

COMPLETED EXTERNALLY AIDED PROJECTS

Project 1: Maintenance of Chakrata NWFP Nursery (UFDC sponsored)

Findings: The maintenance and improvement works of the High Altitude Herbal Garden at Chakrata was done. Important medicinal plants like *Aconitum heterophyllum*, *Podophyllum hexandrum*, *Picrorhiza kurroa*, *Digitalis* spp., *Artemisia annua*, *Swertia chirata*, *Ephedra gerardiana*, *Microstylis wallichii* and *Habenaria intermediata*, etc. were conserved for research and further development in the well protected garden. The nursery is provided with extension boards for education and awareness. The garden has been made fit for taking up research studies of high altitude plants.

Project 2: Development of Ecorestoration Model for Iron Ore Mines of Bihar and Orissa [Funded by MoEF, New Delhi]

Findings: The project is of immense practical utility for the mine areas of Bihar and Orissa, where out of 47,797.00 hectares of mine lease area, nearly 11,500 hectares of the land area is under leases for Iron Ore alone. The objective of this project is to develop ecologically and economically viable restoration model for Iron Ore mines of Bihar and Orissa which are spread over an area of 11,500.00 hectares. Ecorestoration model has to be developed on the basis of detailed soil, vegetation and parent materials in relation to ecological and ethno- botanical information. The model developed can be replicated in all these areas for overburden dumps mined out benches and degraded areas in vicinity of mines. Project report has been submitted.

Project 3: Forest Fire Monitoring and Management

Findings: The quantity of pre fire fuel load, fuel moisture and soil temperature has been determined in all selected sites i.e., Pure Sal, Sal mixed, Pure Pine, Oak, Mixed Deciduous forests and degraded sites. Post fire estimations of all these parameters have also been made in different forest types to evaluate the impact of fire.

The amount of Gaseous emissions of as CO, CO₂ and Methane emitted from the different forest during/after fire have been estimated at different distance such as 10 m, 20 m, 40 m, 50 m, 60 m, 70 m, 80 m, 90 m and 100 m from the source of fire.

Post fire temperature variations along the vertical gradient in different forests have been recorded using Infra red thermometer to assess the impact of fire in the forest stand. Leaf Area Index and canopy gaps are being recorded using canopy analyzer in different forest types, the recording is in progress.

Project 4: Restoration of biodiversity in the hills of Kujapuri following Badriran restoration approach (Funded by G.B. Pant Institute of Himalayan, Environment and Development, Almora)

Findings: Sixteen native forestry species of multi uses i.e. fodder, commercial sacred and ornamental have successfully been introduced in the area during the process of restoration

measures. Among them the most successful species in term of survival and growth were *Fraxinus micrantha*, *Quercus leucotrichophora*, *Aesculus indica*, *Celtis australis*, *Grewia optiva*, *Toona serrata* (Syn.*Cedrela serrata*), *Arundinaria falcata* and *Dendrocalamus strictus*. Species diversity index of shrub layer, which was 0.67 before restoration, has significantly increased to 2.40 after restoration. Similarly in the case of herbaceous layer, the diversity index value increased from 1.40 to 2.21 due to restoration activities. *Chrysopogon fulvus*, a native grass species, has registered a significant dominance in its presence in the area after restoration. A significant reduction in the diversity of *Eupatorium glandulosum*, an exotic under shrub and *Bidens beternata*, an annual weed, has been recorded after restoration.

Project 5: Identification, development and utilization of natural dyes from the forest plants of Uttarakhand (Funded by DSIR, MoEF and ICFRE) [FRI- 249/Chem-12/ Ext.]

Findings: Specifications for the fabrication of natural dye pilot plant were drawn, procured, installed and commissioned for the first time in Uttarakhand. Processes were developed for the isolation of natural dye from abundantly available *Eucalyptus* hybrid (leaves and bark), *Populus deltoides* (bark), *Pinus roxburghii* (needles) *Lantana camara* (leaves) and *Cassia tora* (seeds). Fifty two trials were carried out in pilot plant at 20 to 40 kg batch scale, depending upon the bulk density of the material. Methods were developed for dyeing of different fabrics using the dyes of aluminium, copper, chromium and tin salts as mordants. The blends prepared using the isolated dyes from five plant species did not show appreciable changes in the shades of dyed fabrics. The dyed fabrics having fascinating shades exhibited very good fastness properties. It was established that vacuum tray drying is better than the spray drying in the case of all five dyes. MoU was signed with Sikkim Khadi and Village Industries Board (SKVIB) for installation of pilot plant for isolation of natural dye from plant species occurring in Sikkim under the technical guidance of FRI. An agreement has been signed with Uttarakhand Khadi Village Industries Board for the supply of dye. A documentary on the isolation of natural dyes was prepared by Pulse Media Limited, New Delhi for telecast on Doordarshan. The different parts of these plant species which are not of much use can be used for the isolation of dye thereby finding their utilization. The technology is ready for its transfer to interested entrepreneurs.

Project 6: Utilization of economic potential of *Parthenium* [FRI-262/Chem-13/External; Department of Biotechnology, New Delhi funded/2004-07]

Findings: Phenol formaldehyde resin was prepared and analysed using commercial grade phenol and formaldehyde. Particle boards were prepared at 17.5 kg/cm², 21 kg/cm² and 24 kg/cm² pressure levels using 10%, 12% and 14 % phenol formaldehyde resin with pressing temperature 150°C. For reducing the water absorption of boards, 0.5 and 1.0 % wax emulsion was also used for making particle boards. Particle boards thus obtained were tested for various physical and mechanical properties such as density, moisture content, water absorption, swelling due to surface absorption, Modulus of Rupture (MoR), tensile strength perpendicular to surface etc. as per relevant IS specifications. It was observed that the particle boards prepared at 24 kg/cm² pressure level using 14 % resin meet the IS specifications.

Project 7: Development of improved chemical formulation and equipment for efficient treatment of bamboo for long term preservation and fire retardance

Activity 1: Modification of Boucherie equipment and its extension for the treatment of green bamboo – design etc.

Activity 2: To develop low cost chemical compositions of eco-friendly/conventional preservative and fire retardant for treatment of structural bamboo for rural application NMBA (TIFAC).

Findings:

1. Fabrication, Installation and testing of Automized Boucherie equipment for the treatment of 24 Bamboos at a time.
2. Ten fire retardant and preservative compositions were prepared and tested for performance against fire. Out of ten combinations of fire retardants and preservatives tested, five combinations i.e. I, II, III, IV and VII were passed as per BIS no. 5509: 2000 and 1734 (part III) 1972.
3. The old flame penetration test equipment is modified and upgraded with special attachments

Project 8: Biotechnological approaches for improvement of plant species with special reference to pulp and paper [CSIR-NMITLI funded/2004 – 08]

Findings: This was a multi-disciplinary and multi-institutional project involving FRI, KFRI Peechi, NCL Pune, IHBT Palampur, NBRI Lucknow, CIMAP Lucknow, Lucknow University and Osmania University, who got together for a common goal of improving plant species for pulp and paper having low lignin and higher fibre length. Under its component, FRI achieved the following:

1. 1140 wood samples from different locations / collections of *Leucaena leucocephala* (Subabul) trees representing 14 States were received from the participating institutes including FRI for chemical, physical and anatomical characterization.
2. Large variation was observed in lignin, fibre length and other parameters.
3. Fifty two elites short listed based on higher fibre length and low lignin content.
4. FT-NIR protocols developed for specific gravity, lignin, holocellulose and extractives estimation.
5. List of elites further shortened to 18 and then to 8.
6. Lignin and extractive content variation in wood samples with and without bark and for bark only studied.
7. Ash content studied for all the wood samples.

Project 9: Ex-situ conservation of some critically endangered plants of Uttarakhand [FRI-277/Bot-42/Ext./2005-08]

Findings: The project was funded by National Botanical Research Institute under the Investing in Nature-India (IIN-India) scheme. *Ex-situ* conservation was the prime objective of the project.

A list of 165 rare and endangered species of Uttarakhand was prepared based on published literature such as Red Data Books. An Assessment of Threatened Plants of India, The Indian Plant Red Data Book, etc. Nine endangered species were collected and introduced in the botanical garden of FRI. The monotypic species *Catamixis baccaroides* found only on the shivaliks of Dehradun was successfully grown in the botanical garden. The species has hence been flowered and produced seeds. Five species have been propagated and grown in their original habitats. Awareness training programmes were organized for school children of Kendriya Vidyalaya of Dehradun. In all 52 childrens and 12 teachers attended the programme. The endangered palm *Trachycarpus takil* was provided to NBRI, Lucknow, WII, and Dehradun for planting in their conservation gardens.



Catamixis baccaroides in FRI Botanical Garden



Catamixis baccaroides in original habitat

Project 10: Creation of germplasm bank of medicinally important tree species of Punjab [FRI-336/Bot-50/Ext./2006-09]

Findings: Five medicinally important tree species were selected for establishment of their germplasm banks. The field survey was done for whole of the State of Punjab and two sites selected for establishment of germplasm bank of various species. The lands were developed by removing the existing trees, shrubs and herbs, digging out tube wells for irrigation and fenced the areas by barbed wire fencing. The site maps were prepared providing parks and blocks for each species to be accommodated. The irrigation channels and under ground pipefitting were carried out for proper irrigation. The seedlings of different plus trees were grown as a progenies. The data on seed and seedlings characteristics, nursery performance of planting material etc was recorded and analyzed. The planting material was properly tagged by aluminum foil before shifting it to the field. The germplasm bank map was prepared depending upon the availability of land and the number of plants to be accommodated in the field. Generally, the planting was done in RBD with row or block plantation. The out planting was done generally during rainy season. Proper weeding, watering and soil working is being done as and when required. The casualties' replacement was followed in next growing season by identified material. The display of sign boards for each species giving details of the field map and progenies with other details like date of planting, spacing, no. of plants and area etc was also carried out. The field performance of different species was assessed regularly.

Project 11: Development of suitable propagation technology of three *Terminalia* species [FRI-261/Bot-40/Ext./2003-06]

Findings: Survey for distribution and availability of species in Uttarakhand region has been completed. Vegetative propagation technology through juvenile shoot cuttings of *Terminalia arjuna*, *T. bellirica* and *T. chebula* is developed.

An attempt has been made to study the effect of season and growth hormones on branch cuttings of these three species. The experiment was conducted during February 2005, May 2005, July 2005, August 2005, November 2005, February 2006 and May 2006. Seasonal effect was found important factor in response of callus formation and root initiation. In case of *T. arjuna* and *T. chebula*, maximum rooting response was observed in August planted cuttings. On the other hand in case of *T. bellirica*, maximum rooting response was observed in July 2005 while no rooting was initiated during February, May and November 2005 planted cuttings.

Collection of seed and other reproductive planting materials from plus trees from different areas of Uttarakhand has been completed. Seed dimension (seed length and seed width) and germination behaviour (germination percentage, germination speed, germination period, germination energy, germination value and seed viability) study is completed.

One year seedlings studied for various growth parameters like (height, collar diameter, number of leaves and root length) and biomass production (dry weight of leaf, stem and root) was carried out.

The other propagation methods like air layering and grafting were tried and found successful.

In rooting response of juvenile shoot cuttings (mononodal cutting) of *Terminalia arjuna*, *T. bellirica* and *T. chebula* for mass propagation, the maximum rooting response was observed in case of IBA 4000 (*Terminalia arjuna* and *T. chebula*) and IAA 4000 (*T. bellirica*) treated cuttings.

The branch cuttings collected from mature tree of *T. bellirica* failed to root whereas, the branch cuttings of *Terminalia arjuna* and *T. chebula* favourably responded to rooting.

Three papers were published and one communicated so far under this study.

Project 12: Evaluation and standardization of the methods employed in identity of the medicinal plants employing woods of Himalayan and Sub-Himalayan tract [FRI-276/Bot-41/Ext./2004-07]

Findings: The project evaluated and enlisted the woods of Himalayan and Sub-Himalayan tract that are being used in the production of various medicines. Such woods were studied for standardizing their correct identity through wood microstructure, wood ultrastructure and wood chemistry. Since adulteration in raw materials of medicines is a common problem, therefore, the present study is extremely useful for pharmaceutical companies to check the same.

Project 13: Micropagation of promising interspecific F₁ hybrids of eucalypts and establishment of field trial [FRI-220/G&TP – 11/Ext.]

Findings: Tissue culture plants of *Eucalyptus* hybrids FRI – 5 and FRI – 14 were multiplied and field planted at seven agroclimatic regions. Field data were collected from all the seven sites of field trial with respect to plant height, collar diameter, clear bole length, no. of branches. Attempts were made for protocol development of *Eucalyptus* hybrids FRI – 6, 10, 13 and 15. Aseptic cultures were established in all the four hybrids and *in vitro* shoots were successfully multiplied on media formulated. As a result of large no. of experimentations, a suitable media was also formulated for *in vitro* rooting of FRI – 6, 10 and 15. Tissue culture plants were hardened and acclimatized in mist chamber and shade house.

Project 14: Network program for establishment of demonstrations of Bamboo plantations in Uttarakhand [FRI – 257/Bot. – 36- Ext.]

Findings: *In-vitro* shoots of *Dendrocalamus asper* were multiplied on large scale. 15 and 16 fold shoot multiplication was obtained on MS medium supplemented with 2.5 mg/l BAP. *In-vitro* rooting was standardized. 95% *in-vitro* rooting was standardized on MS supplemented with 10.0 mg/l IBA and 3.0 mg/l NAA.

Tissue culture raised plants were produced and these plants were hardened and acclimatized in mist chamber and shade house. 12,000 plants of *D. asper* were supplied to Uttarakhand Forest Department for field plantation.

Project 15: Development of tissue culture technique for protocol development of *Bambusa balcooa* and *Melocanna bambusoides* [FRI – 258/Bot. – 37- Ext.]

Findings: *In-vitro* shoots of *Bambusa balcooa* were multiplied on MS medium supplemented with 10µM BAP + 2.5 µM Kn, which gave a 3 and 4 multiplication folds. In *Melocanna baccifera* (Syn. *Melocanna bambusoides*) best *in-vitro* multiplication of 3-4 folds were obtained on MS medium supplemented with 10 µM BAP.

In *M. bambusoides* *in vitro* rooting was obtained on MS medium supplemented with 25 µM IBA, while in *B. balcooa* scanty roots were obtained by pulse treatment of IBA. A complete tissue culture protocol has been developed.

Project 16: Study on pathogenic and molecular variability in *Fusarium solani* causing shisham (*Dalbergia sissoo*) wilt. [BT/BR/4273/AGR/16/356/ 2003; 2004-07] Funded by DBT

Findings: Out of 129 isolates of *Fusarium solani* collected from the high infection zones, a total of 53 isolates were selected for various studies. Nutritional studies using four nutrient media viz. Potato Dextrose Agar, Czapek Dox Yeast Extract Agar, Malt Extract Agar and Joff's medium were conducted for variation in growth, sporulation and development of pigmentation. Bavistin and Propiconazole were most effective while Bayleton and Topsin-M were least effective in all concentrations.

Molecular characterization of *Fusarium* isolates

RAPD

Forty five primers showed a total of 659 reproducible bands. Each of these primers varied greatly in their ability to resolve variability among the genotypes. The individual primer produced bands in a range of nine (LC94 and 1319) to 22 (LC-102) with an average of 14.64 bands per primer. Out of the 659 bands, 15 bands were monomorphic *i.e.* they were present in all the 38 isolates. The values of the coefficients were estimated on the basis of 45 primers which ranged between 22% (between F1 and F37) to 94.5% between F29 and F30 isolates. The maximum similarity coefficient between F29 and F30 (0.945) indicated the closeness of these two genotypes.

Cluster analysis

Phylogenetic tree showed clear distinction among all the 38 isolates by dividing the isolates into two major groups. The first major group consisted of 24 isolates while the second major group included 13 isolates, which were isolated from ooze of the plant. Isolate F26 was separated from these two groups. All *Fusarium* spp. except *F. solani* isolates were present in major cluster 2. Principal coordinate analysis was performed in order to highlight the resolving power of the ordination.

ISSR

A total of 206 bands were detected using 20 ISSR primers out of which 202 bands were polymorphic and only 4 were monomorphic. The number of amplified bands varied from 6 with primer LC-6 and LC-7 to a maximum of 14 with primer LC-64 and LC-65 with an average of 10.3 bands per primer while the amplified fragment ranged from 250 bp (primer LC-11 and LC-12) to 3250 bp (primer LC-59). Jaccard's similarity coefficients estimated using twenty ISSR primers ranged from 23 between F22 and F36 to the maximum of 97.3% between F1 and F2. Thus the result revealed closeness between F1 and F2 and high diversity between F22 and F36 isolates.

Cluster analysis

All the 38 isolates were clearly separated by dendrogram. Two major groups could be identified excluding F13 and F26. The first major group included all the *F. solani* isolates excluding F13 while second major group includes all other *Fusarium* spp. isolates obtained from

ooze (F6, F7, F8, F9, F10, F11, F14, F15, F16, F18, F21, F22 and F37). Principal coordinate analysis was also performed in order to highlight the resolving power of the ordination.

SSR

Out of 62 tested, twenty five rice SSR markers revealed 294 bands in the 38 isolates. The number of bands per primer varied widely among these markers, ranging from 1 (LC-285 and LC-319) to 21 (primer LC-310). The average number of bands per primer was 11.76. The value of the coefficient varied from 16.5% between F22 and F36 to 97.1% between F29 and F30 followed by 88.4% between F8 and F9. The isolates F29 and F30 were found to be closely related.

Cluster analysis

All non *F. solani* isolates except F26 were present in two major clusters. The isolates F29 and F30 showing maximum similarity coefficient (>90%) were grouped in one cluster. There were two major clusters where the first major cluster includes 24 isolates and the second cluster includes thirteen isolates.

Project 17: Biotechnological approaches for improvement of plant species with special reference to pulp and paper [2004-06/ CSIR-NIMITLI Funded]

Findings: Chemical screening of subabul with respect to lignin content, holo-cellulose and pentosan was carried out. 1130 samples of subabul collected from different geographical region were analyzed for lignin content and holo-cellulose. The lignin content varied from 17% to 31% and holo-cellulose was in the range of 58-77%. Pentosan was also determined in 50 samples. The project completion report submitted to CSIR.

Project 18: Evaluation of appropriate technologies and its adoption as applicable in rural environment [FRI-321/PLO-3]

Findings: Bamboo seeds were sown in the mist chamber of Silviculture Division. But the germination percentage was low. Later on, fresh seeds were procured and were germinated in the seed lab as well as in the nursery of Shatabdi Van Vigyan Kendra. Germination was better and some of them were shifted to polybags. Observations in the nursery raised seeds are being taken. Bamboo cuttings were multiplied in the polybags in the nursery area. Training to 10 persons was conducted from the villages of Badonwala, Harbajwala and Umedhpur. During training, lectures were given regarding the macro-proliferation technique and also regarding the bamboo protection from fungus and insects. Practical work was done by the trainees in the field and the seedlings were separated and replanted in the field by the trainees to learn the technique. Cuttings were also raised in the bed by the trainees.

Bamboo seedlings/rhizomes of *Melocanna baccifera*, *D. membranaceus*, *D. strictus*, *Japanese Bamboo* and *D. asper* were brought from Shyampur Forest Nursery and were introduced in Shatabdi Van Vigyan Kendra. One sample each was given to Plant Physiology for further multiplication and as germplasm collection. Further multiplication of the seedlings was

also done by separating the young seedlings of the species available in the nursery. Observations are being taken regularly.

Bamboo seedlings raised in Shatabdi Van Vigyan Kendra were maintained and routine watering and weeding was done in nursery. Protection from frost was also provided. The seedlings were kept in polybags, root trainers and in beds. Field observations regarding the bamboo seedlings raised by the villagers were also noted. Separation and further multiplication by adopting macroproliferation technique will be done and the seedlings will be given to the villagers.