

Tree improvement and forest biotechnology*

A seminar on tree improvement and forest biotechnology was held recently, in which a total of 83 delegates representing 25 institutes from all over India participated. The seminar was divided into two technical sessions besides the inaugural and panel sessions. Ten invited lectures by eminent scientists were delivered during the seminar.

A brief introduction was given by all the delegates at the beginning. Ashok Kumar (Forest Research Institute (FRI), Dehradun) welcomed all the delegates and presented an overview of the seminar. He postulated that the seminar supports future research of action and planning for productivity enhancement of Indian forests. An inter-institutional collaboration between different disciplines and among the institutes in the field of genetics, tree improvement, and application of biotechnology is the future research agenda. He also gave an overview of the history, vision and mandate of the Genetics and Tree Improvement Division at FRI, along with the brief highlights of activities and significant achievements. Savita (FRI, Dehradun) also gave an overview of the seminar and extended a warm welcome to all delegates. She briefly introduced the trend of organizing a monthly seminar by the Indian Council of Forestry Research and Education (ICFRE), Dehradun. She highlighted the activities and achievements of the Institute and emphasized the need to encourage farmers establish quality plantations by ensuring the availability of quality planting material. Further, she focused on the research gaps in tree improvement programmes and the need for a dialogue between the researchers and stakeholders to address various problems faced by the farmers, forest departments, industrialists, etc. She also emphasized that selection and collection of germplasm according to the needs of stakeholders of jurisdiction states should be undertaken. She appreciated the efforts taken by FRI, Dehradun for variety development and

population genetic studies in various forestry species.

In his keynote address, K. Gurumurthi (formerly with Institute of Forest Genetics and Tree Breeding (IFGTB), Coimbatore) focused on biotechnology for tree improvement. He shed light on the upstream and downstream technology of tree improvement with various case studies such as selection of *Eucalyptus* recombinants and multiplication through stem cutting, clonal propagation of *Casuarina equisetifolia*, DNA-based techniques for genetic fidelity of clones, distribution of genetic variation of *in situ* and introduced germplasm, characterization of germplasm, biotechnological tools for gene mapping, function and regulation, forest health, adaptability to adverse environment, etc. He strongly focused on the need from tree improvement to trait improvement through collection of samples for adaptive traits, such as engineering dwarf varieties of neem to help in partitioning resources for reproductive structure and easy harvesting. He also suggested developing efficient gene-delivery systems in tree species. He described the concept of eco-gene and testing of hypothesis on the genetic system of tree populations. He stated that fixation of carbon dioxide is different from sink. He also pointed out some major gaps which require fundamental studies, such as identification of stress-responsive genes, understanding plant-microbe interactions, expression profiling in relation to vegetative to reproductive phase changes, marker-assisted breeding, tree genomics, etc. The inaugural session ended with a vote of thanks proposed by Ajay Thakur (FRI, Dehradun).

The first technical session was chaired by M. P. Singh (FRI, Kanpur) and co-chaired by N. Mathivanan (Centre for Advanced Study in Botany, University of Madras). Rajesh Tandon (Delhi University) delivered a lecture on reproductive biology of trees. He enlightened the audience with studies of reproductive biology carried out by the Botany Division of Delhi University for various forestry species like *Acacia senegal*, *Azadirachta indica*, *Salvadora oleoides*, *Oroxylum*

indicum, *Boswellia serrata*, *Butea monosperma*, *Tecomella undulata* and *Wrightia tomentosa*. Sanjeev Thakur (Dr Y.S. Parmar University of Horticulture and Forestry, Solan) delivered a talk on tree improvement of arborescent willows (*Salix* species). He emphasized that willows are the lifeline of the cold desert and are used as fuel wood, in basket and ladder-making, fodder, soil conservation, etc. He also described the methodology adopted for genetic improvement of willow through the introduction of exotic clones, nursery evaluation/screening, and field evaluation (multi-location trial) of selected clones. Some promising clones of *Salix* species were also recommended for commercial cultivation in the middle Himalaya for industrial applications like veneer and plywood industry. Willow logs and sawdust were further tested for cultivation of Shitake mushroom and results were found highly promising for commercial production. He discussed the production of hybrids through controlled pollination and the performance was compared with local checks (Kashmiri willows). He suggested that there is an urgent need to have network and collaborative approach for long term *Salix* improvement programmes. S. P. S. Ahlawat (National Bureau of Plant Genetic Resources (NBPGR), New Delhi) delivered a talk on forest genetic resources. He emphasized that humans are changing life on earth and this may cause loss of forest genetic resources (FGRs); therefore, management of plant genetic resources (PGRs) should be realized as an essential and primary activity. He described the key activities required for PGR management, such as exploration and collection, germplasm exchange, quarantine testing, characterization and evaluation, database generation, etc. He also discussed the status of *in situ* and *ex situ* conservation (i.e. botanical gardens, field gene banks, seedling and clonal seed orchards, etc.) for FGRs in India. S. K. Malik (NBPGR, New Delhi) delivered a talk on implementing cryotechniques to FGRs. He discussed in detail the cryogenic methodologies applied in different forestry trees grown in tropical, subtropical and temperate zones of the country,

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particularly recalcitrant species. He suggested establishing a National Bureau of Forest Genetic Resources (FoGRs) in line with NBPGR, NBAIM, NBFGR, NBSS&LUP, etc. Jagdish Chander (Haryana Forest Department, Pinjore) delivered a talk on tree improvement in the rest of the 21st century, with special reference to Haryana. He focused on the dominance of *Eucalyptus* in Haryana in the past (30 ha seed orchard, Vegetative Multiplication Garden (VMG) 15 ha) and decline in recent years due to biotic stress caused by gall wasp (*Leptocybe invasa*). He suggested that *Corymbia* is the candidate genus which has been found free of gall wasp infestation due to the presence of trichomes on the leaves. He also described the present agroforestry status of Poplar, Shisham, Neem and Kikar along with the problems associated with biotic and abiotic stress in Haryana. Jitender Singh (progressive farmer, Fatehabad, Haryana) delivered a talk on the importance of growing genetically improved planting stocks. He emphasized the problem of price fluctuation which discourages farmers to adopt and practice agroforestry systems. He also mentioned the problems of insect (gall wasp in *Eucalyptus*) and disease incidence (mortality in shisham and Malabar neem) in his plantations causing loss in productivity (timber value) at the time of maturity. Moreover, slow-growing species like Khejri and Rhoeda were suggested for cultivation, but they take about 50 years of maturity duration; therefore, a farmer cannot wait for such a long period. Practising agroforestry faces the problem of sustainability. Therefore, model of animal husbandry (fishery, poultry, dairy, carp culture) and agroforestry work together to achieve the goals of sustainable development. Planting of appropriate species should be well adopted and have mixed cultivation for trees (compatible system).

The second technical session was chaired by Gurusurthi and Jagdish Chander. N. Mathivanan spoke about tree improvement for anti-venom properties and other bioactivities. He discussed

research undertaken for the screening of medicinal plants used by traditional healers for the identification of anti-snake venom. Interestingly, an extract of *Dalbergia horrida* (endemic to Western Ghats) was found promising when tested for anti-snake venom activity under *ex vitro*, *in vitro*, *ex vivo* and *in vivo* experiments. Madhulika Singh (Institute of Biosciences and Biotechnology, Chhatrapati Shahu Ji Maharaj University, Kanpur) spoke on synthetic seeds (*Psidium guajava*, *Artocarpus lakoocha*, *Mangifera indica* and *Andrographis paniculata*), and their importance in germplasm conservation and management. Vishnu Bhatt (Delhi University) gave an overview of apomixis and its importance in angiosperms. A case study on the occurrence of apomixis in *Cenchrus ciliaris* was discussed in detail. Various mechanisms responsible for the induction of apomixis were also described. Shashi B. Tripathi (TERI University, New Delhi) delivered a talk on applying next-generation genotyping technologies in modern tree breeding. He provided exposure to sequence resources available in forestry tree species and modern techniques for marker genotyping like microarray, RAD seq and genotyping by sequencing.

The panel session of the workshop and the question-answer session were chaired by Savita, Gurusurthi and H. S. Ginwal (FRI Deemed University, Dehradun). Ginwal raised some points regarding the need for characterization and conservation of indigenous FGRs for introspection. The need of the hour is to document, characterize, and prioritize breeding strategies of fast-growing species, trait-specific breeding and mapping populations. Yogendra Singh (G.B. Pant University of Agriculture and Technology, Pantnagar), D. H. S. Bisht (IFFCO, Dehradun), Rajesh Kumar (ITC Limited (WIMCO), Rudrapur) and Munish Kumar (Dept of Soil Conservation and Water Management, Kanpur) also participated in this session. The important recommendations arising from the discussions are as follows:

- Basic knowledge of forestry trees such as reproductive biology, mating system, pollination mechanism, phenology, seed characteristics, etc. is lacking and should be prioritized in the research mandate of ICFRE, Dehradun.

- Identify and prioritize the forestry species based on their importance, possible threats, and areas of diversity, niche, hotspots for exploration and germplasm collection.

- Linkages with stakeholders for accessing FGRs, sampling strategy and collection methodology.

- Capacity building of students, young researchers and scientists is required in advanced laboratories for exposure and learning new techniques.

- Bioinformatics infrastructure needs to be developed and whole genome sequencing projects for indigenous forestry trees are required.

- Non-wood forest products and medicinal plants should be included in the improvement programmes.

- Research on natural forests needs to be prioritized as climate change/natural disaster affect the marginal populations of species like oak, pine, acacia, shisham, etc. and may cause loss of valuable alleles, which reduces the resilient nature of our forests.

- Diseases and insect-pests of fast-growing tree species like *Eucalyptus*, *Melia*, poplar and shisham should be screened at the nursery level before diverting germplasm directly to the field.

- Forestry research is in developmental phase; therefore, more substantial and unorthodox methodologies should be incorporated in tree improvement programmes for high productivity of our forests.

- Maturation and rejuvenation aspects need to be addressed for successful clonal forestry programme.

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