of mounting of photographs in Photo gallery is under progress. Process of re-tendering for layout, designing for demonstration of technologies with furnishing of Hall is under progress for TDC.

RFRI, Jhorat procured and installed Vacuum Pressure Impregnation Machine for treatment of bamboo. The superstructure of the Unit was constructed with bamboo.

Fig. 49 Technology Demonstration Centre hall at FRI, Dehradun

Demo Village

For establishment of demo village at Rajhana, Shimla, HFRI, Shimla, signed MoU with Pradhan, Gram Panchyat, Rajhana, Shimla

IFP, Ranchi conducted a meeting for establishment of demo village with Gram Sabha Chairman, Mukhiya, farmers and NGOs in Kutam Torpa, Khunti, Jharkhand, total 23 participants attended the programme. They were made aware about the work carried out by institute and held discussion on their requirement for trainings and awareness programmes. Subsequently a training and demonstration programme on Vermicompost production organized at village Kutam, Torpa, 51 participants attended the training and demonstration programme.

Fig. 50 IFP, Ranchi conducted meeting for establishment of demo village with Gram Sabha Chairman, Mukhiya, farmers and NGOs in Torpa, Khunti, Jharkhand

IWST, Bengaluru, held meeting with Panchayat Development Officer (PDO) regarding adopting Attivata, Karnataka as demo village for conducting demonstration programme to farmers. PDO assured co-operation for adoption of Attivata as Demo village under Extension Programme of IWST.

For DV at Mohangarh, Jaisalmer, AFRI, Jodhpur initiated the work on fencing, Chowkidar Hut and Gate Pillar etc and tender was floated.

Establishment of new VVK

HFRI, Shimla, procured various office items viz., office furniture, LED TV, Projector, Computer, Extension Material, etc. for new VVK, Longani, Dharmapuri, Mandi. The work of eight strand barbed wire with angle post fencing in the core are of Demonstration Nursery at new VVK has

been complete. For establishment of Demonstration Nursery, activities such as bush cutting, digging and ploughing works in one hectare area have been completed and nusery bed preparation in the area of 2500 sq. meter is near completion. Filling work of 18,500 polybags with potting mixture of Soil:FYM:Sand in ration of 2:1:1 has been completed for raising nursery stock of important forestry and medicinal plant speices. Link Road of length 100m to connect Demonstration Nusery from main road (NH-154) has been prepared and construction of breast wall in some portion is under progress. The area is having loose strata; hence breast wall and retaining wall in entire stretch of 100m need to be constructed. For the office use and demonstration of developed technologies, renovation work is under progress at Forest Inspection Hut (FIH), Longani (02 Rooms+01Hall+01Kitchen), Dharmpur, Mandi, Himacal Pradesh. On the request of Director, HFRI; PWD, Dharmapur Division, Mandi renovated the FIH, Longani after instructions of Honourable Jal Shakti Minister. The entire roof and ceiling have been renovated. The wooden doors and windows which were completely destroyed by termites have been replaced with aluminium doors and windows. Sanitary, tile and wiring works etc. are in progress.

TFRI, Jabalpur signed MoU with Chhattisgarh State Forest Department to establish VVK at Metaguda Nursery, Jagdalpur for undertaking extension activities.

For establishment of new VVK, AFRI, Jodhpur conducted survey and series of meeting with Rajasthan Forest Department. Site at Kalkamata nursery, Udipur has been identified for establishing new VVK. Work has been initiated for preparation of display material and literature.

VVK activity

IFGTB, Coimbatore conducted training on Windbreak Clones Based agro Forestry Systems for 40 farmers, volunteers of *Vetry*, Tirupur and officials of Agricultural dept. Tirupur District.

Fig. 51 Training on Windbreak clones based agroforestry systems at Tripur, Coimbatore

IWST, Bengaluru, organized technology demonstration training programme at VVK, Gottipura on the topic Agro forestry models and Sandalwood cultivation techniques. 30 farmers attended the programme. Farmers showed interest in growing *Melia dubia* and sandal-wood in their cultivation land.

HFRI, Shimla maintained 03 VVKs at Brundhar, Manali (H.P.); Janipur, Jammu (UT) and Badamibagh, Leh, Ladakh (UT) and raised 10,000 seedlings of *Picrorhiza kurroa* (Kutki) at VVK Brundhar, Manali (H.P.).

FRI, Dehradun established a Hi-Tech Nursery under VVK, Gorakhpur, which contains mist chamber, green house and root trainers with stands for raising 50,000 saplings.

Documentaries

Tamil version of documentary film on IFGTB "*Pesum Marangal*" was released. A short film on Gass Forest Museum (GFM), Coimbatore, Titled "*Rendezvous with Natural History*" was released in IFGTB YouTube channel on the occasion of International Museum Day. It portrays the historical significance of the museum and its role in promoting students and the general public on natural history.

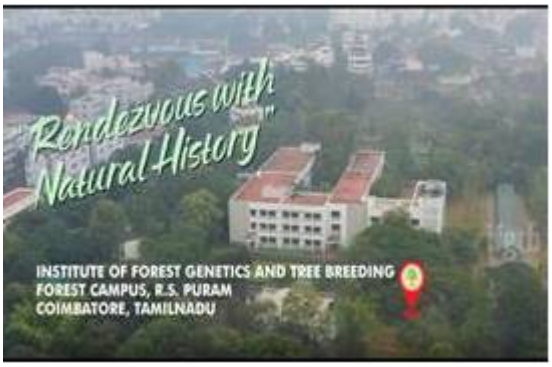


Fig. 52 Short Film on Gass Forest Museum by IFGTB, Coimbatore

Work on preparation of documentary on FRCER, Prayagraj has been initiated. Scripting of the documentary has been done. Shooting is in progress.

At FRI dubbing of six documentaries in Hindi i.e., Insect Diversity, Fungal Diversity, Forest Genetic Resources, Biodiversity of FRI campus, Reclamation of Coal mine and Flora of Bihar has

been completed. Script for shooting of FRI Film has been prepared and given to the agency. Work of shooting is in progress.

HFRI, Shimla, initiated the process for developing a documentary on cold desert. At TFRI, Jabalpur, preparation of Hindi version of Institute documentary is under progress. At IWST, Bengaluru, the script for documentaries on sandalwood spike disease and sandalwood plantation/cultivation models to benefit end users are under preparation.

Publication

IFGTB, Coimbatore published proceedings on "Developing & Popularizing digital interactive platform for Tree Growers and other stakeholders of Tamil Nadu" and distributed to stakeholders in workshop. FRC-ER, Prayagraj, published a training manual in Hindi "Vaniki Se Samriddhi". IWST printed technical Bulletin on "Utilization Potential of Palmyra Palm Wood (*Borassus flabellifer* L.)" for distribution to stakeholders.'

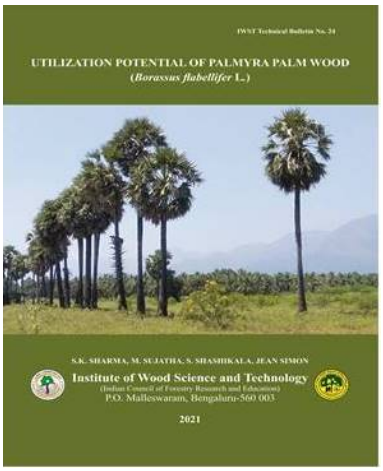


Fig. 53 A booklet by IWST

Tree Growers Mela

IFGTB, Coimbatore organized Tree Growers Mela, under the theme **"**High Yielding Tree Varieties for Agroforestry systems**"**, in collaboration with ICAR KVK MYRADA at Gobichettipalayam, Erode District, 223 tree growers/farmers and SHG members from Erode district participated.

Fig. 54 Tree Growers Mela 2021 organized by IFGTB

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

- Kumar, A., Gurumurthi, K. and Dobhal, S. (2020). Analysis of Genetic Diversity for Wood Variations in *Casuarina equisetifolia* Forst. The Indian Forester, 146 (12): 1158-1163.
- Balasubramanian Aiyar, Sandhya M.C, Shamili Krishnaraj and Mathish Nambiar-Veetil (2020). Composite transgenics as a tool for functional analysis of genes in trees. In Abstracts of the Virtual workshop on "Clonal propagation of tree species" Organised by IWST, Bangalore on 7th October 2020. pp32
- A. Karthikeyan, R. Kalaiselvi and V. Sujithra (2021). Vegetative propagation technique for *Pterocarpus santalinus* L.f. *Indian Forester.*147(3): 316-317.
- B.N. Divakar, S. Pattanaik, M.D. Savio, S. Salam, H.K. Sheela. Genetic variability and divergence studies in seed traits of *Pterocarpus santalinus* L.f. Trees
- 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
- Esakkiammal, S., Sugitha, T., Chitra, P., Nicodemus, A., Nagarajan, B., Mayavel, A. 2021. Evaluation of red tamarind (*Tamarindus indica* var. *rhodocarpa*) pulp extract on phytohistological studies under fluorescent microscope. *Plant. Cell. Boitechnol. Mol.* Biol.22(53&54):37-46.
- Maneesh S. Bhandari, Shailesh Pandey, Aman Dabral, Rajendra K. Meena and Rama Kant. 2021. Global Forestry Perspective: COVID-19 Impact and Assessment. *National Academy Science Letters*. ISSN 0250-541X. eISSN 2252–1754. IF: 0.40.https://doi.org/10.1007/s40009-021-01062-x

- Buvaneswaran, C., Anurag, R. and Nagarnambi, M. 2021. Modern Silvicultural Practices and Productivity of Teak. In.: Yasodha, R., Galeano, E. and Win, T. T. (Eds.). The Teak Genome. Springer Nature, Switzerland. pp 27-44 ISBN: 978-3-030-79310-4
- Muthukumar, A., G. M. Sandhya and Dakshayini, G. 2021. Morphological and Biochemical Characterization – A Comparative Analysis of Non-commercial and Commercial Plant Growth Promoting Microorganisms. Int. J. Curr. Microbiol. App. Sci. 10(02): 867-874.
- Singh, P., Rana, A., Panwar, N. S. and Kumar, A. Review on tree improvement, breeding and biotechnology of *Gmelina arborea* Roxb. *The Indian Forester* (Accepted).
- Berry, N., Shukla, A., & Barkade, E. (2021). Pre-sowing treatment of seeds and its impact on germination of *Gmelina arborea* Roxb.
- 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
- तारा भूयाँ, सिंह, एम॰ के. एवं भोरपुजारी, पी.पी. (2020)। *मेलिना आर्बोरिया* रोक्सबः पूर्वोत्तर भारत का एक महत्वपूर्ण बहुउद्देश्यीय वृक्ष, वन अनुसंधान ई पत्रिका, वन अनुसंधान संस्थान, देहारादून, प्रष्ठ सं 04:15-18।
- 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.

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

- The major constraint was the travel restrictions imposed owing to COVID-19 pandemic, due to which tours in states (other than where institutes are situated), for exploration, population identification, maturity studies of species and their seed collection could not be undertaken and thus the progress of the work was hampered.

- Preparation of boards for replication of preliminary tests to evaluate the physical and mechanical properties could not be conducted completely. Initially there was a shortage of material and it took a long time to procure it is because of the onset of lockdown in May, 2021. The procured material could not be completely converted to fibres since the condux mill started to malfunction and is currently out of order. Efforts are being made to ensure that he condux mill is fixed and further studies could be conducted without further delay.

Abbreviations

ACZ	Agro-Climatic Zones
AFRI	Arid Forest Research Institute
AICRPs	All India Coordinated Research Projects
Cdh	Choline dehydrogenase
CFPR	Centre for Forest Policy Research
CPMB	Center for Plant Molecular Biology
CPT	Candidate Plus Trees
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSO	Central Statistics Office
DLS	Dynamic Light Scattering
DNA	Deoxyribonucleic acid
ERT	Electric Resistance Tomograph
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
GDP	Gross Domestic Product
GFM	Gass Forest Museum
GPR	Ground-penetrating radar
HFRI	Himalayan Forest Research Institute
IAPS	Invasive Alien Plant Species
ICAR-KVK	Indian Council of Agricultural Research- Krishi Vigyan Kendra
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
IWST	Institute of Wood Science and Technology
JFMs	Joint Forest Management Committees
KFRI	Kerala Forest Research Institute, Kerala
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
NPC	National Project Coordinator
NRSC	National Remote Sensing Centre
NTFP	Non Timber Forest Products
PAU	Punjab Agriculture University

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
RF	Radio Frequency
RFRI	Rain Forest Research Institute
SFDs	State Forest Departments
SFRI	State Forest Research Institute
TAFCORN	Tamil Nadu Forest Plantation Corporation Limited
TDC	Technology Demonstration Centre
TFRI	Tropical Forest Research Institute
TNAU	Tamil Nadu Agricultural University
ToFs	Trees Outside Forests
UV	Ultraviolet
VVK	Van Vigyan Kendra