

5. Forest Genetic Resource Management and Tree Improvement

Forest genetics and tree breeding research in ICFRE is oriented towards demands of wood based industries and also to cope with changing climate. Selection of superior genotypes, their field evaluation, quantification of variability and genetic diversity, standardization of propagation methods, establishment and improvement of seed orchards and seed production areas are some of the conventional genetic improvement approaches being followed. The programmes ensure development and deployment of productive and adaptive populations and varieties across the sites for the benefit of end users. Developments of productive and abiotic stress tolerant varieties/ clones, adapted to harsh environments have also been attempted with priority. Field tested genetically superior clones of Eucalypts and Poplars are being used by wood based industries, pulp and paper mills and plywood/veneer factories in the country contributing effectively in our economy. Efforts are being made for other fast growing species like *Melia composita*, bamboos etc. Underdomesticated fast growing tree species needs to be evaluated and domesticated. Biotechnology tools are being further used to strengthen the conventional tree improvement programmes. Characterization of germplasm at DNA level helps in precise quantification of genetic diversity unaffected by the environmental effects of errors. The transgenic approaches are being used to transfer traits across the sexual barriers. Mass propagation through tissue culture is another biotechnological achievement especially for rare and endangered forestry species and also for difficult to propagate tree species and hybrids. The work on forest genetic resource management was initiated to assemble, evaluate and conserve important genetic resource of the country's forest. Also research on genomics was carried out in various institutes of ICFRE for conservation and management of natural forest resources.

5.1 Tree Improvement

Eucalyptus

Eucalyptus tereticornis and *E. camaldulensis* shoots of thirty clones were collected from Sathyavedu, Karunya clonal trials and Vegetative Multiplication Garden (VMG) established. Thirty thousand ramets were produced and twelve clonal trials were established in Karaikkal (Puducherry), Warangal (Jakaram), Rajmundhry, Hyderabad (Mulug) and Tirupathi (Sreevarimetta) in A.P., Badami, Gangargatti (Dharwad), Halbhavi (Belgaum) in Karnataka and Nachiarpettai (Ariyalur), Amaravatipudur (Karaikudi), Tiyagadurgam (Kallakurichi), Marakkanam in Tamil Nadu TAF CORN areas. Seven superior clones viz., 9, 10, 14, 17, 186, 191, 196 based on height and girth data were selected and these were officially released as varieties through Regional Variety Testing Committee (RVTC) and Variety Releasing Committee.

Second generation seed orchards were established and clones were selected for high productivity in Eucalyptus. Seeds were collected from the first generation (FG) seed orchard trials at Karunya and Puthukottai from 52 single trees for establishment of second generation (SG) seed orchards. Efforts were made to select SG clones from trials established at Chennai, Hyderabad, Nellore, Coimbatore, Karunya and Kandiyur. About 25 CPTs were selected and coppiced for mass multiplication of the selected plants. The clonal trial at Karunya was culled based on the growth performance of the clones planted in MLTs. About 25 poor performing clones were removed and seeds were collected from best performing 50 clones and tested for the progeny growth performance in Puthukottai (2 ha) and ANGRAU, Hyderabad (2 ha). The tested clones were also multiplied and CSO established in Salem (2 ha) and Nellore (9 ha). Seedling Seed Orchards at Coimbatore (2 ha) and Chennai (3 ha) are also established. Genetic gain trials were

established at Udumalaipet (3 ha), Kandiyur (4 ha) and Arimalam (3 ha). All the trials were assessed for growth parameters. Growth performance of all the tested half-families were ranked and genetic gain associated with establishment of seed orchards was estimated

Interspecies hybridization between *E. pellita* and *E. urophylla* was carried out at FRI Dehradun and F1 hybrids were produced. Successes have been achieved in production of ramets of *E. pellita* x *E. urophylla*. Clonal trials of FRI-PH4 have been laid out at four locations viz. Satyal, (Punjab), Haldwani (Uttarakhand), Bithmeda (Haryana) and Saharanpur (Uttar Pradesh). Clones of hybrids *E. pellita* x *E. urophylla* and *E. pellita* x (*E. urophylla* x *E. grandis*) were planted in vegetative multiplication garden for further multiplication and deployment.



FRI-PH4

Eucalyptus hybrids FRI-14 (*E. citriodora* Hook. × *E. toriliana* F.Muell.) and FRI –EH001 (*E. camaldulensis* Dehnh. × *E. tereticornis* Sm.) multiplied through micro-propagation technique were field evaluated at three different agro-climatic locations of Punjab, Haryana and Uttarakhand. The study revealed better performance of FRI-14 in respect of growth- and wood-traits than FRI-EH001.

Validation of chemical markers conferring *Cylindrocladium* leaf and seedling blight resistance in *Eucalyptus* germplasm was carried out. Germplasm of seven clones of *Eucalyptus*

was collected and artificially infected with fungus *Cylindrocladium quinqueseptatum*. Correlation of the marker constituents was observed with resistance.

IFGTB, Coimbatore imported seeds of around 25 *Eucalyptus mallee* species from the Australian Tree Seed Centre for testing in semi-arid regions of Tamil Nadu for suitability as a bioenergy crop. Seedlings have been raised from these species, undertaking multilocation field testing during 2014 planting season.

A project “A value chain on Industrial Agroforestry in Tamil Nadu” was initiated by IFGTB Coimbatore with the aim to develop new plant varieties and demonstration and popularization of genetically improved genotypes in the farm lands in collaboration with Industries, farmers cluster groups and Research Institutions. During the current year, seven short listed clones of *Eucalyptus* were multiplied and 6000 plants were transferred to farm fields for establishment of Model Plantation at Karur.

For improving the yield of species, used for bio-energy, a bilateral collaborative project “Yield improvement and adoption of plantation technologies in bioenergy crops for increasing the potential of bioenergy production” was initiated by IFGTB and Kasetsart University, Thailand. Both the Institutes are working on many bioenergy tree species for improving the productivity through genetic improvement programmes. The efforts made by each Institute has been studied through exchange visits in India and Thailand. A study visit was also conducted for a team of scientists from Thailand.

Casuarina

Second generation breeding orchards of *C. equisetifolia* and *C. junghuhniana* were developed using the progeny of the best ranking individuals of first generation orchards located in the States of Andhra Pradesh, Puducherry and Tamil Nadu. Around 20 ha of new orchards were established in different parts of the above mentioned states from the year 2008. These

orchards are periodically assessed for survival, growth, stem form and incidence of pests and diseases. Seeds are being collected from these orchards for supply to users and to establish on-farm genetic gain trials.

The ongoing breeding programme of *Casuarina equisetifolia* and *C. junghuhniana* was taken further from first to second generation. Three community seed orchards established during the previous years have been intensively managed by involving the farming and nursery operator communities. Through pathological screening and field testing, the clones TNIPT 1 and TNIPT 7 showed resistance against the blister bark or stem wilt disease in *Casuarina*. Through systematic selection and multilocation testing, four high yielding clones of *Casuarina* have been released for commercial cultivation. To facilitate registration of these new clones, guidelines for DUS testing in *Casuarina* have been developed and validated with all available clones.

For screening for blister bark disease resistance in *Casuarina equisetifolia*, 250 clones (15 replicates each) were vegetatively propagated and inoculated with the pathogen *Subramanospora vesiculosa*. The inoculated clones were screened for disease resistance through disease severity score. The clone numbers TNIPT -7 and TNIPT -11 showed 0 symptoms and APSKLM-30 and TNRM -8 showed less symptoms. The clones TNPP-4, TNKP-1, TNIPT -5, TNCS -3, TNIPT 12 were showed severe infection. In all, 36 clones are showing resistance and 55 clones showed moderate resistance.

For improvement of *Casuarina* and *Leucaena* for enhanced pulpwood production from farm forestry plantations, a germination study of the seedlots received from IP-APPM was completed. Attempts were made to multiply 53 CPTs of *Leucaena* for rooting studies. Initiated nurseries for production of seedlings / plantlets of *Casuarina* and *Leucaena* for establishing multilocation trials. Convened three interactive meetings, between the officials of IPMA and IFGTB for the purpose.

Gmelina arborea

Genetic Improvement of *Gmelina arborea* Roxb. through selection and clonal evaluation was carried out.



Quality planting Stock Production of *Gmelina*



Progeny trial of *Gmelina arborea*, Kurumpapatti, Salem

Intensive survey conducted in the natural forest of Siruvani, Anaikatti, Anthiyur, Sathiyamangalam, Dindugal, Kodaikanal, Sirumalai, Theni and Farmers plantation in Pudhukottai. Identified natural population of *Gmelina arborea* in the above set location and selected 50 CPTs based on growth superiority, clear bole and pest and disease resistance. The reproductive traits like flowering phenology, pollen fertility, pollen germination on stigma and pollinator interaction of *Gmelina arborea* have been studied on the selected CPTs.

Forty one CPTs of *Gmelina arborea* from Tamil Nadu, Andhra Pradesh and Kerala were collected and seeds were extracted. Data related to seed parameters, seed weight, germination percentage, growth parameters of seedlings upto 4 months during the juvenile phase were recorded. Statistical designs were prepared and progeny trials of CPTs with an extent of 1 ha each were established at Gudalur Research Station and Neyveli Research station during the North East monsoon.

Evaluation of *Gmelina* clones were carried out in the experimental site of Naharoni for its best performance. The clones were ranked based on their height, stem straightness, dbh, pruning ability and crown form. On the basis of initial screening for the pest resistance to defoliator, 8 clones were found showing moderately resistant to this defoliator in the field.

Gmelina mortality in plantation of Madhya Pradesh, Chhattisgarh and its integrated management was investigated. It has been found that sp. of *Hendersonula* and *Phomopsis gmelinae* caused severe damage to the plantation of *Gmelina arborea*.

Acacias

About 63 promising clones of *Acacia auriculiformis* were multiplied and about 12000 rooted plants were produced. Two clonal trials (1.0 ha each) were planted at Chennai (Gudalur) and Neyveli research stations. Two Clone banks of 63 clones have been established and maintained in closed motherbed chamber for propagation through minicuttings at IFGTB.

Significant variation among families was observed for growth and form among 126 families in a progeny trial of *Acacia auriculiformis* at two year age. The first and second year growth data were analysed and ranking of the family was done. The trial was thinned during February 2014 by culling two trees per family in each replication.



Thinning was carried out in 2 year old *A.mangium* progeny trial at Palode



Variation in heartwood formation in 2 year old trees of *A.mangium*

Leucaena leucocephala

Leucaena leucocephala is one of the admirably suited species for paper and pulp manufacture and it expressed superior characters for all the pulp qualities assessed, when compared to other species. IFGTB initiated tree improvement programme on *Leucaena* during July 2013. Various national and international organizations, working on *Leucaena* were contacted to obtain germplasm. Collected 29 seed lots from BAIF, CRIDA, TNAU NAVSARI Agricultural University and seeds imported from University of Hawaii, USA. Raised 3500 seedlings from 29 seed lots at IFGTB Nursery. Established progeny trial at Neyveli field station.

Dalbergia sissoo

- Twenty five numbers of CPTs were identified in Bihar and Jharkhand. Cloning of these CPTs has also been done. Mortality resistant clones developed by FRI Dehradun have been collected and field planted in local conditions at Ranchi. A trial with 12 clones has been established in local conditions of Jharkhand.
- Cloning of *D. sissoo* is standardized for the selected clones and a clonal bank has been established for clonal multiplication and testing purpose in future. Incorporation of more clones from eastern India is in progress.



Dalbergia sissoo roxb. clones for large-scale clonal forestry

Melia composita

Commonly known as Burma Neem, is fairly large, deciduous and fast growing tree. It grows upto a height of ~20 m with straight cylindrical bole of ~ 9 m. Due to its fast growth and multiple uses, it is emerging as a favourite tree for agroforestry plantation in the North-Western states of India. If tested, it may be a good introduction in agro forestry in arid and semiarid tracts, where irrigation is available. Open pollinated seeds of 42 CPTs were germinated in nursery with family identity. It was observed that there exists considerable variation in speed as well as germination percent amongst the selected phenotypically superior trees.

Different progenies were evaluated for genotype x environmental interactions over different geographical locations in the state of Haryana, Punjab, Uttar Pradesh and Uttarakhand to understand growth performance, stability and adaptability through G x E interactions. Trials were successfully established in the states of Rajasthan, Gujarat, Karnataka, Tamil Nadu, Bihar, Assam and Jharkhand. A series of scientific trials of target species were established to evaluate performance of various germplasm at different geographical locations for comparative performance and G x E interactions. Further selection and characterization of genetically divergent *Melia composita* using index method based on different traits was carried out. The selected trees were marked and seeds were collected and processed and now been sent for establishment of multi-locational trials over the states of India. Genetic evaluation of the most suitable progenies was carried out in various geographical locations to analyze stability and adaptability and screening of suitability of genotypes for arid and semi-arid regions. The progenies / genotypes, which survive and sustain in toughest of the conditions of more than 48°C of temperature and very little rains are expected to play a crucial role in rehabilitation of arid and semi-arid zones.

Progeny trials established at IFB, Hyderabad and at Bangalore, Karnataka were measured periodically in terms of height, DBH, number of leaves and number of branches. The screening of populations has been carried out and new source of plus trees were found for *M. dubia* in Khammam district of Andhra Pradesh, Kollegal of Karnataka and Kothur, Krishnagiri of Tamil Nadu. Similarly, for *M. azedarach* new source was found in Ballampally Forest Division of Adilabad district of A.P. The seeds from plus trees selected by IFGTB were supplied to augment the base of germplasm and accordingly all the collections were raised in Hyderabad and the progeny trials established in Gudalur in Chennai (Tamil Nadu). Experiments were conducted for rooting of stem cuttings of *M. dubia* and

M. azedarach inside the mist chamber as well as outside the mist chamber using shade net by giving different treatments of auxins. The vegetative propagation technique was successful with more than 80 per cent rooting.

In RFRI Jorhat, progeny trials were established at two locations viz. FRC, Mandar and Experimental field Nagari (Ranchi) in Jharkhand and at one location, KVK, Manjhi, Saran in Bihar with 21 progenies collected from FRI, Dehradun. The survey for identification of promising genotypes and provenances has been carried out in North Bengal, Jharkhand and Bihar and seeds have been collected.

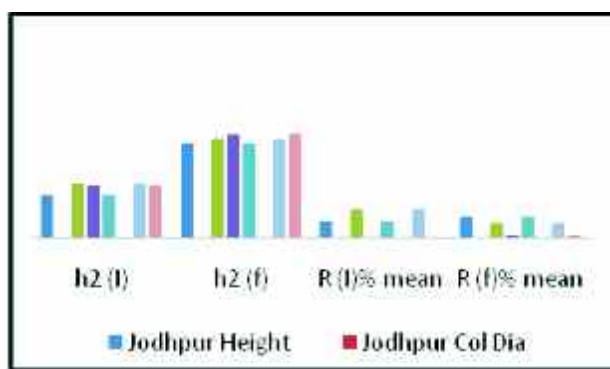
To study the genetic variation and investigate inheritance pattern of this species, three progeny trials consisting of 24 families at Jodhpur (Rajasthan), Gandhinagar and Deesa (Gujarat) were established. Growth data were collected from these trials and analysis of variance performed at six month age revealed that both height and collar girth exhibited significant variation amongst the tree tested, except in the case of collar girth at Jodhpur and Gandhinagar. The growth performance and survival (96%) at Jodhpur trial was best followed by Gandhinagar and Deesa.



Progeny trial of *Melia composita* at Jodhpur



Self pruning segregant in Jodhpur trial




Heritability and genetic gain estimated in *Melia composita*

In IWST Bangalore, progeny trial was laid at Agundapalli. Survey of *M. dubia* population in Kollegal, Hunsur, Perryapatana HD Kotte, Ramanagara and Kanakpura was carried out.

Assessment of growth and genetic diversity of *Melia dubia* was carried out with funding from Karnataka Forest Department. The project was envisaged with two objectives viz. Growth potential of *Melia dubia* and to evaluate the genetic variation in *Melia dubia*. Survey was carried out to identify various plantations in Karnataka and growth observations recorded. From the natural population and plantations, leaf samples were collected and genetic diversity assessed.

Surveys were undertaken in the states of Kerala and Karnataka to identify superior



Germplasm. A Vegetative Multiplication Garden was established in the Model Nursery of IFGTB with the identified material. 42 accessions from FRI and 15 accessions from RFRI were received which were subjected to germination studies. An evaluation trial comprising seedlings, cuttings, tissue culture raised, plantlets were laid out in the experimental design. Identified 10 CPTs of *Melia* in Karnataka in natural growing areas.

***Bombax ceiba* (Semul)**

Evaluation of *Bombax ceiba* for seed sources was carried out in Northern India. Seeds of 14 CPTs were collected and seedlings were raised. Seedlings were maintained for establishing field trial in the next year. Germplasm from Assam was also maintained. Rooting of branch cutting was achieved in juvenile cuttings.

***Azadirachta indica* (Neem)**

Neem progeny trial was established in the year 2002 at Govindpura, Jaipur with seedlings of selected 17 CPTs for high Azadirachtin content. This trial is almost, now, 11 year old and significant variation in flowering and fruiting observed. Overall fruiting and flowering was very poor. Moreover, conversion rate of flowers into fruit was also very poor. It appears that frost has affected the leaf biomass of trees, which resulted in inefficient photosynthesized reserve energy resources required for conversion of flowers into fruit and their growth. Progenies of CPT numbers 4, 7, 11 and 12 were found superior over other remaining CPT's progenies. Seeds collected from 33 plants showed oil content between 40 to 52 % in them.

Sapindus emarginatus

Populations of soapnut in Tamil Nadu were identified in areas, such as, Hogenakkal, Aliyar, Maruthamalai, Pillur, Dhimbham, Thirumurthy hills, Thengumarada, Thalavadi, Mettupalayam, Palani, and Sarkarpathy. Identified 133 CPTs and collected seeds. The number of fruits per metre length of branch was taken as selection criteria. Recorded seedling parameters in the germinated

seedlings. Seedlings were transplanted and maintained in nursery. Chemical analysis of saponin by gravimetry was completed for each CPT. Established germplasm bank of Soapnut at Panampally. Average of 13% saponin was identified as benchmark for shortlisting high saponin yielding CPTs. Thirty high saponin yielding accessions were laid out as multilocation trials in three locations namely, Chennai, Salem and Neyveli.

Dalbergia latifolia

Field surveys were conducted in Kalpi, Udaypur and Seoni for selection of superior trees. Twelve trees were selected at different locations in Kalpi, three trees at Seoni and 7 trees at Udaypur. The growth data and GPS locations of the selected trees were recorded.

Sandal and Bamboos

Demonstration of modern nursery for producing quality planting stock of *Santalum album* and bamboo was established with funding from Punjab Forest Department by IWST, Bangalore (Centre for Excellence in Research on Sandalwood). Some of the most outstanding contributions come in the fields from propagation (both micro- and macro-propagation), population assessment, germplasm bank, plantation technology, agro-forestry systems, pest management, chemical profiling, etc. States like Gujarat, Rajasthan, Uttar Pradesh, Maharashtra and others have already adopted the technologies and considerable plantations of the species are coming up in these areas. It is in this regard that the Institute proposed to extend these technologies to the State of Punjab. The idea in the project was to establish a modern nursery of sandalwood and bamboo species, and provide training to the personnel of the Punjab Forest Department. 4000 QPM of sandal raised at IWST transported from IWST, Bangalore was sent to Punjab for Demo plantation, which were established in Bhatola nursery area, Talwara Range, Desuya Forest Division, Mullanpur, Mohali Forest Division, Mathewada, Ludhiana forest Division and Ropar forest Division. Plants

of 4 species *Dendrocalamus asper*, *Dendrocalamus hamiltonii*, *Bambusa balcooa*, *Bambusa nutans* (1200) procured from IHBT, Palampur. Plantations of 0.5ha each were established at Bhatola nursery area, Desuya Forest Division, and 1 ha each in Talwara Range, Desuya Forest Division, Punjab. 35kg of sandalwood seeds collected from IWSST germplasm bank were given to Punjab Forest Dept. for establishing modern nursery for quality planting stock of *Santalum album* at Bhatoli, Talwara. Nursery was established and 50,000 sandalwood seedlings raised during 2014.

Distribution, diversity and productivity of *Dendrocalamus stocksii* (Munro) in Western Ghats of Karnataka was studied with fundings from Karnataka Forest Department. *D. stocksii* is cultivated in coastal belt of Karnataka. This is considered as an important agroforestry species, ideal for plantations in watershed and coastal regions. This is an extremely manageable species with a great economic and ecological importance, finding large scale utilization in scaffolding, paper and pulp, crafts, construction, making baskets, umbrella handles and poles. The National Bamboo Mission has also prioritized this species for mass scale cultivation in Maharashtra and Karnataka. Genetic diversity is essential to the long term survival of species. Without it, species cannot adapt to environmental changes and are more susceptible to extinction. This study aims at documentation of the extent of distribution of *D. stocksii* in the Western Ghats of Karnataka and will help in approximating the extent of growing stock of this species. The distribution of *Dendrocalamus stocksii* clumps, along the districts of Central Western Ghats in Karnataka, Kerala, Maharashtra and Goa was surveyed. A total of 102 genotypes of *Dendrocalamus stocksii* were evaluated and offsets/ culm cuttings collected and transported first to Dapoli Nursery by road and rail. The coordinates of selected genotypes were plotted using GPS. The edaphoclimatic parameters were also recorded. The morphological and genetic diversity of the species in the region and its physiological adaptations, if any, will help identifying better genotypes for further study. The

culm biomass productivity of the clumps distributed in different ecological conditions will be estimated, which will form the baseline for developing management regimes to improve the productivity.

Teak

For developing breeding populations of teak with broad genetic base for long term genetic improvement, about 200 CPTs of teak were selected from SPAs in Topslip, Parambikulam, Nilambur, Kulathupuzha, Konni and seed orchard in Walayar. The trees were selected based on the growth superiority. Seeds were collected from these selected trees and sown in the nursery maintaining the identity of each seedlot. Germination per cent of each lot was recorded and seedling growth data in the nursery recorded.



Teak seedlings in IFGTB Nursery



Teak seed germination in mist chamber



Teak seeds from single tree collection



Teak seedlings in IFGTB Nursery

About 8000 seedlings were raised at IFGTB Nursery. One ha of breeding population of Teak was established at Neyveli field station and is being maintained.

To estimate genetic gain from teak seed orchards, flowering, fruiting and out crossing behaviour was studied in successive years starting from 2009. Comparing the data obtained from the previous five years in an earlier project, the trends in flowering of different clones in different locations were identified. Seeds were collected from ramet and clone-wise and subjected physical, X-radiography and germination studies. Seeds of seed orchards

consistently showed poor seed filling and germination across the years and locations compared to seeds of seed production areas. Out crossing studies were also conducted using SSR markers.

Descriptors are now important for registering varieties and clones. Development of descriptors and DUS testing guidelines for indigenous forest tree species was carried out in *Tectona grandis* and *Melia dubia* including establishment of field gene bank.

Molecular assessment of breeding patterns in clonal seed orchards of Teak in Andhra Pradesh was initiated to strengthen the breeding programmes. DNA extraction work using CTAB protocol was completed for all mother plants and 450 progenies. Fifteen microsatellite primer pairs were screened for their amplification efficiency and polymorphism on a batch of test samples. Polymorphism was observed in the banding pattern of nine primer pairs. Genotyping of mother and progenies with the selected primer pairs is under progress.

Evaluated four progeny trials of Teak established with 16, 16, 28 and nine half-sib families at Rajpipla, Shivrajpur, Sajjangarh and Jodhpur, respectively. Individual tree data from these trials were collected. Analysis of variance of these trials revealed that variation due to families was highly significant for height and girth in Rajpipla; girth and clear bole length in Shivrajpur and for both height and girth in Sjjangarh and Jodhpur trials. This indicate scope for family selection.

Under all India Coordinated Projects on Teak with TFRI, Jabalpur as Nodal Institute, selections of plus trees, raising their progeny trials and establishing germplasm bank was initiated as coordinated programme for genetic improvement of Teak. Rukad and Kurai range of Seoni (South) Forest Division was surveyed, seven CPTs marked and data recorded on them along with the 35 comparison trees.



Marking of CPTs of Teak in Seoni (South)
Forest Division

Ailanthus

Ailanthus excelsa is an important tree species in Rajasthan and locally known as Ardu. Its timber is used in plywood industries and leaf as green fodder. Demonstration trial of male and female plants was raised of the selected trees using grafting technique developed by the AFRI. Analysis of the growth data collected from the trial after the fifth year revealed significant differences between female and male plants in all parameters recorded on growth (above and below ground), except number of primary roots. Female plants were far superior (above 60%) to male plants in production of leaves (average fresh weight of leaves) and number of branches.

Selection of superior genotypes and developing clonal technology for raising clonal plantation of indigenous species *Ailanthus excelsa* and *Ailanthus triphysa* in Tamilnadu and Kerala was done. Survey done in western zone and Cauvery delta zone, western and southern zone of Tamilnadu. 170 CPT's of *Ailanthus excelsa* and 120 CPT's of *Ailanthus triphysa* were identified with GPS marking in Kerala and Tamilnadu. The shortlisted CPT's were felled and allowed for coppice production. The coppice shoots performed better than the branch cuttings and gave optimum of 65-70% of rooting. The rooted cuttings are being mass multiplied for the multilocation clonal trial.

Populus deltoides

Nursery stock of 30 clones of *Populus deltoides* was raised in the nursery. Field trials of these clones were established at four sites during 2013-14. The trials established during 2012-13 were also maintained. Cellulose content estimation and wood anatomical studies of 30 clones were completed. Screening of poplar genotypes against *Alternaria alternata* toxin(s) is being done at FRI. Screening of the commercial clones of *P. deltoides* namely, G-48, Udai, WSL-22 and WSL-39 against toxin of *A. alternata* was done. Initially, 15 isolates of *A. alternata* were studied for their relative growth, and dry mycelium and toxin weights. The work is in progress.

Neolamarckia cadamba

For genetic improvement of *Neolamarckia cadamba*, selections in the natural population and existing plantation in different parts of Tamil Nadu, Kerala, A & N Islands and North Eastern State (Assam) was carried out. About 118 CPTs were identified, fruits collected from all the selected CPT's and progenies raised and maintained for out planting in the next monsoon season.

Pterocarpus santalinus

Study of variation in *Pterocarpus santalinus* for growth and heartwood content according to



Planting of progeny trial of red sanders at Neyveli during December 2013



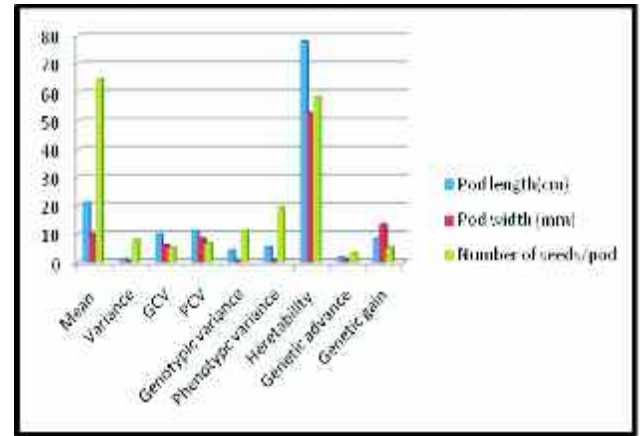
Red sanders seedlings ready for planting progeny trial

edaphic and climatic factors in Tamil Nadu was carried out. During current year, 65 CPTs of red sanders were selected from various plantations. Single tree seed collection done from selected CPTs. Germination was done in seed bed after seed treatment and 6000 seedlings were raised in polybags. Morphological characterization of seedlings was done. Two progeny trials were planted at Chennai and Neyveli Research stations during December 2013.

Tecomella undulata

Tecomella undulata is an important timber yielding tree species of arid region. During 2013-

14, pods were collected from the selected CPTs across 20 different sources from six districts of



Estimation of genetic parameters of pod characters of *Tecomella undulata*



Seedlings raised with family identity at model nursery



New progeny trial of *Tecomella undulata* at Jodhpur

Raising of seedlings and progeny trial of *Tecomella undulata*, at Jodhpur

Rajasthan (Pali, Jalore, Nagaur, Sikar, Bikaner and Churu). All the pod parameters were moderately heritable ranging from 53 to 78 percent. Seedlings were raised in the nursery and the progeny trial of 36 CPT's established.

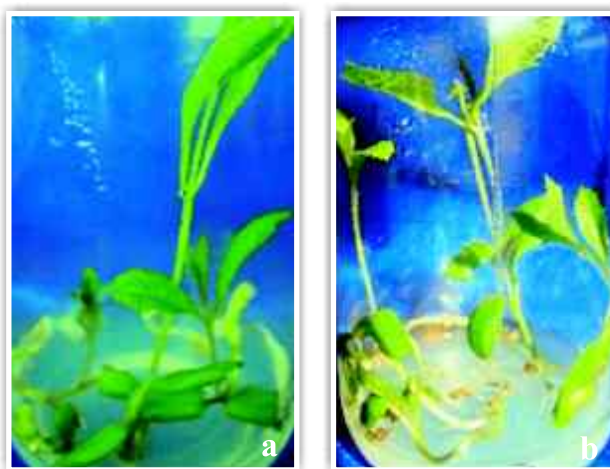
Existing (old) progeny trials of *Tecomella undulata* at Beechwal Bikaner and Jodhpur were also evaluated. It was observed that the progeny trial at AFRI Jodhpur performed better as compared to that at Bikaner with 87% of survival at Jodhpur and 58% at Bikaner at the age of 5 years.

5.2 Biotechnology Intervention

Substantial importance was given to the biotechnological approach for the tree improvement and conservation of genetic resources. The biotechnology research achievements are summarised as below;

- Two thousand seed progenies from first and second generation progenies were studied using Image Analyser for seed area, perimeter, width, length and roundness. Significant variation was observed in the orchard progenies. Second generation progenies indicated high mean value of all the parameters studied. One hundred and fifty progenies from ten different trees in the first and second generation orchard seed collections, were raised in the nursery. Both first and second generation progenies were screened completely for five microsatellite markers. Amplified unexpected product sizes of microsatellites were sequenced and were confirmed through BLASTn analysis. The sequences were deposited in NCBI. (KG699501.1, KG699563.1, KG699564.1). The microsatellite allelic data are being analyzed using MLTET software for estimating out-crossing rate in the orchards.
- Production of transgenic teak tolerant to defoliating pests is in progress. Shoot explants from the *in-vitro* germinated seedlings were multiplied in shoot induction medium. An experiment was designed to

study the effect of different strengths of TDZ, different auxins (IBA, IAA and NAA) and their interaction on callus formation in different explants obtained from the seedling viz., internode, leaves, roots and hypocotyls. The effect of auxins, TDZ and their interaction on callus formation was found to be statistically non-significant. The type of explant used had significant effect on callus formation. Callus derived from different seedling explants were regularly subcultured and multiplied in fresh callus induction medium for designing further experiments



Effect of different MS strengths and GA3 doses on *in vitro* seed germination in teak after 30 days of inoculation: (a) $\frac{1}{2}$ MS and 0.1% GA3 (b) Full MS and 0.4% GA3





Callus formation in different explants obtained from the seedlings viz., (a) internode in 0.1 TDZ and 0.1 IBA after 30 days, (b) roots in 1 TDZ and 0.1 IAA after 30 days, (c) leaves in 1 TDZ and 0.1 IBA after 15 days, and (d) hypocotyls in 1 TDZ and 0.1 NAA after 30 days of inoculation.

- Studies on population structure, linkage disequilibrium and marker-trait association mapping of Indian teak.

Germplasm collection, present at NTGB Chandrapur, Maharashtra was selected for pilot/baseline study. Cuttings and Leaf samples



A view of National Teak Germplasm Bank Chandrapur (MS) and sprouting in collected cuttings from NTGB, Chandrapur for DNA extraction

from 217 teak trees were collected for DNA isolation. Genomic DNA from 186 trees was isolated and 154 DNA samples and screening of microsatellite primers is under progress. Morphometric data (Height and GBH) were also recorded from 217 trees.

- Development of DNA-marker based technique for *Cedrus deodara* for wood/timber forensics was attempted. Three cpSSR primers reported in *Pinus sylvestris* L. PCP1289, PCP9434, PCP6377, and three Pt15169, Pt26081, Pt30204 from *P. thunbergii* showed positive amplifications as well as variation, specific to the geographical area. The results also showed population specific allelic variations in some SSRs which indicate the possibility and usefulness of the SSR markers in identifying the timber source in case of illicit felling of *C. deodara*.
- Characterization of *Pinus roxburghii* for resin yield and spiral grain formation in wood using association studies and using molecular markers was done. DNA isolation and quantification of all twisted pine sample (144) and normal pine population (20) completed. All the above samples characterized using 10 primers, scoring of gels and data analysis and in progress. 6 populations of twisted pines and DNA bands are being scored for polymorphism in twisted and normal pine samples. ISSR primers are also being screened for low and high resin yielders. Data analysis and interpretation is under progress.
- Population genetic analysis of Himalayan Banj Oak (*Quercus leucotrichophora*) is being carried out. Banj oak is the most common broad leaf tree in the mid-elevation Central Himalaya in India. It is the most preferred tree species in the temperate region, mainly used for fodder, fuel, and small timber. Twenty four populations, each with 30 individual trees covering Himachal Pradesh and Uttarakhand were sampled for DNA marker based study. DNA extraction techniques standardized and genomic DNA isolated from all 24 populations (720 samples). RAPD fingerprinting of 510

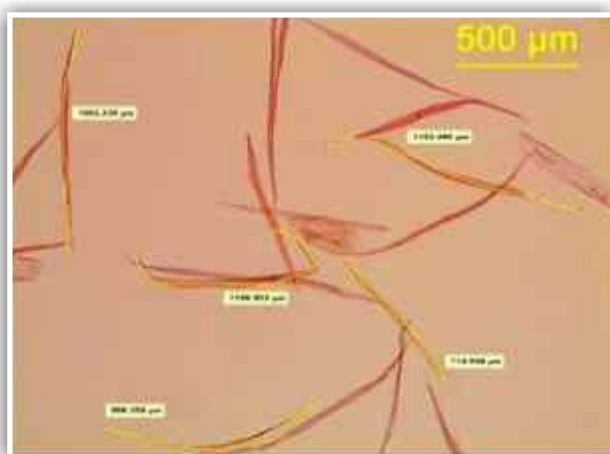
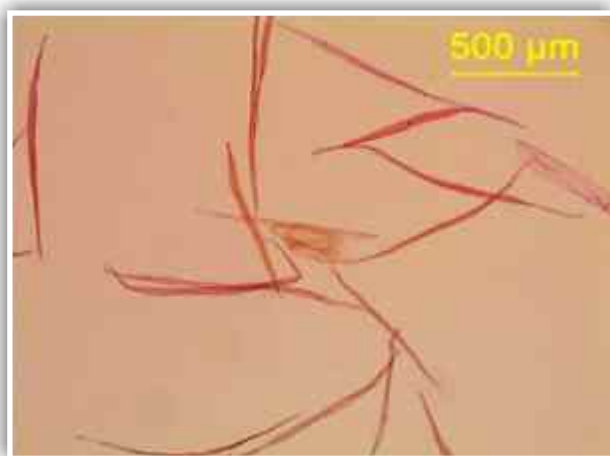
samples, representing seventeen populations using, 10 selected primers were completed. Their scoring work has also been completed. For SSR marker analysis, a total of 15 polymorphic microsatellite markers were screened for population genetic analysis work. Initial data analyzed revealed low to moderate level of genetic diversity in populations of Ban Oak in Himalayas.

- Assessment of genetic diversity and structure of *Boswellia serrata* Roxb. Population was done through RAPD and ISSR markers. DNA samples from 12 populations of M.P. were analyzed for their purity index. Results revealed that the quantity of genomic DNA was higher than 200 ug in 1 gm of leaf sample of all the populations. Genomic DNA was also checked qualitatively on 1% agarose through gel electrophoresis. A considerable

variation in fibre length was noted which ranged from minimum 887 um (Mandla and Sheopur) to maximum 1560 um (Rewa).



Flowering in *Jatropha curcas*



Measurement of wood fibre length in 5X magnification using Leica microsystem EC 3 (A) Wood fibres in unmeasured form (B) Measured wood fibres

- Development of gene markers for high seed oil content and dissecting molecular basis of female flower development in *J. curcas* attempted for genetic improvement for high seed yield. This is a new and collaborative project with JUIT Wagnaghat (Solan, HP) and was initiated recently.
- Open pollinated progenies of the clonal trial (*Eucalyptus camaldulensis* established in 2003 by IFGTB) tested for genetic gain. Clones available in the trial were shortlisted as parents; samples were collected for DNA extraction. The protocol for obtaining quality DNA was standardized. The DNA samples were checked for amplification. Primer amplification was carried out using 25 primers. Both gel electrophoresis and genetic analyser techniques were standardised to obtain the SSR profiles of the shortlisted parents.
- In the programme of control crossing of *C.torelliana* x *Corymbia citriodora*, germination test was carried out for the *Corymbia* and full sib seeds harvested. A hybrid field trial using vegetatively propagated seedlings of seven combinations was also established in Walayar (Kerala) and silvicultural practices followed after planting. Performance of 12 months old full sib hybrid



trial existing at ITC premises was evaluated jointly with ITC team and field data recorded. Morphological markers (leaves, spines, color of spine, stem and leaves), physiological markers (stomata and its distribution) and molecular markers (DNA) were studied.

- Under the quantitative trait loci (QTL) mapping programme of eucalypts, genotyping of dihybrids of *E. tereticornis*, *E. camaldulensis* and *E. grandis* using 300 SSR markers are in progress. *Eucalyptus* being an obligatory outcrossed species with potential to self pollination, possibilities of pollen contamination is high. Hence, in this study, *Eucalyptus camaldulensis* x *E. tereticornis* inter-specific hybrids were genotyped, using 25 fluorescent labeled microsatellite markers available in public domain. Multiplex loading of PCR products was performed successfully for most of the microsatellite loci. A subset of six fully informative simple sequence repeats was identified for routine quality control genotyping for these hybrids. Detection of non essential genotypes observed among the hybrid seedlings proved the significance of hybrid purity tests and the false hybrids were removed at the seedling stage. The hybrids with proven hybridity will be used for generation of genetic linkage. Discovery of quantitative trait loci and the individuals with high productivity can enter into mass clonal multiplication.
- A microarray was designed and printed representing 25,908 genes sourced from RNA-Seq and EST datasets involved in wood formation in different eucalypt species. The expression patterns of these transcripts were documented in four distinct genotypes of *E. tereticornis* with low/ high cellulose and lignin content. The data will be used to develop a gene regulatory network (GRN) for xylogenesis in tropical eucalypts. The GRN will be subsequently used to identify major regulatory switches for xylogenesis and wood formation. This will help in identifying major effect genes for candidate gene based association analysis to identify markers tagging wood property traits.

- To study the role of HKT1 gene in *Eucalyptus*, gene silencing construct for EcHKT1 was developed and being used for developing composite transgenic *Eucalyptus*. The full length coding region of EcHKT1 gene (1653 bp) was isolated from *Eucalyptus camaldulensis* cDNA and is being used in developing the transformation construct for over expression in Tobacco and *Eucalyptus*. Determination of sequence information of insect- genes is crucial for application of transgenic RNAi technology for control of the insects. In this direction, the partial gene sequence information for chitinase gene (596 bp) of *Eucalyptus* insect pest *Leptocybe invasa* and the beta-tubulin gene of the teak insect pest *Hyblaea puera* (560 bp) and *Eucalyptus* insect pest *Leptocybe invasa* (691 bp) were sequenced and published with accession numbers, KC818286.1, KC818287.1, KC880336.1 at the Gene Bank Database of the National Centre for Biotechnology Information (NCBI), National Library of Medicine and National Institute of Health, USA. dsRNA was synthesized for *L. invasa* chitin synthase and an accessory for delivery of dsRNA molecule into galls in potted *Eucalyptus* plants was developed.
- The antipest lectin (*WsMBP1*) isolated from the salicylic acid treated leaves of *Withania somnifera* was cloned into two plant transformation vectors and the constructs (*pUH-WsMBP1* and *pCambia-WsMBP1*) were transformed into tobacco. The putative transgenics were selected on antibiotic selection medium and transgene integration was confirmed through PCR. The functional validation of the transgene will be conducted subsequently to confirm the antipest property of the encoded gene.

Additionally, a 294 bp antipest cysteine protease inhibitor, cystatin (*WsCYPI*) was cloned from *W. somnifera*. Two gene constructs (*pUH-WsCYPI* and *pCambia-WsCYPI*) were developed for ectopic expression and functional analysis in tobacco. The transformation events have been conducted and putative transgenics have been

selected for confirmation of transgene integration.

The leaf transcriptome data of *W. somnifera* were mined for pathogenesis-related (PR) genes and seventeen genes, representing PR families were identified and their expression pattern post 17 and 36 hours of salicylic acid treatment was documented. The analysis revealed significant up-regulation of all families of PR genes by 36 hours post treatment except *WsPR10*. The relative fold expression of transcripts, ranged from 1 fold to 6,532 fold.

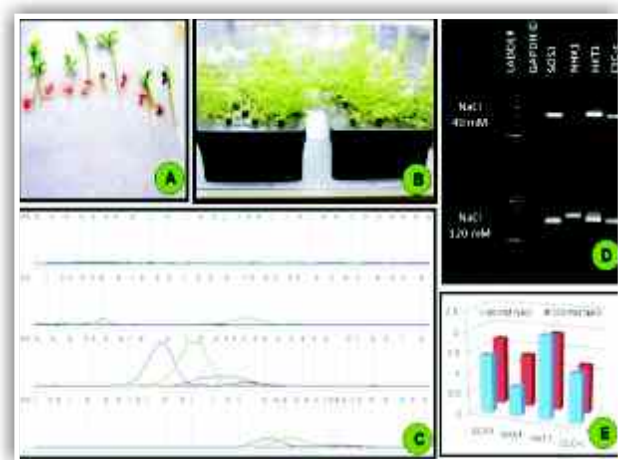
- Study of salt tolerance through gene expression pattern analysis conducted at AFRI. The project aims at analyzing the pattern of expression of four genes (NHX1, SOS1, HKT1 and CLC-c) that are known to function in maintaining ionic balance within the plant, particularly, in regulating the non-toxic levels of sodium chloride, which is the dominant salt in saline soils. A halophyte (salt tolerant plant) – *Lepidium sativum* was used and grown hydroponically at different levels of salinity ranging from 40 to 200 mM NaCl. RT-PCR was performed on transcripts of selected genes. The amplified gene products were

separated electrophoretically. Using semi quantitative approach, level of gene expression (up-regulation/down-regulation) has been analyzed. Significant up regulation of NHX1 gene in leaf tissue of *Lepidium sativum* at high concentration (120 mM) of NaCl has been observed as compared to remaining three genes. NHX1 (Sodium/Proton Exchanger) gene in *L. sativum* was found as one of the important gene conferring salt tolerance to the plant.

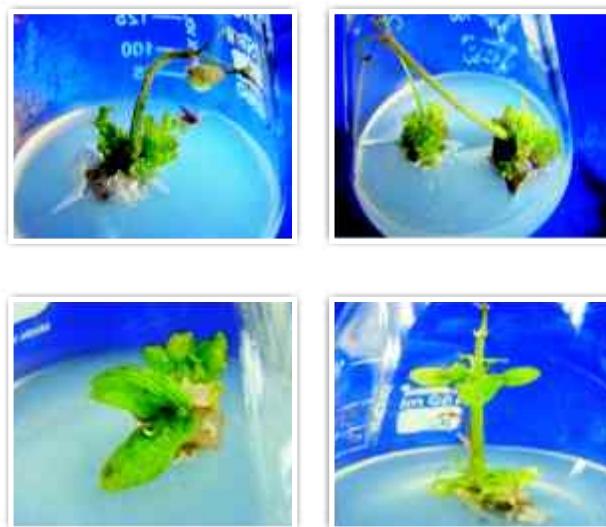
5.3 Micro and macro propagation

Micro propagation techniques standardized for important forestry species

- Experiments on rooting of cuttings were carried out for *Melia dubia*, *Ailanthus excelsa*, *Grevillea robusta*, and *Anthocephalus chinensis*.
- Attempts were made to develop micro propagation technique to regenerate/multiply mahulpatta for getting higher production. Shoot multiplication and elongation of mahul on MS medium supplemented with 1.0 μM TDZ gave encouraging results.



Study of gene expression pattern: A. Seed germination in *Lepidium sativum* (5 days old); B. *L. sativum* plants growing hydroponically at (7 weeks old); C. Gene sequence data D. Gel images showing four genes expression at two salt concentrations. (*GAPDH* used as positive control) E. The graph showing higher expression levels of NHX1 gene in *L. sativum* at high salinity level.



Shoot multiplication and elongation of mahul on MS medium supplemented with 1.0 μM TDZ



Rooting in Mahul cuttings collected from keonchi and treated with 1000ppm IBA and 800ppm thiamine.

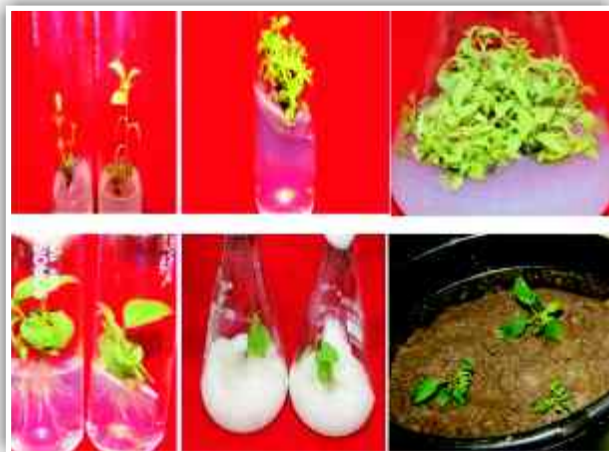
- Refinement and standardization of protocols for *in-vitro* propagation and genetic fidelity studies of micro propagated plants of two bamboo species of *Bambusa balcooa* and *Thyrsostachys oliver* carried out. In *Thyrsostachys oliver*, plantable clonal plants are obtained in 5 months period with 7-8 tillers with miniature rhizome. Further multiplication can be done by macro proliferation. In *B. balcooa*, MS liquid medium supplemented with kinetin proved least effective as compared to BAP and TDZ for shoot multiplication.
- Work in progress to refine existing micro-propagation protocols of *Dalbergia latifolia* for production of improved planting stock for genetic improvement of germplasm in central India. Different cytokinins and 2, 4-D

treatments were tested for *in-vitro* callusing and organogenesis in immature seeds collected from Kalpi. Seeds collected from selected trees were germinated. Cotyledons of seeds collected from three different genotypes were tried for shoot formation. *In-vitro* shoot cultures are being maintained.



Callus formation in immature seeds and cotyledons of *Dalbergia latifolia*

- *In-vitro* seed Culture has been initiated from green capsules of *Vanda coerulea*, collected locally in RFRI. Seeds have already started germinating in different media. Different plant parts are also being assessed to induce somatic embryos.
- Efforts were made for the development of macro and micropropagation technology for multiplication of economically important desert plant- *Salvadora persica*. MS medium was found to be the best for *in-vitro* shoot multiplication. Macropropagation through



In- vitro propagation of *Podophyllum hexandrum* Royle through axillary bud

stem cutting from mature plants was carried out using sand as rooting medium in mist chamber. Results revealed that use of various concentration of IBA (500,1000, 2000 4000 ppm) resulted in low rate of rooting from the cuttings.

- Complete tissue culture protocol for *in vitro* multiplication of *Podophyllum hexandrum*, an endangered but high value medicinal plant, through two regeneration pathways namely, organogenesis and axillary bud proliferation was developed.
- Tissue culture technique for clonal propagation and supply of genetically superior trees of Neem, ardu and bamboos was initiated at AFRI, Jodhpur.

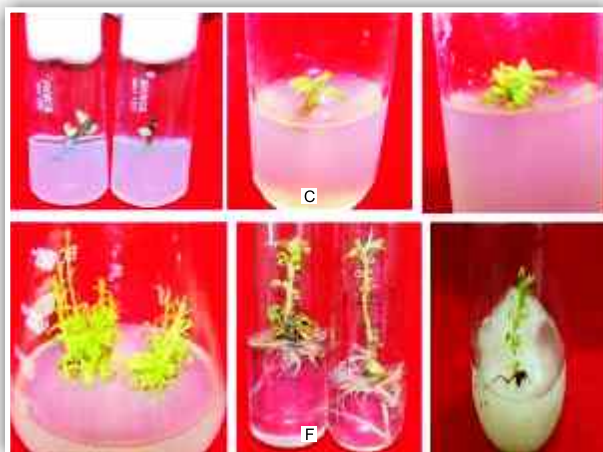


Multiple of multiple shoots of *A. nilotica* on MS medium with BAP (2.0 mg/l)+ Kn (2.0 mg/l)



Shoot initiation in *A. excelsa* MS medium with BAP (2.0 mg/l) + IAA (0.5 mg/l)

- Plantlets of Sea Buckthorn (*Hippophae salicifolia*) have been produced from epicotyle of the in-vitro raised seedlings and nodes of the field grown plants in MS medium. Different plant hormones were tried for shoot induction, multiplication, shoot elongation and rooting. These plantlets are under the process of acclimatization.



A-F: *In -vitro* propagation of *Hippophae salicifolia* through axillary bud

- Under studies on pollarding and propagation in kusum (*Schleichera oleosa*) for lac cultivation collection of stem cuttings & scion of plus trees of Kusum from Jharkhand (Basia, Simdega, Bano, etc) were carried out. Accordingly grafting operation & stem cutting trials were conducted. VMG has been

established. Clonal trial of kusum has been initiated with the plantation of clones of 20 plus trees with three replications. Survivability data were also recorded. Ten year old kusum trees were pollarded at height of 1m & 1.5m. Data are being recorded on number of shoots / branches emerged. Some sapling of kusum were pollarded also. Periodically data are being recorded on number of shoots / branches emerged, collar dia. etc from pollarded trees. Brood lac (25 kg) was collected from Heasardih in July 2013. Inoculation was carried out on pollarded trees of kusum at FRC, Mandar. Total of 336 nets were used (av. 74.4g/net). Around 100 trees/ saplings were inoculated. Removal of phunki was done after two weeks of inoculation.



Quality planting stock production of *Gmelina*

- Studies initiated for standardization of propagation method and germplasm conservation of *Machilus villosa* & *Quercus lineata*. Twentyfive plus trees of each species were selected on the basis of phenotypic characteristics in Darjeeling and Jalpaiguri Districts. On the basis of growth characteristics, 6 plus trees in case of *Q. lineata* and 10 plus trees in case of *M. villosa* were selected.
- Development of micro propagation protocols for production of superior germplasm of *Dalbergia latifolia* Roxb. and *Pterocarpus santalinus* L completed. The project aimed to establish tissue culture lab at IFB, Hyderabad and subsequently, to standardize micro-propagation protocol for *D. Latifolia* and *P. santalinus*. Accordingly, complete protocol for *in-vitro* propagation was standardized for *D. latifolia* and 200 plantlets were raised through the established protocol. Plantlets survived 100 per cent, during acclimatization process and hardened plants were planted out in the field for demonstration. In case of *P. santalinus*, the multiple shoot initiation and multiplication of culture was standardized through explants and callus culture. The experiments on *in-vitro* and *ex-vitro* rooting were carried out for *P. santalinus* and finally *in-vitro* rooting was successful. With this, the tissue culture protocols of both the species have come out successfully.

5.4 Tree Borne Oil seeds (TBOs)

- Selection, improvement and molecular characterization of *Pongamia pinnata* in eastern India was done. The original germplasm was multiplied for plantation at different places along with stockplant management. DNA extraction protocol was standardized using different plant material and 4 methods available in literature. Designing and synthesis of 30 SSR primers. PCR amplification of DNA extracted from all the germplasms were carried out and amplified products checked on electrophoresis. SSR's from related forestry species have also been evaluated in *P. pinnata*.



Fruit & Flower of *Pongamia pinnata* (L.)

A total of 91 high fruit yielding candidate plus trees of *Pongamia pinnata* were selected from different agro-climatic zones of Tamil Nadu, Pondicherry and Kerala. The selected



High pod yield in selected CPT of *P. pinnata* at Hosur (Tamil Nadu)



Vegetative Multiplication Garden (VMG) of *Pongamia pinnata*.

trees were multiplied clonally and a vegetative multiplication garden established. Clones are being multiplied from VMG for establishing multilocation clonal trials. 7 trees showed 103 to 250 kg pod per tree, and the oil percentage in the selected CPTs varied from 15 to 33%. The clones which showed high fruit yield with high oil content will be recommended for large scale planting programme.

Candidate plus trees of *Pongamia pinnata* selected from northern part of the country were screened for phenotypic characters in different states, and progeny trails conducted. Oil content ranged from 27.89 to 41.43 % with an average value of 35.27 %. In fact, 48.42 % genotypes yielded more oil than average (35.27%) and maximum oil content was recorded as 42.17 %. On the basis of higher oil content and high seed germination ability, the genotypes were further narrowed down to forty nine (49) which were established as progeny trials in the different geographical regions of Punjab, Haryana and Uttarakhand to assess their genetic worth.

Seed behaviour and effect of differential drying and temperature on viability of *Messua ferrea* and *Madhuca insignis* (species of wet evergreen forest of Western Ghats) was studied with fundings from Karnataka Forest Department. Preliminary results revealed that seeds show recalcitrant behaviour on the basis of



Pongamia clones

habitat, seed size, and moisture content at maturity, germination, seed coat ratio and model on probability of recalcitrant. However, the seeds can be dried to moisture content as low as 1.78% with 50% viability.

5.5 Conservation of Forest Genetic Resources

- Forests are the world's most important and most valuable renewable natural resource, evolved and conserved over millions of years in their natural habitat. However, increase in the world's population, together with higher standards of living has resulted in continuous pressure to transfer areas previously under forest to agricultural or other uses. The resulting large scale disappearance of natural forests is leading to an accelerated loss of valuable or potentially valuable germplasm. The objectives of conserving forest genetic resources are to secure the ability of forest tree species to adapt to environmental changes and to maintain the basis for improving production and other benefits of growing trees through future selection and breeding activities. In Western Himalayas, where the tree vegetation is mainly confined to the northern-aspect and the southern slopes are devoid of vegetation. The ever increasing human and cattle population over the years has put lot of pressure on forests of *Pinus roxburghii* (chir pine), *Cedrus deodara* (deodar), *Abies pindrow* (silver fir) and *Picea*

smithiana (spruce), *Pterocarpus santalinus* etc. consequently, resulting in decreased density of these forests, though over all forest area may have increased. Hence, FGR are indispensable elements for effective and long term conservation for the betterment of the society, sustainable utilization and conservation.

- Sandalwood is recognized worldwide as one of the most valuable commercial tree species with an estimated market volume of more than \$1 billion. Genetic diversity study for prioritization *in-situ* conservation sites for sandal populations in southern India has been initiated. Genetic diversity studies will probably help to unravel this confusion and the results will expectedly help in better management and conservation strategies for this flagship species.
- For conservation of *Garcinia* species in Upper Brahmaputra Valley, Assam, surveys were conducted in Tinkupani and Tipong Reserve Forest, Dihing Patkai rain forest in Tinsukia District, Jokai, Namdang, and Medela Reserve Forest in Dibrugarh district, Sola and Abhoipur reserve forest in Sibsagar district, Gibbon WL Sancturay, Jorhat district and Nambor Reserve Forest in Golaghat district for study of *Garcinia* with respect to its distribution and ecology.



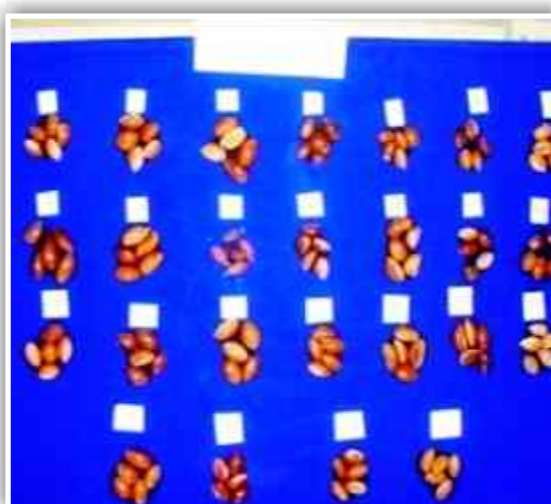
Garcinia kydia in Dihing Patkai Rain forest Assam



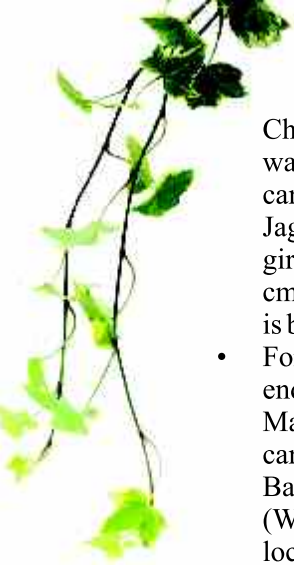
Mahua trees selected in Bhanupratapur and Jagdalpur

Garcinis dulcis in Dihing Patkai rain forest Assam

- A study was conducted with aims at introduction of *Morinda citrifolia* L. (Noni) into NE States as livelihood option for the people of North East India. Collected 750 numbers of tested clones of Noni from CARI, Port Blair for experimental trial in North East. Successfully raised the Noni plants in RFRI campus and further monitoring of growth performance are in progress.
- Collection of germplasm of *Madhuca indica* J. F. Gmel for identification of best sources in



Variation in size and shape in fruits and seeds of mahua collected from Bilaspur



Chhattisgarh through phytochemical evaluation was carried out. Survey and selection of trees was carried out at Balod, Bilaspur, Jashpur, Kanker and Jagdalpur. Mahua trees were selected from five girth classes, viz., 61-90 cm, 91-120 cm, 121-150 cm, 151-180 cm and over 181cm. Saponin content is being estimated in seeds.

- For collection and characterization of critically endangered *Litsea glutinosa* germplasm from Madhya Pradesh and Chhattisgarh, visited and carried out survey of Chhindwara (West) Forest & Balaghat (South) Forest division. In Chhindwara (West) Forest Division, Total 31 trees were located and detailed morpho-metric data was recorded along with GPS location in specified format. Out of 31 trees, propagating material from 10 trees was collected and established in the nursery of the division. From Balaghat (South) Forest division, total 26 trees were located and detailed morpho-metric data recorded along with GPS location in specified format. Out of 26 trees, propagating material from 7 trees has been collected and established in the nursery of the division.



Field survey in *Litsea glutinosa* Balaghat Forest Division

- An improved holistic approach was adopted for development of database on fast growing tree species targeting stakeholders in Tamilnadu and Kerala. The information related to fast growing tree species viz., *Acacia auriculiformis*, *Acacia mangium*, *Neolamarkcia cadamba*, *Azadirachta indica*, *Bambusa bamboos*, *Bombax ceiba*, *Calophyllum inophyllum*, *Casuarina equisetifolia*, *Eucalyptus camaldulensis*, *Eucalyptus teriticornis*, *Gmelina arborea*, *Grewia tiliifolia*, *Melia dubia*, *Paraserianthes falcataria* and other species were collected and updated. The database contains information on the important characteristics of the fast growing tree species. The information, such as, genus, family, local and common names, botanical descriptions, taxonomy and nomenclature, habitat, distribution and environmental conditions, important pest and diseases, different products, services, uses, seed characteristics (seed descriptions, weight, dimensions, size, germination, details type, size, percentage), seed collection, handling, processing, agro forestry practices, growth and yield, reproductive biology and breeding system, genetics and tree improvement, ecology, fruiting, flowering, cultivation, propagation, origin, wood (colour, grain, texture, strength, treatability, working properties, durability), planting stock (SSO,CSO, Progeny trial), reference etc were collected and updated.
- Mapping and monitoring of *Casuarina* and *Eucalyptus* Plantations in Tamilnadu using RS and GIS was done. The extent of *Casuarina* and *Eucalyptus* plantations in Ariyalur District of Tamilnadu has been mapped using LISS IV Resourcesat-2/ L-4FMX, geo corrected using Survey of India Topo Sheets. The identification of training pixels and plots were done by using the plantation data collected with the help of GPS from the field survey. Supervised classification was used to classify the image supplemented with visual analysis of the image and recode technique was used to reclassify the misclassified pixel with the

help of Google Earth and field check. Based on the field survey and data collected from TNPL, various land uses, including extent of *Eucalyptus* and *Casuarina* plantations were delineated. The results indicated that the data and processing technique used could offer a reliable approach for mapping *Casuarina* plants and other plantation crops.

- Forest Research Institute, Dehradun and Institute of Forest Genetics and Tree Breeding, Coimbatore have been designated as the nodal centres for Forest Genetic Resource Management Network (FGRMN) in the country. A FGRMN cell has been constituted at FRI Dehradun which will be housed in a fullfledged building for operation. A new building for Forest Genetic Resources Management Network (FGRMN) is being established at IFGTB campus to take up the FGRMN activities. These centers will gradually be upgraded under the one time special grant of ICFRE. Exploration, collection, conservation, characterization and documentation are the key activities envisaged under FGRMN. Dr. S. Nagarajan, FGR Chair of Excellence appointed by ICFRE has prepared a document on National Forest Genetic Resources Conservation and Usage Plan in consultations with Forestry Research organizations and State Forest departments and submitted to ICFRE/MoEF for implementation.

Database on Forest Genetic Resources: Genetic Resources in the form of seed orchards, seed production areas, genetic trials, germplasm bank, plus trees etc have been established for important trees species by various stakeholders across the country. A database on candidate plus trees assembled by IFGTB was prepared for *Thespesia populnea*, *Pongamia pinnata*, *Neolamarckia cadamba*, *Ailanthus excelsa* and *A. triphysa*, *Calophyllum inophyllum*, *Sapindus emarginatus*, *Eucalyptus* and *Tamarindus indicus* and retrieval mechanism also developed. In addition, database has also been developed for seedling seed orchards, clonal seed orchards, seed production areas, clonal trials, progeny trials, clone banks and permanent preservation

plots for Teak and *Eucalyptus* maintained by Tamil Nadu and Kerala forest departments.

Under the project, “Exploration, Collection and Evaluation of Forest Genetic Resources and Development of National Gene bank”, 23 teak populations in Central and Northern part of Kerala were surveyed and recorded the variation on growth, tree form, branching pattern, reproductive characteristics, pest incidence, topography, soil pattern etc with GPS data. Eleven populations which showed distinct and desirable characteristics were marked for *in-situ* conservation.



Teak population marked for conservation at Nilambur, Kerala



Teak population marked for conservation at Iduki, Kerala



Seed Production Area of Teak at Varagaliar, Topslip
(Tamil Nadu)

- Survey was conducted on populations of *C.inophyllum* in Trivandrum, Allepey, Kollam, Kazargod, Nagercoil, Kanya Kumari, Courtrallam. Chidambaram, Aliyar, Chennai, Karur, Annur, Avinashi, Anaikatti, Nagapattinam, Tenkasi, Sengottai, Puducherry, Karaikkal, Havelock, Mayabunder, Diglipur, Wandoor, Chidiyatapu, Rangat and Betapur in total covering Tamil Nadu, Kerala and Andamans and 159 CPTs were identified. The passport data were also collected. Vegetative multiplication through stem cuttings and produced rooted clones of selected CPTs standardized. Conducted germination tests, recorded seedling parameters, raised stock and standardized nursery management practices. Standardized seed processing for oil extraction from *Calophyllum inophyllum* kernels and oil analysis by Soxhlet method. Established Clone bank and Half-sib Progeny trial at Panampally and maintained. Shortlisted 40 high yielding clones having more than 55% oil content.
- Extensive field surveys were undertaken in the Western, North Western, Cauvery Delta Southern, North Eastern and high rainfall zones of Tamil Nadu, Puducherry, Northern and Central regions of Kerala and selected 128 CPTs of *Thespesia populnea*. Cuttings from these trees were collected and kept for rooting in the vegetative propagation complex of IFGTB. Bud sprout could be

observed in all the cuttings and the rooting percentage was 60. No pest attack was observed till September 2011. However, 3 clones were affected by Mealy bug, later and, control measures adopted. Established a Clonal Multiplication Area with 82 clones at Panampally Research Station, Kerala.

- Tamarind orchards located at Neyveli, Thoppur, Theni & Mullangaddu have been evaluated for flowering and fruiting. Among different treatments, soil drenching of Cultar @3000 ppm and spraying of 2% KNO₃ found positive implication on enhancing fruit productivity.
- Studies on variation in reserpine content in some high yielding genotypes of *in-vitro* and seedling raised *Rauvolfia serpentina* revealed that the highest *in-vitro* rooting of 81.67% and maximum number of roots (7) was obtained with GO-MN accession on ½ B5 medium. The hardened plantlets were transferred to the field for trial comprising *in-vitro* and seedling raised plants of five genotypes.



Field trial of five genotypes of *Rauvolfia serpentina*

- Multilocation trials of *Jatropha curcus* were conducted in different agroclimatic zones. Overall, 30 % mortality was observed in MLT after two year of plantation. On the basis of fruits/plant, three accessions are identified viz. IC 468907, IC 468919 and IC 471353.



Trial plot July, 2013, Luxurious growth (above) & fruiting (Right)

Seed variation for germination and seedling growth of *Michelia champaca* was studied and seedling seed orchard established. Survey was conducted in Mizoram, Tripura, Arunachal Pradesh and Assam to identify the natural plantation distribution of *M. champaca* and variation among different population. Huge variation for morphological traits was observed and from the different population phenotypically superior genotypes were selected for establishment of seedling source orchard. Also, identified variation in natural regeneration and further investigation on the subject is under progress.