CHAPTER-II

FOREST RESEARCH INSTITUTE
DEHRA DUN

Established in 1906, the Forest Research Institute, Dehra Dun is one of the oldest institutions of its kind and acclaimed the world over. Institute's history is a chronicle of evolution and development of scientific forestry not only in India, but over the entire Indian sub-continent.

The Institute caters, in particular, to the research needs of the Indo-Gangetic plains of Punjab, Haryana, Chandigarh and Uttar Pradesh, as well as the U.P. Himalayas. This Institute is also a Deemed University and presently offers post-graduate courses in forestry (economics and management), wood science and technology; post-graduate diploma courses in plantation technology, pulp and paper technology; and doctoral programmes on various forestry aspects.

During 1996-97, the main activities of FRI are described below :

BOTANY

With a view to conserving the rare and endangered plants, floristic surveys in diversity rich tracts of U.P. Himalayas were carried out to assess the status of taxa, namely, *Calanthe, Dendrobium, Leucomeris spectabilis, Pseudodanthonia himalaica, Indigofera retusa* var. *mussooriensis, Hovenia acerba* and *Aechmanthera gossipifolia*. Field observations to assess genetic variabilities were made on morphology, phenology and ecology of indigenous poplar (*Populus ciliata*) growing in U.P. Himalayas. Propagation of rare and spectacular orchids such as *Paphiopedilum, Phaius, Arundina* and *Dendrobium* was successfully carried out. Enumeration of 100 rare species of ethnobiological importance and conservation value, typical of Indian Himalayas and North-east region, was completed.

The work on "Indian Softwoods -with notes on properties and uses" has been published as a book. Anatomical studies have been completed for 75 genera and 200 species belonging to 21 families in connection with writing up of the book "Indian Woods - their structure, properties and uses Vol.I" (Revision work). Manscript is under finalization. Identification of over 1500 wood samples received from various Govt. and Private organisations was carried out including vigilance, CBI and Police Departments.

Clonal material of *Dalbergia sissoo* collected was multiplied and seedlings were raised for progeny testing. Clonal seed orchards have been established at Lachiwala (U.P.) and Poanta Sahib (Himachal Pradesh). Seedlings of 60 provenances have been sown at five locations and data on height, collar diameter, and survival percentage of Clones is being recorded.

CELLULOSE AND PAPER

Oxygen bleaching

In order to reduce the environmental pollution, researches were carried out to replace the conventional bleaching sequence involving chlorinations, alkali extraction/ hypochlorination etc. by much environmental friendly bleaching sequences using molecular

oxygen followed by partial or complete elimination of elemental chlorine by the use of chlorine dioxide/hydrogen peroxide/hypochlorite. Kraft pulps of 20 and 40 kappa number (degree of delignification) of *Eucalyptus tereticornis* and *Anthocephalus indicus* were prepared after a series of experiments.

All the pulps were subjected to physico-chemical analysis viz, solubilities, kappa number, holocellulose, pentosans etc. and strength properties determination. Evaluation of pulps obtained under optimum conditions and their bleaching is in progress.

Bagasse soda pulp (kappa number 40) and mechano-chemical pulp (kappa number 101 and 83.4) were prepared and treated with oxygen 8.00 kg/cm^2 pressure, 90^{o}C for one hour using 2.00% alkali. Kappa number of pulps was reduced by 5 to 7 points. These oxygen pretreated pulps were bleached with hypochlorite in two stages alongwith control sample. Gain in brightness by 6-8 point was observed in case of oxygen pretreated pulps at the cost of marginal drop in bleached pulp yield.

Recycling of waste paper

Laboratory scale deinking experiments on mixed waste were carried out using various combinations of NaOH, Na_2CO_3, sodium silicate, sodium salt of benzen sulphonic acid and detergent. Deinked pulp possessing optimum properties was bleached with calcium hypochlorite and hydrogen peroxide alone and also in combinations. It was concluded that hypochlorite bleaching was more suitable for computer waste (brightness, ISO 71.5%) and office waste (brightness ISO 72.09%) while hydorgen peroxide bleaching yielded better pulp from magazine grade paper (brightness 61.94% ISO) and newsprint (brightness 52.20% ISO).

Improved utilisation of fibrous raw material

Cold soda pulp from *Populus deltoides* was treated with oxygen (8 kg/cm^2 pressure) in presence of alkali at 130^{o}C, 8% consistency for one hour with and without additive. It was observed that the pulp yield decreased with increase in alkali dosage whereas gain in pulp yield was observed on addition of additive. The pulp is under evaluation.

Utilisation of alkali spent pulping liquor lignin-Production of polyol and polyurethane

Conditions were optimised to produce polyol by copolymerisation of lignin with maleic anhydride, saponification and oxyalkylation with propylene oxide. As a result of optimised conditions, the production of polyol in large scale is in progress.

Production of corrugating media from *Populus deltoides*

Neutral sulphite semi-chemical (NSSC) pulp was prepared using different concentration of sodium sulphite and sodium carbonate. It was concluded that *P. deltoides* could be used for production of corrugating medium using NSSC pulping process.

Rayon grade pulp from *Populus deltoides*

Rayon grade pulp was prepared from *P. deltoides* adopting prehydrolysis kraft pulping process followed by multistage (chlorination/alkali extraction/hypochlorite/ chlorine dioxide) bleaching sequence.

Biotechnological modification of *Dendrocalamus strictus* fibres

Physico-chemical analysis of control and artifically decayed chips by a white rot fungi, *Coriolus versicular* revealed that in the initial period of decay, the crystallinity and

degree of polymerisation of cellulose remain almost unaffected but accessible amorphous cellulose is more prone to degradation/metabolisation. Decayed sample yielded more pulp as compared to control sample which compensated for the material lost during inoculation. Brightness and bonding properties of unbleached chemical pulp were superior to that of control. Bleaching response of fungal pretreated sample was better than the control.

CHEMISTRY

Chemical investigations were carried out on non-wood forest products with the follwing objectives:

(i) Substituting over exploited non-wood forest products with readily available non-forest based material.

(ii) Optimum utilisation of abundantly available non-wood forest products, and

(iii) Development of products required by forest based industries.

Experiments carried out at Satia Paper Mills, Muktsar revealed that modified *Cassia tora* gum (CTG) improved the strength of the paper as well as removed the suspended solid (99.6%) from the back water. Gum ghatti (*Anogeisus latifolia*) was autoclaved from 100 to 170°C under pressure to see its melting behaviour and reshaping characteristics. Both the results were demonstrated to the sponsor of the project. Twelve samples of adhesives (code C1 to C12) were prepared by grafting formaldehyde and melamine on to guar gum and starch. Tackiness, adhesiveness and film formation were observed. Shelf life of adhesives samples were not enough. Wax isolated from the pine needles, was hydrolysed to get the w-hydroxy acids. Macrocyclic lactones were prepared from hydroxy acids using p-Toluence Sulphonic Acid (PTS). Dyeing trials with aqueous and alkaline extracts from the pine needles, *Jatropha* (bark and leaves), *Populus deltoides* (bark), teak leaves, silver oak, *Lantana* and *Parthenium* leaves were done. Dyeing trials with *Eucalyptus* saw dust and Bakain on different fabrics was done. Seventy silk scarfs were dyed in different shades. Different types of fabrics were dyed for a private party who was interested in natural dyes. *Cephalotaxus griffithii* needles were extracted with different solvents.

Extensive literature survey has been carried out on *Jatropha curcas* seed oil. After removal of the toxic constituents from the oil, preliminary toxicity evaluation report has revealed that the oil was non-toxic.

FOREST PRODUCTS

Wood seasoning

Preminary drying trials carried out recently on 40 mm thick planks of plantation grown *Eucalyputs* hybrid using vacuum press drying kiln have shown very encouraging results. It is found that the timber could be dried in short time of 96-100 hrs with much lower degrade levels than with conventional drying where it takes nearly 25-28 days. Almost all the planks thus dried were free from warp. The total energy consumption per kg of removed water in vacuum drying is about half in comparation to conventional kiln drying. This drying system is also pollution free though the initial costs are higher.

A full kiln load of 75 mm thick champ wood planks were dried in a recently developed desiccant based dehumidification kiln. Its performance was compared with conventional steam heated kiln. Drying time saving to the tune of 15-20% and energy saving of atleast 20-25% could be achieved in comparision to conventional steam heated kiln drying.

Bending behaviour of two new timber species namely *Mehcelia champaca* and *Terminalia myrocarpa* at different radii of curvature after temporary plasticization with vapour phase ammonia treatment was studied. The optimum treatment time at 5 kg/cm^2 pressure for 12 mm and 25 mm thick samples was worked out.

Wood preservation

Termite resistance tests on semul samples treated to different retentions with lindane & chloropyriphos 20 EC for two successive termite seasons were completed. Both the chemicals were found effective. Threshold values are being calculated.

Samples of *E.* hybrid heartwood were treated in ACA - Ammoniacal copper arsenate formulation and ACZA- Ammoniacal copper zinc arsenate formulation. Analysis of copper, arsenic is complete and that of zinc is in progress. Experiments were conducted for termination of treatment sehedule by application of additional vacuum for 1/2 hr. in the treatment chamber.

Composite wood

Work on improving the quality of medium density fibre (MDF) boards made from *Eucalyptus* hybrid was continued. Pulp was prepared using different alkali concentration in cooking wood chips as well as by keeping chips in 10% alkali for 24 hrs. MDF boards were prepared using Phenol Formaldehyde (PF) adhesive with different percentage of wax emulsion. Boards prepared using 10% PF resin (50% solid content basis) with 2% wax emulsion have almost all the properties as per IS Specification. However, some properties i.e. water absorption after 24 hrs and % swelling in thickness are higher.

Veneered particle board were prepared from bark of *Populus deltoides* as core and toon (*Toona ciliata*) veneers as face and back veneers using varying amount (6% to 14%) of PF resin. These were tested for various physical and mechanical properties.

Experiments were conducted to develop methods for increasing the durability of plywood made from *Populus deltoides* through glue line treatment. Control and preservative treated 3-ply plywood was prepared using 0.8 mm, 1.6 mm and 3.2 mm thick veneers of *Populus deltoides* and PF resin mixed with 1%, 2% and 3% chloropyrifos and 2%, 4% and 6% arsenic trioxide each separately.

Wood working and finishing

Working, finishing, and assembly line trials were conducted on *Acacia nilotica* (babul) to find its suitability for furniture items. Its was observed that this species is useful for this purpose and fumed furniture items give antique look with rose wood hue. It was also observed that mild soaking of eucalyputs planks in urea solution (40%) results about 60% energy saving in planing operation which is a major wood working operation in furniture and joinery making. Studies were initiated on developing *Eucalyptus* laminated wood with a view to utilizing waste wood.

Timber mechanics

Testing of *Melia azedarach* in green and dry condition, and bamboo in green condition was completed. Studies on effect of knots on Chir, Kail and Deodar were completed. Studies on creep behaviour of *Populus deltoides* were continued. Static and dynamic modulus of elasticity of *Pinus roxburghii, Populus deltoides* and *Mangifera indica* were determined. Material of 20 clones of *Populus deltoides, Paulownia fortunei* and plantation grown *Tectona grandis* for evaluation of physical and mechanical properties was procured and taken up for test. Steps

Plantation of *Acacia auriculiformis* on overburden dumps of iron mines

Eucalyptus furniture being fumed in ammonia fumigation chamber

Patch mortality in sal, Barkot range of
Dehra Dun Forest Division

Excavated mine benches in iron ore mines

were taken for software development and computerisation of physical and mechanical properties data.

Timber engineering

For development of solid wood construction, *Eucalyptus* columns were fabricated and erected by application of different jointing techniques. Also, 4 m span trusses with bamboo and *Eucalyptus* poles were designed, constructed and tested confirmining their suitability for constructing cost effective houses. Bamboo and eucalyptus poles are being tested further in construction of 6 m span trusses and robust bamboo bundle column.

ECOLOGY AND ENVIRONMENT

Regeneration and mortality in Sal Forests of U.P.

An extensive survey in Dehra Dun, Lansdowne and Ramnagar Forest Division was carried out during the year in connection with the regeneration and mortality studies in Sal Forests of U.P. Whatever may be the cause of mortality, it has been observed that all these sites have capability to regenerate. It has been established that *Mallotus phillippensis* in Barkot, Laldhang and Kothari areas and *Miliusa velutina* at Musabangar are taking benefit of the disturbed nutrient cycling whereas at Bhakra, because of excessive moisture, the site is being invaded by *Ehretia laevis*.

Regeneration studies have been initiated in Ramnagar Forest Division. Preliminary observation of regeneration study at Fatepur range of Bhakra block shows *Miliusa* reverse `J` shape curuve with 30% seedlings and 23% sapling. However the percent frequency of other age groups is almost constant.

Canopy openings of sal forest created long back in Musabangar Block of Ram Nagar Forest Division led to invasion by *Meliusa velutina*. But at present, the total absence of seedlings and inadequate representation of saplings indicate that this species is giving way to other associates of sal.

Reclamation and ecological monitoring of mined areas

Reconnaissance survey of eastern sector Iron Ore Mines of SAIL in Saranda-Bonai forest range was done around Gua, Chiria, Kiriburu-Meghahtuburu, Bolani, Barsua, Kalta mines. A rapid ecological appraisal was made on the basis of types of land degradation due to mining, identification of areas under each type and areas available for restoration.

Identification of plant species in forest areas around mine with 1-5 year old O.B. (over burdened) dumps, 15-20 year old O.B. dumps, and dumps under plantations was done. Species suitable for ecorestoration and species of ethnobotanical importance were also identified.

FOREST ENTOMOLOGY

Monitoring and surveillance of the insect pest

Monitoring of the insect pest activity, pest population and their distribution, conducting field surveys, record of incidence and extent of damage of insect pests in nurseries and plantations of agroforestry tree species was taken up. During the period under report, 11 insect pest of major, and 117 of minor forestry importance were recorded. 41 insect species represent casual feeders. Surveys were conducted at different locations in U.P., Haryana, Punjab and H.P.

Plantation pests

Detailed studies were conducted in laboratory and field conditions on the key pests of poplar, shisham and bamboos (agroforestry species). Population dynamics, and seasonal histories of shisham defoliators *Plecoptera reflexa* and *Dichomeris eridantis*; and poplar defoliator *Clostera cupreata* were studied in detail at Haldwani, Yamunanagar and Dehra Dun. Damage to shisham was also found due to foliage feeding beetles *Apoderus, Mycllocerus* and *Aulacophora* species during field studies, surveys etc.

Pests of natural forests

In sal forests, the studies on sal heartwood borer *Hoplocerambhyx spinicornis* were continued in detail at various places in U.P. Experiments were laid out for monitoring and evaluation of the borer population (*Haplocerambyx spinicornis*) in borer infested sal forest in Thano Range, Phanduwala (Comptt. No. 5,6, 7,8,9,10), Dehra Dun Forest Divsion, Comptt. No. 10,12,23,24,25, 26, in Ram Nagar and Forest Division in Rajaji National Park, Dehra Dun. Trap Tree operation was carried out during the previous years, bringing down the borer population to 6% at Thano and 9% at Phanduwala sal forest. Recently, the incidence was found increased from 9% to 12% at Phanduwala and from 6% to 10% at Thano (Dehra Dun Div.) due to discontinuance of the trap tree operation, showing built up in borer population. It requires to be further investigated by felling the badly infested dead and dying trees and restarting trap tree operation.

Timber entomology

Natural resistance of various timbers and bamboos against test termite *Microcerotermes beesoni* was assessed.

Test blocks of *Bambusa vulgaris* treated with different concentrations (0.2%, 0.5% and 1.0%) of ZnCl2, BaCO3, Phenylhydrazine, Boric acid, P-Nitrophenyl hydrazine and Diesel oil were exposed to termite *Microcerotermes beesoni* Snyder. The test blocks treated with 1.0% BaCO3. (wt. loss 67.4%), 0.5% Boric acid (wt. loss 29.5%), 0.5% Phenylhydrazine (wt. loss 37.7%) and 50% Diesel oil (wt. loss 67.4%) were found comparatively more resistant than untreated and treated with lower concentrations blocks. Test blocks of *Mangifera indica* and *Bambusa vulgaris* treated with insecticide Confidor 200 S.L. (Bayer's India product) were found highly promising as no damage has been recorded even at 0.1% concentration level. Further studies are in progress.

Seed entomology

Assessment of damage due to seed insect was carried out in coniferous and broad leaved tree species in hills (Dehra Dun, Kanasar, Chakrata, Deoban, Shimla) and in plain areas (Gonda, Gorakhpur, Dehra Dun) in the state of U.P. and H.P. Studies have been conducted on ecology of the major seed pest infesting the inflorescence and seeds, cone etc. in seed production areas, seed orchards and seed stands. Control experiements were laid out to protect the seed from insect attack to get healthy planting stock. Survey and collection of insect infested cones, seeds, and pods of various tree species in different locations were carried out. The insect species responsible for the damage and their incidence of attack were recorded.

Biological control studies

The biological control research work has been carried out by making use of natural parasites and predators against key pests of poplar (*Clostera cupreata*) and shisham (*Plecoptera reflexa* and *Dichomeris eridentis*) as an alternative to insecticides. In case of

poplar defoliator *Clostera cupreata*, two egg parasitoids *Telenomus* sp. and *Trichogramma* sp. on eggs of *Clostera*, and two larval parasitoids are found effective in parasitising in the infesting stages. The larval parasite was identified as *Aleoides* sp. Among predators, a pentatomid polyphagous predatory bug *Canthecona furcellata* and preying mentis were found preying upon the larvae of the defoliator. The parasitisation and predation potential were studied along with studies on the biology and life history of such promising biocontrol agents. Experiement were laid out to study the alternate food plants/food preference of these defoliators. Bioecological progression, seasonal history, and population dynamics of the defoliators and their natural enemies were studied throughout the period under report. Thus, biocontrol of defoliators of shisham (*Plecoptera reflexa* and *Dichomeris eridentis*), and the biology, ecology, population dynamics of the pest were investigated in detail. The natural enemies comprising *Paralitomastex varicornis*, *Apantales* sp., *Brachymeria* sp. were found effective in reducing the population of shisham defoliators. As regards predatory insects, *Hierodula* was found preying upon the larvae (*Plecoptera*) of the pest. The predation and prasitisations potential is under study.

FOREST SOIL AND LAND RECLAMATION

Studies on geology, geomorphology and micromorphology were conducted in Haryana and Uttar Pradesh. Micromorphological studies revealed that parallel orientation of particles, deposition of humus in the matrix and plugging of voids resulted in perched water at calcium rich horizon. The studies further indicate that salt build up in the soil profile of these areas may be due to salt rich parent material. The research data have been compiled, tabulated and presented in the form of a project report.

Provenance trials on *Dalbergia sissoo*, *Azadirachta indica*, *Prosopis cineraria* and *Acacia nilotica* are being conducted in sodic soils of Sultanpur district (Uttar Pradesh). The observations indicate that *A. nilotica* of Dhaund (Maharashtra) showed greater survival and growth rate followed by those of Solapur and Sangli (Maharashtra). *A. indica* from Karnal (Haryana) showed faster growth and *P. cineraria* of Ajmer (Rajasthan) region proved superior to other provenances for this set of soil and climatic conditions. The provenances of *D. sissoo* from Nautanva and Chapra region followed by that of Kanpur region of U.P. were more promising.

Studies on technology for improvement of land based biomass productivity for different social forestry plantation patterns reveal no significant influence of land use variations on the soil pH. Soil enrichment for organic matter was greater under agroforestry and natural fallow compared with agriculture farming and fruit tree farming. Soil P was more under fruit tree farming, farming and agroforestry than under natural fallow. Soil K was more under farming, fruit tree farming and agroforestry than under natural fallow.

GENETICS AND TREE PROPAGATION

Micropropagation offers high potential for rapid clonal multiplication. Keeping this in view, efforts are on for clonal multiplication of selected plus clones of *Eucalyptus*, Chirpine and Shisham. In the process, explant material was collected from mature, identified trees and *in vitro* rejuvenation was tried. Large scale shoot multiplication was achieved through enhanced axilary bud proliferation in *Eucalyptus*. Similar success was obtained in case of Shisham, *Paulownia* and *Dendrocalamus asper* (edible bamboo). Attempts were also made to rejuvenate the mature material of chir pine.

For clonal propagation of *Eucalyptus*, experiments were conducted on hormone specificity, effect of substrates on rooting behaviour, effect of prunning at different hight etc. The results have been analysed and it was observed that Indole Buteric acid - IBA & Naphthal acetic acid - NAA have profound effect on rooting. Soil mixture has substantial effect on rooting. Coppices are profuse when prunning is done at lower most level.

Progeny trials of *Dalbergia sissoo* were continued. *Ex-situ* gene conservation bank of *Azadirachta indica* raised in different locations viz; New Forest, Gaindikhata, and Kalsiya were maintained. Observations were made on various parameters in progeny trial of *Dalbergia sissoo* at New Forest. Some of the provenances were found to be promising in regard of straight bole which is one of the most desired trait for the species. Progenies of different provenances of *Dalbergia sissoo* were raised at J&K, Hoshiyarpur (Punjab) and Chichrauli to establish field trials in these states. Necessary designs were prepared and supplied to respective states for laying out trials. Screening of 20 provenances of *Acacia nilotica* for radio-sensitivity to delineate the provenances using this technique was completed.

Chirpine provenance trials at Lacchiwala and New Forest are under evaluation for early cone production. At new Forest, one tree was observed bearing female cones at the age of 15 years. These cones were used in developing *in vitro* technique via embryogenesis.

NON-WOOD FOREST PRODUCTS

Cultivation and exploitation of medicinal and aromatic plants

Preliminary studies on cultivation of *Valeriana wallichii* and *Digitalis purpurea* (which are basically found in the temperate Himalayas) conducted at Dehra Dun, revealed that *Valeriana wallichii* is quite successful in slopy land under shady condition with proper irrigation facility. This species grows throughout the year and remains evergreen, under Dehra Dun conditions whereas in temperate areas this species remains leafless and dormant during winter. As regards *Digitalis purpurea*, when planted in September, it flowered and fruited well in March-April and seeds could be collected in the last week of May, but plants failed to survive during August - September due to excess rain or water logged condition. Further trial on cultivation is under progress.

Survey of natural distribution of *Taxus baccata*, *Picrorrhiza kurroa* and *Nardostachys jatamansi* species in the Garhwal Himalayas of U.P. hills was undertaken under IDRC project. Four provenances of *T. baccata*, *P. kurroa* and *N. jatamansi* were collected and established at Chakrata Nursery. Propogation trials on *T. baccata* by vegetative shoot cuttings were initiated using various phytohormones.

Resin tapping

Tapping of Chirpine trees by rill method in the Champion block, New Forest to identify high yielders was initiated in 1995. The results revealed that trees of Lansdowne origin are the highest resin yielder (4.11 kg/season) and of Darjeeling origin are the poorest (2.42 kg/season). A comparative study to assess the resin yield by using 20 % acid mixture and Ethiphon revealed that 20 % mixture is superior to Ethiphon.

Fibres

Market studies were conducted in number of cities and fairs to assess the actual demand of raw fibre articles and to evaluate the prospects of supplementary substitute fibres of forest

origin. Result were encouraging which indicated a great potential of substitute fibers in rural economy.

FOREST PATHOLOGY

Research in Forest Pathology is aimed at growing trees free from diseases and thereby increase forest productivity. Priority areas of research in Forest Pathology include (i) Seed Pathology (ii) nursery and plantation diseases and their management (iii) application of biofertilizers to produce quality seedling and (iv) Edible mushroom cultivation. An account of research carried out and achievements made during the year is given below:

Seed pathology

Seed borne fungi of *Eucalyptus, Albizia lebbek* and bamboos were studied to find out the extent of fungal contamination of seeds and impact of fungicidal treatment on seed mycoflora. Seed treatment with Emisan proved most effective followed by Thiram in controlling seed mycoflora of bamboo and *A. lebbek*. Based on the above findings, recommendations were made to the effect that seed dressing with fungicide @ 2-4g/kg seed be practised to control seed mycoflora as it is economical, easy, and effective.

Nursery diseases

High incidence of Bipolaris leaf blight was recorded in G-3 clone of *Polulus deltoides* at New Forest, Dehra Dun. Infected plants were defoliated to the extent of 40-80% which adversely affected plant growth. It was found that Bayleton (0.08%) was effective in checking the growth of the fungus. *Maravalia achroa*. The leaf and twig rust of sissoo was found highly destructive during April and high incidence of the rust during 1996 was correlated with relatively low temperature, high humidity and shading. The disease was effectively controlled by the application of Bayleton (0.08%). Application of deoiled neem cake @ 10 g per polypot in Lacchiwala nursery caused appreciable improvement in growth of *Acacia catechu* seedlings with concomitant reduction in nematode population in the soil.

Plantation diseases

Pink disease caused by *Corticium salmonicolor* was recorded in trial plantations of different clones of *Populus deltoides* and *P. x euramericana* at New Forest, Dehra Dun. An assessment of heart rot in a 20 yr old khair plantation at Kishanpur, Hardwar showed 30% incidence and the affected trees showed multiple infection as evident from sporophores of *Phellinus badius* developed on the stem at different heights.

Biofertilizers

New VAM technology was developed which requires use of 25-30g of VAM inoculum per seedling as against 200g used earlier. The impact of VAM inoculation on the growth of *Acacia catechu* seedlings was studied and it was found that inoculated seedlings showed appreciable increase in growth as compared to uninoculated ones. Substantial economy in VAM inoculum for fortification of containerised seedlings is a step forward towards taking the VAM technology from laboratory to land.

Mushroom cultivation

Shiitake, the Japanese Mushroom, was cultivated on saw dust logs under controlled conditions.

RESOURCE SURVEY AND MANAGEMENT

Forest Productivity

Study on biomass and its distribution among various tree components at 9, 11 and 13 years of age was undertaken in *Dalbergia sissoo* plantation raised in Hastinapur Forest Division of Uttar Pradesh. The total standing biomass in these plantations ranges from 49003 Kg/ha to 115622 Kg/ha. It has been observed from the study that the percentage increase in bole is from 39.4 to 61.9 percent between the age of 9 to 13 years, whereas in case of other components (branch, leaf and twig) there is a decrease except in bark where it varies between 7 and 11.5 percent. Linear regression analysis was also carried out. Among the predictor variables (D^2H,DBH,D^2) tried, DBH alone was found to be the best fit as reasonably precise value of biomass can be obtained with this variable. Litter studies were conducted in teak plantations raised in central Tarai Haldwani Forest Division with periodic litter collection. The annual litter production in different plantations is given in the following table:

Litter production in teak plantations

Age	No. of trees/ha	Leaf litter Kg/ha	Twig litter Kg/ha
11	956	2616	777
13	670	2567	531
23	538	2421	759
28	567	3075	865
30	544	2954	1114
32	500	1724	877
39	600	3330	1034

Forest economics

Market intelligence in respects of 14 tree species from 10 selected markets was collected. The collected intelligence was compiled and published as monthly "Market prices of forest products". The monthly price bulletins were finally sent to all state forest departments, forest corporations, district panchayat officers of U.P., Haryana and Punjab, newspapers, N.G.Os, timber traders and institutes of ICFRE.

Forest mensuration

Volume tables of *Prosopis juliflora* have been compiled for regional application. The volume tables are based on data collected from Kurukshetra, Aligarh, Agra, Mathura and Meerut Divisions by laying out temporary sample plots of different spacing and age in compact and road side plantations. Single tree data of 106 trees were collected from ground level to the top diameter limit of 5 cms. (over bark). Equations for the stem content and total wood over bark and under bark were developed.

SILVICULTURE

Study was initiated on the productivity of Teak plantations with high inputs. The plantations of Teak have been raised by the various private companies of India with public equity. These companies have invited large public investments on Teak farming by projecting the future yield from their plantations. In this connection, the Government has constituted a committee to study the economics of commercial plantations undertaken by the companies. The draft report of the committee has been prepared for submission to Govt. of India.

Studies were carried out to see the effect of growth promoting hormones on sympodial bamboos through binodal/single nodal culm cuttings. Vegetative propagation techniques for ornamental bamboos such as *Bambusa vulgaris* forma *waminii* , *Bambusa vulgaris* var. *striata*, *Gigantochloea atroviolacea* etc. have been developed.

Work on improvement of nursery techniques of various forestry species was carried out in nurseries. Studies were carried out to see the effect of different soil mixtures on *Dalbergia sissoo* seedling in root-trainers. Five soil mixtures were tried. The results showed that 1 part of soil: 2 part of sand and 3 part of manure was the best soil mixtures for shishum seedlings in root-trainers. Experiments were also conducted to see the effect of shade and mulch on germination behaviour of *Dalbergia sissoo* seeds in nursery. It is concluded that the germination of seeds was higher where mulch was provided.

Improved seed storage methods for *Dendrocalamus strictus*, *Bambusa nutans*, *B.membranaceous*, *Dalbergia sissoo*, *Ulmus wallichiana*, *Acer caesium*, *Azadirachta indica*, *Grewia optiva*, *Ailanthus excelsa* and *Syzygium cumini* have been developed. It is seen that reducing moisture contents of the seeds and keeping temperature low during storage increases the germination percentage while storage at room temperature and original moisture levels reduced their viability to below 50% of their original viability.

SOCIAL FORESTRY

Effect of trees on agricultural crops

In a case study in Eucalyptus-sugarcane agroforestry model, planting of eucalyptus trees in north-south oriented rows was found to be less detrimental to sugarcane crop than planting in east-west oriented rows. The study will be extended to more sites during the next year in order to draw general conclusion.

Data about wheat growth and yield have been collected from 16 fields located in three districts in U.P. and Haryana. Data are being analysed to compare the effect of north-south and east-west orientation of *Eucalyptus* rows on wheat crop. A spacing trial of poplar with agricultural crop was carried out.

EXTENSION

1. A project on manufacture of newsprint from a blend of waste paper and chemi bagasse pulp was successfully handled.
2. Equipments, jigs, fixtures etc. were fabricated for testing of door shutters. Two baggase particle board and MDF boards were tested for evaluation of physical and mechanical properties. 36 Panel/Flush doors; 12 particle board, plywood and MDF boards; and 160 wood samples were tested and test reports were sent to concerned organisations. Efforts were initiated for development of functional tests for tool handles and furniture items.
3. Advisory service on the insect pest problems was provided after thorough investigations.
4. During the period under report, 36 phytosanitory certificates were issued, following the treatment (fumigation) of the material. Technical matters on Plant Protection and Quarantine (PPQ) measures regarding clearence of import/export of indigenous and exotic insect species, plant material etc. were attended.
5. Transfer of technology and dessemination of entomological information was effected by demonstration, discussion and attending to querries from various quarters.

6. Soil testing for farmers, Forest Departments, Private bodies, etc. was done.

7. Charcoal production technology from waste wood was demonstrated and transferred to a private party of Dehradun.

8. A workshop on "Marketing of forest products" was organised at Chandigarh in the month of August 96.

EDUCATION/TRAINING

1. One Year Post Graduate Diploma course in Pulp and Paper Technology was conducted.

2. Starting from July 1996, four training programme on Environmental Management of Mine Areas have been organised for senior level executives of Steel Authority of India Ltd. So far 78 executives have been trained successfully.

3. The scientist are also contributing in forestry education, by way of teaching various Forestry subjects (Theory and practical) in various Post graduate and Diploma cources run by FRI-Deemed University of S.F.S. College and I.G.N.F.A.

4. Training was imparted to forest officers of Mysore Paper Mills, Shimoga and two forest officers of Sri Lankan Forest Departments in Rill method of resin tapping.

5. Classes for various Ayurvedic Colleges and foresters/Rangers training colleges of the country were arranged on researches being conducted specially in medicinal and aromatic plants.

6. One week compulsory training course for in-service IFS officers was also conducted on Non-Wood Forest Products Management Techniques on behalf of the Ministry of Environment and Forests, Govt. of India.

7. A Pruning Clipper has been developed for pruning of branches of trees.

8. Three training programmes on Seed Technology and Management (including one with International input), were conducted. In all 51 scientists/Foresters were trained.

9. A course on Assisted Natural Regeneration was conducted to train the officers of U.P. forest Deptt. In this course, 174 officers of U.P. Forest Deptt. have participated in 8 batches.