

2. Managing Forests and Forest Products for Livelihood Support and Economics Growth

Forestry research that will truly benefit the people in terms of their economic upliftment has been stressed upon in the ICFRE and its institutes. This thrust area has been carved out for sustainable management of the forests and natural resources as well as to protect and conserve the natural resources on the one hand and, to provide opportunity for economic well being of the people on the other. It aims for integration of environmental issues with the suitable developmental strategies; those will pave the way for sustainability of the resources and provide livelihood support to the people. It is beyond any doubt that the diversity of products, goods and services that are available from the forests are tremendous. In view of this, the ICFRE is implementing the research projects that are highlighted below.

2.1 Silviculture and Forest Management

Identification of extent of forest land in forest fringe villages

In 275 forest fringe villages identified in rainfed districts using GIS, the forest types, area of each forest type and density classes estimated. The socio-economic status and dependence of forest fringe villagers on forests and the ecological status of such forests were assessed in depth in 194 districts. A web portal was also developed for storage and analysis of data generated for 275 rainfed districts.

Assessment of soil quality indicators for different forest stands in Uttarkashi district

Soil health assessment cards of *A.pindrow* / *P.smithiana*, *Cedrus deodara*, *Pinus roxburghii*, *Quercus leucotrichophora*, and miscellaneous forests were prepared. Maximum SQI values were found in soils under miscellaneous forests followed by *A.pindrow* / *P.smithiana* forest stand,

Cedrus deodara forests, *Quercus leucotrichophora* forests and *Pinus roxburghii* forests.

Soil organic carbon store under different land uses in Haryana

Information generated from the project on SOC store will provide authentic information on this important aspect of climate change. Maximum SOC stock was found under chir (*Pinus roxburghii*), followed by dhak (*B.monosperma*) miscellaneous forests and the least was under sal (*Shorea robusta*). Maximum organic carbon stock was found in the soil of Panchkula district. In total, forest land of Haryana holds 7.88 million tons of soil organic carbon while soil under horticulture land use has 1.37 million tones of SOC stock. Under horticulture land use, maximum organic carbon stock was estimated under mango, followed by nimbu, ber, guava, kinnu, aonla, etc. Similarly, under plantations, maximum carbon was under neem followed by khair, teak, eucalyptus, poplar, *Ailanthus* and shisham and the least SOC stock was under *Pongamia*.

Assessment of soil microbial community and soil quality under poplar and eucalyptus plantations in Haryana

Soil sampling was done three times in a year at a depth of 0-30 cm, 30-60 cm and samples collected and analyzed for soil pH, organic carbon, available Nitrogen, Phosphorus and Potassium. Along with this, some growth promoting bacteria and fungi were also isolated, characterized and their plant growth promoting ability tested on Poplar and Eucalyptus by pot experiments.

Soil Quality Index (SQI) for different land uses of Tehri Garhwal district of Uttarakhand (Externally aided project UCOST):

About 200 soil samples have been collected from miscellaneous forest, pine forest, oak forest and agriculture field and grasslands in the project area. The samples were processed and analyzed for physico-chemical and biological properties. Soil Quality Index of all these villages were calculated seasonally and accordingly, a database and a soil Health card was prepared for the different villages.

Clonal screening of *Dalbergia sissoo* in relation to nitrogen fixation and biomass production

24 clones of *D. sissoo* were assessed for nodulation, nitrogen fixation, nitrogen assimilation and biomass production under pot culture condition. Taking into consideration all the parameters studied, it was concluded that clone no. 9058(1) & 9058(2), Dhani Kakarhawa, (Sidharthnagar); 9064(2), Tilkhana Village, (Maharajganj) and 9093(1), Galla Mandi, (Behrampur), 002 (Bijnor, Uttar Pradesh); 009 & 013 (Haridwar, Uttarakhand) and 057 (Ambala, Haryana) performed better. All clones are available in the VMG of G&T P Division of FRI, Dehradun.

Creation of field germplasm bank of *Grewia optiva* and *Quercus leucotrichophora*, the important indigenous fodder tree species of Uttarakhand

Germplasm banks for *Grewia optiva* at Dudhli, Lachhiwala Range, Dehradun Forest Division and for *Quercus leucotrichophora* at Magra, Jaunpur Range, Mussoorie Forest Division were established and strengthened through more plantings.

Multiplication, conservation and promotion of Ringal cultivation for socio-economic upliftment of hilly rurals in Uttarakhand

The Ringal cuttings were planted at FRI and Magra Nursery (Mussoorie) for outplanting. Nearly 300 plants were produced through macroproliferation technique for dissemination.



Multiplication of Bamboo through macroproliferation




Bamboos transplanted in polypots

Influences in regeneration of silver fir (*Abies pindrow*) and spruce (*Picea smithiana*) forests - Effect of natural leachates on seedling growth in nursery

Litter, humus and soil samples were collected from fir and spruce forests in Deovan, Chakarata and soil samples analyzed for nitrogen, phosphorus and organic carbon. Leachates of litter, humus, soil and under-storey plants were prepared, analyzed for allelochemicals and also applied on fir and spruce to observe their effect on growth and establishment of the seedlings in nursery. The readings are completed and its analysis is in progress.

Allelopathic potential in regeneration of Sal (*Shorea robusta*) forests

Litter, humus and soil samples were collected from sal forests, Dehradun and analyzed for total



Nitrogen, available N and organic carbon. Seeds of sal collected and germination experiments were conducted in laboratory to observe the effect of leachates on germination and early growth of sal seedlings.

Impact of Sal-ANR in Shiwalik region of Dehradun and Kalsi forests (Externally aided by Uttarakhand Forest Deptt)

Under the project, field survey was carried out in March 2014 and geo-references of sal ANR were recorded for GIS map for further data collection in the field.

Revision of National Working Plan Code

With the objective of incorporating criteria & indicators for SFM, usage of modern technologies like GIS, GPS, etc., addressing new concepts like climate change, carbon sequestration, inclusion of focused management of NWFPs and people forest interface, the working plan code was revised by FRI, Dehradun and the new National Working Plan Code 2014 prepared after incorporating suggestions in several consultative and regional workshops was finalized by MOEF &CC, New Delhi for its implementation in the country from 01-04-2014.

Study on constraints in the export of carved out wood products and its economical and social impact on the livelihood of dependent people in North India

To address the issues of wood carving industry and its impact on the people engaged, this project was undertaken by FRI for which ten wood carving centers were selected spread in J&K, H.P., Punjab, western U.P. and Rajasthan. Questionnaires were developed to assess the economic condition, literacy level, specialization, working tools or machines (technology) used, alternate sources of income, type of working and constraints. Draft report has been completed.

Survey of bamboo resources and quantitative assessment of their production and consumption in North India

The data on production, supply, consumption and market mechanism was collected from the study area in Chandigarh, Delhi, Haryana, Punjab, Uttarakhand and Uttar Pradesh. The analysis of the data showed that the contribution of state own production in the consumption of bamboo of state under study area was between 4 and 31 % except Chandigarh and Delhi, that have no production of their own. Project completed and final report submitted to MoEF &CC in May 2014.

Screening of some forest tree species for their antioxidant properties

The bark of *Prunus cerasoides*, the leaves and the bark of *Toona serrata*, *Bauhinia retusa*, *Populus ciliata*, *Robinia pseudoacacia* and the saw dust of *Ailanthus excelsa*, *Melia azedarach*, *Toona serrata*, *Toona ciliata* were collected and extracted with different solvents, under vacuum. Screening of these extracts for their antioxidant capacity (AOXC) and total phenolics contents (TPCs) was also carried out.

Phytochemical screening of selected wild edible plants for exploration of new sources of luteolin

Total polyphenolic and flavonoid contents of edible parts (fruits) of *Prunus armeniaca* and *Hippophae rhamnoides* were estimated at FRI. DPPH Free radical scavenging potency of different fruit extracts of target plant species was determined to establish a credible correlation between total phenolic content and antioxidant activity of fruit extracts.

Value addition of Acacia resources of the Nilgiris for employment generation and livelihood support

Nutritive and anti-nutritive chemical analysis of seeds of *Acacia mearnsii* was carried out wherein, extracts from the pods were developed and tested for insecticidal / microbial activity and crude samples of essential oils were extracted from plant material.

Restoration ecology and species recovery studies in tsunami impacted mangrove areas in Andamans

15 Sample plots in each island group were selected, based on stratification and the damaged areas were stratified and vegetation surveys done. Studies on tidal fluctuations and vertical zonation of mangroves species in the affected areas are going on. Mangrove nurseries of *Rhizophora* sp, *Ceriops* sp, *Bruguiera* sp, *Xylocarpus* sp have been established in South Andaman and Middle Andaman. Supplementation of natural regeneration by introduction of seeds directly into the selected sites and collection of seeds and establishment of nursery for rare mangroves species will also be carried out.

Developing yield tables for short rotation tree crops in Kerala

The project aims to develop regional prediction models for constructing yield tables for fast growing five tree crops viz. *Acacia auriculiformis*, *A. mangium*, *Albizia falcataria*, *Eucalyptus pellita*, and *E. grandis* in Kerala. Sample trees were felled and field measurements completed for all the five species. Regression analysis will be used to develop models for volume estimation and preparation of volume tables.

Growth and yield studies on forest plantations of teak in Karnataka for their sustainable management.

Annual measurements carried out in 27 sample plots laid out in five Forest Divisions in Karnataka and growth data of teak recorded in all the plots. Compiled data were analyzed. Stand density diagram has been constructed and relationship between stand density, dominant height, quadratic mean diameter, relative spacing and stand volume was developed. An equation was developed to enable prediction of reduction in tree number due to density-dependent mortality.

Biomass, net primary productivity and shoot productivity of seven industrially important bamboo species in semi-arid and humid tropics of Peninsular India

Growth observations including various culm and clump parameters were recorded for all the seven species in two agroclimatic zones (Humid tropics - Koppa, Chickmagalur and Semi-arid - Hoskote, Bangalore). Basic nutritional analysis of the juvenile edible shoots of the various bamboo species was also done.

Standardization of plantation techniques for major forest plant species in Madhya Pradesh

Eight species viz., *Tectona grandis*; *Gmelina arborea*; *Dalbergia sissoo*; *Dalbergia latifolia*; *Terminalia tomentosa*; *Albizia procera*; *Terminalia beleirica*; *Dendrocalamus strictus* were chosen for the experiments for which pits of three different sizes were dug post site preparation and plantation at different spacing under irrigated and non- irrigated conditions done for all. Growth data (quarterly) and rate of



Pit digging at site



Fixing of earthen pot (Surahi)

photosynthesis (half yearly) are being recorded in these plantations.

Integrated nutrient management for improved growth of trees on overburden dumps

Overburden samples were analyzed for its physico-chemical properties at Shivpuri open cast mine-1. Plantation was done with 10 tree species. Physicochemical analysis of overburden dump showed nutrient status of the spoil increased gradually with the increase in age of the plants with respect to EC, organic carbon and available N, P, K. Combined treatment with farm yard manure (FYM), vesicular arbuscular mycorrhiza (VAM) and NPK showed good result in survival in *Gmelina arborea*, *Mangifera indica*, *Moringa oleifera*, *Cassia siamea* and *Emblia officinalis*.

A coordinated project on integrated management of 'khejri' mortality for socio-economic upliftment in Rajasthan

Component 1 of project focuses on forest protection studies where the result of field trials at six sites in five districts of Rajasthan revealed that the best treatment was AFRI, followed by CAZRI and ARS in managing the 'khejri' mortality. The major biotic factor responsible for 'khejri' mortality is root rot disease (*Ganoderma lucidum*), followed by *Acanthophorous serraticornis* (root borer). The II component on

genetics aspect involved survey and selection of 5 CPTs in various districts. The biotechnological component achieved 5 to 6 fold multiplications of shoots from fresh shoot. Standardization of DNA extraction, purification and quantification was done. The ecological component assessed the effects of abiotic stresses with relation to 'khejri' mortality for which meteorological data of Churu, Jhunjhunu and Jodhpur districts were collected along with ground water table data, and soil samples analysed. Data were correlated with metrological figures from previous years. Biochemical studies on causal organism, *Ganoderma lucidum* indicated that for screening of healthy trees from diseased trees, proline and ash content could be used as biochemical markers. The socio-economic aspects of 'khejri' mortality were assessed in 190 villages. Lastly, under the extension component, awareness generation programme on 'khejri' mortality and its management was done during visits to AFRI, in mela, workshop, meeting, trainings.

Participatory forest management- Identification of extent of forest lands in forest fringe villages funded by NRAA, Govt. of India

The project aims undertake socio-economic survey and ecological studies in North-eastern region except Sikkim, covering different aspects of livelihood including dependence on forests etc. During this year, seven states of Northeast India were covered.

Identification of extent of forest land in forest fringe villages



In-vitro cloning and DNA fingerprinting of *Prosopis cineraria*: A & B. Shoot initiation from nodal shoot segment of lopped trees, C. Six fold shoot multiplication on MS+5mg/l BAP+ additives in 8 week; D. DNA fingerprint using 25 RAPD primers.



Socio-economic survey in Barumal village

Socio-economic survey through questionnaires and vegetation studies were carried out in Jamnagar, Junagarh, Panchmahal, Surat, Vadodra, Valsad, Dahod and the Dangs districts in Gujarat dominated by tribal communities. Due to continuous hacking or clearing of trees for cultivation and uncontrolled grazing and repeated fires, the natural regeneration of teak was low, whereas, regenerations of *Diospyros melanoxylon*, *Anogeissus latifolia*, *Butea monosperma* and *Lagerstroemia parviflora* were relatively better. People have small and marginal land holdings and due to poor irrigation facilities, have to depend on kharif crops.

Innovative approaches for augmentation of composting and biofertilizer production in hot arid regions

Vermi- compost samples were analysed for mycoflora associated with various pedding material adopting dilution plate technique. The mycoflora, *Acremonium sp.*, *Cladosporium sp.*, *Penicillium sp.*, *Aspergillus niger*, *Aspergillus flavus*, *Alternaria sp.*, *Trichoderma viride*, *Fusarium spp*, *Actinomyces* and *Streptomyces* were isolated and identified. Three litter decomposing fungi, *Trichoderma viride*, *Aspergillus niger* and *Streptomyces* and PSBs were selected for amendment for rapid composting process and to enhance nutritive value of compost. Training on production of



Vermi- compost ready for use



Multiplication of in AM fungi (*Glomus fasciculatum*) in pot with maize host

Vermi- composting and AM fungi (*Glomus fasciculatum*) multiplication

composting, vermicomposting and biofertilizer multiplication and their application in forestry was imparted to stakeholders/VVK.

Enhancing fodder productivity through silvipastoral system on degraded land of India

Annual growth data (height and collar diameter) were recorded in *Colophospermum mopane* plants. Structure repairing was undertaken and grass sowing was carried out. Green grass yield for *Cenchrus ciliaris* was, then, measured. Soil analysis indicated that pH was high (9.08 -10.0) of soil structures, where, grass establishment was poor. Yield of other grass



Preparation of vermicompost using neem leaf + cow dung



(a) Establishment of *S. nudiflora* on soil bunds



(b) Establishment of *C. ciliaris* on soil slope with *C. mopane*



(c) Various salt tolerant grasses with *C. mopane*

(a to c): Silvipastural trials at Gangani, Jodhpur

species was measured. *S. nudiflora* seedlings were planted post preplanting operations on soil bunds.

Tapping potential of some selected indigenous lesser known wild edible plants for food and nutrition in arid and semi arid region

Selected lesser known wild edible plants viz. *Cordia gharaf* (Goondi), *Cassia tora* (Puad), *Ceropegia bulbosa* (Khedula), *Haloxylon salicornicum* (Sajji) and *Grewia tenax* (Gangeran), *Calligonum polygonoides* (Phog), *Leptadenia pyrotechnica* (Khimp) and *L. reticulata* (Rai dodi) with edible leaves/fruits /tubers consumed in arid and semi arid forest regions of Rajasthan were evaluated for their nutritive value in order to identify alternative bio-nutritional sources.

Productivity enhancement of Kair (*Capparis decidua*) fruit to generate livelihood in rural areas of Thar desert

Gogelao in Nagaur was selected for field trial and plants of *Capparis decidua* were divided into three blocks. Fertilizer treatments with leaf compost, goat FYM and VAM in combination with different fertilizers; were applied with irrigation. Data analysis indicated that maximum flowering (73.5%) was in compost treated plants, followed by AM fungi treated plants (24.3%). Flowering was minimum (14.4%) in goat FYM treated plants.

Productivity and biometrics studies on some important species in semi-arid regions of Rajasthan for their sustainable management

Felling of trees to develop regression equation to estimate biomass of *Prosopis cineraria* & *Ailanthus excelsa* plantations was done in 14 permanent sample plots laid in the IGNP area. Annual observations were recorded. Models for deriving the total volume, merchantable volume over bark and under bark for both species were developed. Growth and yield models are under process. Similarly, fodder and fire wood yield models in *Prosopis cineraria* were developed using multiple regression techniques.

Productivity study and growth and yield in teak plantation in Gujarat state

The main objective of this project is to construct and validate tree volume function and to develop growth and yield models. For this purpose, annual observation on growth parameters of *Tectona grandis* were recorded from 14 sample plots spread across various locations in Gujarat. Linear regression equations developed between height and diameter were fitted. The Quadratic Equation between H and D is $H = 2.55 + 0.877 D - 0.086 D^2$ was found most suitable with $R^2 = 0.737$. Also, the frequency curve of *Tectona grandis* was found asymmetrical and positively skewed in comparison to normal frequency distribution.

Studies on seed germination and longevity of *Abies spectabilis* (D. Don) Spach

Extensive surveys were conducted during the year for identifying the additional natural populations of *Abies spectabilis* in the state. Eight new natural populations in Kinnaur, Parvati, Kullu Forest Divisions and Sarahan Wildlife Division in Himachal Pradesh were identified, georeferenced thereby, raising the total locations to 25. Site characteristics were analysed. The seeds were extracted from cones of *A. spectabilis* from two sites i.e., Chhitkul and Churdhar forests for carrying out trials on seed germination both in the laboratory and in nursery conditions and the germination data are being recorded.

Determination of nursery requirements and initial planting performance of *Diploknema butyracea* (Roxb.) H. J. Lam and *Myrica esculenta* Buch. Ham. under mid-hill conditions of Himachal Himalayas

Germination studies in 'kaphal' were initiated from the seeds collected during May 2013 from Shimla and Mandi districts. Seed germination trials in 'kaphal' at Baragaon and Shilly nurseries had little success. Trials with root cutting were also initiated. Similarly, seeds of 'cheura' collected from Uttarakhand and sown in



Root cutting plants of Kaphal

nurseries at Shilly (Solan) and Bir Plassi (Nalagarh) recorded about 80% germination. Planting of 'cheura' in Solan district showed good initial establishment.

The succession trends and productivity studies of Sriharikota (SHAR) and Pulicat lake ecosystems for conservation of biodiversity

In this ongoing all India coordinated project, phyto-sociological data of terrestrial and aquatic ecosystems from 30 quadrats, data on people's perception about natural regeneration on communities, priorities and local vegetation was collected along with the phenological observations. Biotic interference and productivity aspects of terrestrial ecosystem were assessed and recorded in permanent quadrats with portable photosynthetic system.

2.2 Agroforestry and people-forestry interface:

Development of agroforestry model of some important medicinal plants with *Melia composita* and *Emblica officinalis* in degraded land of Punjab and Uttarakhand

Selected sites at Naukra grant (Buggawala) and Handesara (Punjab) were developed and experimental areas at Naukragrants (Buggawala), Haridwar and Handesara, Mohali were maintained along with data recording on growth performance of tree species, medicinal plants and yield of agri crop from both the sites.

Study on status of agroforestry systems existing in Punjab, Haryana, Uttarakhand and North-West Region of Uttar Pradesh.

17 villages were surveyed and data collected on socio-economic status and agroforestry practices from Rangadwala, Imalikheda, Mewarkhurd, Shahpur and Ranimajara districts of Haridwar (UK) and Sherpur, Nahartarpur, Baloli, Khurdi, Damla, Dhoraung, Gulabgarh, Machrrouli, Parboli, Taharpurkhurd, Khijari and Mandewala districts of Yamunanagar (Haryana). Compilation work of 31 villages of Punjab (3), Haryana (12) and Uttarakhand (16) has been completed.

Enhancing fodder productivity through Silvi-Pasture system on degraded land of India

Grewia optiva and grasses procured and established silvi-pasture agroforestry models established on degraded land at Kharakhet, Dehradun and observations on survival noted along with maintenance of experimental site at Kharakhet, Dehradun

Introduction and evaluation of fast growing tree species under agroforestry systems in different agro-climatic zones of Tamil Nadu

Established agroforestry systems under 15 ha farm land in three zones (Northeastern, Cauvery delta and Southern zones) with fast growing tree species of *Melia dubia*, *Gmelina arborea*, *Neolamarkia cadamba* and *Sweitenia*



Establishment of agroforestry system with *Melia dubia* and sorghum in farmers' field

macrophylla. Intercropping activities carried out and the biomass and yield of annuals of various species (as intercrops) assessed. From the intercropping activities carried out in the first year, *M. dubia* with turmeric registered highest net annual return followed by *G. arborea* with Banana, *M. dubia* with Tapioca on per ha basis. Allelopathy study was conducted with exudates prepared from fast growing tree species and study completed in maize, sorghum and black-gram. Training on capacity building of farmers of Pudukottai district was also conducted.

Development of Integrated Dry Land Agroforestry Systems in Tamil Nadu for enhancing livelihood opportunities

Seven Agroforestry systems demo units in all talukas of Ramanathapuram district in Tamil Nadu done with creation of farm ponds on six farm fields in six taluks. Superior planting stocks of Casuarina, pungam, neem, teak, amla, sapota and mango multiplied and seven agroforestry plots established and recorded soil parameters, survival and growth of tree components. Also, completed two collaborative projects with State Agricultural Universities on NTFP Network Project on selected NTFPs of Kerala.

Capacity building, skill up-gradation of artisans and promotion of traditional bamboo handicraft and art with improved technology, suitable design and value addition under 'Direct to Consumer' scheme of ICFRE.





Training on bamboo handicraft and agarbatti stick making at Bamboo Composite Centre, RFRI, Jorhat

A training programme on Agarbatti stick making was organized on 5th September '13 at Nemuguri, Dist. Sivsagar, Assam for 135 women members of 16 SHGs and at Meleng, Jorhat on 7th October, '13, where 37 ladies from 17 SHGs participated. For, skill upgradation of artisans, a 10 days training- cum- workshop from 26th September to 5th October, '13 was organized and was attended by 21 artisans from 4 districts of Assam. Similarly, a training was organised on bamboo products for a group of Don Bosco, drop out students of the Mishing tribal community of Assam from 21st to 25th October, '13 with 21 participants.

Development of lac based agroforestry (silvi-agri-lac) system

Broodlac of 'kusumi' strain from the Kanker Forest Division was inoculated on *F.semialata* and *F. macrophylla* after organic manure was added and irrigation, avoiding water logging. The growth data revealed gradual increase in height - maximum 2.5m in *F.semialata* and 2.4m in *F. macrophylla* and intercropped with oleri crop viz. *Lycopersicon esculentum* as summer crop. The system is maintained with regular irrigation and other cultural operations and monitored.

Evaluation of *Madhuca indica* based silvi-agri system in arid and semi arid region of India (AICP project)

Grafted plants and seedlings of *M.indica* were transplanted in the experimental area of

TFRI in 2012 and growth data on survival % revealed 50% survival of grafted plants as compared to seedlings. Data of growth and nutrient status at the initial stage of the study and one year after its plantation were recorded indicating that all the parameters of soil decreased from the initial stage i.e pH value from 8.36-7.96, EC value 0.25-0.21 but OM value increased from 0.86 to 1.376, N and 169.34-287.89.

Development of silvi-agri-medicinal/agri-medicinal systems in Vidharbh Region of Maharashtra


A farmer's field in Chandrapur district was selected as OFR and an experimental area of agroforestry division was selected as an OSR for the establishment of silvi -agri-medicinal and agri - medicinal system. Root-shoots of *Gmelina* (silvi crop) were transplanted and seedlings of *R.serpentina* and *Withania somnifera* and rhizome of *A.calamus* at 30 cm x 30 cm and 45 cm x 45cm transplanted as an intercrop along with *Oryza sativa*. Data on survival and growth parameters showed 80% survival of *Gmelina* and only 20% of *R.serpentina* and *W.somnifera*. *A.calamus* crop is performing well.



Farmer at his farm with *Gmelina* seedlings, Chandrapur district

Empowering tribal community through lac cultivation in Madhya Pradesh

Experiment was conducted to cultivate lac as baisakhi crop after the pruning of lac host trees i.e.



Butea monosperma and *Zizyphus mauritiana* existing in farmer's field. The data were recorded and phunki removed and the lac was scrapped. Data show 30% survival of the crop despite adverse conditions. Simultaneously, broodlac of kusumi strain was also cut and inoculated on the remaining branches of *S.oleosa* as aghani crop in study site. The crop is being maintained and monitored.

Raising planting material of selected cane species and establish plantation in fringe villages of Karbi-anglong, Assam to sustain rural livelihood.

Three villages namely Jongpha village, Akhaiphutia, Lakhan Terang village, Chowkiholla and Kingdir Terang village, Dolamara were selected to have collection of planting material of cane and other important NTFPs.

Managing resources to enhance productivity of agroforestry system in dry areas of Rajasthan

Established *Hardwickia binata* and *Colophospermum mopane* trees based agroforestry trials in AFRI, Jodhpur. The four treatments for each species viz; intact tree (T₁), Tree branch removal only (70% of total tree height) (T₂), root barrier treatment (T₃) and both tree branched removal and root barrier treatment (T₄) were adopted and *Cymopsis tetragonoloba* crop grown with *H. binata*. The grain production of *C.tetragonoloba* was higher in T₄ than T₃ treatment. The crop production of *C. tetragonoloba* increased significantly in T₄ treatment as compared to other treatments. Clump number and diameter and production of *C. ciliaris* grass were significantly higher in control plot. Physico-chemical properties of soil were analyzed.

Designing and development of urban forestry model for Indian Institute of Technology (IITJ), Jodhpur, Rajasthan

This project was developed for shelterbelt –cum- urban forestry model for 5000 m long

stretch along the boundary of IIT Rajasthan campus. Six thousand plants of different species have been planted in strip plots in three tier system. Due to shallow soil depth and gravel, amendment was made by replacing with good soil, application of FYM, neem cake, bio-fertilizer and micro-water harvesting structure (saucer pits). Growth parameters have been recorded and technical report submitted to the funding agency

Development of agro-forestry models in *Wrightia tinctoria* and *Gmelina arborea* as tree species in semi-arid tropics of Andhra Pradesh.

This ongoing project aims to develop *Wrightia tinctoria* R.Br and *Gmelina arborea* based agroforestry models in semi-arid tropics of Andhra Pradesh and to study the interactions of tree and crop combination of agroforestry system based on the combination with pigeon pea and sorghum. Data of agricrop and tree crop had been collected.

Introduction of selected genotypes of 'karanj', 'kusum' and bamboo as tree components in Agroforestry models in lateritic belt of eastern India

Grafting was done for clone production of 'karanj' & 'kusum' trees and seedlings raised. Two year old seedlings of 'karanj' and 'kusum' were used for tree plantation. 60 grafts of both species were planted at Mandar. Five agricultural crops viz, ginger, turmeric, colocasis, black gram and ragi were sown, harvested and yield data recorded. Soil samples were analyzed. Shade reduction was done in bamboo plots through clump management.

2.3 Wood Science and Technology

- A project on the performance of ZiBOC treated imported wood species is under progress. Results on termite mound test revealed complete protection of treated meranti and Douglas Fir against termites.

- Evaluation of performance of treated timber in cooling tower is under progress with observation that CCA and ZiBOC performance are comparable. Also, in another project, to study the durability of *Melia composita* after treatment with CCA and ZiBOC in different agro climatic conditions through stake test for exterior/structural uses has shown that boiling treatment followed by vacuum and pressure for a specified time and capacity resulted in optimum retention of CCA and ZiBOC preservatives.
- A project funded by BTSG-NMBA is under progress to set up bamboo processing facility centre at FRI for product development. 20 trainings were organized where participants learnt the technique of bamboo sliver mats and products processing techniques for glue preparation and board making or press. Another DST funded project post harvest management for value addition of wood/bamboo for livelihood support of rural population is under progress.
- A project on chemical modification of wood with citric acid (CA) and sodium hypophosphite monohydrate (SHP) for durability improvements is under progress.
- Six projects on composite wood/ reconstituted wood are in progress in F.R.I that includes projects on 'Studies on the suitability of paper mulberry for plywood', 'Study of the effect of nano-clay on physical and mechanical properties of plywood', 'Study the suitability of combi-ply from *Melia composita* and poplar' through which different plantation species can be utilised for developing plywood and for effective utilization of timber. In project 'Studies on the suitability of different combinations of plantation grown species for laminated veneer lumber (LVL)' wood for load bearing components is being studied. In project on medium density fibre boards, lops and tops of Poplar are being used for preparing boards. Under the ongoing project 'Refinement in vacuum timber dryer designed by FRI and its performance', vacuum drying experiments were carried out on

Cedrus deodara wood to study its drying behavior under vacuum.

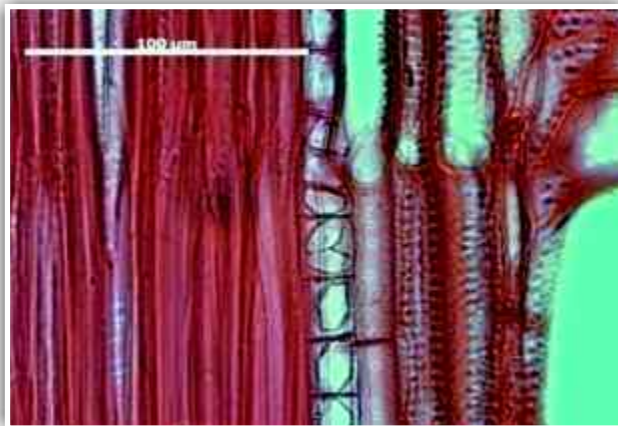
- An ultrasonic technique was developed and modified (based on eight point testing) for defect detection for trees.

Utilization potential of timber from *Melia composita* syn *Melia dubia*

Lops and tops of *Melia composita* are also being utilized to prepare particle board and medium density fibre board. Under the ongoing project 'Vacuum press drying studies on *Melia composita*', wood was dried in a vacuum press dryer. The drying was done at two temperatures, above and below boiling point of water and drying rates were found higher for the temperature above boiling point of water.



Caragana brevispina: RLS showing storied structure and spiral thickening: DDw 4461 at 40x (Papilionoideae)



Desmodium tiliaefolium RLS showing chambered crystals in parenchyma: DDw 2934 at 40x (Papilionoideae)



Wood anatomical studies of Indian shrubs

The study of microstructure of 200 species of Indian shrubs and Lianas species with species identification key developed can be utilized to distinguish the studied species for the purpose of their efficient utilization by timber and pharmacological industry. Photomicrographs of all the studied species have been added as follows for understanding the anatomical features.

Effect of treatment with micronized copper preservative on the strength, treatability and durability of selected wood species

Wood samples of *Acacia auriculaeformis* and *Melia dubia* were treated with 1-2% MCA using vacuum-pressure cycles. Copper retention, weight gain, physical and mechanical properties were evaluated. Amount of copper retention and penetration was found to increase with increasing concentration and pressure duration. Density was also found slightly increased while some mechanical properties were either comparable or reduced. Water treated and untreated rubberwood installed in test site were most affected by termite attacks while MCA treated stakes were not attacked even after three years.

Furfurylation of wood to improve properties for various applications

Maleic anhydride and citric acid were found to be optimum for higher resin yield. Uptake of furfuryl alcohol solution was less in *Melia dubia* followed by *Grevillea robusta*. However, the uptake in *Bombax ceiba* and *Maesopsis eminii* was good. Weight percent gain (WPG) in *Bombax ceiba* and *Maesopsis eminii* are significantly higher. WPG increased with increase in furfuryl alcohol concentration in the treating solution. Moisture absorption was reduced and dimensional stability significantly improved due to furfurylation of wood. Modified samples showed improved decay and termite resistance.

Natural Fibre-PVC composites for light structural applications

Fusion property of PVC was studied and its processing temperature and time optimized. Concentration of plasticizer required to process PVC-biofibres has also been optimized. Rheological studies of PVC- biofibers has been completed. The results showed an increase in fibre content increases torque. This study helped in processing thermoplastic-biofiber composites in the extruder. Also, injection moulding of PVC-biofibre composites has been completed.

Nanoparticles based wood coatings for outdoor applications

UV resistance of rubberwood coated with zinc oxide nanoparticles dispersed polyurethane (PU) exterior clear coating, was evaluated. Weathering performance of rubberwood specimens coated with nano object embedded PU was evaluated under accelerated and outdoor conditions. Results indicated potential of nanoparticle based wood coatings for providing protection from harmful UV radiation in outdoor environment.

Wood quality variability in sawn timber from three plantation grown species

Wood quality parameters and drying defects were found to be highly variable in seemingly identical sawn timber of silver oak, *Acacia auriculiformis* and eucalyptus. Eucalyptus exhibited highest dynamic modulus of elasticity. Pilodyn penetration was strongly negatively correlated with wood basic density in all. Acoustic velocity in clearwood samples exhibited strong negative association with longitudinal shrinkage. Potential utility of acoustic technique in determining the magnitude of moisture loss in sawn timber and round logs during storage and drying was suggested.

Studies on macro wood deteriogens at Kakinada port and Narsapur Greenfield port, Andhra Pradesh

Marine exposure trials at Kakinada port and Narsapur test site were continued and

observations made along with digital photographs for analysis using the software *Photogrid*. Water samples were analysed and internal destruction of wooden test panels was recorded and species of marine wood borers identified. The project concluded on 31-3-2014.

Effect of flowering on culm quality of *Dendrocalamus brandisii* and to explore its potential for making bamboo composite products

Histoanatomical studies completed. Biochemical studies and assessment of physical and mechanical properties under progress. Static bending test on samples from during and after flowering stages of bamboo being carried out.

Screening of oil of *Pongamia pinnata*, *Jatropha curcas* and *Simarouba glauca* for developing eco-friendly wood preservatives

Observations were made on the treated rubber wood specimens with pure and copper incorporated oils of *Pongamia pinnata*, *Jatropha curcas* and *Simarouba glauca* untreated control rubber wood specimens at Nallal. *Jatropha* oil treated rubber wood specimens were also exposed to fungus and borers in the laboratory and the percentage of decay was evaluated. Chemical analysis of decayed specimens was analyzed for the wood content using FTIR.

Screening of certain plant extractives for developing eco-friendly wood preservatives

The extracts from two plant species were incorporated with copper ions. Rubber wood of two different sizes, Test-yard specimens (40x5x150mm) and Fungus specimens (20mm³) were converted and treated with 5% concentration of these formulated preservatives by different methods. The treated fungus specimens along with untreated controls were exposed to two types of fungus in the laboratory and the percentage of decay was evaluated.

Evaluation of the performance of Steam Volatile Creosote (SVC) as a wood preservative

Eight species of wood specimen were treated with Steam Volatile Creosote (SVC) along with natural and synthetic dyes and evaluated the preservative activity. Pressure treatment of wooden specimen with SVC has withstood attack of insects and pathogens for almost 2 years for less perishable woods, 18 months for medium perishable woods and 12 months for highly perishable woods. In pressure treated specimens with natural dye and synthetic dye there was no infestation up to 2¼ years. Treated wood samples exhibited resistance to brown and white-rot fungi. FTIR spectroscopy showed effectiveness of SVC treated wood in restricting chemical degradation.

Determination of the treatability and durability of imported timbers as per Bureau of Indian Standards

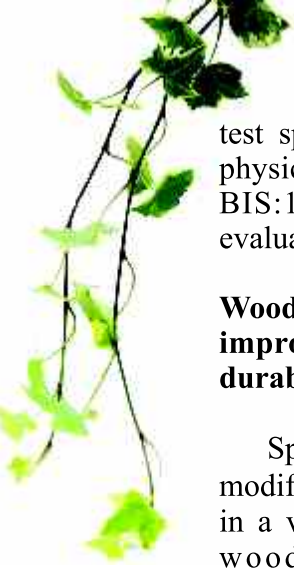
Observation at 72 months after implantation has been taken in all the testing sites, on the durability of moderately resistant timber *Quercus robur*, and highly resistant timbers viz., *Dryobalanops aromatica*, *Tectona grandis*, *Shorea laevis*, *S. marcoptera*, *S. robesta*, *Pterocarpus soyauxii* and *Xylia dolabriformis*. Natural durability experiment with imported timber species viz., *Instia palembanica* (Merbau) from Malaysia and *Dipterocarpus grandiflorus* (Gurjan) from Myanmar were initiated.

Development of Sandal (*Santalum album* Linn.) Information System

System analysis about sandal web database and feasibility study completed and model web database and its detail design completed. System coding, and testing, data validation and feeding and its implementation in server are under process.

Evaluation of wood properties of *Melia dubia* of different ages from southern India for finding suitability for various end products and development of value added products

The logs of the trees of different age groups (5-6 and 9-10 years) converted into planks and



test specimens tested for different anatomical, physical and mechanical properties as per BIS:1708. Wood working qualities were evaluated with the help of artisans.

Wood modification of *Melia composita* for improving its dimensional stability and durability

Specimens of *M. dubia* wood were thermally modified in the temperature range of 180–235 °C in a vacuum oven and evaluated. Heat treated wood was characterized using FTIR spectroscopy. Work on chemical modification of *Melia dubia* wood with acetic anhydride was initiated.

Variability of growth stresses in *Melia composita*

Growth strain measured in standing trees and logs of *Melia composita*. Measurements were carried out in plantations of 3 age groups growing in Punjab.

Durability and treatability of *Melia composita*

Melia composita specimens were air seasoned, moisture content and specific gravity were determined. The specimens were treated with oils of *Pongamia*, Neem, CNSL regular, CNSL distilled and CCB (8.5%) by non-pressure method and pressure methods. Retention of the preservatives was calculated on weight basis.

Bio-thermoplastic composites: Evaluation of physical, mechanical, morphological and thermal properties.

Experiments on blending of coir+HDPE and Rubberwood + HDPE completed.

Microwave assisted chemical modification of wood

In this DST funded project, solvent free acetylation of rubberwood carried out and effect of temperature, reaction time, and NBS concentration studied. The extent of acetylation

was measured by weight percent gain and the modified wood was characterized by FTIR-ATR method. Further work on optimization of reaction conditions and hydrophobic properties of modified wood is in progress. Microwave-assisted solvent free acetylation and butyrylation of rubberwood was carried out and investigated. Extent of modification of wood for microwave and conventional heating reactions was compared.

New methods of chemical modification of wood for improving dimensional stability and durability

Experiments on chemical modification of wood and its constituents using isopropenyl acetate (IPA) using iodine as catalyst has been carried out. The average weight percent gain increased with increasing reaction time. Samples upto weight gains of 17 % were obtained. Further work was in progress.

Development of natural fibre filled thermoplastic composites from natural resources available in the State of Punjab

Tensile and flexural strengths of *Lantana* wood fibre PP composite was far superior than pure PP and also is comparable with the strength properties of wood and bamboo filled PP composites at the same fibre loading. Impact strength of *Lantana* filled PP composites was better than wood and bamboo filled composites at the same fibre loadings. Composites could be prepared with bark intact. Moulded products from the *lantana* filled composite material have been successfully developed.

Thermal modification of wood for value addition to plantation timbers in Punjab

The colour change and surface roughness was observed in wood blocks with increasing heat treatment temperature. EMC was found to be reduced by 50-70% compared to untreated wood. Specific gravity and few mechanical properties were found to decrease slightly at 220°C. The mass loss was found to be up to 15%. Higher

treatment temperature made the wood more water resistant and dimensionally stable. MOR was found to decrease slightly with increasing temperature.

Assessment of wood quality variability in tree species prevalently grown in Punjab

In-situ assessment of morphological and wood quality traits were done in the plantations of *Melia composita*, Poplar and Eucalyptus hybrid growing in different locations and of different age groups. Variability was also assessed in morphologically superior trees selected in a 11 year old plantation of *Melia composita*. Based on the wood quality parameters, 20 trees were screened as the superior trees for wood quality and seeds from these trees were collected. The trees were identified as the potential superior trees for further propagation.

Testing and evaluation of wood quality of plantation Teak grown in Andaman and Nicobar Island

The teak wood quality at five locations in Andaman & Nicobar Islands was evaluated with the objectives of studying various anatomical, physical and mechanical properties. Based on properties studied and suitability indices, the wood quality was compared with the standard teak. Report including the recommendation on the quality of the timber based on physical and mechanical properties was submitted to the Andaman & Nicobar Forest Department.

2.4 NWFP and medicinal plants

Assessment of economic contribution of NTFPs of Chir Pine in the economy of forest dwellers in North India

The project work in the states of J&K, Himachal Pradesh, and Uttarakhand studied the economic contribution of NTFPs of chir pine, mainly resin, on economy of forest dwellers. The observation shows that resin extraction work contributes 73% -83% share in the total income of dependent forest dwellers, besides, other benefits bonafide uses. The final report of the project was submitted to MoEF in May 2014.

Process refinement for extraction of quality fibre and optimal isolation of bioactive constituents from *Agave sisalana*

Leaves juice of *Agave sisalana* was fractionated with organic solvents & solvent combinations of varying polarity at FRI. Saponin from the leaf juice was subjected to hydrolysis followed by partitioning to aglycone (sapogenin) and glycone (sugar) components.

Enzyme aided alternative process for the extraction of oil from *Cymbopogon citratus*

An innovative approach for isolation of essential oil from *Cymbopogon citratus* (lemon grass) was evolved by using enzymes and mechanical process that enhanced yield and superior quality of oil and reduced the artifacts formation.

Development of category shades of natural dyes of *Pinus roxburghii* and *Mallotus philippensis*

Various category shades from the dyes isolated from *P.roxburghii* (needles) and *Mallotus philippensis* (fruits) on silk, wool and cotton were developed. It was observed that *M. philippensis* dye could be 50% replaced with much cheaper substitute *Pinus roxburghii* needles dye.

National study on commercial production of NTFPs for ensuring fair economic returns to primary collectors

The study sponsored by MoEF, GoI aims to document various non-nationalized commercial NTFPs in selected states of India. Primary data collected in 10 states of more than 100 NTFP species doing household survey. The collectors are earning sizeable income from the sale of these NTFPs apart from self-consumption of some NTFPs. The final report has already been submitted.

Development of sustainable model for enrichment of selected Medicinal Plant Conservation Areas (MPCAs) of Uttarakhand Himalayas

Collection of seeds and enrichment field trials of Atish, Kutki and Jatamansi laid out at identified sites at Khuliya and Kandara MPCAs. Data was recorded on habitat types, frequency and density.



Picrorhiza kurrooa (Kutki)



Nardostachys grandiflora (Jatamansi)

Baseline survey/inventory of guggal and salai guggal distribution in Haryana

This study aims at preparing district-wise availability of guggal and salai guggal in forest and non forest areas of Haryana for serving as baseline documentation for future conservation and potential utilization of *Commiphora wightii* and *Boswellia serrata*. The surveys have been completed and mapping of their distribution is in progress.

Structural studies and utilisation of *Acacia tortilis* gum exudates

Polysaccharide was isolated and purified followed by complete hydrolysis. Alditol acetates

of the hydrolysed polysaccharide were prepared. The GLC analysis of alditol acetates of the hydrolysate of the native polysaccharide confirmed the presence of L-arabinose, D-galactose D-glucose, L-rhamnose, D-xylose and D-mannose in the molar ratio of 78.1%, 18.65%, 0.60%, 1.17%, 0.16% and 0.74% respectively.

Augmentation of medicinal plants resources for primary health care practices by the tribal communities in the Nilgiris and enabling their livelihood enhancement



Ezhumuram tribal village herbal garden near Gudalur, Nigiri district

Information on knowledge of 15 different medicinal plants on 14 diseases among tribals in seven villages was recorded along with the traditional practices adopted by the communities with regard to their primary health care. Data of NTFPs were also documented and marketing linkages established for marketing at the village level. Nursery and two herbal gardens with 30 medicinal plant species were established in two selected villages.

Distribution, assessment and growth of *Santalum album* L., an important medicinal plant of Karnataka

This funded project involves surveying the sandalwood growing areas in Bangalore, Kolar, Mysore and Mandya forest divisions laying 12 sample plots. Data have been collected, processed and compiled.

Standardization of pruning practices and optimum doses of organic and inorganic fertilizers to increase leaf surface area of tendu (a sub project of "Standardization of technique to enhance the quality and sustainable production of *Diospyros melanoxylon* leaves in Chhattisgarh")



Pruning experiment conducted at Kotadol

Experiments at three sites in three Forest Divisions of Chhattisgarh were conducted using different doses of foliar spray. A combination of 2% nitrogen and 1% phosphorus was found to be the best treatment in Kotadol and Morga and 2% nitrogen (no phosphorus) in Litipara. Different doses of urea, single super phosphate (chemical fertilizers), vermicompost and neem based biofertilizer showed that combined dose of 100 kg/ha nitrogen and 25 kg/ha phosphorus had the maximum enhancement in tendu leaf size in Kotadol and Morga with an individual dose of 100 kg/ha nitrogen in Litipara. Experiments on pruning practices of tendu show that maximum size of tendu leaves was found when seedlings having 2 – 4 cm diameter pruned at ground level. Surface and sub-surface soil samples were analyzed for their physico-chemical characteristics.

Standardization of sustainable harvesting practices of Mahul Patta (*Bauhinia vahlii*)

To standardize sustainable harvesting limits, leaves were harvested as per different treatments T0 (No harvest/control), T1 (40% harvest), T2 (60% harvest) and T3 (80% harvest) with 4

replications and 4 treatments and observations made. On the basis of average % increase of *B.vahlii* leaves, it was observed that T3 i.e., 80% harvesting treatment was found to be the best followed by T2, T1 and T0. 'Dona' with different type of layering materials were made to avoid plastics use.

Studies on harvesting time of some medicinal plants for their natural antioxidants constituents

To standardize method for the estimation of antioxidant activity, total phenol, flavonoids and antioxidant activity were assessed in fresh and dried samples of *Asparagus racemosus*, *A. officinalis*, *A. speciosa*, and *C. orchoides* in selected sites in Nasik, Akola, Wardha, Buldana and Amravati districts of Maharashtra.

Evaluation of *Schleichera oleosa* (Kusum) fruits for their nutritional value and development of value added products for economic development of local people

Prepared three value added products -'kusum' concentrate, 'kusum leather' and 'kusum katmith'. Nutritional values in Kusum concentrate was analysed and total carbohydrates, ascorbic acid, CFC and protein was noted. Sensory test analysis was carried out by following Hedonic scale. Further work as per action plan is under progress.



Kusum katmith

Chemo-profiling of some Dashmoola species in Madhya Pradesh

A study was initiated to quantify the active ingredients of three Dashmoola species (*Solanum*

indicum, *Solanum xanthocarpum* and *Uraria picta*) collected from different agroclimatic regions of Madhya Pradesh to locate the best areas/populations. Under the above said study, forest area was surveyed and the different plant parts of *Solanum xanthocarpum* and *Solanum indicum* were collected from eight agroclimatic regions and of *Uraria picta*, from six agroclimatic regions. It was dried, processed and preliminary phytochemical screening and quantitative analysis of total phenols carried out. Quantification through HPTLC is under progress.

Standardization of processing and storage techniques of Malkangni (*Celastrus paniculatis*), Baheda (*Terminalia belerica*) & Baividang (*Embelia tsjeriam -cottam*) fruits/seeds

Under the study, the fruits/ seeds of Malkangni, Baividang and Baheda collected from Chhindwara district of Madhya Pradesh were dried, processed and analyzed. Malkangni seeds were found to have 58% oil content. Baividang seeds will be analyzed for embelin content and baheda fruits for gallic acid content. Some samples were also stored at 4-5°C to examine the effect. Quantification of major active ingredients is under progress.

Studies on the traditional knowledge of the medicinal plants used by Nepali community in Assam and identification of important species for chemical analysis.

Survey was conducted in 12 Nepali villages in Kamrup, Morigaon, Jorhat, Golaghat, Sivasagar, Dibrugarh and Tinsukia districts of Assam for the collection of information recording commonly used medicinal plants by the villagers. It was found that women have fair knowledge on use of traditional medicine particularly those plants available in homestead gardens and in the villages. Present status and comparison with other communities on its use were also studied.

Preliminary phytochemical analysis of *Abroma augusta* L.

Samples of root, shoot and leaves collected during the survey in Guwahati, Garbanga R.F.



Wild *Abroma augusta* plant



Collection of root for analysis

Nakachari, Namti, Amguri were analyzed for various phytochemical constituents and compared with same constituents in inoculated *Abroma augusta* plant parts planted in RFRI campus.

Quantification, value addition of NTFPs and improved agricultural productivity to enhance livelihood opportunities in tribal belt of Sirohi District of Rajasthan

Village profile of 24 tribal dominated villages of Sirohi districts on NTFP collection and selling was done and key NTFPs identified in them. Identified *Butea monosperma* as a dominated species for value addition. Organized meeting of tribal farmers to acquaint them with the various uses of *Acacia senegal* and other species to be planted in agriculture land. Planted seedlings of *Acacia*

senegal, *Dalbergia sissoo*, *Bambusa bambos*, *Azadirachta indica* and grafted ber on farm bund.

Standardization of non-destructive harvesting practices of *Commiphora wightii oleogum resin*

The project aims to survey the guggul population in Rajasthan and Gujarat states and to relate the gum yield based on plants girth size. Project was initiated in February 2014 and the initial data collected from the plant population in Kailana, Jodhpur and Jawai dam area in Pali district.

Status, survey and mapping of 'ashtavarga' group of medicinal and aromatic plants (MAPs) in Himachal Pradesh

Survey was continued for the 'ashtavarga' group of medicinal plants in Sirmour, Solan, Kinnaur, Shimla and Kullu districts collecting samples of 'ashtavarga' group of plants and their associated species that were processed and herbarium sheets prepared and preserved. Household data were also collected from different villages of Sirmour and Shimla districts.

Assessment of optimum harvest limits of *Picrorhiza kurroa* and *Valeriana jatamansi* in Himachal Pradesh

The trials were conducted at three sites where five harvesting treatments viz. control, 25, 50, 75 and 100 per cent harvest of selected medicinal plants/plant parts were tried with ten replications. Population status, number of fruit/seed productions, growth, regeneration and the ability of the population to withstand the extraction was monitored and a training manual for sustainable harvest for selected medicinal plants in Hindi was distributed during trainings organised.

Identification of superior chemotypes and *ex-situ* conservation of *Podophyllum hexandrum* Royle from Himachal Pradesh and Jammu & Kashmir (Ladakh Valley)

Podophyllum hexandrum species were


collected from 30 georeferenced locations of the two states, processed and sent to the Institute of Himalayan Bio-resource and Technology (IHBT), Palampur for carrying out their analysis for further identification of superior chemo-types on this basis. Subsequently, data were statistically analyzed to identify the superior chemo-types from most probable geographical locations. Also established Field Gene Bank (FGB) at Field Research Station, Bruhandhar, Manali (HP). Trials were undertaken for devising user friendly propagation techniques and training programmes were organized for different stakeholders.

Production of quality planting material of *Aconitum heterophyllum* Wall. *ex* Royle, *Podophyllum hexendrum* Royle & *Angelica glauca* Edgew and extension of their cultivation technology to local communities

Under this ongoing project, quality planting stock of 'atish', 'ban kakri' & 'chora' was raised for distribution amongst local communities. Seeds sowing of these species was accomplished in the Field Research Stations at Shillaru and Bruhandhar, Manali during November-December 2013. Training programmes were also conducted for the farmers and forest officials of both states. A poly-tunnel under this project was established at Shillaru for raising QPM.

Network project on “Population assessment and identification of superior genetic stock of *Picrorhiza kurroa* Royle *ex* Benth and *Valeriana jatamansi* Jones by screening different populations from North-Western Himalayas (H.P. and Uttrakhand)”

Post initial groundwork, extensive survey of probable sites in Rampur, Shimla, Chamba, Dharamsala, Nahan, Kullu and Mandi forest circles of Himachal Pradesh was done. Habitat and population status was recorded and plant samples collected from the identified sites. They were dried, processed and sent to IHBT, Palampur and J.P. University Wanknaghat for carrying out a.i. analysis to screen out the superior genetic



stock. One portion of the samples was used to establish the Field Gene Bank. DNA fingerprint profiling of superior genetic stock of *P. kurroa* was also carried out.

Studies on nutrient management practices in *Flemingia* species for lac cultivation and promotion of rural livelihood

The project aimed to develop a nutrient management protocol in *Flemingia* sp. to increase lac yield. The application of nutrients showed the significant effect on *Flemingia* plant growth, lac development and pest attack. Superior plant growth of *Flemingia semialata* was found to be 130.0 cm in T5 over control (78.30cm) while in *F. macrophylla*: maximum plant height was found to be 203.0 cm in T2 over control (107.0cm). The lac production on *Flemingia semialata* was found to be 284 gm in T2 over control (57gm), While on *F. macrophylla*: the production was 280 gm in T7 over control (82gm). Lac parasitization in *Flemingia semialata* was found to be 6.0 parasite /cm in T2 over control (19.0/cm), While in *F. macrophylla* parasitization was found 5.2/cm in T2 over control (15.6/cm).

Raising of model nursery under the project of A.P. Medicinal and Aromatic Plants Board

Seedlings of *Santalum album*-25000, *Pterocarpus santalinus*, *Terminalia bellicrica*, - 40000 each, *Terminalia arjuna*-50000, *Aloe vera* – 25000, *Coleus forskohlii*- 100000 and *Asparagus* plants -16000 were raised along with other medicinal species like *Ocimum sanctum*, *Andrographis paniculata*, *Asparagus racemosus*, etc. An SSO of myrobalans (*Terminalia arjuna*) was raised in one hectare area in Mulugu.

Quality standardization of some important medicinal plants of Madhya Pradesh

Samples of *Gymnema sylvestre*, *Ocimum sanctum*, *Phyllanthus amarus* and *Tinospora cordifolia* were collected from 16 districts, processed for chemical analysis and phenol, flavonoid and antioxidant property was estimated in all the collected samples. Fingerprints were

generated using HPTLC. Harvesting and processing experiments were laid in NWFP nursery. Harvesting techniques were standardized for *O. sanctum* and *T. cordifolia*.

Development of descriptors and evaluation of artificial inoculation in *Aquilaria malaccensis* Lamk

Surveys were carried out in different agar growing areas of Assam and Manipur under NMPB funded project to evaluate the variants of *A. malaccensis* and at least three variants could be located based on foliar morphology. A trial on artificial inoculation for agarwood formation was laid out at Bongaigaon District.

Study on Indigenous Knowledge and documentation of extent of utilization of herbs in folk medicines prevalent in tribal pockets of Madhya Pradesh.

The study has been initiated in 7 agro-climatic zones in MP inhabited by Kol, Mawasi, Raj Gond, Gond, Bhilala and Pardhi ethnic communities collecting information on existing flora with names, species overexploited, plant parts used in herbal medicines, formulations prepared along with dosage, utilisation of plants in JFM and harvesting methods. 95 uses from 68 plants of local flora existing were recorded in cure of various ailments. There was high demand in trade of species. Threat status in forest of over exploited species in Chhatatrpur, Satna districts was recorded in this ongoing study.

2.5 Fungus and microbes

Interaction between *Pseudomonas fluorescens* and AM fungi on *Dendrocalamus strictus*:

Efficient P solubilizers (6 in no.) were tested for their *in-vivo* behavior by quantifying their effect on the growth of *D. strictus* using unsterilised and sterilised soils under glass house condition. Destructive sampling revealed that except in culm number, in other plant parameters, the inoculated seedlings behaved marginally better in sterilized soil. The findings indicated that

D. strictus rhizosphere supported plant growth and biocontrol populations of fluorescent pseudomonas.

Prospecting fungal resources for development of natural dye

Dyes were extracted from cultured fungi, *Fusarium sp.* and *Penicilium sp.*, and applied on various fabrics such as silk, wool and cotton. The results indicated that the dye produced from fungi have some unique shades as compared to the plant based dyes.

Bioassay of plant extractives for antibacterial activity of marine biofilm isolates

Processed leaf biomass of *Parthenium hysterophorus* was subjected to separation process in water medium. The crude extractive collected and preserved for further experimental work.

Development of certification criteria and production of microbial inoculants for application in forest nurseries and plantations



Effect of growth promoting microbes on tinsa (*Ougenia oojeinensis*) seedlings.

(From left to right: Control, *Aspergillus niger*, *Trichoderma harzianum*, AM fungi, *Azospirillum sp.*)

Inocula of AM fungi, Rhizobium and PSB were developed and used for development of certification criteria of plant growth promoting microbes (*Azospirillum*, AM fungi, PSB and *Rhizobium*). The total number of infective

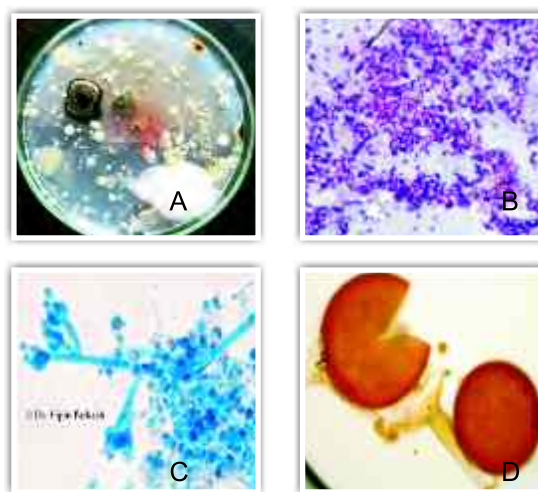
propagules of these microbes, required for proper infection/colonization of target host plant were standardized. Pot experiments were conducted on bel, beeja sal, mahua and tinsa to test the effect of biofertilizers on these species. It was concluded that application of AM fungi along with *Azospirillum sp.*, enhanced dry biomass and shoot P content of bael seedlings.

Studies on ecological and ethno mycological aspects of wild mushroom of Nagaland.

Ethnomycological survey and collection of wild edible mushrooms has been carried out from the selected areas of Mokokchung and Kohima districts of Nagaland. Twenty four nos. of mushroom species were collected, out of which, only five spp. were edible, 19 were non edible and eight species were recorded as new from Nagaland. All details of site including vegetation documented and traditional knowledge on wild mushrooms recorded.

Effect of the endomycorrhiza along with other bio-agents on biomass production, conservation and accumulation of some phytochemicals in *Abroma augusta* L.

Assessment of the endomycorrhizal biodiversity and presence of other beneficial microbes in *Abroma augusta* L. along with physico-chemical variability analyses in all the rhizospheric soil samples collected from eight natural provenances of Brahmaputra valley





Legend: A- Rhizospheric bacterial and fungal colonies in media, B- Rod shaped (Gram +ve) rhizobacteria, C- *Trichoderma harzianum*, D- *Acaulospora denticulate* X 400, E- Trap culture (mass multiplication) of AM strains with maize as host, F- Conservation of *A. augusta* seedlings inoculated with bio-agent/s.

completed. A total of 26 species of fungi belonging to 14 families were isolated. First-stage and second-stage inoculation of the target plant species with three bio-agents (viz., a bacterium, a non- mycorrhizal fungus and an AM fungus), alone or in consortia (i.e. 8 treatments; along with a non-inoculated/ control set) for biomass production has been done. The inoculation experiments showed good significant results on growth and development of this target plant species.

Studies on the diversity of soil borne entomopathogenic fungi in different land use system of North East India and their utility for the management of major defoliators of *Gmelina arborea* roxb. and *Aquilaria malaccensis* lamk.

Field tours were carried out in 11 villages in Nagaland, 4 villages in Assam and 6 villages in Meghalaya. Total 46 soil samples were collected from different locations. Five fungi were isolated from the infected insects and identified. The soil borne fungi *Fusarium oxysporum*, *Aspergillus flavus*, *Beauveria bassiana*, *Rhizopus* sp. and *Metarhizium anisopliae* were isolated from the cadavers of *G.mellonella*. Pure cultured *Fusarium oxysporum*, *Beauveria bassiana* and *Rhizopus* sp. and mass multiplied in artificial media.

Evaluation and selection of efficient strains of AM fungi and *Rhizobium* for *Acacia nilotica* and *Ailanthus excelsa* in western Rajasthan

In order to evaluate most efficient mycorrhizae to enhance survival and growth of seedlings, rhizosphere soil and root samples of *Acacia nilotica* and *Ailanthus excelsa* were collected from various forest nurseries and plantations in Rajasthan. The important five genera were identified as *Acaulospora*, *Gigaspora*, *Glomus*, *Sclerosystis* & *Scutellospora*. Among these five genera, 12 species of *Glomus* occurred most frequently. Field trials have been established to demonstrate the impact of biofertilizers (AMF + *Rhizobium* strain) on survival and growth of *A. nilotica* and *Ailanthus excelsa*. One day training was organized on application of VAM in *Acacia nilotica* and *Ailanthus excelsa*.

Evaluation of antifungal potential and identification of broad spectrum antifungal compound from selected tree/shrubs/weeds of Indian arid region

Antifungal properties of selected plant species viz; *Balanites aegyptiaca*, *Tephrosia perpurea*, *Citrulus colocynthis*, *Tribulus terrestris*, *Argemone mexicana*, *Solanum xanthocarpum* and *Datura stramonium* were evaluated. Two types of extract prepared viz; aqueous and ethanolic from every plant species were evaluated against five fungi; *Rhizoctonia solani*, *R.bataticola*, *Fusarium moniliforme*, *Fusarium solani* & *Alternaria alternata*. Antifungal activity of extract was determined by poison food technique. Ethanolic extract of *Datura stramonium* leaves has been identified with most potent broad spectrum antifungal activity among all the tested extracts.

Induction of systemic acquired resistance in Rohida (*Tecomella undulata* (Sm.) Seem.) against stem canker

In order to find out casual organism and development of aquired resistance on Rohida (*Tecomella undulata*) six fungi were isolated from infected cankered stem. The pathogenecity studies were conducted on one and half year old rohida seedlings. Once the pathogen was established and disease symptoms were developed, 10mM Salicylic acid, 10mM

Jasmonic acid and *Trichoderma viride* were sprayed on these seedlings to study the induction of defense enzymes. The level of total protein and sugar was high in control (healthy plants), whereas, phenolics and Phenylalanine lyase were high in diseased plants at 30, 60, 90, 150, 220, 330 days.

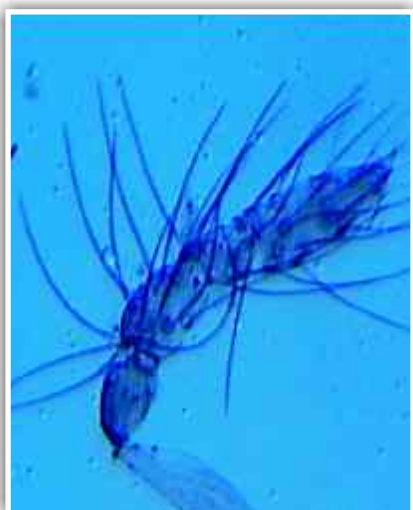
Occurrence and diversity of the entomopathogenic fungus, *Metarhizium* in the soils of varied ecoclimatic forest habitats of South India

In this DBT funded project collection of soil sample from selected area, its culturing, isolation of desired fungus, *Metarhizium* and analysis of physical parameters of soil with the assistance of NBSS and LUP Bangalore is done. Identification of the fungus on the basis of morphological characteristics has been initiated.

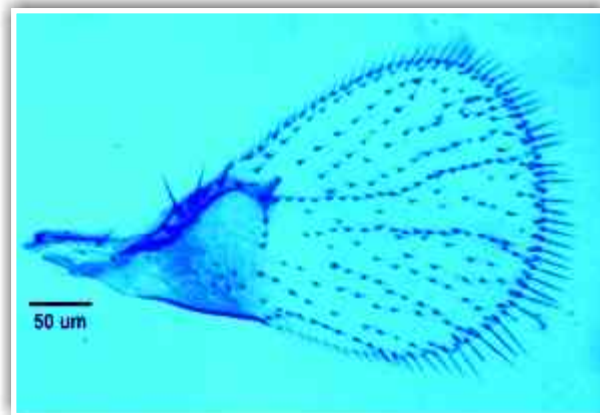
2.6 Insect pests and their control

Studies on diversity of egg parasitoid wasps *Trichogramma* spp. from Punjab and Haryana and their application in biological control of important forest insect pests

150 specimens of *Trichogramma* were recovered from five agro climatic zones of Punjab out of which eleven were identified up-to species level and their morphological and



Trichogramma chiloetraeae (♂): antenna



Trichogramma chiloetraeae (♂): fore wing



Trichogramma chiloetraeae (♂): genitalia

taxonomic characters studied. *Corcyra cephalonica* culture was developed and maintained for utilizing its eggs for multiplication and maintenance of *Trichogramma* culture. Two cultures of indigenous species of *Trichogramma* spp. (*T. chilonis*, *T. japonicum*) have been taken from the fields of Punjab, identified and are being maintained.

Biology of hispine bamboo borer- *Estigmene chinensis* Hope. (Coleoptera: Chrysomelidae) damaging green standing bamboo and its management

Collection of bamboo specimens damaged by *E. chinensis* was done in Timli, Jhajra, Thanu, Choharpur Forest Range areas to find out periods



1 *E. chinensis*; 2&3
Feeding pattern of adult and larvae

of mature and immature stages and feeding pattern of adults and larvae. Young beetles eat the tissue of bamboo walls. Seven bamboo species viz- *Dendrocalamus longispathus*, *D. giganteus*, *D. asper*, *D. calostachyus*, *Bambusa wamin*, *B. tulda* and *B. multiplex* were found to be attacked for the first time by *E. chinensis*.

Biological control of Eucalyptus Gall wasp, *Leptocybe invasa* in Punjab

Eucalyptus gall wasp, *Leptocybe invasa* (Hymenoptera: Eulophidae), an exotic insect of Australian origin, devastates young eucalyptus plantations. Biological control work using *Megastigmus viggianii* (Hymenoptera: Torymidae) to manage the pest population was started for which it was reared in the insectary on *L. invasa* galls and was released in gall infested eucalyptus plantations in Hoshiarpur district.

Screening of Eucalyptus germplasm for disease resistance against *Cylindrocladium* leaf and seedling blight

The eucalyptus germplasm was screened for disease resistance against *Cylindrocladium quinqueseptatum*. Leaf and Twig Blight (L&TB) disease resistance was recorded on different germplasm inoculated with different pathogen isolates and their resistance / susceptibility was tested. The DNA fingerprinting of Eucalyptus germplasm was done using RAPD primers and polymorphism recorded.

Development of molecular diagnostic kits for identification and early detection of nursery and plantation pathogens of Eucalyptus

For the amplification of nrDNA, different isolates of pathogen *Pestalotiopsis* sp were isolated from diseased samples, pure cultured and multiplied. nrDNA amplification of different isolates of three more pathogenic fungal isolates were successfully done. After sequencing and primer designing, it will be extremely helpful in quickly authenticating the collected isolates.

Shisham mortality – Finding solutions for future plantations

Eight clones of *D. sissoo* have been performing well in the sick plot suggesting possibility of disease resistant clones against *F. solani* wilt disease. The new stem canker disease caused by *Lasiodiplodia theobromae* was found increasing at Malekan, Sirsa (Haryana) and Mansa (Punjab) from 13% to 18% up to last six months.

Anti-insect secondary metabolites from fungal endophytes of selected tree species

Fungal endophytes such as *Botryto* sps., *Phoma* sps; *Aspergillus flavus* and *Nigrospora sphaerica* species were extracted from age correlated young and mature leaves of teak and *Ailanthus* and spore suspensions made and evaluated for bioefficacy against the defoliators of teak and *Ailanthus*.

Biopesticide against papaya mealybug

The prospecting bioactive compounds from certain flora viz., *Vitex negundo*, *Aristolochia brachteata*, *Pongamia pinnata*, *Adathoda vasica* and *Melia dubia* could be seen to manage to contain the population and damage to papaya by papaya mealy bug in different districts of Tamil Nadu. Based on the promissory results obtained in the laboratory, the field bioassay studies were conducted at various concentrations to confirm the bioefficacy and to finalize the dose for the management of *P.marginatus*.

Contributory factor in the establishment of *Leptocybe invasa*

Survey was conducted in TAF CORN and TNPL Eucalyptus growing areas of the thirty eight clones and clones such as C10, C3, C7, C271, T61, C283, and KK5 were found infested with gall insect, *L. invasa*. Species in high altitude zone are free from gall insect. Survey on gall infestation in eucalyptus seedlings and IFGTB clones were made at IFGTB Central Nursery and Bharathiar University and observed no gall infestation. Locally produced seedlings were found to be more susceptible to gall insect

incidence. During the survey, it was found that the density of eucalyptus gall was high during April-June.

Biological control of weeds


Study on the biology of newly prioritized Green colour leaf webber *Phycita* sp. B on cut foliage and live plants of prickly *Acacia* revealed that the total life span of the species was 30-38 days during the months of July to October. The species was observed to inflict considerable damage on the foliage of seedlings and saplings of *Vachellia (Acacia) nilotica* sp. *indica*. Host specificity study for four prioritized insect species was done on 9 more Australian *Acacia* species. Further, the host specificity tests by choice method was carried out for the prioritized species.

Influence of Eucalyptus species on the natural enemies incidence on the gall wasp *Leptocybe invasa*.

Parasites did not show variation in growth on different clones but preference in stage of galls for oviposition. Through electrophysiological studies, and analytical studies it was proved that both *L. invasa* and *Q. mendeli* use the same volatiles for the identification of host plants. Identified a mixture of compounds as attractants for *L. invasa*. The dispenser along with the delta trap gave satisfactory results in multilocational trials in Karnataka and Tamil Nadu. The product and the process is being patented. Several important compounds were identified from *Croymbia citriodora* which can act as very good repellent for *L. invasa*.

Assessment of disease problems of selected fast growing indigenous tree species in Tamil Nadu

Pathological problems were enumerated in SFD nurseries in 20 different districts in Tamil Nadu and recorded foliar, stem and root diseases on important tree species caused by both fungi and bacteria. The study also highlighted that the level of secondary metabolites was high in uninfested leaf samples, as compared to seedlings affected by diseases in most of the nurseries. Hence, more in-depth studies are needed. Details



about method of preparation of fungicide solutions and its application were also provided for effective management of different disease problems in nurseries and young plantations.

Screening and evaluation of selected members for Rutaceae from Southern India for anti-malarial activity

The extracts of plants are evaluated and mosquito repellent property assessment completed at NIMR. LC 50 values have shown that some extracts of *Toddalia asiatica*, *Ruta graveolens* and *Zanthoxylum rhetsa* can be potential larvicides and mosquito repellents.

Development of botanical pesticidal formulations and demonstration of application in forest nurseries and plantations

Extensive work was carried out and a formulation by name “PESTILL” was developed using the weed *Lobelia nicotianefolia* which was applied in field condition in some of the selected KFD nurseries in Sirsi and Mysore against some forest pests of teak plantation, where we recorded up to 50% mortality at 5% concentration of the formulation. In all the experiments, neem was used as control for comparison along with the additives as control. Results showed the weed, *Lobelia nicotianefolia*, which is developed into a liquid formulation, could be recommended as insect pesticide along side neem products.

Population dynamics of pests and suitable control measures in selected silvi-horticultural models in Karnataka

Management of sap-suckers in sandal using Imidacloprid was effective in controlling the population followed by Chlorpyrifos and Metasystox. The use of plant product Nimbecidine indicated increase in nymphal population and recorded negative percent reduction (-26.59). The host plants of sandal viz. *Mangifera indica* and *Pongamia pinnata* shared many insect pests of sandal and considered not an ideal host of sandal. Three new stem borers, 1

seed borer, 5 defoliators, 2 pollen feeders, 9 parasites on coccids were all new records on sandal and the check list on sandal was updated. The important disease associated with sandal was the root rot of sandal saplings.

Microbial biosynthesis of polyhydroxy alkanooates (PHA) from wood waste

The main objective of the project was to obtain a bacterial strain which could synthesize polyhydroxy alkanooates (PHA). *Pseudomonas lignicola* was the only strain which was able to synthesize PHA, when compared to other bacterial strains.

Development of coccinellids based biocontrol programmes for the management of sandal scales and mealy bugs

Among the 20 species of coccinellids found breeding on scales and mealy bugs infesting sandalwood plantations, *Cryptolaemus montrouzieri* Mls and *Chilocorus nigrita* (Fabr.) were found more prevalent. Release of *C. montrouzieri* against *Nippaecoccus viridis* and *C. nigrita* against *Ceroplastes actiniformis* were found very effective.

Studies on hard substratum fauna in five major ports on the East Coast of India

Under this ongoing project, marine exposure trials at four major ports, i.e., Chennai, Tuticorin, Kolkata and Haldia were continued and observations were made on percent cover of fouling on the test panel surface, species recruited, sizes attained and biomass built up. Collected water samples were processed for analysis of hydrographical parameters; digital photographs of panels obtained and analyzed using *Photogrid* software. Species of wood borers were identified.

Bionomics and management of *Purpuricenus sanguinolentus* Oliver (Cerambycidae: Coleoptera) the stem borer of Sandal (*Santalum album* L.) in Karnataka (2012-2015)
Funding Agency: DST

Roving survey conducted in nine districts of Karnataka covering naturally growing and plantations of sandalwood revealed moderate level of infestation by *P. sanguinolentus* only in Jarackbandae in Bangalore while other wood borers viz., *Aristobia octofasciculata* and *Zeuzera coffeae* were found more prevalent on sandalwood in Mysore, Sagar, Shimoga, Hassan, Raichur, Gulburga and Tumkur districts. So far, four different types of hymenopteran parasitoids were collected and they were sent to experts for identification.

Biological control of insect pests of medicinal plants-*Abelmoschus moschatus*, *Gloriosa superba* and *Withania somnifera*



Larvae of *Anomis flava* feeding on leaves of *Abelmoschus moschatus*

Five insect pests on *A. moschatus*, four on *G. superba* and two on *W. somnifera* were identified from different localities in Madhya Pradesh, Chhattisgarh and Maharashtra. Seasonal history of key insect pests and sampling of natural enemies was also done. Two parasites *Ichneumon spp* and *Stermia sp.* were recorded on *P. gloriosae*. Experiments revealed that *B. thuringensis* 1% and combination of Bt + neem based Gronim 1% were most effective against *P. gloriosae* and *A. flava*. In another experiment predator *C. cornea* was found to be most effective for reduction of the larval population. **Also**, neem based Gronim 1% followed by Bt 1% was found most effective against *D. cingulatus*. One day training programme on “Insect pests of important medicinal plants and their biological control

measures” was organized at CFRHRD on 19 December 2013 for SFD officials and farmers.

Standardization of management practices for tendu leaf gall forming insect and diseases (a sub project of 'Standardization of technique to enhance the quality and sustainable production of *Diospyros melanoxylon* leaves in Chhattisgarh')

Status of gall forming insect, *Trioza obsoleta* and foliar/leaf spot disease, *Pseudocercospora helleri* and *Pestolotiopsis versicolor* on, *Diospyros melanoxylon* (tendu) was monitored in nine different sites in Chhattisgarh. About 50-60% incidence of *T. obsoleta* was recorded. *P. versicolor* was major pathogen causing leaf blight in tendu. Field experiment to study the effect of different pruning periods against *T. obsoleta* / foliar diseases revealed that first pruning including control fire in first week of March (06.03.2013) was found to be most effective in less incidence of *T. obsoleta* and also increase the weight and leaf area.

Status of sal heartwood borer, *Hoplocerambyx spinicornis* Newman and its management

In the study to monitor sal borer incidences in Dindori Forest Division, North Balaghat Forest Division, and East Mandla Forest Division in MP,



39554 sal trees were marked under different categories of borer attack. Recorded ant as a predator found feeding on grubs of borer inside the sal tree. Carried out 'Trap Tree Operation' for management of sal borer beetles in Dindori Forest



Infestation of Sal heart wood borer. A- Sal borer affected tree of T₃ category, B-Sal borer grub in heart wood of tree, C-Sal borer grub.

Division. Examined borer incidences and facilitated subsequent management of sal borer. Distributed leaflet on sal heartwood borer to front line staff and organised training.

Eco-friendly management of bark eating caterpillar, *Indarbela quadrinotata* on aonla (*Emblia officinalis*) in plantations

Study was conducted in TFRI, campus Jabalpur, Balaghat, Chhindwara, Research Extension circles on bark eating caterpillar, *Indarbela quadrinotata* in aonla plantations. Three entomopathogenic fungi were isolated and identified. Thirteen varieties were screened against *I. quadrinotata*. Observations and field experiments showed that crude extract of *C. collinus* + cow urine + vermiwash was most effective against *I. quadrinotata* in first trial. Solvent extract of *C. collinus* in petroleum ether was found most effective in second trial and application of fungal suspension of *Fusarium moniliformae* 1.5×10^{-6} was most effective against this pest in third trial.

Development of rearing technique for production of insect predator, *Canthecona furcellata*, as biocontrol agent for larval defoliators

Eggs, nymph and adult of *C. furcellata* was collected from nurseries and natural forests of teak, shisham, khamer, anjan and bamboo at various locations in M.P. Also surveyed teak SPA compartment no. 421 Range Rukhar and Dudhiya nursery, SFD nursery at various locations in Maharashtra, visited Entomology Division, Punjab Rao Deshukh Agriculture University, Nagpur and TFRI nurseries and plantations. Observations recorded on predation behavior and life cycle of *C. furcellata* on larvae of *E. machaeralis* and *Caveria sericia* at different temperatures regimes (20 ± 1 , 27 ± 1 and 35 ± 1 °C) in the laboratory.

Studies on insect biocontrol agent, *Chrysoperla carnea* and its potentiality as insect predator

Periodical surveys were carried out in teak, sal and bamboo forests of Madhya Pradesh, Chhattisgarh and Maharashtra for collection of predator, *Chrysoperla carnea* and its habit and habitat were recorded, specimens identified and preserved in insect reference collection of Forest

Entomology Division, TFRI, Jabalpur and ZSI, Jabalpur. The rearing of this predator carried out on the respective host insects in the laboratory. An investigation on predation potential along with the detailed life cycle of the predator has been initiated. Further work is in progress.

Studies on the effect of introduction of honey bee on seed production of teak seed orchards

Selection of Teak Seed Orchards (TSOs) has been initiated for artificial establishment and further monitoring the bee hives, established artificially in these sites.

Biocontrol potential of native isolates of entomopathogenic nematodes, for management of insect pests of teak.

Maintained laboratory culture of EPN host waxmoth, *Galleria mellonella* and native EPN isolates from central India and *H. indica*, *S. carpocapsae* (NABII populations). Determined and compared biocontrol potential of six native Steinernematid and Heterorhabditid EPN isolates against teak defoliator and skeletonizer. Results indicated that EPN 50, 56 and 57 were infective at above 10 IJs/ Larvae dose in laboratory. Field experiments carried out with individual and combination of EPNs with insecticides proved that EPNs were tolerant to insecticides and can be combined with desired concentration of insecticides for spraying in field on seedlings.

Evaluation of non edible oil seeds for development of surfactants and their utilization in pest management

Seed biochemicals from *Pongamia pinnata*, *Schleiochera oleosa*, *Jatropha curcas* and *Sapindus mukrossi* were isolated and modified. Amide formation was standardized at different temperature and free amine content was estimated. The properties of surfactants at different dilution, the phytotoxicity, and pesticidal activities of product formulations were assessed against forest insect pest of *Tectona grandis* and *Albizia* spp. i.e. *Eutectona*

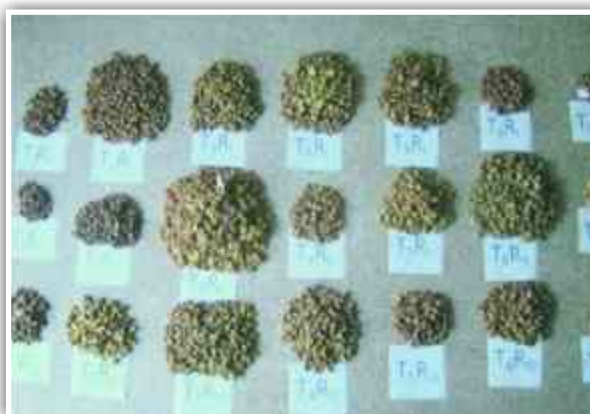
machealaris and *Spirama retorta*, *Heliothis armigera* and fungicidal activities against wood decaying fungi.

Potential pathogens and insects responsible for the low seed production in teak seed orchards and their management

Spermoplane micro flora of Teak seeds was recorded in the inflorescence, immature and mature stages of fruits, wherein, it was seen that *Fusarium* sp. systemic infection during seed setting and seed boring insects like *Pagyda salvalis*, *Dichocrosis punctiferalis* and *D. pendamalis*, caused less fruiting in TSO's and SPA's. One field experiment, using biopesticides, insecticides, fungicide, trace elements and growth hormone applied in 16 years old TSO in Nandigram Seoni, M.P. showed that application of Monocrotophos (0.05%) + Bavistin (0.02%) in



Spraying in teak seed orchard for enhanced seed production at Nandigram, Seoni, MP



Comparative seed yield in different treatments

the month of July and 2nd dose during 1st week of August could enhance fruit productivity in TSO's.

Biological control of teak leaf skeletonizer *Eutectona machaeralis*

Studies in Choral Range of Indore Forest Division, where large scale epidemic defoliation of leaf skeletonizer in teak forests was observed, showed that release of biocontrol agent, *T. raoi*, @ 1.25 lakh ha⁻¹, effectively reduced the larval, pupal and adult population of teak leaf skeletonizer in TFRI Tricho cards released sites of teak forests, demonstrating the potentiality of egg parasitoid, *Trichogramma raoi*, as biocontrol agent for management of teak pest.

Studies on the incidence and management of Pine mortality in Manipur

An experiment laid out in the most affected area i.e., at Ukhrul, Manipur to study mortality of Khasi pine using three fungicides and two biocontrol agents i.e., *Trichoderma viridi* and *T. harzianum* revealed that Carbendazim (Trade name-Zoom) was most effective fungicide in checking further spread of the disease

Studies on the economically important diseases of medicinal and aromatic plants of Assam to develop management practices through organic approach

Plant pathogens causing leaf spots, leaf blight, anthracnose, damping off and tip blight in



A new leaf necrotic disease of *C. orchoides*

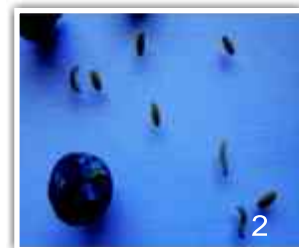
medicinal plants at Rani Nursery, RFRI and North Eastern Development Finance Corporation Ltd (NEDFi) in Guwahati and nearby areas were isolated, identified and pure cultures were maintained. Isolated *Trichoderma* sp. was found effective against *Curvularia andropogonis* in dual culture and field testing. A new leaf necrotic disease of *Curculigo orchoides* was observed.

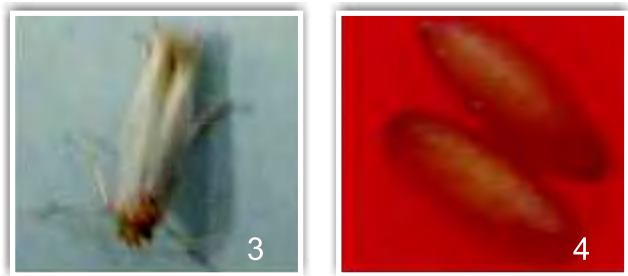
Studies on seed insect pests of indigenous and exotic forest tree species and to develop IPM package for major insect damages in Gujarat

Studies on fluctuation in seasonal population of important seed pests were carried out. For the IPM studies, two experiments have been laid down at Basan Research Centre, Gandhinagar of Gujarat Forest Department to test the efficacy of various containers for seed storage on seeds of *Acacia nilotica*, *Prosopis cineraria* and *Ailanthus excelsa* showing least infestation in tin containers. Another experiment was conducted to test the efficacy of various botanicals against the insect pests of stored seeds. Out of these, three botanicals were found effective viz.; Rockon, Weapon and Ryder.

Biology and Management of Insect pests of seeds of *Juniperus polycarpos* C. Koch and evaluating the insectpests resistance performance in nursery

Trials were initiated with neem based pesticides, safer chemicals to analyze the control of insect pests during storage in berries of Juniper collected from Lahaul and Kinnar, Himachal Pradesh. Extracted larvae were kept separately for detailed observations. Nursery trials of the healthy, infected and treated seed were taken up to study the impact of insect- pests in developing nursery stock.





1.&2. Larvae & Pupae of infected berries
3. Adult emergence 4. Pupae

Biological Control of *Thysanoplusia orichalcea* (F.) (Lepidoptera: Noctuidae): A potential insect-pest of *Saussurea costus* in northwestern Himalayas and extension of protection technology to local communities

Surveys in this ongoing project were conducted in Chenab and Lahaul Valleys for identification of the sites and collection of base line information of *Saussurea costus* (Kuth). Nursery established and trials laid in 10 beds of the size 10 m² each at Bruhandhar, Manali to raise the planting stock of the species for subsequent experimentation. Efforts were made to record the incidences of *T. orichalcea* on other alternative host around Shimla and in the nursery conditions as well.

Survey and identification of insect pest associated with *Dalbergia sissoo*, *Gmelina arborea* and *Shorea robusta* of eastern states of India

Collection of insect pest stages and plant samples of *D.sissoo*, *G.arborea* and *S.robusta*, their observations were done. The identification of the insects is completed.

Treerich Biobooster: A novel approach to synergise growth and pest management

About twelve treatments of bioinoculants along with coir pith and vermiculite as base material were prepared to study the effect of mixture along with biomanure on growth of casuarina and eucalyptus. FYM, effluent

compost, vermicompost, and green manure along with vermiculite and coir pith as base material were prepared for making pellet, Treerich Biobooster. The growth performance was found to be significant from 30 to 60 days after treatment which reduced the use of chemical fertilizers. The combined effect of bioinoculants with organic biocompost significantly increased the germination percentage, survivability and biomass yield. Hence, the organic biocompost product, *Growth Promoting Treerich Biobooster* may be considered as a potential potting media as an alternative to conventional potting mix for production of healthy quality planting stock of Casuarinas.

2.7 Pulp and Paper

Evaluation of *Sesbania grandiflora* and *Lannea coromandelica* for paper making

Bleaching of craft pulp of *Lannea coromandelica* with targeted kappa number 25.00 was done using conventional CEHH and eco friendly DEpD sequences. The effluent analysis of each stage of bleaching was carried out and results indicated that eco friendly bleaching sequence DEpD produces less pollution load. In experiments, it was seen that eco friendly DEpD bleaching sequence resulted in paper with much better physical strength properties. The blending of bleached chemical pulp of bamboo (5-15%) with bleached pulps both by CEHH and DEpD bleaching sequence further improved the physical strength properties. The project was completed with the recommendation that *Sesbania grandiflora* was suitable for making strong craft paper and *Lannea coromandelica* is suitable for making bleached grade writing and printing paper.

Chemical derivatization of α -Cellulose into value added products

New route has been developed for synthesis of value added product of cellulose. The standardization of etherification/ esterification / protection/ and deprotection protocol of alkali or pre-dissolved cellulose or cellulose derivatives

were carried out with respect to temperature, concentration, reaction (pH) and nature of alkalinizing agents.

Evaluation on phyto-polymers as eco-friendly bioadhesives

Starch and crude protein were isolated from *S. robusta*, *J. curcus*, *M. indica*, *C. aungustifolia* and *P. acularis* for the preparation of bioadhesives by alkali and acid hydrolysis at different concentration and its effect on adhesive properties were evaluated. Water holding capacity of *M. indica* and *A.companulatus* was determined. Adhesiveness, drying time and effect of storage was assessed on different adhesives. The pH and viscosity of protein adhesives were increased after storage. Similarly, effect of quantity of different additives were also assessed.

2.8 Bio oils and Biodiesel

Study on the effect of microwave assisted heating and seed storage conditions on quality of *Pongamia pinnata* (L.) seed oil for cost effective production of biodiesel

Cleaned seeds were irradiated to microwave for different time and stored at different storage temperatures. The oil from the seeds (treated and untreated) was extracted to estimate the initial physical and chemical properties of the treated and control oil sample. Periodic assessment of viability of stored seeds by germination was carried out along with biodiesel production from different acid value oil and assessment of yield and quality of biodiesel.

Production of synthetic biodiesel from wood wastes

Physical properties of biomass wastes collected from AWTC were measured, calorific value determined and proximate analysis done. TGA analysis was done for bamboo and wood wastes. Saw dust pellets were used to produce the producer gas and it was cleaned and tested in GC. Tar cracker was used to increase the production of CO gas production. Required producer gas for FT reaction was filled in the 500 litre cylinder at 30

bars. Yield of reactant was not in appreciable level due to more concentration of CO₂ and other pollutants.

Refining of process for detoxification studies of *Jatropha* seed oil

The oil extracted from the seeds of *Jatropha curcus* was fractionated using different techniques for the removal of phorbol. Laboratory analysis by TLC showed that the phorbol can be removed using a simple method.

Evaluation of *Santalum album* grown in plateau area of Uttar Pradesh adjoining Madhya Pradesh and Uttarakhand for yield, quality and composition of essential oil

For the first time *S. album* trees were infected by fungi for better yield of oil and also for improvement in oil quality. Samples of heart wood of sandal wood which were infected by fungi were extracted using organic solvents.

Field evaluation of superior accessions of *Jatropha curcas* under micro-mission programme in Himachal Pradesh

Evaluations of superior accessions of *Jatropha curcas* were undertaken in Bilaspur and Kangra district of Himachal Pradesh wherein, the plantation established at Jawalaji, in Kangra district, showed comparatively better results for its growth and seeds parameter. Various fruit and seed parameters were measured, analysed and compiled.

Building upon the above observations,



Half-sib *Jatropha* plantation at Shri Jawalaji



Fruiting in half-sib trial of *Jatropha*

maintained the trials at Jawalaji, distt. Kangra recording growth, survival, fruiting and flowering data. Various parameters pertaining to physico-chemical characteristic of soil analyzed and a

detailed technical report prepared.

Establishment of multilocal trials of 100 superior accessions of *Jatropha curcas* under the network programme of DBT

A multilocal trial, comprising of 100 superior accessions of *Jatropha curcas* was established in July-August 2010 at GRC, Jabalpur. The trial in experimental field of 400 equal sized plots and 9 plants per plot at 3m x 3m was performing well with more than 78% survival. Regular observations on various growth attributes were recorded and data sent to Biotech Park, Lucknow for compilation.