

CHAPTER-V

TROPICAL FOREST RESEARCH INSTITUTE JABALPUR

The Tropical Forest Research Institute (TFRI) is one of the 8 institutes and 3 centres under the Indian Council of Forestry Research & Education (ICFRE). It came into existence as an institute in April 1988, though its origin goes back to 1973 as a regional centre of FRI, Dehra Dun. The centre not only advanced steadily in terms of infrastructure, but also distinguished itself as a nucleus for research on forestry and ecology related problems of tropical forests of the region. The TFRI is undertaking diverse and intensive research on tropical forests under national as well as externally aided research projects.

The institute has the mandate of carrying out research on issues like rehabilitation of mined areas, eco-restoration of Vindhyan, Satpura, Maikal hills, and western ghats; planting stock improvement; agroforestry; non-wood forest products; and forest protection.

Some of the notable achievements made during the year have been given below :

PLANTING STOCK IMPROVEMENT PROGRAMME

Genetic testing

Genetic testing was carried out in respect of three progeny trials of teak established with half-sib seeds from first generation clonal seed orchards at Dhandatopa, Orissa during 1986 and 1987. The analysis of variance indicated significant differences among the families (clones) in all trials for height, diameter and basal area. The results indicated scope for family selection and for conversion of these trials into seedling seed orchard for immediate genetic gain.

Plus tree selection

Twenty (20) plus trees of Safed siris have been selected in the Bilaspur, Balaghat region. Seeds have been collected from these trees for genetic testing. Also these trees are clonally multiplied for establishing first generation clonal orchard.

Seed production area

Teak and *Casuarina equisetifolia* are two important species of the central India. Based on tree growth, flowering and fruiting behaviour, and past records of seed yield, 150 ha teak and 50 ha *Casuarina* seed stands have been finally selected in Maharashtra, M.P. and Orissa for converting into seed production areas (SPAs). The conversion work is in progress.

Provenance trials

Provenance research is aimed at identifying suitable seed sources for specific environments for maximum productivity. Provenance trials of *Acacia mangium*, *Acacia nilotica*, *Azadirachta indica*, *Dalbergia sissoo* and *Derris indica* have been laid out by the division of Silviculture in the institute.

Seed orchards

Clonal seed orchards, consisting of 12 ha of teak, 3.8 ha of *A. procera* and 3.5 ha each of *Dendrocalamus strictus* and *Bambusa nutans* have been established in the Institute. Seedling

seed production areas (SSPA) having an area of 20 ha teak, 13.5 ha of *Albizia procera* and 14 ha each of *D. strictus* and *B. nutans* have also been raised. Multiplication garden comprising 2 ha each of teak and *A. procera* and 1 ha each of *D. strictus* and *B. nutans* have been set up.

Vegetative propagation

Azadirachta indica

Seasonal variation on adventitious root formation in mature trees (25 years) was studied. Percentage of rooting in 1000 ppm IBA treatment in different months was 50 % (Jan.), 80 % (Feb.), 7 % (March), 0 % (April, May, June, July), 15 % (Aug.), 10% (Sept.), 13 % (Oct.), 23 % (Nov.) and 17 % (Dec.). Biochemical changes such as total soluble sugars, phenol and peroxidase activity during rhizogenesis in the cuttings was studied periodically and correlated with rooting. A low cost technique for the mass multiplication of superior genotypes has been developed.

Pongamia pinnata

Comparison of physiological, biochemical and root morphological characteristics of seedlings and rooted cuttings of *P. pinnata* was carried out. The number of root nodules, fresh and dry weight of roots were higher in seedlings than rooted cuttings, while net photosynthetic rate, water use efficiency and total soluble sugars showed marginal enhancement in rooted cutting compared to seedlings. The level of total chlorophyll, protein, nitrate reductase activity, transpiration and stomatal conductance were similar in both seedlings and cuttings, indicating that physiological performance of the rooted cuttings is similar to those of seedlings. It is concluded that rooted cuttings of *P. pinnata* from superior planting stock can be utilized for raising high production plantations.

Albizia procera

Air-layering was tried on 100 trees of *A. procera* in the month of September, 1996, taking six branches from each tree. After 45 days there was luxuriant adventitious root formation in air-layering branches of all trees. The rooted air-layering branches were removed from the mother tree and planted in the polythene bags containing sand, soil and farmyard manure in the ratio of 1:1:1. About, 80 % plantlets survived, proving thereby that *A. procera* can be clonally propagated on a large scale by air-layering.

Tectona grandis

Bud grafts of *T. grandis* from 100 selected clones maintained at Chandrapur were obtained and established in the field as clonal seed orchard.

Bamboo

Vegetative propagation techniques for *Bambusa vulgaris* and *Dendrocalamus strictus* have been standardized, using branch cuttings. The techniques may be adopted for large scale propagation of these species.

Micropropagation

Bambusa nutans

Shoot cultures obtained from seed explants were multiplied in shoot proliferation medium. Experiments with respect to effect of growth regulators, liquid and semi-solid medium, pH, and other factors on shoot multiplication were repeated. Studies were also conducted in



Selected seed production area



Marking of trees in SPA



Training farmers, women, tribals & forest officials etc. in nursery & plantation technology at Kanker, Baster



Demonstrating use of modern nursery tools, developed at TFRI, to user groups

respect of various physiological parameters in shoot multiplication stage. Rooting experiments were carried out using auxins in combination with cytokinins. Experiments were taken up concerning hardening of *in-vitro* rooted plantlets. Shoot cultures were also prepared from mature culms using single nodal segments.

***Bambusa vulgaris* (green)**

Shoot multiplication experiments were conducted with various combinations of auxins and cytokinins. Rooting experiments were carried out to obtain maximum rooting percentage. Hardening of *in-vitro* raised plantlets was also standardized.

Dendrocalamus strictus

Shoot cultures were established using nodal segments. Multiplication experiments were carried out to standardize optimum shoot multiplication.

Albizia procera

Explants were collected and shoot cultures established. Experiments were carried out to obtain regeneration from different explants viz., leaf disc, shoot and nodal segments. Direct shoot regeneration was obtained from leaf disc.

Development of model research nursery

A modern research nursery over an area of 1.5 ha has been developed with efficient, precise and cost effective tools, equipments and vegetative propagation system designed and developed at the institute. The nursery gives scope to carry out extensive research on different aspects of nursery technology besides producing 2 to 3 lakh specimen of quality planting stock. Improved methods of seed storage; seed bed preparation; precision sowing and planting; improved containerized seedlings production system; non-misting systems; and low cost mist and shade houses have been developed to provide conditions varying from conducive germination and growth of young plants increasing to environmental stress (so that the plants are properly hardened off prior to planting). Achievements made in nursery experimentation are described as:

- (a) Trials were carried out to compare the performance of polybag seedlings of *Dalbergia sissoo* raised in Mounted Angle Iron (MAI) beds with those raised in nursery beds. It was observed that seedlings raised in MAI beds recorded significantly higher fibrous-root biomass, dry weight (1.28 gm/seedling), number of roots (47/seedling) and number of nodules (131/seedling) as compared to 0.84 gm/seedling, 31/seedling and 29/seedling respectively in nursery raised polybag seedlings after 6 months of sowing. The improved polybag seedling production system has significantly enhanced the quality parameters of *Dalbergia sissoo* seedlings i.e., fibrosity and nodulation.
- (b) Preliminary standardization of potting mixture for root trainers has been achieved with soil, sand and compost in ratio of 1:1:2 for good results.
- (c) In a rooting trial carried out using cuttings obtained from 4 year old plants of *A. nilotica* treated with auxins under mist conditions, the results suggested that IAA 100 ppm significantly enhanced the rooting percentage, number of roots and root length as compared with all other treatments.
- (d) Yet another rooting trial carried out using juvenile cuttings of *Azadirachta indica* treated with different root inducing substances resulted in 70% rooting with IBA 1000

ppm. The IBA 1000 ppm treatment also gave maximum number of roots, root length and root dry weight.

Studies on seed germination viability and standardization of seed vigour tests in multipurpose tree (MPT) species

Seed technology

Variation in pod, seed, and germination characteristics in respect of 33 different mother trees of a single source (Jabalpur region) was studied. For the study, 33 randomly distributed good seed bearers were identified in the Jabalpur region. Fully ripened pods were collected from each such trees and kept in separate lots. Observations were recorded as regards pod and seed morphology including size and weight; germination characteristics; and field emergence. Analysis of variance (ANOVA) of data obtained for pod and seed characteristics showed that the difference between mother trees were statistically significant except for seed width. ANOVA of germination characteristics also showed highly significant differences. However, no significant relationship of mother tree height with any of the pod, seed or germination traits was observed.

Eleven trees above 20 cm dbh bearing apparently different types of capsules were selected. Capsule characteristics i.e., colour, longitudinal surface furrows, form, length, girth, weight of full capsule, weight of capsule after seed extraction, number of seeds per capsule and seed characteristics i.e., seed coat colour, weight of 100 seeds, wing colour, wing capacity and wing fragility were recorded. Germination tests were conducted immediately after collection and after six months of storage in polybags under ambient temperature conditions.

Highly significant differences were observed in germination attributes as well as morphological characters of seed and capsule. The germination percentage and peak value of fresh seed varied from 57.7 to 94.0 % and 9.83 to 21.36 units respectively whereas corresponding figures after six months of seed storage ranged from 7.3 to 90.3% and 0.94 to 21.75 units.

Seeds of *Hardwickia binata* show a lot of variation in germination capability. Ocular observations of seeds indicated that seeds can be classified into two different categories on the basis of seed coat colour i.e., green and brown coloured seeds. Germination studies revealed that brown coloured seeds have much higher germination percentage and field emergence as compared to the green coloured seeds. Also, the brown seeds had higher 100 seed weight (22.37 gm) as compared to the green seeds (15.00) which may be due to more amount of reserve food in brown seeds showing higher germination values. Three types of abnormal seedlings were observed during germination.

Fresh seeds of *Derris indica* were stored in different types of containers viz., glass bottles; tin boxes; plastic jars; and bags of polythene, jute, and cloth for a period of one year. A total of 10 species of fungi were noted on seeds with minimum number on seeds stored in plastic jars and maximum on seeds stored in cloth and jute bags. There were no significant differences in oil content of seeds stored under different storage conditions. Seed mycoflora also did not have any significant effect on seed oil content.

Germplasm collection

Bamboos

Rewa, Sidhi, Sarguja and Bastar Forest areas were surveyed and germplasm of *Bambusa nutans*, *B. vulgaris* (green) and *Dendrocalamus membranaceus* collected. Four

localities in Central India viz. Chhindwara, Nagpur, Bastar and Jabalpur were selected for introduction trial. Experiments on vegetative propagation in the mist chamber through culm cuttings of *B. vulgaris* (green) and *D. membranaceus* after giving hormonal treatment of 50, 100, 200 ppm, IAA, IBA and NAA gave best sprouting for treatment of 200 ppm of NAA in these two species.

***Diospyros melonoxylon* (Tendu)**

Survey for suitable and superior trees of tendu for germplasm collection in different forest areas in MP and Orissa was carried out. Fruits and seeds from Bhateli, (Bargarh) Orissa, Ranapur (Jhabua) and Dungaria, Jabalpur (MP) were collected. Seeds from these localities were sown in polybags for raising seedlings for further multiplication trials. Studies on fruits/seeds revealed that the weight of fruits was variable depending upon the size and number of seeds in the fruits. The number of seeds in different individual varied from 1 to 5. Average weight of a single seed varies from .78 g to .97 g and total number of seeds per kg varied from 780 to 1150 seeds.

Grasses (*Cymbopogon martinii*)

C. martinii, an essential oil yielding perennial grass, has been selected for germplasm collection because of the importance of palmarosa oil, which has no synthetic substitute and it is used as a base for perfumes and other cosmetics. Over the years, because of good demand for oil in India and abroad, this grass is being over exploited.

Cymbopogon martinii slips collected during 1995-96 were planted in polybags to determine the survival percentage of slips from 13 localities. The slips from Dhar have shown highest survival percentage i.e., 80.77% whereas those from Raisen have shown lowest (16.15%).

FOREST PROTECTION

Chemical analysis of forest species for their antifungal activity

Vitex negundo leaves were extracted in different solvents viz., acetone, ethanol, methanol and distilled water for testing its fungitoxicity against *Fusarium pallidorozeum*. Among the extracts tested, 70% ethanolic and aqueous extracts were found most effective showing maximum inhibition of conidial germination (83.3 and 81.22 percent respectively as compared to control with 16.88 percent inhibition).

Chemical screening of different species

Five species of bamboo (viz., *Bambusa nutans*, *Dendrocalamus asper*, *Bambusa vulgaris* (green) *Bambusa vulgaris* (yellow), and *Bambusa arundinacea*) were chemically analysed. On the basis of chemical parameters and field observations, *D. asper* was found most resistant species while *B. nutans* was observed most susceptible against their key insect pests.

Twenty clones of teak of Orissa, Maharashtra, UP, AP, Tamil Nadu, Kerala and Gujarat were chemically examined. On the basis of chemical parameters and field observations, 11 clones were screened as susceptible clones. ORANR-3 of Orissa was judged to be the most resistant clone and MHAL-P3 the most susceptible clone.

Chemical screening of species tolerant in Lime kiln areas

Evaluation of the pollutants (SPM, SO₂, NO_x) was done in different seasons at different grid point. Pollutant concentration was found to be maximum in winter followed by

summer and monsoon. In winter season, at 10 m distance SPM, SO₂ and NO_x concentrations (Mg/m³) were 680.2, 188.9 and 198.4, while at 500 metre distance these values were found to be 33.4, 11.0 and nonsignificant respectively.

Phytosociological study was done in summer and rainy seasons. The number of species increased as a function of distance of the sites from lime kiln. Six communities were identified on the basis of IVI value (Importance Value Index).

Seed diseases

Seed mycoflora of *Albizia lebbek*, *Albizia procera*, *Sesbania grandiflora* and *S. aculeata* were recorded. *Aspergillus flavus*, *A. niger*, *Fusarium* sp., *Rhizopus* sp. and *Curvularia lunata* were found associated with the seeds.

Nursery diseases

Foliar disease of *Gmelina arborea* by *Leptosphaeria gmelinae*, of poplar by *Macrophomina phaseolina*, of *Pongamia pinnata* by *Fusicladium pongamiae*, of *Dalbergia sissoo* by *Phoma joliana*, of teak by *Leptosphaeria trifolii* and *Phomopsis tectonae*, and of *Sterculia urens* by *Cercospora sterculiae* were recorded.

Chemical control experiment against the foliar diseases of *Albizia lebbek*, *Pithecellobium dulce*, *Acacia auriculiformis*, *Boswellia serrata* and *Acacia nilotica* were conducted. Dithane M-45, Dithane Z-78 and Bavistin @ 0.2 % were found effective to check further spread of diseases.

Plantation diseases

Mortality in one year old teak plantation raised by ENBEE Plantation Ltd. at Bundi was found to be caused by *Fusarium pallidroseum* a soil borne pathogen. Nearly 20 % disease was recorded due to this pathogen. Detailed studies regarding pathogenecity test and control measures were conducted in the laboratory as well as in the field. The disease can be controlled by drenching with 0.2 % bavistin @ 200 ml/plant before monsoon.

Diseases of non-wood forest produce

Survey of Non-wood Forest Produce nursery and TFRI campus plantation was conducted and diseases occurring in seedlings were studied. Pathogen associated with the diseased plants were identified as *Alternaria alternata* causing leaf spots on *Hedyechium spicatum*, *Indigofera tinctoria* and *Acorus calamus*; *Fusicladium* sp. causing leaf spots in *Emblica officinalis*; *Cercospora* spp. causing leaf spot in *Artocarpus heterophyllus*; and *Colletotrichum* sp. causing leaf spot in *Ceiba pentandra*. Bavistin @ 0.2 % was found effective in checking further spread of diseases.

Research on biological control of some major diseases of forest tree species

The chemical pesticides are harmful to other non-target organism also. Alternative biocontrol measures are safe, long lasting and effective. Formulation of biocontrol agent *Trichoderma harzianum* and *T. pseudokoningii* has been achieved on bagasse in powder form, yielding 2x10⁹ colony forming units per gram. This formulation has been successfully tested for biological control of decay fungi in stored bamboos in field conditions. The treatment gave protection for more than a year during storage against basidiomycetous decay fungi.

Leaf extracts of *Vitex negundo* in different chemical solvents were tested against *Fusarium* spp. causing wilt in seedlings. Ethanolic extract was found most effective followed by aqueous extract.

Role of biofertilizers

Effect of VAM fungi on growth, photosynthesis rate, and NR activity of ten different clones of teak was studied in nursery. Variations were observed among different clones.

Effect of inoculation of three isolates of VAM fungi and FYM application on mycorrhization in *Dendrocalamus asper* seedlings and VAM spore production in its rhizosphere were studied in nursery. Application of VAM significantly increased height, dry biomass, per cent root colonization, and phosphorus uptake in VAM inoculated seedlings. Application of FYM significantly increased production of VAM spores in the rhizosphere of *D. asper* seedlings. Different inocula of VAM were used to study the growth of *Bambusa nutans*. Mix inocula containing root, spore and soil was more effective.

Screening of pesticides of botanical origin

Feeding inhibition efficacy of methanolic leaf extract of nine plant species viz. *Ricinus cumini*, *Phyllanthus reticulata*, *Lowsonia innermis*, *Chloroxylon swietenia*, *Cleistanthus collinus*, *Acorus calamus*, *Lippia geminata*, *Cassia tora* and *Ailanthus excelsa* was tested against the larvae of bamboo leaf roller, *Crypsiptya coclesalis* and teak defoliator, *Hiblea puera*. The results showed that the methanolic leaf extract of *Ailanthus excelsa* is best to inhibit the test larvae to feed on sprayed host leaves.

Antifeedant activity of various solvent extracts of *Lantana camara* leaves were also tested against the larvae of bamboo leaf roller. The results showed that petroleum ether extract is most effective in inhibiting larval feeding.

Resistance in bamboo against leaf roller

Three varieties of *Bambusa vulgaris*, viz., green, wamin and yellow were screened out for their resistance against leaf roller, *Crypsiptya coclesalis*. Feeding bioassay in laboratory through no choice test against different larval instars revealed relative resistance among the varieties studied. The green variety of *B. vulgaris* was found to be more resistant to leaf roller than others.

AGROFORESTRY

One of the most promising agroforestry models under rainfed system with minimum inputs and maximum outputs has been found to be *Dalbergia sissoo* (5x5 m) + *Sesbania sesban* alternated with sissoo in the same row + perennial pigeon pea 1x1 m spacing. It yielded 18 q/ha of pulse while *D. sissoo* growth was 25 per cent better and *Sesbania* attained 6 m height in third year.

Agroforestry models of bamboo cultivation on degraded agricultural lands

Agroforestry models aim at improving the soil of agricultural land and checking soil and water run-off. 144 experimental plots of size 30 m x 25 m each have been laid out to study bio-physical interaction of three species of bamboo viz. *Bambusa bambos*, *B. nutans* and *Dendrocalamus strictus* with at least four main agricultural crops : Soyabean, niger, mustard and wheat on degraded agricultural lands. Observations with regard to comparative growth, survival percentage etc. have been recorded regularly. Study of 288 randomly selected bamboos

of each of the three species revealed that the average growth of leading shoot of *Bambusa bambos* is higher compared to *Dendrocalamus strictus* and *Bambusa nutans*. Similarly, another study of 288 randomly selected bamboos of each of the three species revealed that maximum number of shoots per clump occur in *Bambusa bambos*. It has further been observed that maximum average thickness occurs in *B. bambos*.

Silvi-olericultural system

A silvi-olericultural model has been conceived and is being tried for the past 5 years with 9 vegetable crops and 5 tree species viz., *Acacia nilotica*, *Albizia procera*, *Dalbergia sissoo*, *Gmelina arborea*, and *Tectona grandis*.

Horti-silvi-agri system

The present system is based on Seedless lemon (*Citrus* spp.), poplars (*Populus deltoides*), and soybean (*Glycine max*) + wheat rotation in kharif and rabi season respectively. Seedless lemon has been planted at 5x10 m and evergreen poplars were planted at 2.5 m between two rows of seedless lemon i.e., seedless lemon rows and poplar rows are separated by an effective distance of 5 m. Soybean for kharif (black varieties in the first two years to facilitate the *rhizobium* species specific strains followed by white varieties subsequently) was raised. No irrigation is provided to the kharif soybean under experimental trials. The sowing of soybean is timed to catch the first rains. Crops sown in first rains resulted in higher yield. Crop sown in irrigated field in the second week of June also resulted in higher yield. For rabi crop, wheat varieties were raised. Inputs were given at a level of 25 Kg P₂O₅, 50 Kg K₂O, and 10 t/ha FYM during kharif. No fertiliser was added to rabi crop. The soybean yields was 25 q/ha and that of wheat supported by irrigation was 30 q/ha.

Alley cropping of maize and cow pea with sesbania sesban to optimize productivity

An alley cropping experiment was laid out in June 1994, with *Sesbania sesban* hedge rows (0.5x3.5 m), maize *Zea mays* (kharif), and Cow pea *Vigna sinensis* (rabi). The hedge rows (at quarterly cuttings) yielded 0.689, 0.679 and 0.554 t/ha, respectively of biomass for green manuring. The yield of maize was 2.4 t/ha. Similarly, the yield of cow pea, on an average, was 4.69 t/ha. The productivity of *Sesbania sesban* in alley cropping has been worked out to be 3.106 t/ha/year under rainfed conditions.

ECO-RESTORATION IN MINED AREAS

Rehabilitation of mined land requires a fundamental understanding of ecosystem structure and functions including the process of primary as well as secondary succession. Ecological restoration of mined areas can be achieved speedily by introduction of herbaceous species which can enhance the natural succession. Some pioneering nonleguminous and leguminous species of herbs and shrubs have been identified through successional studies in different mined areas which are useful for initial stabilization and nutrient enrichment of the spoils. These are given below:

Coal mined areas

Aristida adscencionis, *Blumea lacera*, *Eragrostis ciliata*, *Eragrostis uniloides*, *Tridax procumbens*, *Argimone mexicana*, *Hyptis suaveolens*, *Cassia tora*, *Calotropis procera*, *Solanum nigrum*, *Corchorus aestuans*, *Atylosia scarabaeoides* etc.

Iron mined areas

Alternanthera ficoidea, *Eulaliopsis binata*, *Echinops echinatus*, *Atylosia scarabaeoides*, *Tridax procumbens*, *Phyllanthus fraternus*, *Hyptis suaveolens*, *Cassia tora*, *Tephrosia purpurea*, *Desmodium triflorum*, *Heteropogon contortus* etc.

Lime stone mined areas

Argemone mexicana, *Cynodon dactylon*, *Eragrostis barbeta*, *Eulaliopsis binata*, *Evolvulus nummularia*, *Phyllanthus urinaria*, *Solanum surattense*, *Tridax procumbens*, *Xanthium strumarium*, *Echinops echinatus*, *Cassia tora*, *Achyranthus aspera* etc.

After stabilization of the mined areas to some extent by herb and shrubs, plantation work should be taken up. Technological packages (Engineering and biological) for reclamation of mined areas (coal, copper, iron) through a systematic research have been developed and perfected by this institute. Engineering method includes easing of steep slopes, terracing, levelling, bunding or ridge formation, spread of top soil, excavation of suitable size pits, gully plugging etc.

Coal mine overburden

Trials conducted in Gebra (M.P), Bishrampur (M.P), Singrauli (M.P) and Talcher (Orissa). Species suitable are: - *Pithecellobium dulce*, *Simaruba glauca*, *Acaçia mangium*, *Cassia siamea*, *Dalbergia sissoo*.

- 75 gm urea and 20 gm SSP per plant in the first year is best.
- Overburden and compost (1:2) in the pit is best compared to $(\text{NH}_4)_2\text{SO}_4$, NH_4Cl and Urea.
- Husk mulch is better than stone/gravel or leaf litter mulch to conserve moisture.
- 3 species of VAM fungi were identified in FYM amended plantation. Percentage infection is positively correlated with growth and biomass.
- Nitrogen enrichment is more by *P. dulce* followed by *A. mangium*, *D. sissoo*, *P. pinnata* and *Albizia procera*.

Copper mine overburdens

- Trials in Malanjkhand (M.P) indicate that *Gmelina arborea*, *Eucalyptus camaldulensis*, *E. grandis*, *E. teriticornis*, *Acacia lenticularis* and *Albizia procera* are most suitable species.
- Mixer of Natrin, Phosphin and Bactin, each of 1 gm, gives better performance.

Iron mine overburden

- Trials in Dalli, Rajhara and Mahamaya (M.P) indicate that *Leucaena leucocephala*, *Eucalyptus teriticornis*, *Albizia procera*, *Gmelina arborea*, *Dalbergia sissoo*, *Emblia officinalis*, *Dendrocalamus strictus* are the best species.
- Overburden and compost (1:1) in the pit is best.
- Grass mulch is better than stone/gravel husk and leaf litter mulch.

Dolomite mine overburden

- Trials in Hirri (Bilaspur, M.P) indicate that *G. arborea*, *Acacia auriculiformis*, *Eucalyptus*, *Pongamia pinnata*, and *D. strictus* are the most successful species.

Bauxite mine overburden

- Trials in Amarkantak (M.P) indicate that *A. auriculiformis*, *Grevillea pteridifolia*, *Pinus caribaea*, and *P. pinnata* show better performance.

Lime stone mine overburden

- Trial in Katni (M.P) indicate that *Ailanthus excelsa*, *Azadirachta indica*, *Butea monosperma*, and *Madhuca indica* are most suitable species.

Extent of application in the field

The technological packages developed are being utilised by South-Eastern coal fields Ltd., Northern Coal fields Ltd, Steel Authority of India Ltd., Limestone mine Authority etc.

Pollution absorbing efficiency of plants

Trees have been graded and indexed according to their sensitivity/tolerance on the basis of percent leaf area damage, reduction of chlorophyll, N and P contents, reduction of sugar and ascorbic acid etc. The results may be applied in the industrially polluted areas to reduce the air pollution. The following species have been graded according to their tolerance.

Ficus religiosa > *Butea monosperma* > *Azadirachta indica* > *Ficus bengalensis* > *Diospyros melanoxylon* > *Shorea robusta* > *Terminalia arjuna* > *Syzygium cumini* > *Terminalia tomentosa* > *Pongamia pinnata* > *Mangifera indica* > *Madhuca indica*.

ECONOMICS

Data related to marketing practices of wood and non-wood products of *Acacia nilotica* were collected at Bilaspur, Kota, Mungeli, Katghora and Pendra by using predesigned questionnaires. Five traders at each place were interviewed to study the market structure of round logs. Data on selling prices of round logs (length and girthwise) from primary, secondary, and final markets have been collected and analysed to study price variation in respect of market, time, and size. Seed and Gum traders have also been interviewed and price variation in different market channel have been studied.

The price of Round logs in primary market varies from Rs.60/- to Rs.65/-, in secondary market Rs.80/- to Rs.85/- and in final market, it is Rs.120/- to 130/-. It has further been observed that the share of Babool's products in farmers total income is 5-7 percent and per acre average of trees is 10 to 12 in Agricultural land.

All the three (primary, secondary and final) markets of Round Logs are situated in Bilaspur and Raipur and in surrounding villages but in case of non-wood products such as Gum, bark and seed, primary markets are in villages only and secondary markets are in Bilaspur, Bilha, and Raipur but products of gum, bark and seed are exported to other states e.g. seed as fodder to Haryana, Punjab and Uttar Pradesh, bark to West Bengal and Uttar Pradesh, and Gum is mainly exported to Delhi. It is, thus, concluded that the secondary and final markets of wood and non-wood products of Babul are well established but it is not the same for primary market because there is no competition and farmers do not get proper price for these products.

Remoteness of village markets and lack of other marketing arrangements have led to exploitation of growers by local traders.

Market survey for the prices of round and sawn timber, bamboo, fuel wood

Quarterly market survey during the months of June 96, September, 96, December, 96 and March, 97 have been carried out at Jabalpur, Raipur and Nagpur to collect the market prices of Round and sawn timber of teak, sal, eucalyptus, bamboo and fuel wood. The collected data were compiled and submitted to ICFRE for publication of bulletin.

BIODIVERSITY AND SUSTAINABLE MANAGEMENT

In Satpura National Park, located in the Satpura hills of Pachmarhi, forests occur at 800-1300 m elevation comprising species like *Syzygium cuminii*, *Mangifera indica*, *Terminalia tomentosa*, *Mimusops hexendra*, *Miliusa tomentosa*, *Ficus hispida* etc. Sal forests at 800-1100 m elevation are dominated by pure sal followed by *Terminalia tomentosa*, *Embllica officinalis*, *Chloroxylon sweitenia*, *Buchanania lanzan*, etc. Mixed forest at less than 1000 m elevation occurs where species like *Chloroxylon swietenia*, *Diospyros melanoxylon*, *Gardenia latifolia*, *Buchanania lanzan* and *Lagerstroemia parviflora* etc are found. Mixed forest are more diverse as compared to other types.

Following the concept that tree planting on degraded land induces the growth of native ground flora, an investigation was taken up to estimate and compare diversity indices of ground flora species grown under various plantations taken on degraded Bhata (lateritic) land near Bilaspur in Madhya Pradesh. Regional native ground flora is essential in the concept of biodiversity conservation and, accordingly, future plantation strategy in the region can be decided upon.

A maximum of 25 ground flora species in 1 x 1 m quadrats have been identified in September under *Gmelina arborea* and *Eucalyptus* hybrid plantations followed by 23 species under *Buchanania lanzan* and *Tamarindus indica* as against 7 species under open land.

In forests protected for 13 years by forest protection committee in Sambalpur, total number of species in tree community, shrub community and herb community were 29, 29 and 26 respectively per quadrat with the highest Importance Value Index (IVI) of 105.30 for sal, 40.26 for *Holarrhena antidysenterica* and 50.71 for *Ixora parviflora* and with diversity index of 1.1452, 1.2945 and 1.2946 against unprotected (control) one where number of species were 17, 14 and 17. The highest IVI was 125.87 for sal, 60.56 for *Holarrhena antidysenterica*, 57.33 for *Diospyros melanoxylon* with diversity indices of 0.9308, 1.0290 and 1.1160 respectively.

In forests protected for 8 years, total number of species in tree, shrub and herb communities were 23, 15 and 24 respectively per quadrat with the highest IVI of 139.37, 106.64 and 61.67 for *Shorea robusta* and with diversity index of 0.9692, 1.5566 and 1.1142 as against unprotected control where number of species were 20, 8 and 13, with the highest IVI of 125.59 for sal.

UNDP PROJECT-IND/92/038

In order to increase the productivity of our forests and other degraded lands, concerted research efforts have been made to transfer proven technologies to the fields ensuring peoples participation under the ongoing UNDP project 'Strengthening and Developing ICFRE and its institutes'. Attempts have been made to build up strong linkages between Research Institutes,

Farmers, Tribals, Industries, NGOs, private enterprises, and State Forest Departments of M.P., Maharashtra and Orissa. Following programmes were successfully carried out.

Distribution of quality planting stock for raising demonstration plantations

A total of 39,366 plants of different Multipurpose trees (MPTs) have been distributed during the year to various user groups mainly farmers and tribals. These plants of very high quality were raised in the silviculture nursery of the institute and provided to the selected farmers and tribals at their farms/fields for raising demonstration plantation.

Training programmes in demonstration villages

In order to educate and create awareness among farmers, tribals, women, children, and rural masses, training and demonstration programmes were organised frequently in the 15 villages of M.P., selected for raising demonstration plantations. A team of scientists of relevant disciplines demonstrated the techniques of planting, soil working, weeding, manuring, application of biofertilizers, mulching, agroforestry practices and propagation of bamboos in an easy and effective way. As many as 24 on farm demonstration programmes were organised in which 514 people were trained.

NABARD PROJECT

Nurseries were established in the farmers field at Gandagouri and Karaboh for production of planting material. Seedlings raised in these nurseries and procured from other sources were transplanted in the farmers' field under various models like agri-silvi, agri-horti, agri-silvi-horti, and block planting in three micro water sheds viz. Saliwara, Karaboh and Gandagouri. A study was conducted around Bilaspur and Raipur areas for economic analysis of existing agro-forestry systems.

IDRC

An IDRC assisted project for establishment of appropriate agroforestry models for Bamboo cultivation on degraded agricultural land has been taken up in Jabalpur district of Madhya Pradesh since 1st January, 1995. This project includes a comprehensive programme of research and development to maximize sustainable productive use of degraded agricultural lands with soil and water conservation measures.

During the year maintenance of bamboo seedlings through watering, weeding, and soil mounting etc. operations was carried out. Replanting was done to beat the mortalities. Results of bamboo plantations and agricultural inter crops have been very encouraging and farmers are getting increasingly interested.

Ford Foundation

The Joint Forest Management (JFM) programmes in different Indian States have attempted to induce local participation. A four year research project funded by Ford Foundation was launched by the ICFRE during Jan 1995 to address various issues involved in the JFM.

As per the project document, sites were selected to cover three major forest types :

- (i) Dry deciduous teak forests of Central India - Jabalpur Forest Division, M.P.
- (ii) Dry sal forest of Central India - Sambalpur Forest Division, Orissa.

- (iii) Dry deciduous mixed forests of low hills in North India - Yamunanagar Forest Division, Haryana.

The studies on site (i) & (ii) are being conducted by scientists and staff of Tropical Forest Research Institute, Jabalpur and the site (iii) is being looked after by Forest Research Institute, Dehra Dun.

EXTENSION

1. Demonstration was given from time to time in TFRI, Jabalpur and in Orissa during Regional Silviculturist's meet of fuel operated drought type drum for drying mahua, bidi leaves, oil seeds medicinal plants product.
2. Babul-paddy model on agroforestry has been prepared for Chhatisgarh and demonstrated through charts, photographs and slides. Training in field has been also given to 24 farmers in TFRI, Jabalpur and Bilaspur.
3. "Agroforestry models of bamboo cultivation on degraded agricultural land in central India", under IDRC project was successfully popularized among farmers.
4. Biofertilizers, VAM and rhizobium were distributed for boosting up growth of bamboo, teak, and *Albizia procera* to SFDs, NGOs and some farmers. 100 pkts of VAM and 50 pkts of rhizobium were distributed.
5. TFRI developed technologies, particularly in NWFP, Agroforestry, Silviculture and Biofertilizer, were demonstrated to 250 members of forestry co-operative society at workshop organised by IFFDC project Sagar.
6. The technological package developed for the reclamation of mined over burden area are being utilized by South-Eastern Coal Fields Ltd., Northern Coal Fields Ltd, Steel Authority of India Ltd (SAIL), Lime Stone Mine Authority etc.
7. As per the MOU signed with Steel Authority of India (SAIL), eco-restoration work has been started recently in Dalli. Some technologies on industrial polluted area have been demonstrated/applied in thermal power plant to reduce the air pollution by raising some important pollution tolerance species. The developed technologies of TFRI were demonstrated to 15 officials of SFDs, 10 Universities professors, and 14 farmers.
8. A workshop was held on 14-15 Feb 96 on Forestry extension at TFRI, Jabalpur. Delegates from SFDs, NGOs, University and industries have participated.
9. Extension publicity material in the form of brochures, pamphlets on nursery technique; biofertilizer; agroforestry; and extension methodologies has been packaged and distributed.
10. A video film named "Forestry at your door" has been prepared on research technologies of the institute. 200 transparencies, 180 photographs and 12 laminations were prepared on different activities for demonstration.
11. Demonstrated TFRI technologies at exhibition held in Delhi from 21st to 23rd Feb 97.
12. A Kisan Mela was organised at Kanker from 24th to 26th Feb 97 in which TFRI developed technologies were demonstrated to the farmers and others.
13. Demonstrated TFRI developed technologies in Swarojgar mela held in Jabalpur from Dec 20-22, 1996.

EDUCATION/TRAINING

1. Two special training programmes of duration 3 days each were organised under UNDP project for Farmers, women, tribals, NGOs and forest officials in the remote areas of M.P., one at Kanker (Bastar) on Nursery and Plantation Technologies, Mushroom cultivation and Biofertilizers, and the other at Panchwati (Chhindwara) on Agroforestry.
2. Under UNDP programme, demonstration plantations have been raised by the farmers on their fields in selected villages of Central India with technical know from the scientists of TFRI. Quality planting stock for the purpose was raised in the silviculture nursery of the institute, and FRI, Dehradun and was made available to the farmer on their fields during regular training and demonstration.
3. Training was imparted on "Ecorestoration of mined areas" to SAIL executives from all over India from 30 Sept. 13 Oct'96, and 9th - 22nd Dec. 96 demonstrating technologies developed by TFRI.
4. A training programme on Statistical methods and design of experiments was organised by the institute for a week w.e.f. 2/12/96 under World Bank Project.
5. A one week training course on "Seed Technology and Management" was organised for officials of Orissa Forest Department w.e.f. Aug. 19 to 24, 1996.