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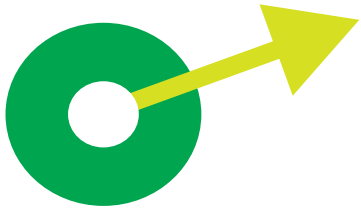


MANAGING FORESTS AND FOREST PRODUCTS FOR LIVELIHOOD SUPPORT AND ECONOMIC GROWTH

Managing Forests and Forest Products for Livelihood Support and Economic Growth

In view of the importance of forestry in livelihood support and economic growth of the people of the country, an ambitious programme has been envisaged with emphasis on areas including Agroforestry, Chemistry of Forest Products for Value Addition, Utilization of Forest Invasive Species, Wood Science and Technology, Wild Fruits, sustainable Management of Fringe Forests, microbes in service of mankind, Tree Resource Management for livelihood and economic growth with particular reference to species, including Bamboo, Rattans, *Buchanania lanzan, Madhuca latifolia, Juniperus, Hippophae, Melia composita* besides other target specific programmes. Also programmes were developed on tussar, lac and honey by the concerned institutes. Important outcomes of various components of the programmes are presented below.

2.1 Silviculture and Forest Management

Baseline Survey/Inventory of Guggal and Salai Guggal distribution in Haryana

This study aims at preparing districtwise 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*. Two districts namely Gurgaon and Mahendragarh have been surveyed so far. The study also involves documenting phyto associates of the species. Surveys in other districts is continuing.

Survey of Guggal

Natural population of Salai Guggal

Preparation of the management plan of Asola Bhatti Wildlife Sanctuary, New Delhi

Identification of flora and fauna of the PA carried out and vegetation survey for different sites including abandoned pits of Bhatti mines area conducted for biodiversity assessment. Sample plots have been laid for the assessment of tree species and estimation of tree population in both Bhatti and Asola areas. Mapping of PA boundaries, Forest roads, terrain etc has been done by using LISS-IV, Cartosat-I and Google Earth satellite data in association with IIRS. Forest cover and density class maps and Land use maps for the PA prepared. Estimation of faunal elements is aimed at by both Direct sighting and Indirect evidences. Line

Transect method adopted for both types of estimations.

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

Required data for the states of Punjab, Haryana, Chandigarh, Delhi, Uttarakhand and Uttar Pradesh have been collected through field visits. Data on demand, supply and market intelligence of bamboo have also been collected.

Revision of National Working Plan Code

With the objectives of incorporating Criteria & Indicators for Sustainable Forest Management, usage of modern technologies like GIS, GPS, etc., addressing new concepts like climate change, carbon sequestration, etc., inclusion of focused management of NWFPs in view of their high economic and livelihood importance in National Working Plan Code, this project was assigned to FRI by MoEF. FRI has initially conducted a consultative workshop cum- meeting at Dehradun, followed by three regional workshops at Kolkatta, Benguluru and Dehradun, inviting opinions and comments from various quarters of forest fraternity. The suggestions and comments received were communicated to all states. The comments received therein are likely to be discussed and deliberated at the national level in MoEF, New Delhi, for finalizing the national working plan code.

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

System Analysis for sandal web database has been completed. Collected inputs on various aspects from Sandal subject experts of the Institute for designing the database. Model web database created. Collection of information on sandal from various Forest Departments/Depots and Plantation areas has been completed. Sandal data have been collected from Andhra Pradesh, Chhattisgarh and Kerala and to be collected from the States of Tamil Nadu, Karnataka, Madhya Pradesh, Rajasthan and Gujarat. Data collection is under the progress through Internet from forest depots, university, journals and libraries.

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 Yellapur, Haliyal, Koppa, Madikere and Virazpet Forest Divisions and growth data recorded in all the sample plots. Data collected have been compiled and analyzed.

Lead Institution for Achanakmar-Amarkantak Biosphere Reserve, Chhattisgarh

Surveyed and collected a total of 558 insect samples which included butterflies, moths, beetles, bugs, grasshoppers, dragon and damsel flies. Identified 82 species of butterflies and moths, out of which 67 species were new addition to insect faunal composition of Achanakmar-Amarkantak biosphere reserve. Maintained periodical interface with Bioshpere Researve manager and assessed the research needs, such as tree mortality in Biosphere Reserve and other activity like monitoring and evaluation of developmental activities of MAP, 2011-12. Created web based information centre for Achanakmar-Amarkantak biosphere reserve and linked to the website of TFRI. Submitted project proposal for designation of Achanakmar-Amarkanatk Biosphere Reserve on World Network of BRs recognized by UNESCO. The International Council of UNESCO's Man and the Biosphere Programme (MAB) meeting in Paris from 9-13 July 2012 declared Achanakmar-Amarkantak Biosphere Reserve under the World Network of Biosphere Reserves (WNBR). Organized workshops/

trainings on Achanamar-Amarkantak Biosphere Reserve and training materials provided to the frontline staff of biosphere reserve. Published Biosphere Reserve Information Series BRIS 2(1 2): 158 pp. and 3 (1-2): 93 pp. and prepared Biosphere Reserve Information Series BRIS 4(1-2): 50 pp., for publication.

Standardization of pruning practices and optimum doses of organic and inorganic fertilizers to increase leaf surface area of tendu

- Experiments on foliar spray of chemical fertilizers were conducted in Morga to observe the effect of different doses of fertilizers, either individually or in combination, on increment in size of tendu leaves using RBD factorial design.

Conducting Experiment on Application of Chemical Fertilizer on tendu leaves: (A) Foliar Spray and (B) Collecting Tendu Leaves from Experimental Site at Morga

- Experiments on chemical and biofertilizers viz. urea, single super phosphate, vermicompost and neem based biofertilizer on enhancement of quality and sustainable production of tendu leaves were conducted at Morga, Kotadol and Litipara using RBD factorial design.
- Experiments on pruning practices of tendu with treatments including time interval of pruning, height of pruning and girth classes were conducted at Morga, Kotadol and Litipara using RBD Factorial design.

Studies on the effect of different level of seed collection on natural regeneration of Sal (Shorea robusta) in Chhattisgarh

Three sites, Bastar, Raipur, Bilaspur and two sites at Koria Forest Division and Marwahi Forest Division were selected and laid out sample plots to study the effect of different level of seed collection, fire and grazing in pure, mixed and degraded sal forests. Experiments were also laid out in pure, mixed and degraded sal forest of the three sites.

Population dynamics of selected threatened medicinal plant species and conservation management through community participation in buffer and transition zone of Achanakmar-Amarkantak Biosphere Reserve, Madhya Pradesh

- A pilot survey of the East Karanjiya range, comprising 105 compartments and Amarkantak range with 47 compartments was undertaken to locate populations of the target species *viz. Celastrus paniculatus, Embelia tsjeriam-cottam, Peucedanum nagpurens, Rubia cordifolia* and *Thalictrum foliolosum*.
- The permanent plots for monitoring population dynamics were laid and marked with target plants. Nine species of medicinal plants *viz.* pudina, kali tulsi, bach, lemon grass, gwarpatha,

adusa, giloe, aonla, harra and bel of direct use to villagers, were distributed to encourage herbal homestead garden and promote use of herbals among them. Socio-economic profile of participants was assessed through a questionnaire. It was observed that 90% of participants had not harvested medicinal herbs and other NTFP's, commercially other than sal leaves, aonla, harra and mahul whenever available in last 2-5 years, mainly because of unavailability of the produce.

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

Different girth/age group populations of *Bauhinia vahlii* (Mahul) were selected to lay out experiments for standardization of sustainable harvesting practices. Different methods of drying (room temperature, oven and sun drying) were experimented. Sun drying was found to be the best method for drying of leaves followed by oven drying. The quality of leaves collected from study area was assessed by measuring their size (length and width), insect and fungal infestation.

Productivity study and modeling growth and yield in Teak Plantation in Gujarat state

The survey of teak plantations was conducted at Varodara, Narmada, Panchmahal, Baria, Vyara, Dangs, Rajpiplla, Dahod and Godhara divisions. Out of the thirty two sites visited, nine suitable sites were selected for studies. The PCCF, Gujarat State Forest Department has granted permission of lying out of nine permanent sample plots and also permission for felling of total 40 numbers of trees of *Tectona grandis* of different diameters classes, five each from the surrounding of each permanent sample plots of the plantations for productivity studies.

Market survey on selected species in selected markets

- Data pertaining prices of timber such as *Tectona grandis, Dalbergia sissoo*, fuel- wood of mixed species, bamboo and poles were collected from the private markets of Jaipur and Ahmedabad in the end of each of four quarters. Data were compiled on prescribed formats and submitted to ADG (Stat.), ICFRE, Dehradun for publication of Timber and Bamboo Trade Bulletin.
- **Application of GIS for identification and monitoring of lac host belts in Chotanagpur area -** surveys and marking of pockets of Lac yielding belts were done for ground truth verifications. Documentation of information regarding production of lac during the respective seasons were carried out. The production in an area has been documented for a general assessment of the areas, where lac hosts are used for lac production. Marking of pockets of lac yielding belts through GIS/RS has been done for confirmation through ground truth verifications and a distribution pattern of lac host areas has been obtained through imagery. Database regarding production of lac in different areas has been developed.
- **Integrated strategy for evaluation of indigenous fast- growing multipurpose trees of eastern India for plantation forestry-** protocol for successful root induction with >70% rooting in semi hardwood cuttings has been developed in *A. chinensis* and >50% rooting in case of *B. ceiba*. Hedging schedule has been standardized for obtaining perennial supply of vegetative propagules and optimized rooting for both the species. The experiment conducted in randomized block design with hedging treatments once in a year, twice in a

year and three times in a year. Regular tending and maintenance was carried out of vegetative multiplication gardens established under the project. Clonal techniques have been scaled up and perfected for these important plantation forestry species of Eastern India.

Determination of Morphological and Physiological Quality Parameters of Nursery Stock of Deodar (*Cedrus deodara*) and Ban Oak (*Quercus leucotrichophora*)

Raised and maintained nursery stock of Deodar and Ban Oak at Model Nursery, Shimla and also at Field Research Station, Shilly, Solan respectively. Visited nurseries (35nos.) of the State Forest Department of Himachal Pradesh and collected the relevant information from the field functionaries regarding nursery raising and quality parameters being adopted by them for raising Deodar and Ban Oak nursery seedlings. Interim minimum standards of quality of Deodar and Ban Oak nursery stock were developed in consultation with the field functionaries. Based upon their morphological gradings, initiated studies for judging quality of Deodar and Ban Oak nursery stock. Studies pertaining to Root Growth Potential (RGP) and chlorophyll grading were also taken up and related observations recorded.

Deodar Out planting in Gunny bags

Training programme at Chail (HP)

Development of Techniques for Raising Deodar (*Cedrus deodara*) Plantations through Tall Plants

- After extracting wildlings of deodar from the adjoining forests of Shillaru and Kandyali, district Shimla, an experimental plantation, using these wildlings on the basis of their height and root collar diameter classes was established near Shillaru.
- For reaching out more effectively amongst the end-users i.e. State Forest Department, a training and demonstration programme on 'Modern Nursery Techniques and Production of Tall Plants of Deodar' was successfully organized in active collaboration with Divisional Forest Officer, Shimla at Mashobra near Shimla. Data pertaining to field and

Raising of Deodar tall plants in nursery

Training programme at Mashobra (HP)

nursery trials were compiled and analyzed statistically for drawing logical conclusions. The final project report is under preparation.

Studies on Seed Germination and Longevity of *Abies spectabilis* (D.Don) Spach

- During the last two years of implementation of this project, extensive surveys were conducted for identifying the natural populations of *Abies spectabilis* in five forest divisions of Himachal Pradesh. In the process, identified nine natural populations of *Abies spectabilis* were selected and various edaphical and other physical parameters were recorded.
- During the year 2012-13, survey was continued for identifying the natural populations of *Abies spectabilis* and accordingly, added eight more natural populations of the species to the already existing data. Till date, a total of seventeen natural populations of *Abies spectabilis* have been identified from different Forest Divisions of Himachal Pradesh. The soil samples collected from the identified sites for estimation of soil pH, organic carbon, moisture content, electrical conductivity, nitrogen and potassium content to know the site characteristics of the identified locations. The germination trials of

Tress of *Abies spectabilis* gowing in Jani Beat and at Foktodar, Panvi Beat

the seeds carried out in the laboratory and germination data recorded. The seeds of *Abies spectabilis,* treated with different pre-sowing treatments recorded around 40 per cent germination under laboratory condition. It was, however, observed that almost 60-65 per cent seeds were found empty. The seed storage trials were maintained and viability of stored seeds tested periodically in laboratory. The seeds of *Abies spectabilis,* stored in air tight polysac container in refrigerator at -5^{0}C retained around 26 per cent viability after nine months of storage, as compared to other storage container and storage environment that showed less seed viability.

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

The project was initiated during April, 2012 and during the period, seeds of *Myrica esculenta* commonly known as Kaphal were collected from Shimla and Solan districts of Himachal Pradesh and subsequently, germination studies were initiated both in the nursery and in laboratory conditions. Also initiated vegetative propagation studies in Kaphal under semi-controlled conditions at Model Nursery Baragaon, Shimla. Similarily, seeds of *Diploknema butyracea* (Cheura) collected from Champawat district of Uttarakhand was sown in two nurseries, namely Shilly (Solan) and Bir Plassi (Nalagarh) falling in mid and lower Himalayas respectively.

Vegetative propagation studies in Kaphal and Cheura seeds collected from Champawat (UK)

Productivity and biometrics studies on some important species i.e. *P. cineraria* and *A. excelsa* in semi-arid regions of Rajasthan for their sustainable management was carried out.

2.2 Agroforestry and JFM

Study on status of existing Agroforestry systems in Punjab, Haryana, Uttarakhand and North-West region of Uttar Pradesh

Twenty villages were surveyed and data collected with regard to their socio-economic status and agroforestry practice systems in Baldi, Kuahedi, Ulheda, Narsankhurd, Saheedwala Gherpemma and Naukra Grant, (Haridwar) and Shergarh, Lakhanwala (Dehradun), Handesra, Sarangpur and Singhpur, Mohali (Punjab), Kheda jatan and Chhajjumajra (Ambala), Kotla, Lalpani, Bishanpur, Rawathawn, Beyal, Uphulda and Danga (Pauri Garhwal).

Studies on the enhanced fodder productivity through Silvi-Pasture system on degraded land of India is being done on selected sites of Kharakhet in district Dehradun

Development of Lac Based Agroforestry (Silvi-Agri-Lac) System

Kusumi strains were collected from Flemingia bushes planted at Kanker Forest Department on the new shoots of Flemingia species viz. *F. macrophylla* and *F. semialata* under the lac based Silvi-agri-lac system as an OSR trial during January, 2013. Agriculture crop *Cajanus cajan* were intercropped in the interspaces of *Flemingia* plants- a bushy lac host species. Leaf folder attack on the seedlings of the *Flemingia* was recorded. The affected plants were controlled by spraying of Spinosit.

Evaluation of *Madhuca indica* based Silvi-Agri system

The field was selected and established with Mahua seedlings (grafted as well as seed originated) in the experimental area of Agrofoestry Division. Soil samples from the experimental area were collected and the status of soil nutrient available in the field evaluated.

Development of Silvi-Agri-Medicinal and Agri-Medicinal systems in Vidharbha Region of Maharashtra

The adjoining villages of Chandrapur district of Vidharbha Region of Maharashtra state were surveyed to select the farmer's field, for the establishment of the Silvi-Agri-Medicinal system and to create awareness and adaptation of agroforestry system among the farmers of Maharashtra.

Introduction of selected genotypes of Karanj, Kusum and Bamboo as tree components in Agro-forestry models in lateritic belt of eastern India

Cultivation of five agricultural crops viz., ginger, turmeric, colocasis, black gram & ragi were done under the three tree components. Growth & yield data were recorded. To increase the yield of intercrops under bamboo, reduction of shade was done through removal of mature culms from clump. Soil analysis is going on.

Documentation of Agroforestry systems and wood flow to wood based industries in Tamil Nadu

Documented the supply chain existing between farmers and industries, particularly, paper and matchwood industries. The data on the supply chain were worked out for pulp, paper and match industries. The market demand and supply was looked into. The various agroforestry systems, practised in Tamil Nadu were documented and the socio-economic status of farmers practising agro and farm forestry was also attempted.

Evaluation of selected phenotypes of Casuarina for establishment of windbreaks in farmlands in the western zone of Tamil Nadu

Efforts initiated to select phenotypes of Casuarina which are suitable for developing a windbreak agroforestry system. The selected phenotypes will be useful to address the recurrent problem of crop damages, particularly in plantain growing belt of the Coimbatore District, which is caused by strong gusty winds, particularly during monsoon period. This damage costs about Rs. 5.0 crores annually. In this effort IFGTB has now developed productive clones of Casuarina, exclusively suitable for windbreak.

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

Established agroforestry systems, with fast growing tree species under 15 ha farm land in three zones (Northeastern, Cauvery delta and Southern zones of Tamil Nadu) *viz., Melia dubia, Gmelina arborea, Neolamarkia cadamba* and *Sweitenia macrophylla* over 5 ha each, in three zones. Allelopathy study has also been conducted with the exudates prepared from the fast growing tree species leaf, stem and root. Study completed in Maize, Sorghum and Black-gram. One training has been conducted on 'Capacity building on agroforestry plantation establishment and management to farmers' of Pudukottai District.

2.2.1 All India Coordinated Projects on Agro forestry

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

The project aims at to develop *Wrightia tinctoria* R.Br and *Gmelina arborea* Roxb. based

agro-forestry models in semi-arid tropics of Andhra Pradesh and to Study the interactions of tree and crop combination of Agroforestry system based on *Wrightia tinctoria* R.Br and *Gmelina arborea* Roxb in combination with Pigeon pea and Sorghum.The aim has been defined into two long term and three short term objectives. The project has completed in fourth year and running in the fifth year. So far, the agri-crop and tree crop growth data had been collected three times. Pot culture and Bioassay experiment were conducted twice to study the allelopathic interactions between tree crops and agri crops. The soil samples were also analyzed twice for physical and chemical properties. The project is on the way to achieve all the proposed objectives.

Tree crop interaction study of existing MPTs based silvi-agri system in arid and semi-arid region of India

Managing resources to enhance productivity of Agroforestry system in dry areas of Rajasthan and carrying out agroforestry trials in the field, comprising of 17 years old *Hardwikia binata* and *Colophospermum mopane* trees at a spacing of 5 m x 10 m.

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

The work of development of model of *Melia composita* and *Emblica officinalis* is being carried out at two selected sites at Naukra Grant (Buggawala) and Handesara (Punjab). Design layout On Farm Research (OFR) trials established at Handesra and Naukra grant.

Emblica officinalis with Sarpgandha at Buggawala

Melia composita plantation at Buggawala

2.2.2 Evaluation of Joint Forest Management in Northern India

A study was carried out on impact of Joint Forest Management in order to strengthened Joint Forest Management practices in north Indian states of J & K, Himachal Pradesh, Uttarakhand and Punjab.

Evaluation of Potentials and Constraints of Agroforestry Development of Uttarakhand based, on Econometric Analysis.

2.3 Wood Science and Technology

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

Composite wood discipline has initiated two new projects on *Melia composita*. First project is to develop Particle Board and medium density Fibreboard from lops and tops of *Melia composita*.

The second project on plywood from *Melia composite*, in which nano -clay as filler, is being used to improve the properties of plywood.

Utilization of *Bambusa bambos* (L.) and *Dendrocalamus strictus* (Roxb.) as an alternative of wooden dunnage pallets

Two bamboo species i.e. *Bambusa bambos* and *Dendrocalamus strictus* were studied for their various physical and mechanical properties to find the suitability of these two bamboo species to be used as dunnage pallets specially for warehousing corporations.

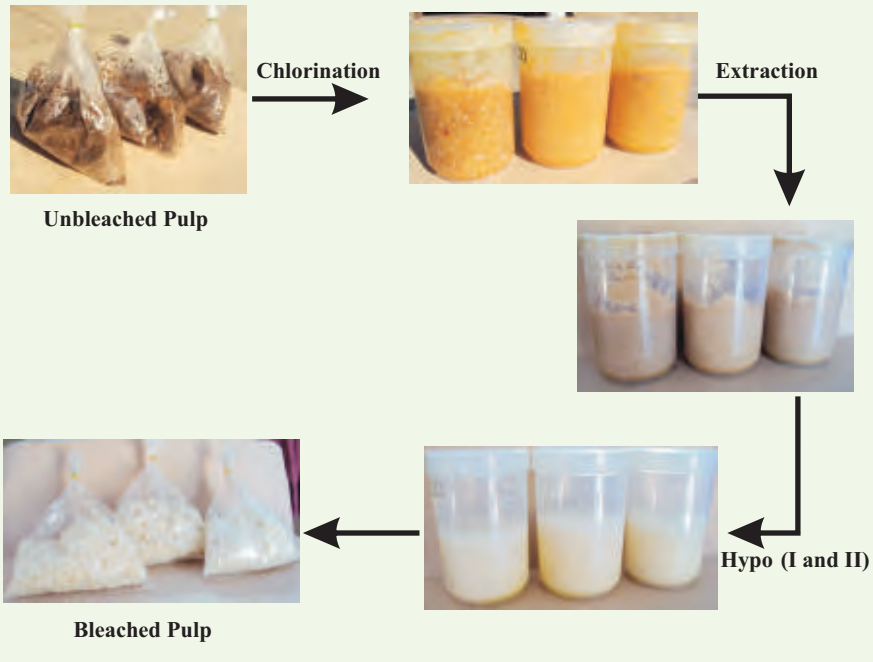
Study on constraints in the export of carved out wood products and its economical and social impact on the livelihood of, dependant people in north India

- To address the issues of distribution of Wood Carving Industry, its economic contribution and identification of problems, with focus on raw material procurement, manufacture of carved out wood products and their marketing, this study has been assigned to FRI by MoEF. Ten wood carving centres have been selected throughout North India *viz.* Srinagar and Rajouri in J&K, Chamba and Kullu in H.P., Hoshiarpur and Amritsar in Punjab, Saharanpur and Nagina in U.P., Udaipur and Jodhpur in Rajasthan, to assess the economic condition, literacy level, specialization, working tools or machines (technology) used, alternate sources of income, type of working and constraints.
- Various types of carving, the tools used there in, the range of products and the marketing channels and export of end products along with constraints have been studied and assessed.

Assessment of economic contribution of NTFP of Chir Pine in the economy of forest dwellers in North India is being done

Evaluation of the identified raw materials *Gmelina arborea* and *Prosopis juliflora* was carried out under the study "Alternative Raw Materials for Pulp and Paper Making". The results showed the suitability of *Gmelina arborea* and *Prosopis juliflora* for writing and printing paper.

Bleaching of *Prosopis juliflora and Gmelina arborea* using CEHH sequence



Effect of improved operational parameters on hydrolysis of lignocellulosic biomass to enhance total reducing sugar yield for bioethanol production was studied by carrying out the hydrolysis of *Lantana camara* and Pine needle at different temperatures for bioethanol production.

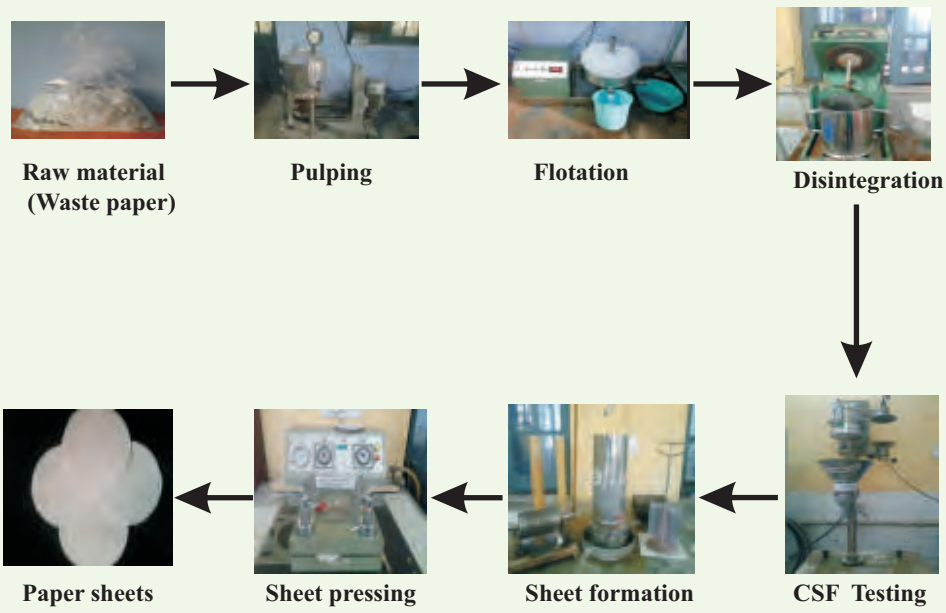
Evaluation of *Sesbania grandiflora* and *Lannea coromandelica* for papermaking was also done.

Biodeinking of waste paper was carried out to study biodeinking of mixed office waste paper with the enzymes produced by the best cellulose producer i.e. *Trichoderma viridae* and *Coprinus disseminates*.

Wood Science and Technology for livelihood and Economic growth- Following studies are being carried out-

- Composite wood products refer, to the family of engineered wood panels, and includes Particle board, Plywood, MDF and other hardboards. F.R.I has two ongoing projects in this direction. One project on Paper-mulberry, is being studied for plywood. In this project, a new species is being worked up upon as an alternative for commonly used plantation species of paper-mulberry and poplar at different pressure levels. The second ongoing project is to study LVL from different species combinations. A new project has also been initiated to study the suitability of lops and tops of poplar for medium density fibreboard.
- One modular plant for treatment of wood with ammonia vapours has been designed and fabricated under an already completed plan project. Five wood species, *viz.*, Shahtoot (*Morus alba*), Kharig (*Celtis australis*), Benteak (*Lagerstroemia lanceolata*), Bakain (*Melia azedarach*) and Jamun (*Syzygium* spp.) have been studied under this project, for their bending properties in making hockey blades.
- Under the Plan Project, an ultrasonic technique, developed for defect detection of logs, was modified for trees. Using this modified

Deinking of waste paper and paper sheet formation from deinked pulp



technique, more than 60 trees of different species situated along the road side in FRI Campus, were tested for assessing their current status.

- Finger jointing as a tool, for utilizing economically mill waste has been catching the imagination of solid wood industries worldwide. However, this technique is yet to be pierce in the Indian market. FRI has, therefore, initiated research into utilizing finger joints for structural and semi-structural uses. In this direction, a project on the role of L/P ratio of finger profiles in deciding the bending properties of finger joints has been completed.

Comparative study of clones of Eucalypts and Acacia hybrid for handicraft sector

Eucalyptus tereticornis, E. eurograndis and *Acacia Hybrid* clones were studied for their various physical, mechanical, anatomical properties and wood working qualities. The clones were recommended for various end uses based on their suitability indices. Various handicraft items of both the species (Eucalyptus and Acacia) were made with the help of artisans.

Products made from Eucalyptus and Acacia clones

Enhancing dimensional stability and durability of wood for flooring application by eco-friendly thermal processing

Heat treatments of wood of *Acacia auriculiformis, Eucalyptus* spp. and *Hevea brasiliensis,* (Rubberwood) were carried out using different temperature profiles under vacuum, nitrogen and atmospheric pressure in air. Various physical properties of control and treated specimens were evaluated and compared.

Heat treated Acacia woods at different temperatures

Evaluation of strength properties of Finger Joints of A. auriculaeformis A. Cunn. Ex Benth of different Ages (6-7 and 10-11 years old) for various end uses

Acacia auriculaeformis wood of two different age groups was evaluated for finger jointing using different adhesives and performance of finger joints

in terms of strength properties evaluated. Different finger jointed products viz, door and window frame were also made and kept for demonstration.

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

- Plant material of Ruta graveolens and *Zanthoxylum rhetsa* was dried, pulverized and secondary metabolites were extracted by different solvents and quantified. The extracts were subjected to phytochemical test and group test.
- The extracts of *Ruta graveolens* root, stem and leaves were used to evaluate larvicidal effect and ovi-position activity completed. Mosquito Repellent property by hand exposure method completed at NIMR.

Quantitative estimation of sandal oil from different locations, by colour reaction is done by carrying out a survey in sandal bearing areas of Karnataka, Tamil Nadu and Kerala States

Exploration of the efficacy of extractives of four plant species for developing eco-friendly marine wood preservatives

Four plant species, viz., *Ageratum conyzoides* L (Asteraceae), *Croton bonplandianum* L (Euphorbiaceae), *Lantana camara* L (Verbenaceae) and *Parthenium hysterophorus* L (Asteraceae) were selected for exploring the efficacy of their leaf extractives in preventing marine wood borer attack.

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

Preservative treatments of *Melia dubia* and *Acacia auriculiformis* species with micronized copper azole (MCA) wood preservative having different concentrations were carried out.

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

Eco-friendly wood preservatives were prepared from oils of *Pongamia pinnata, Jatropha curcas* and *Simarouba glauca* by incorporating copper ions into the oils by refluxing with cupric oxide for different time periods to increase the biocidal properties.

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

The aim of this project is to develop eco-friendly wood preservatives from plant origins. For this, barks of *Acacia auriculiformis* and *Acacia nilotica* and leaves of *Gliricidia sepium* were extracted, separately for studies.

Natural Fibre-PVC composites for light structural applications.

Natural fibre-Poly Vinyl Chloride (PVC) for light structure application, aims at composites, which can be used to manufacture door shutters, windows, railings, etc. are new screw profile, for processing wood-PVC, were taken up as a trial.

Nanoparticles based wood coatings for outdoor applications was also carried out

- Synthesis and Characterization of Hybrid Polypropylene - Montmorillonite -Wood Fibre Nanocomposites is being investigated.
- Wood quality variability in sawn timber from three plantation grown species was also carried out on wood quality of silver oak boards.
- Evaluation of the performance of Steam Volatile Creosote (SVC) as a wood preservative was done.

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

Observation at 60 months after implantation, has been taken in all the testing sites, viz., Hyderabad, Jabalpur, Jodhpur, Nallal, Palode and Visakhapatanam on the durability of moderately resistant timber *Quercus robur*, and highly resistant timbers viz., *Dryobalanops aromatica, Tectona grandis* (from five countries), *Shorea laevis, S. marcoptera, S. robusta, Pterocarpus soyauxii* (from two countries) and *Xylia dolabriformis.* Highly susceptible timbers viz., *Fagus sylvatica, Fagus grandifolia, Fraxinus angustifolia, F. excelsior, Acer pseudoplatanus* were treated with CCB and Timber Protect and the experiment was laid at Nallal.

Chemical Derivatization of a-Cellulose into Value Added Products

Commercial cellulose procured from market (Sigma Aldrich) and analyzed for cellulose content, ash content and DP. The characterization of etherified cellulose is under process.

2.4 Non Wood Forest Products

Data compilation of R & D in Medicinal and Aromatic Plants by ICFRE Institutes and Other Institutional Projects funded by ICFRE

R&D researches on 55 medicinal and aromatic plant species conducted by ICFRE institutes and aided Institutions, under available 93 research projects and 72 published research publications have been collected and documented under the categories of **Nursery techniques** (Seed biology, Protocols for propagation through seed; Protocols for clonal propagation; Protocols for micro-propagation); **Genetic improvement** (Multi-locational trials of promising clones, Provenance trials, Germplasm conservation); **Agroforestry and intercropping** (Intercropping models, Organic cultivation protocols, Cultivation practices); **Value addition** (Phytochemical and biochemical screening for active constituents, Bio production of secondary metabolites, Quality assessment) and **Disease and pest management** (Diseases and insect pest of medicinal and aromatic plants; Testing of bio active constituents against insect pest and pathogens).

Field trials for increasing NWFP Productivity using *Piper pedicellatum*

Piper pedicellatum plant grows in moist subtropical and sub-tropical forest areas. The germ plasm was collected and nursery technique developed in FRI nurseries. Site developed was in FRI Central Nursery under, *Prunus cerasoides* and *Dalbergia sissoo* plantations and their trials carried out.

Female *Piper pedicellatum*

Male *Piper pedicellatum*

Creation of Seed Production Areas and Commercial Cultivation Trials of Uraria picta

Seed Production Area (SPA) of *Uraria picta,* an important ingredient of famous Ayurvedic Dashmula formulation has been established at FRI campus and is being maintained. The seed production from seed bank has been used for production of field planting stock and *ex-situ* conservation of this

species. Commercial cultivation trials have been undertaken in collaboration with farmers in Dehradun district. Final crop harvesting has been undertaken to estimate productivity and economic viability. Data analysis is in progress.

Field trial of borehole method of resin tapping for Chir pine of Uttrakhand for better oleoresin yield

Pinus roxburghii trees were selected for developing effective and non-harmful resin tapping technique in Mussoorie Forest Division (Magra Compartment). The site in the selected compartment was divided in three plots on the basis of altitude. The total resin yield was slightly higher in rill method of tapping as compared to bore hole method of tapping.

Bore Hole Method of tapping

Rill Method of tapping

Testing of Vegetative Multiplication Technique of *Microstylis wallichii* in its Natural Habitat

Vegetative propagation technique of *Microstylis Wallichii* was carried out in its natural habitat at Chakrata., Mussoorie and Dhanolti. Surveys were conducted for occurrence of species in Chakrata, Mussorie, Tehri, Narendra Nagar, Nainital, Almora, Badrinath, Pauri, Lansdowne and Uttar Kashi Forest Division and more than 50 sites were identified. The propagation by seed was also tried but the seed not germinated. Maintenance trials are on at three sites.

Jeevak in natural habitat

Jeevak in nursery beds

Diversification of hill agriculture through integration of medicinal/aromatic plants for livelihood using vegetative multiplication of *Thymus serpyllum* was tried directly in nursery bed.

Thymus serpyllum on stone walls of Farmer's field at Khirsu Pauri Garhwal

Harvesting of *Thymus serpyllum* from stone walls of Farmer's field at Khirsu Pauri Garhwal

Phytochemical screening of selected wild edible plants for exploration of new sources of Luteolin is being done

Edible parts of targeted species were studied for physicochemical values and phytochemical profile. Phenolic and non phenolic components were fractionated and total phenolics were quantified. Phenolic fraction was chromatographed, over

column chromatography, for isolation of pure compound.

Process refinement for extraction of quality fibre and optimal isolation of bioactive constituents from *Agave sisalana* is being carried out.

Screening of some forest tree species for their antioxidant properties.

Structural studies and utilisation of *Acacia tortilis* gum exudates.

Utilization of *Pinus roxburghii* needles for value added products

Wax was isolated from the pine needles using different extraction protocols and derivatisation of the extracted wax is being done.

Phytochemical studies on medicinally important *Diploknema butyracea* (Indian Butter Tree) Seeds'

Chemistry of ethno-botanically, unexplored medicinal plant, *D. butyracea* (Indian Butter Tree, Cheura butter) was worked out through characterization of its oil by GLC & GC-MS analysis.

Enzyme aided alternative process for the extraction of 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*

Condition for extraction of dye and then dyeing of various fabrics, using extracted dye was optimized. Dyes were extracted from two target species in acidic and alkaline medium. Dyeing trials on various fabrics viz. silk, wool and cotton was carried out which produced different shades on the fabrics.

Evaluation of *Santalum album* grown in plateau area of Uttar Pradesh adjoining Madhya Pradesh and Uttarakhand for yield, quality and composition of essential oil from sample of *Santalum album* provided by SFD, Uttarakhand.

Prospecting fungal resources for development of natural dye

- Dyes were extracted from the culture of *Pycnoporous sanguinius,* using distilled water as solvent. Silk, wool and cotton fabrics were dyed using extracted dyes. Different colours were produced on silk, wool and cotton fabrics by using different mordants.
- Initiated two new collaborative projects with State Agricultural Universities. (1) NTFP Network Project I: Survey, Documentation and Value Addition Studies in Selected NTFPs of Tamil Nadu. Collaborating institutes: FCRI, Mettupalayam (TNAU) & IFGTB and (2) NTFP Network Project II: Survey, Documentation and Value Addition Studies in Selected NTFPs of Kerala. Collaborating institutes: KAU, Thrissur & IFGTB. A status report on NTFPs of Tamil Nadu is being prepared in collaboration with TNAU. A status report on NTFPs of Kerala is being prepared in collaboration with KAU.

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

Surveys were conducted at Amravati, Akola, Buldhana and Nasik districts of Maharashtra for the collection of *Argyreia speciosa* (*Samudrashokh*), *Asparagus officinalis* (*Satavari*), *Asparagus racemosus* (*Satawar*) and *Curculigo orchioides* (*Kali Musli*). A. racemosus was found available, at all the above mentioned places.

Quality standardization of some important medicinal plants of Madhya Pradesh

Surveys were conducted in different agroclimatic zones of Madhya Pradesh for collection of plant samples of *Gymnema sylvestre* (Gudmar), *Ocimum* sp. (Tulsi), *Phyllanthus amrus* (Bhui aonla) and *Tinospora cordifolia* (Giloe). Samples were collected from Kymore Plateau and Satpura Hills, comprising Katni, Umaria, Panna, Satna, Rewa and Seoni districts; Gir Region, comprising of Gwalior, Shivpuri, Morena and Satpura Plateau comprising of Chhindwara and Balaghat.

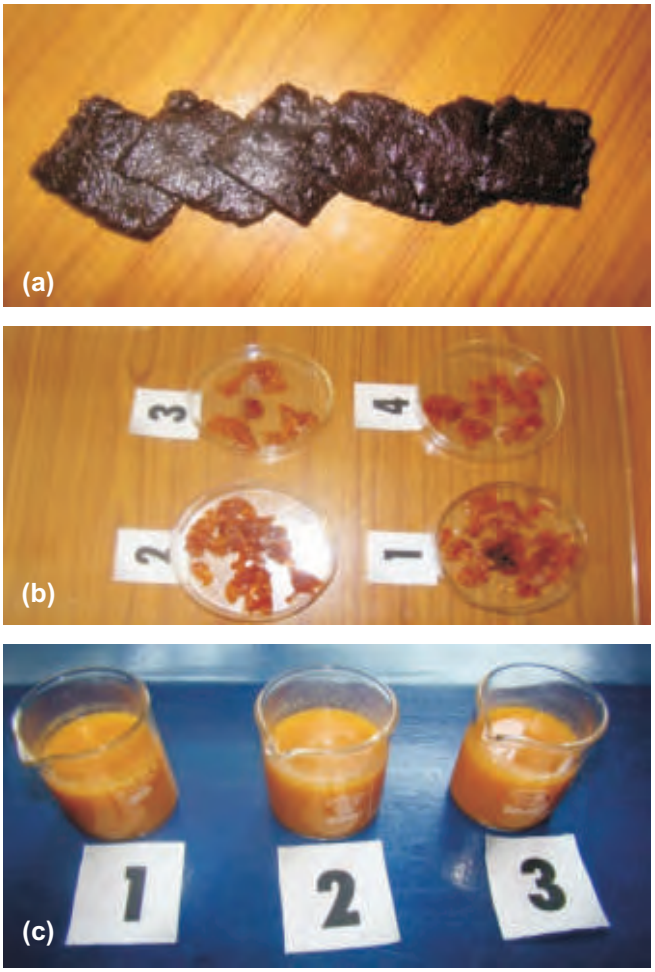
Tulsi plants were planted in nursery for carrying out experiments of harvesting limits. Plants were trimmed before flowering and after flowering for investigating the effect of flowering on the emergence of new branches.

Chemo-profiling of some Dasmoola species (*Uraria picta, Solanum indicum* and *Solanum xanthocarpum*) 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.

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

Immature and mature fruits were collected, processed fruit and separated their pulp. Three value added products (A) Kusum concentrate (B) Kusum leather and (c) Kusum katmith were prepared from the pulp.



Value added products of kusum: (a) Kusum leather, (b) Kusum concentrate and (c) Kusum khatmith

Evaluation on phyto-polymers as eco-friendly bioadhesives

Samples of *Shorea robusta* (seeds), *Madhuca indica* (seeds) and *Amorphophallus companulatus* (tubers), *Pheonix acularis tubers,* were collected. Starch was isolated from potato, and *Amorphophallus companulatus* for the preparation of bioadhesives. Starch, total phenols, protein and tannins were estimated in defatted *S. robusta*, *M.indica* and *J.curcas seeds*. The adhesive was prepared with alkali and acid as gelatinization modifier at different concentration and its effect on viscosity.

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

Seeds of *Jatropha curcas, Sapindus mukrossi, Schleiochera oleosa* and *Pongamia pinnata* were collected and processed. Seeds biochemical were isolated. Physico-chemical properties of different oil seeds were also determined. Standardized modification i.e. saponification and diethanolamide of oil and protein of seeds was carried out.

Network research project on Guggal (*Commiphora- wightii* Arn. Bhandari)

Keeping in view the important medicinal properties and large scale demand of oleo gum resin, derived from *Commiphora wightii* (Guggal), experimental trials have been laid out to standardize various aspects of macropropagation of Guggal. The main finding of these experiment is that *Commiphora wightii* can also be propagated through micro cuttings, having diameter of <0.25-0.50cm , at large scale.

Component II - To develop methodology for enhanced/non-destructive gum production

A non destructive Ethephon (a plant growth regulator) injection based method was worked upon, in arid conditions for the tapping of oleogum resins from *Commiphora wightii*. The results of this method were very encouraging and Guggul plants survived even after three time gum exudations.

Making holes with the increment borer in *Commiphora wightii*

Gum oozing (first time) from *Commiphora wightii*

Gum oozing in healed plant (third time) of *Commiphora wightii*

Quantification, value addition of NTFP and improved agricultural productivity of the tribal belt of Sirohi district of Rajasthan

This project was initiated to document the extent of NTFP collection, processing, storage and marketing in selected villages of Mount Abu Block (Bhakhar area) of Sirohi District in Rajasthan.

Momordica diocia

Cassia tora

NTFP Selling in local market

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

- Survey was carried out and sample was collected from 2-3 regions in Rajasthan. Morphological data were taken and samples analysed for their nutrient content.
- *Cassia tora, Haloxylon salicornicum, Cordia gharaf* and *Grewia tenax* species could be important biosources of protein, fibre, vitamins alongwith, providing essential micronutrients. The results have shown significance of wild edible species as important source of nutrient for rural poor.

Standardization & dissemination of complete package of cultivation & marketing in relation to principle active ingradient of ten selected medicinal plants of Jharkhand, Bihar, West Bengal and Orissa

Plants of six species [*Withania somnifera* (L.) Dunal (Ashwagandha), *Andrographis paniculata* (Burm. f.) (Kalmegh), *Rauvolfia serpentina* Benth. Ex Kurz. (Sarpagandha) in Jharkhand & *Stevia rebaudiana* Bertoni (Stevia), *Wedelia chinensis* Merrill (Bhringraj) and *Gloriosa superba* L. (Kalihari) in West Bengal] were cultivated using RBD design in Jharkhand and West Bengal. Complete optimized cultivation practice has been standardized in these species. Active-ingredient analysis is under progress. As per the marketing part, price and demand data from 30 companies have been taken and disseminated to the interested farmers. As per extension activities, two workshops have been carried out. Two demonstration plots of medicinal plants have been established in farmer's field in West Bengal.

Study of various factors effecting the quantity of active principles in some commercially important medicinal plants under cultivation

The seedlings *Rauvolfia serpentina, Asparagus racemosus, Gymnema sylvestre* have been raised under the shade of Sissoo and Teak.

Standardization of nursery techniques for cultivation of *Celastrus paniculatus* and *Vitex peduncularis*

Medicinal plants are highly exploited in Jharkhand. Sixteen sites of natural occurrence of *V. peduncularis* and *C. paniculatus* in Ranchi, Gumla, Simdega, Hazaribagh, Lohardaga districts of Jharkhand have been identified. *V. peduncularis* has been successively propagated from root stock and suckers. Nurseries have been developed of these two species from cuttings and air layering experiments. Fertilizer application and spacing schedules have been standardized.

Identification of Superior Chemotypes and *Ex-situ* Conservation of *Podophyllum hexandrum* Royle from Himachal Pradesh and Jammu & Kashmir (Nubra Valley)

- Identified superior genetic stock of *Podophyllum hexandrum* Royle. after carrying out extensive surveys in 30 sites falling in different geographical locations of Himachal Pradesh and in Ladakh Valley of Jammu & Kashmir.
- Each of the site was also geo-referenced and characterization of micro-habitat recorded. Field Gene Bank (FGB) to conserve the sources, as collected during various surveys was also established at Field Research Station, Brundhar, Jagatsukh (HP). Seed and vegetative propagation trials had been established to develop user friendly propagation trials of *P. hexandrum*.

Podophyllum hexandrum study site at Lahoul (HP)

Status, Survey and Mapping of Ashtavargha Group of Medicinal and Aromatics plants (MAPs) in Himachal Pradesh

A new research project initiated from April, 2012 and accordingly, detailed activity and implementation plan, including the design of floristic surveys was formulated. Besides, a questionnaire design and survey for ethno-botanical data was also prepared and finalised for collecing information from the stakeholders. Stress was also laid on the literature survey and collection of basic information of the Ashtavarga group of species growing in the region. Baseline survey was conducted in few locations falling in Shimla and Kullu districts of the state of Himachal Pradesh.

Habenaria intermedia

Malaxis muscifera

Orchid

National Medicinal Plants Board (NMPB)-Conservation Project

For effective implementation of this project, a Memorandum of Understanding (MoU) for active collaboration between Himachal Pradesh Medicinal Plant Society (HPMPS), an autonomous body of the Himachal Pradesh State Forest Department and Himalayan Forest Research Institute, as the collaborating institute was signed in the month of February, 2013. As an outcome of signing of this MoU, a dedicated project team was

constituted at the institute for undertaking the various works under the study as per the agreed terms. Also a detailed activity implementation plan was formulated including the design of floristic surveys. A field survey was undertaken in Sirmour district of Himachal Pradesh during March, 2013 to identify viable wild populations of medicinal plants, assessed as 'threatened' in Shimla CAMP Workshop, 2010. During this survey, *Gentiana kurroo* was found to be as the main species.

Gentiana kurroo Royle (Kutki) flower

Gentiana kurroo Royle (Kutki) plant

Arnebia benthamii (Wall. ex G. Don) John. (Ratanjot)

2.4 Diseases and Microbes

Assessment of disease problems of selected fast growing native tree species in Tamil Nadu and their management

The present project is proposed to investigate the economically important disease problems of fast growing native tree species such as *Ailanthus excelsa, Gmelina arborea, Melia dubia, Neolamarkia cadamba, Pongamia pinnata* and *Thespesia populnea* in nurseries and plantations, including agro-forestry system in Tamil Nadu and develop suitable management strategies for production of better planting stock to increase the productivity.

Interaction between *Pseudomonas fluorescens* and AM Fungi on *Dendrocalamus strictus*

Isolates from Uttarakhand, Haryana and Punjab were assessed for biocontrol properties against important forest pathogens, *A. alternate, Bipolaris sp., C. ovoidea, F. solani, Rhizoctonia* sp. and *S. rolfsii.* Interaction between the pathogen and bacterium were assessed in dual culture using PDA.

Eucalyptus germplasm used by forest department / industries were screened for disease resistance, against Cylindrocladium leaf and seedling blight.

Screening of poplar genotypes against *Alternaria alternata* toxin(s) were conducted in Uttarakhand (Paniyala) and Uttar Pradesh (Saharanpur).

Studies on macro wood deteriogens at Kakinada port and Narsapur Greenfield port, Andhra Pradesh is conducted by way of Marine exposure trials at Kakinada port and Narsapur test site.

Studies on the incidence and management of Pine mortality in Manipur

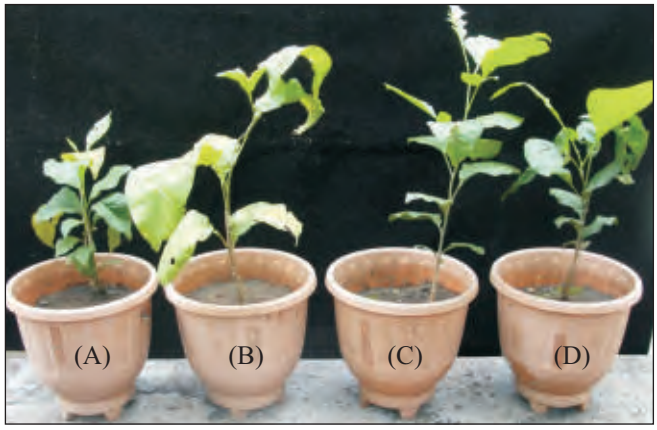
Surveys were conducted in Khasi pine inhabiting areas of Manipur to assess the disease incidence Maximum of 100 per cent disease incidence was recorded in Ukhrul. PH of the collected soil samples were found to be near neutral to slightly alkaline. Different fungal genera were identified from collected soil samples. One fungal genus (*Pestalotiopsis*) was found to be associated in the disease sample. The fungus, *Fomitopsis pinicola* was found to be associated with most of the diseased trees in Manipur. A control experiment was carried out at Ukhrul (Manipur), by using five treatments (three fungicides and two biocontrol agents i.e., *Trichoderma viridi and T harzianum*).

Microbial biosynthesis of polyhydroxy alkanoates (PHA) from wood waste

A project was started during 2011-12 on identification of a bacterial strain synthesizing high content of Poly Hydroxy Alkanoates (PHA). The speciality in this project was utilization of cellulosic material obtained by degradation of wood waste by lignicolous fungi, which was never attempted elsewhere. The long-term outcome would be focused on effective utilization of the microbes for production of PHA/bioplastics for commercial purpose. The objective of this project was to evaluate various white rot fungi for their efficacy to degrade wood waste under laboratory conditions.

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

Inocula of AM fungi and bacterial biofertilizers were produced for quantification of infective propagules. Infective propagules in different inocula regularly determined exhibited decline in infective propagules with the time. Decline in population of soilrite based inocula of *Rhizobium*



Effect of different growth promoting microbes on growth of bael seedlings in pot experiment (A) Control (B) AM fungi (C) *Azospirillum* (D) AM + *Azospirillum*

(isolated from tinsa nodules) was also recorded.

Induction of systemic acquired resistance in rohida against stem canker has been carried out with various tests performed on sugar, phenotic level, PAC etc.

When the seedlings were treated with JA (Jasmonic A), SA (Salicylic Acid) and Trichoderma, after 30 days, 60 days and 90 days, protein content in 1gm of leaves, treated with Salicyclic acid (5mM) 0.76 mg, 0.94 mg and 0.94 mg, treated with Salicyclic acid (10mM) was 0.52 mg, 0.68 mg and 1.00 mg, treated with jasmonic acid (10mM) was 0.61, 0.71 and 0.90, treated with Trichoderma (1 plate full growth population plate used at 500ml of water) was 0.42 mg, 0.63 mg and 0.80 mg and with pathogen 0.82 mg, 0.76 mg and 0.76 mg, respectively.

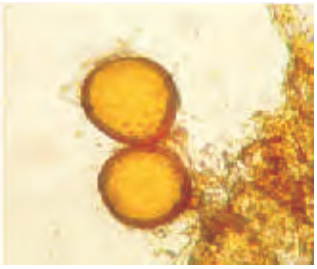
Evaluation and selection of efficient strains of AM fungi and Rhizobium for Acacia nilotica and Ailanthus excelsa in Western Rajasthan

- Rhizosphere soil of Acacia nilotica var. cupressiformis and Ailanthus excelsa were collected from Pali and Sojat. Soil samples were analyzed for pH, EC, (%) organic carbon (%OC) and phosphorous (P). The important five genera namely, *Glomus, Gygospora,*

Scutellospora Acaulospora & Sclerosystis and 12 sp. viz. G. aggregatum, G. constrictum, G. deserticola, G. fasciculatum, G. macrocarpum, G. microcarpum, G. occultum, G. pubescens, Glomus sp., Sclerosystis indica, Scutellospora bionarta, Acaulspora biculata were isolated and identified in natural plantations of *A. nilotica var. cupressiformis* from Jodhpur and Pali districts.

- The AM/Rhizobium treated plants performed better in increasing biomass (shoot height, root length, shoot and root fresh weight, shoot and root dry weight), percentage of root colonization than un-inoculated plants.

Glomus spores attached with root of *A. excelsa*



Two young sporse of *Glomus sp.* collected from *A. excelsa*

Sclerocystis sp. Collected from *A. nilotica cupressiformis*

Sclerocystis sp. Collected from *A. nilotica cupressiformis*

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

- Litter decomposition mycoflora were isolated and identified as *Aspergillus niger, Aspergillus flavus, Trichoderma viride, Fusarium* sp and *Actinomycetes* and identified as *Streptomyces*. Three litter decomposing fungi, *Trichoderma viride*, *Aspergillus niger* and *Streptomyces* were selected for amendment for rapid composting process.
- Multiplications of bio-agents *Trichoderma viride* has been successfully maintained in sorghum seeds and are being used as amendment in aerobic and anaerobic composting process. The bacterial biofertilizers like, *Azospirillum leporum*, Bacillus coopilense and Azotobactor crucoccum are being maintained in nutrient broth medium and further mass multiplication in liquid media for experimentation.
- Aerobic composting (heap method) is being prepared in shade house by using indigenous strain of *Trichoderma viride* and dried leaves. The composting process has taken 90 days, whereas in traditional process, it takes 120 days. The nutrient status and microbial population was also recorded high with the amendment of *Trichoderma* and PSBs.

(A) *T. viride* (indigenous strain) and PSB suspension

(B) Mixing of *Trichoderma* culture in FYM

(C) Layering of *Trichoderma* culture on raw material

(D) Drenching with PSB suspension

(A-D). Aerobic composting by using Trichoderma viride and PSBs

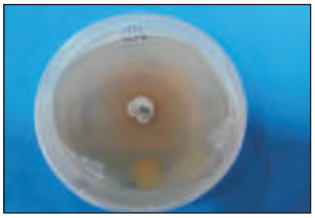
Evaluation of antifungal potential and identification of broad spectrum antifungal compound from selected tree/shrubs/weeds of Indian arid region

Name of plant Species:

i. *Balanites aegyptiaca* Linn
ii. *Tephrosia purpurea* (L.) pers
iii. *Citrullus colocynthis* L. (Tumba)
iv. *Tribulus terristis* L.

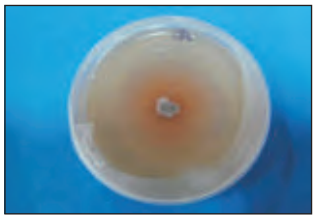
v. *Argemone maxicana*Linn. (Prickly poppy)
vi. *Solanum xanthocarpum* L. (Kantakari)
vii. *Datura stramonium* L. (Thorn apple)

Antifungal properties of selected plant parts were evaluated against fungal pathogen. Collection of leaf, root and flower bud of *Datura stramonium,* leaf and root of *Tribulus terrestris*, root, flower and fruit of *Argemone mexicana*, seeds of *Tephrosia purpurea* were carried out.

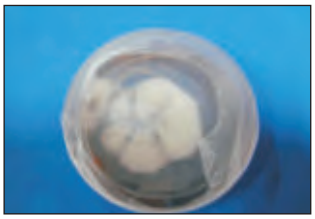


Datura root ethanolic extract against *Alternaria alternata*

Datura root ethanolic extract against *Fusarium solani*



Tephrosia purpurea seed aqueous extract against *Fusarium solani.*



Tephrosia purpurea seed aqueous extract against *Rhizoctonia solani*

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

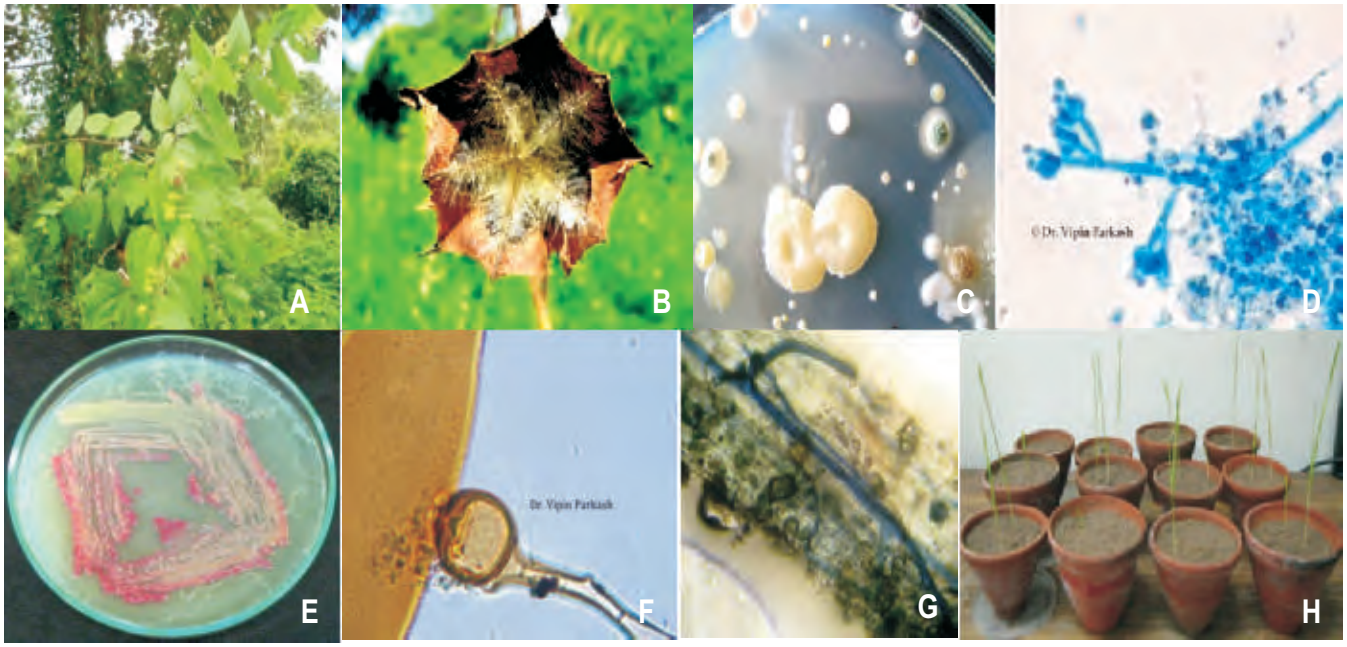
Ethnomycological survey and collection of wild edible mushrooms has been carried out from the selected areas of Kohima, Pulibezie forest, Mon and Mokokchung districts of Nagaland. Eighty eight species of mushrooms were collected from three districts of Nagaland. The collected samples are being analyzed in laboratory for their taxonomic identification. Some of the identified mushrooms include the species of Pleurotus (edible), *Schizophyllum* (edible), *Ganoderma* (medicinal), and some saprophytes/ wood decaying fungi are identified as the species of *Polyporus, Phelliunus, Xylaria, Pycnoporus, Clavaria, Auricularia, Russula,* Puffball, etc.

Russula sp.

2.4.1 Mycorrhizae, Rhizobia and Other Useful Microbes

Influence of beneficial microbes in conferring salt tolerance to *Casuarina* clones

Alleviating plant salt stress and remedying saline soils are of great economic interest. Beneficial microbes, such as, mycorrhizal fungi, Frankia and PGPRs are associated with many plants including trees. These beneficial microbes can cope up with salinity and help the plants to survive in such soils. Hence, in the present project, it is planned to investigate the status of beneficial micro flora from the samples of salt affected areas and also to test their tolerance against salinity *under in- vitro* and study the efficacy of these beneficial microbes on the growth improvement of selected *Casuarina equisetifolia* clones in nursery. Pure cultures of 51 isolates of Plant Growth Promoting Rhizobacteria (PGPR's) [18 isolates of Phosphate Solubilizing Bacteria (PSB), 16 isolates of *Azotobacter* sp. and 17 isolates of *Azospirillum* sp.] were isolated and identified from the samples collected from different salt affected areas in Tamil Nadu and Puducherry and maintained in culture bank of IFGTB. Biochemical characteristics of different isolates of PGPRs (*Azotobacter, Azospirillum* and Phosphobacteria) have been studied and species



A-*Abroma augusta* L. plant, B- Matured *A. augusta* fruit, C- Fungal colonies in media, D- *Trichoderma harzianum*, E- Culture of Bacterial colonies in media, F- *Gigaspora* sp. with bulbous attachment, G- Hyphae in *A. augusta* root, H- Trap culture of AM spores in earthen pots.

level identification of all the PGPR isolates and AM fungi were undertaken in laboratory. Experiments were conducted and tested for the efficacy of salt tolerance ability of all the beneficial microbes, isolated from salt affected areas, by using 3 different salts viz., sodium chloride, sodium citrate and sodium sulphate and short listed the best salt tolerant beneficial microbes for further study. An experiment was conducted by applying inoculum of selected isolates of beneficial microbes (AM & ECM fungi, Frankia and PGPRs) to the selected clones of *C. equisetifolia* under nursery condition and promising results obtained for growth and biomass enhancement of different clonal plants of *Casuarina equisetifolia* under nursery condition.

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

Field surveys were conducted to visit Titabor and Borhola, Joypur forest, Kaziranga and Amsoi Forest Range areas in which natural vegetation of *Abroma augusta* L. was found to occur. A total of 24 rhizospheric soil samples of *A. augusta* species from Titabor and Borhola, Joypur forest, Kaziranga and Amsoi Forest Range were collected for physical and qualitative analysis of parameters including GPS location, elevation, soil colour, soil pH, soil humidity, soil moisture content, organic carbon per cent and electrical conductivity. Sub-culturing of bacteria and fungi in respective media for pure culture is under progress. Colonization of root samples and their photography is under way. Fungal staining of isolated fungi is going on for identification. Trap culture of eighteen samples has been started and is under progress. The seedlings of *A. augusta* are raised with the help of VAM inoculation in bigger earthen pots along with bacterial and fungal bio-agents have been established and are under progress. The out planted seedlings were primarily established in field conditions through extension activity.

2.5 Insect Pests

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

Collection of damaged bamboo species

Bioecology and management of the gall insect in Eucalyptus from roadside plantations was studied at three sites, viz. Chidiyapur, Shakumbhari Devi and Roorkee.

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

The field survey was conducted in different district *viz.* Gumla, Khunti and Ranchi, Lohardaga, Garhwa, Ramgarh, Hazaribag. Collection of insect pest stages and plant samples of *D. sissoo*, *G.arborea* and *S. robusta* were done. From *S. robusta*- Green bug, Psylla, black weevil, leaf miner, and trunk borer, aphid were observed. From *G.arborea* trees leaf eating caterpillar, leaf folder, leaf miner, Thrips and trunck borer were collected and from *D. sissoo* seed feeder, leaf miner, leaf scrapper, small pod borer, cow bug and plant hopper were observed. Some of the insects were identified in the laboratory and some are in progress.

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

- **Model -1:** At Bevanahalli *Tectona grandis* (Teak and *Grevillea robusta* (Silver oak) with *Mangifera indica* (mango) (Sandal and silver oak with Mango, Pomegranate and guava) - *Coccid Aonidella orientalis* (Newstead) infestations were high, compared to the other coccids. Bark feeding termites were also high on sandal and silver oak. The red coffee borer *Zeuzera coffeae*- (Nietner) infestation was randomly distributed on *Santalum album*.
- **Model-2:** At Mudenahalli (Sandal with amla and tamarind). *Tectona grandis* with Mango Bark eating caterpillar *Indarbela quadrinotata* was dominant on both Sandal and Amla. Bark feeding termites were found on some sandal trees.
- **Model- 3:** At Kolar (*Tectona grandis*, *Terminalia arjuna*, *Dalbergia latifolia, Pterocarpus santalinus,* Eucalyptus, *Grevillea robusta* grown along with *Mangifera indica* (Mango), *Achras zapota* (Sapota), *Citrus maxima,* Pomergranate, *Citrus limonia* and guava) *Pterocarpus santalinus* was heavily infested by an unidentified membracid and unidentified weevils. *Tectona grandis* was infested by the teak defoliator and skeletonizer. *Dalbergia latifolia* was also heavily infested by unidentified weevils. Many *Grevillea robusta* showed severe infestation of termite and bark eating caterpillar *Indarbela quadrinotata. Tectona grandis, Psidium guajava* (Guava) was severely affected by white flies (*Aleurodicus dispersus*). The leaf gall wasp *Leptocybe invasa* was observed on the *Eucalyptus hybrid* trees.
- **Model-4 :** At Devanahalli, Teak with Mango and sapota. Termite infestation was severe on most of the trees of *Tectona grandis*.

Studies on hard substratum fauna in five major ports on the east coast of India

- Marine exposure trials at two major ports, i.e., Chennai and Tuticorin were initiated. Internal destruction of wooden test panels was assessed after splitting them open. Species of wood borers were identified. Voucher specimens were preserved for record.

2.5.1 Biological Control

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

Biological control of Eucalyptus Gall wasp, *Leptocybe invasa*

- Obervation recorded on gall wasp infestation in different plantations in Punjab such as on Road side plantation of Eucalyptus at Dasuya road, Hoshiarpur, At Satyal Nursery, Hoshiarpur Vegetative Multiplication Garden and Phillaur nursery.
- Eucalyptus twigs, containing parasitized galls with two species of parasitoids, *Quadrastichus mendeli* and *Megastigmus viggiani* were brought from NBAII, Bangalore and their multiplication carried out at FRI, Dehradun, for biological control of Eucalyptus gall wasps *Leptocybe invasa*.

Megastigmus viggiani

Biological control of Forest pests

Efficient isolates of bacteria, *Bacillus* spp. and the fungi, *Beauveria* sp. and *Metarhizium* sp., selected through laboratory bioassay studies were tested for field bioefficacy against the targetted insect pests, viz. *Atteva fabriciella, Eligma narcissus* and *Lymantria ampula* of Ailanthus and Casuarina.

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

Predatory Efficiency of *Stegodyphus Sarasinorum* Karsch (Arachnida: Araneae: Eresidae) against Insect Pests of Plants in the Forest- Nursery

- For the evaluation of predatory efficiency of the social spider, so far 25 mature colonies were reared in the laboratory as well as insectery of the Institute. Communal hunting and feeding as well as magnitude of prey-species were determined during this study.
- Experimental plots were set up in Nogli, near Rampur, district Shimla by taking approximately, 50 nos. nursery beds of oak, deodar and kail. New colonies were placed in and around beds on the bamboo poles. This was also observed that retaining hedges and shrubs around the nursery, encourage the establishment of spider colony when introduced, which would enhance trapping and killing of insect pest by this predatory social spider.

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

The study aimed to identify the more potential coccinellids in sandal dominated ecosystems of Karnataka revealed the presence of 25 coccinellids in selected provenances of sandal in Karnataka.

Feeding of *Cryptoplaemus montrouzieri* on *Nipaecoccus viridis* infesting sandal

Studies on the species diversity of whiteflies (Aleyrodidae: Homoptera) and their natural enemies in Mangrove habitats of India

Surveys were conducted in mangrove habitats of south India viz., Muthupet (Tamil Nadu), Vypeen Island (Kerala), Udupi, Karwar and Honnawar (Karnataka), Coringa (Andhra Pradesh) Chorao (Goa) and Thane (Maharashtra). The collected whiteflies were mounted and preserved. The host plants are being identified.

Development of Entomopathogenic Nematode based strategy for the management of termites and white grub pests of major forest tree species was carried out.

Biological control of teak leaf skeletonizer *Eutectona machaeralis*: studies clearly demonstrated the potentiality of egg parasitoid, *Trichogramma raoi*, as biocontrol agent for management of teak pest.

Damage assessment of gall making insect species of eucalypts and its management by pesticides

Developed insectary/nursery of eucalypts for experimental purpose to study the gall insect and its subsequent management at seedling stage. Results revealed that spraying of biopesticide and chemical pesticides on seedlings of eucalyptus effectively reduced the gall formation and increased the growth of seedlings, both in height and collar diameter.

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

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

Surveyed sal forest areas of Mandla and Dindori Forest Division of M.P. for monitoring of sal borer and collection of information on borer incidence. Prepared leaflet and brochure on, sal heartwood borer for distribution to front line staff of M.P. Forest Department.

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

The Greater waxmoth, *G. mellonella* was continuously cultured in laboratory, round the year for use as fictitious host for *in-vivo* culture of entomopathogenic nematodes. Determined optimum doses of native EPN populations against teak defoliator and skeletonizer. Experimented, innovative method of field application of EPNs and related parameters, affecting field applications. Pilot experiments carried out with individual and combination of EPNs with insecticides in field. Observations taken on other important related aspects, which can contribute to successful application of EPNs against defoliators, as a part of IPM programme. Further work is in progress.

Eco-friendly management of bark eating caterpillar, *Indarbela quadrinotata* on aonla (*Emblica officinalis*) in plantations was studied.

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

Surveyed nurseries / plantations and natural forests of teak, bamboo and aonla and collected eggs, nymphs and adults of *C. furcellata.* Carried out rearing of predator at different temperatures in laboratory. Observations recorded on predatory behaviour of *C. furcellata*

Studies on larval parasitoids, *Apanteles* spp. (Hymenoptera: Braconidae) of major defoliators of teak and sal forests of Odisha

Surveyed teak and sal forests of 106 localities belonging to 13 districts of Orissa (Angul, Bargarh,

Balangir, Boudh, Ganjam, Jharsuguda, Kalahandi, Koraput, Phulbani, Nawapara, Sambalpur, Sonepur, Sundargarh) for the collection of larvae and pupae of major defoliating insects. Collected 336 samples of larvae and pupae of teak and sal defoliators from field during their population outbreak. Identified 37 species of *Apanteles*, all *Apanteles* spp. are indigenous and these are being recorded for the first time from Odisha. Worked out natural field parasitisation of different species of *Apanteles*, parasitising the defoliators of teak and sal. Studied biology of *Apanteles machaeralis* on teak skletonizer, *E. machaeralis* and conducted laboratory tests of *Apanteles* species against target insect pests.

2.5.2 Seed Pests and its Management

Potential pathogens and insects responsible for the low seed production in Teak Seed Orchards (TSO) and their management

Microflora of teak (*Tectona grandis*) during inflorescence period were recorded from the Mandla and Jabalpur Forest Division during August 2012.The fungal flora recorded were *Absidia fusca, Alternaria alternata, Alternaria raphani, Ampulliferina fagi, Aspergillus flavus, A.fumigatus, A.niger, Cladosporium cladosporoides, Colletotrichum capsici, Curvularia lunata, Fusarium moniliformae, F.pallidoroseum, F.solani, F.oxysporum, Gliocladium deliquescens, Helminthosporium australiensis, Humicola grisea, Phialophora lagerbergii, Phoma glomerata, Rhizopus stolonifer, Rhizoctonia solani, Scytalidium sp., Septonema philippinum, Sporotrichum pruinosum, Sterile mycelium, Trichoderma koninghii* and *T. pseudokoninghii.* One field experiment, using biopestcides (*Bacillus thurengensis, B.amylolequifaciens*), insecticides (Monocotophos), Fungicide (Bavistin), Trace elements (Rallis tracel-2) and Growth hormone (Planofix) in different combinations was taken up.

Studies on seed insect pests of indigenous and exotic forest tree species and to develop IPM packages for major insect damages in Gujarat was carried out and suitable IPM packages developed for all known major pests.

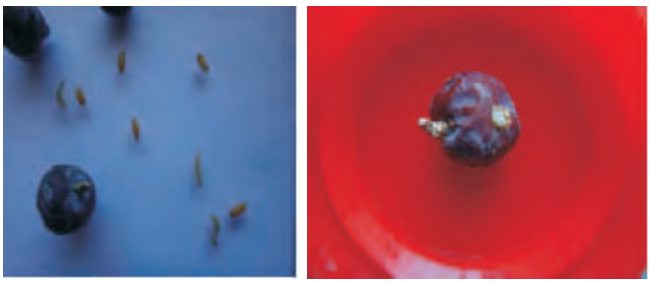
Regular surveys conducted during flowering, seed setting and monitoring during seed storage of eight fast growing species like *Ailanthus excelsa, Anthocephalus cadamba, Thespesia populnea, Melia dubia, Pongamia pinnata, Sapindus emaginatus* and *Gmelina arboria* resulted in identification of various species of insects infesting buds, flowers, maturing seeds and seeds during storage.

Integrated pest management methods, standardized for seed pests during seed storage including periodic monitoring, trapping and need based receptacle / seed treatment.

Biology and Management of Insect Pest of Seeds of *Juniperus polycarpos* C. Koch and Evaluation the Insect-pests Resistance Performance in the Nursery

The project has been initiated from April, 2012 and to accomplish the objectives under the project, field surveys were conducted to assess seasonal abundance and biology of pre and post-harvest insect-pests of berries and seeds of *Juniperus polycarpos*. The larvae are being monitored to study the complete biology and behavior of the insect and will be identified after emergence. To observe insect-pest incidences, the seeds were kept in different containers such as Cotton bag and airtight containers. Different concentrations of Neem based pesticides and safer chemicals were also applied to analyze the control of insect pests during storage. Nursery trials of healthy, infected and treated seeds are being established to study the impact of insect pests in developing nursery stock. Seeds were extracted from the Juniper berries collected from two sources of Lahaul and Kinnaur and the seeds,

thus, extracted were observed for the emergence of insect pests. Replications of treated Juniper Seeds have been kept under observation to study the impact of treatments. Field trial of treated seeds was established at Baragaon Model Nursery, Shimla and two similar trials will be initiated subsequently in the Field Research Stations located at Shill, Solan and Shillaru, Narkanda.



Larvae and pupae of infected Juniper berries

Lepidopteran Larvae, pupae and adult of infected Juniper berries

2.5.3 Integrated Pests and Disease Management

Assessment of insect pest problems of selected Bamboo species in Assam and their management

Field tours were undertaken to the SFD, JFM and homestead Bamboo plantations and nurseries of selected Bamboo species (*Bambusa tulda, B.nutans, B.balcooa* and *B.pallida*) to conduct the pest surveys in Assam. Recorded data on the incidence of insect pests in the selected bamboo species at regular intervals. Thirty four insect pests belonging to various orders have been recorded so far. Among the recorded pests, *Antonina* sp., *Psara licarsisalis, Crocidophora* sp., *Pyrausta coclesalis, Hexacentrus unicolor* and the aphid *Ceratovacuna silvestrii* were categorized as major pests. Field surveys conducted on natural enemies of the bamboo leaf rolling defoliator *P.coclesalis* resulted in detection of a species of pathogenic bacteria Bacillus sp. Two new hosts were recorded as the aphids *Ceratovacuna silvestrii, Myzus* sp. on *B. pallida* and *B.nutans*.

The efficacy of the native pathogenic bacteria *Bacillus* sp., isolated from the infected larvae of *P. coclesalis*, Neem oil, *Acorus calamus* rhizome powder methanol extract and the botanical pesticides *Adhatoda vasica* leaf aquous extract were evaluated against the key pests of Bamboo species and found effective in controlling the pests in both lab as well in field condition.

Predatory spider

P. coclesalis infected by *Bacillus* sp

Mealy bug attack on *Bambusa nutans*

Bamboo culm attacked by Termites

Studies on the incidence and management of culm rot and bamboo blight disease in Assam

Survey, carried out in different agroclimatic zones Assam revealed the highest disease percent of 55.26 in *Bambusa balcooa* in Bongaigaon district. The causal organism was identified as *Fusarium udum* Butler. Field experiment revealed Bavistine (0.1%) as the most effective fungicide against the disease.

Fungus associated with the diseased tree

Seeds with fungal infestation and unaffected seeds

Management of Insect-pest and Pathogens of Seeds of *Pinus gerardiana* Wall. in Storage

The project was aimed at developing management strategies for insect-pests and pathogens attacking the seeds of Chilgoza-pine by applying different methods in the laboratory conditions.

Regular data were recorded and during observations bio-pesticides and safe chemicals were used to test their impact in controlling the insect pests and pathogen attack. Heavy mite attack was also observed subsequently in the stored Chilgoza pine seeds even in controlled conditions. The data of seed damage were recorded.

The findings reflected the presence of seed borer during the month of July, which was, later, identified as *Cateremna tuberculosa* Meyrick and reported for the first time infesting the seeds of the Chilgoza pine. Due to its attack, upto 50 per cent of seeds were found damaged within a month and the borer attack was recorded in between the months of July and December. Different treatments were given to the seeds to test their efficacy against different insect-pests and diseases. Statistical analysis of the data on various treatments applied to stored Chilgoza seeds, revealed that the freezing treatments were very successful against insect pests attack since, there was no insect-pest attack in the seeds when stored at 0^0C and - 5^0C in all the stored conditions. Since, it is not feasible for a common farmer to store Chilgoza seeds in freezing conditions, it is, therefore, advised that they may use most suitable treatment for effective storage of Chilgoza seeds during the storage.

2.5.4 Bio Pesticides

The properties of modified products viz., solubility, surface tension, viscosity, foaming power, critical micelle concentration and alkalinity were assessed at 1-10% concentration. Viscosity of different dilutions varied from 1.19-47.7 MPa. The pesticidal activities, of products formulations were assessed against forest insect pest of *Tectona grandis* and *Albizia* spp. i.e. *Eutectona machealaris* and *Spirama retorta* and fungicidal activities, against *Fusarium oxysporum, Penicillium crysogenum, Alternaria alternate,Flavodon flavus, Ganoderma lucidum, Tramatis cingulated, Stachylidia* spp. *S. mukrossi* and *P. pinnata* surfactant formulations showed

Caryedon serratus attack on seeds of *A. nilotica*

Pupa of *Caryedon serratus*

5th instar larva of *Eligma narcissus* on *A. excelsa* leaves

Adult of *Eligma narcissus* on *A. excelsa* leaves

feeding deterrency, mortality and fungicidal activities.

2.5.5 Biological Control of Weeds

Based on the host range surveys at the field, two more insect species, viz. *Phycita* sp. and *Pachnephorus* sp. (a chrysomelid beetle) were prioritized and the cultures are maintained in the lab for further studies.

Feeding of a leaf webber larva, *Phycita* sp. on *A. nilotica*

Defoliation *A. nilotica* ssp. *indica* leaf by a chrysomelid beetle *Pachnephorus* sp.

Host specificity studies through no-choice method on live hosts were continued and completed for four prioritized insects (*Anomalococcus indicus, Isturgia disputeria, Dereodus denticollis, Physita* sp.) involving nine species of acacias and two other reported plant species of pepper and *Dilonix regia*.

Leaf rust on *A. nilotica* ssp. *indica*

Rust gall on *A. nilotica* ssp.*indica* fruit pod

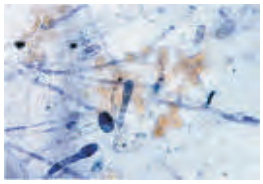
2.5.6 Botanical Fungicides and Pesticides

Phytochemical Examination of *Acacia albida*

Crude extracts of *Acacia albida* leaves and bark (Petroleum ether, Chloroform, Methanol, and ethyl acetate and butanol fractionated part of methnol extract) were screened for antifungal activity and it was found that extracts were effective against *Cylendrocladium quinqueseptatum, Aspergillus niger* and *Rhizoctonia solanii* at 0.5% concentration.

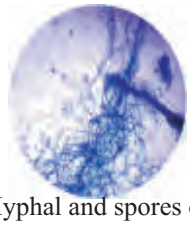
Powdery mildew disease symptom on *Ailanthus excelsa*

Pure culture of *Oidium* sp. isolated from powdery mildew on *Ailanthus excelsa*



Conidial spores of pathogen *Oidium* sp.

Root rot disease on *Melia dubia*



Hyphal and spores of *Sclerotium rolfsii* causing root-rot disease on *Melia dubia*

Conidial spores of *Fusarium oxysporum* causing root rot disease on *Melia dubia*

Biopesticide against papaya mealybug (DST)

Conducted extensive survey on mealy bug in teak agroforestry plantation, tapioca, eucalyptus, teak, casuarinas, *Ceiba pentandra,* ailanthus and *Thespesia populanis* plantations in Tanjore, Madurai, Dindugul and Viruthunagar, and papaya plantations and in other agriculture farms at Annadhasampalayam Sirumugai and Poondi hills and recorded the pest incidence and population pattern.

Contributory factor in the establishment of *Leptocybe* invasa (Fisher and aLaSalle) on Eucalyptus plantations in Tamilnadu (MoEF) was investigated.

Mealybug infestation in Papaya

Mealybug attack on teak

Swift of mealybug on Ailanthus

Extent of damage by mealybug on Casuarina

Evaluation of certain flora, based on ethno-botanical records for their pesticidal properties against important forestry insect pests

Ten plants have been short listed based on ethnobotanical records to identify their pesticidal properties against insect pests of forestry importance.

Studies on oil: chemical composition, antifeedant, insecticidal and antifungal activities of tree borne oil seeds

The selected Tree Borne Oil seeds (TBOs) were collected from the natural stands in Tamilnadu and Kerala. Seeds were processed and extracted oil fractions were tested for bioassays and chemical analysis. Antifungal activity of TBOs oils was tested against five fungal pathogens in comparison with fungicide and observed no antagonistic activity but found to have synergetic activity. New product Tree Pal (H) has been developed and released during the Tree Growers Mela 2013.

Tree Pal (H) oil based biopesticide developed and released to manage insect and disease attack

Studies on Essential Oils: Chemical constituents and toxicity assessment of the Leaf oil of *Lantana camara* from Tamil Nadu Regions

Essential oil was steam distilled from the leaves of *Lantana camara*, differing in flower colour (orange, pink, white pink, pink yellow, orange yellow) collected from different agro climatic zones. The bioefficacy of the bioactive compounds Aromadendrene and Caryophyllene identified from the essential oil of *L.camara* tested against *H.puera, Eligma narcissus* and *Atteva fabriciella*, showed significant larval mortality. Based on the significant insecticidal activity of the *L.camara* essential oil, against teak defoliators, developed preformulation. Developed preformulation, containing bioactive fractions, extracted from *Lantana camara*, *Hydnocarpus pentandra*, Neem, Pongamme were tested for its bioefficacy, against the defoliators of teak/ ailanthus, casuarina. A new product Tree Pal

(H) has been developed and released during the Tree Growers Mela 2013.

Biotransformation of some secondary metabolites by sporulate surface cultures of Frankia strains for nodulation capacity in *C. equisetifolia* and *C. junghuhniana* was carried out.

Studies on the impact of *Indarbela quadrinotata* on growth of *Casuarina equisetifolia*, factors influencing the pest infestation and developing eco-friendly management practices

Two plant based formulations developed were evaluated against the bark eating caterpillar, *Indarbela quadrinotata* in the Casuarina plantation, raised at Pitchavaram Forest Range, Cuddlaore Forest Division, Tamil Nadu.

2.6 Biodiesel

Production of synthetic biodiesel from wood wastes was investigated, using different wood wastes.

- The effect of microwave assisted heating and seed storage conditions on quality of *Pongamia pinnata* (L.) seed oil for cost effective production of biodiesel was studied
- The study on production of biodiesel from different acid value oil is under progress.

Refining of process for detoxification of Jatropha seed oil

A number of experiments were performed for developing a facile process for the removal of phorbol from *Jatropha curcas* oil.

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

A multilocational trial comprising 100 superior accessions of *Jatropha curcas,* received from DBT network partners was established in July-August 2010 at GRC Farm House, Sita Pahad, Jabalpur.

Fruiting in Jatropha plants

National Network on Integrated Development of Jatropha and Karanja

One hundred seventy five (175) Candidate Plus Trees (CPTs) of *Jatropha curcas* were selected from Jabalpur, Chhindwara, Seoni, Balaghat, Dindori, Mandla, Betul, Katni, Shahdol, Satna, Rewa, Panna, Gwalior, Shivpuri, Sagar, Damoh and Sheopur-Kala districts of Madhya Pradesh. CPTs were selected on the basis of seed yield, oil yield and germination percentage. Thirty six accessions in national trials and 14 accessions in zonal trial of Jatropha were established at Institute's campus, Jabalpur. Data on growth performance, seed yield and seed characters were recorded at regular intervals and oil estimation of the samples was done.

Field Evaluation of Superior Accessions of *Jatropha Curcas* L. Under Micro-Mission Programme in Himachal Pradesh

- Department of Biotechnology, New Delhi funded project under its micro-mission programme where field evaluations of superior accessions of *Jatropha curcas* L. are being carried out simultaneously in various parts of the country by the network partners and HFRI,

Shimla, is being one of them, executing this project in the state of Himachal Pradesh. Under this project, first multi-locational trial was established at Solag village of Bilaspur district, Himachal Pradesh in October 2008. The material for this trial *i.e.* rooted plants of ten accessions were brought from Bio-tech Park Lucknow (UP) and other partners. The experiments, thereafter, continued for studying the superior accession of *Jatropha curcus*.

- During the year 2012-13, maintained the trials and the realted observations pertaining to growth and survival data of field trials were recorded regularly. Compiled the progress of the project during February, 2013 and submitted the detailed report to Jatropha National Coordinator of DBT, New Delhi.

Half-sib Progeny Trial at Jwalaji, HP

2.7 Livelihood

Identification of extent of forest land in forest fringe villages and conductance of anthro-botanical as well as social survey in 230 rainfed districts.

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

Survey for identification of habitats of target species at Khuliya and Kandara MPCAs has been done. Collection of seeds of Kutki, Atish done from Kandara and Khuliya. Enrichment field trials of Atish (seed sowing), Kutki (seed sowing and rhizome cuttings) and Jatamansi (seedling transplantation) were laid out at identified sites at Kandara and Khuliya. Gap filling and weeding, in enrichment trials was also done. Data recorded on habitat types, frequency and density of target species from experimental sites.

Enrichment trails *Nardostachys jatamansi,* and *Picrrohiza kurroa* in MPCAs

National Study on Commercial Production of Non-Timber Forest Products for Ensuring Fair Economic Returns to Primary Collectors

The study aims at documenting the diversity and estimating production of various Non-Nationalized Commercial NTFPs in selected States of India and is sponsored by Ministry of Environment & Forests, Govt. of India. Under this programme, Household level primary data collection has been organized in states of Chhattisgarh, Gujarat, Himachal Pradesh, Jharkhand, Madhya Pradesh, Maharashtra, Orissa,

Data collection in Rajasthan

Phoenix leaves being traded in Jharkhand

Sabai grass traded in Jharkhand

Rajasthan, Uttarakhand and West Bengal. More than 80 NTFP species have been recorded to be collected by communities in the surveyed states. Data analysis is in progress

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

The project was initiated during February 2013 in Kathagiri taluk for further detailed study pertaining to documentation of traditional and indigenous knowledge, socio-economic status of the villages and propagation of RET medicinal plants/ NTFPs.

Empowering Tribal Community through Lac Cultivation in Madhya Pradesh

To revive the lac cultivation in the villages of Jabalpur, through training and demonstration, for additional income generation of the villagers/ farmers and for the sustainable production of lac on conventional host (*S.oleosa, B.monosperma* and *Z.mauritiana*) as well as non-conventional host (*Flemingia species*) in the selected ten villages, interacted and explained the objective of the Project to the villagers of Narai-Sohad, Bahmnoda and Ranipur village and sensitized them towards lac cultivation.

Productivity enhancement of Kair (*Capparis decidua*) to generate livelihood in rural area of 'Thar Desert"

- This project was sanctioned in March 2013 for three years. Fruits of *C. decidua* are valuable products which yield supplementary income to the rural people. Project aims to develop technology for fruit yield enhancement of Kair.
- Kair has the ability to survive in various habitats under extreme condition of temperature of arid region. Preliminary survey was undertaken in Khari Khurd Jode, Forest Range Luni, Grass Jode A, Hariyada in Bilada and Panchayat land at Joliyadi phanta near Bambore, Jodhpur for site selection, at Khari Khurd Jode Forest Range Luni and Grass Jode A, Hariyada in Bilada.

Studies on edible shoot production potential of selected indigenous and introduced bamboos in Jharkhand and enhancement of production period through cultural practices

A total of 225 villages and 93 markets in Jharkhand have been covered during field survey and information on quantity of edible shoot consumed by villagers, species used, persons engaged in collection, self bamboo utilization, quantity marketed, persons involved in shoot trade, average quantity sold and earnings etc. have been collected. Conducted field trials with *Bambusa nutans, Dendrocalamus asper* and *D. strictus* in

order to enhance duration of shoot season and shoot yield by improving soil health through soil working, mulching, irrigation and organic and inorganic amendments and also through clump management. Effect of shoot removal at different intensities have also been studied on quality and quantity of edible shoot production and on the general health of the clumps of the said species so as to standardize shoot extraction method.

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

The field experiment conducted for nutrient effect on lac is being conducted. Brood lac, inoculated in July 2012 had been harvested in the month of February, the observations on predation, parasitisation and nutrient effect has been recorded. The growth data of plant have been completed, weeding and irrigation and other management practices are carried out as per the requirement.

Quality and yield improvement in agroforestry based food products under integrated nutrient management

Quality and yield improvement of Rabi (Lady's finger, Cucumber) and Kharif (Spinach, Cabbage) crops under agro forestry trial were studied by applying different concentration of Iodine and Iodate (KI and KIO3) in the soil and foliar. Iodine with integrated nutrient management is also tried in different rainfall zones of Assam. This study revealed that although there is no direct evidence on the essentiality of iodine to plant growth, low concentration is beneficial for uptake of plant, whereas, high concentration is detrimental for plant growth. Different plant species responded differently in iodine uptake. Iodine applied as iodate had a significant effect over the biomass production and uptake of leafy vegetables like spinach and cabbage. Soil application was found

Iodine application in spinach and cabbage

better than foliar application. Moreover, iodine application in soil with integrated nutrient management increased the yield and also the iodine content significantly in spinach followed by cabbage, lady's finger and cucumber respectively.

Identification of Extent of Forest lands in Forest Fringe Villages, Funded by NRAA, Govt. of India

NRAA funded project for the North Eastern states was initiated at RFRI in the month of October, 2011. The project aims to identify forest fringe villages with the aim of Socio-economic survey and ecological studies in North-Eastern region, except Sikkim. During this year, twelve districts have been completed with socio-economic information and vegetation sampling of fringe forest, which includes Manipur, Mizoram, Tripura, Assam and

Ecological sampling and Socio-economic survey in Darang (Assam)

Socio-economic survey in Agartala (Tripura) and soil sampling in Sibsagar (Assam)

Nagaland. Data collected from field were entered on NRAA portal, developed by Forest Research Institute.

Extension strategy to "Improvement of degraded shifting cultivation lands through introduction of *Thysanolaena maxima* (Broom grass) along with *Cajanas cajan* as N_2 fixing plant" Under "Direct To Consumer" scheme of ICFRE

Survey was conducted for identifying the areas and selection of various villages of Assam and Meghalaya. PRA exercise was carry out to evaluate the problems and prospects of Broom grass cultivation in the selected villages. Strength, weaknesses, opportunities and threats (SWOT) were explored regarding existing practices of broom grass cultivation during the interactive session with farmers, villagers and elderly people. The team built a good rapport with the target groups and willing farmers were identified to participate in the extension activity.

PRA exercise and SWOT analysis in Karbi Anglong, Assam

Broom grass plantation in Dawki, Meghalaya

Calculating economics of broom grass

Rehabilitation of jhum land through potential bamboo species with reference to carbon sequestration and livelihood development

- Progressive growth data of 22 months old *Bambusa balcooa, Bambusa nutans* and *Bambusa tulda* raised from both the rhizome and seedling showed maximum length and GBH in *B. balcooa* followed by *B. tulda* and *B. nutans* in both the experimental plot studied.
- Analysis of plant carbon has been carried out by collecting plant samples of *B. balcooa, B. tulda* and *B. nutans* from experimental plot at regular intervals. Percentage of organic carbon was recorded higher in *B. balcooa* followed by *B. tulda* and *B. nutans*.

Preparing bundle of broodlac

Bundles of broodlac ready for inoculation

Inoculation of broodlac on new host kusum trees