

RESEARCH IN GENETICS & TREE IMPROVEMENT: OUTLOOK 2020

Dr. A. K. Mandal

Tropical Forest Research Institute
(Indian Council of Forestry Research & Education)
Jabalpur, Madhya Pradesh, India



Asia Pacific Region

Bangladesh, Bhutan, Cambodia, China, India, Indonesia, Lao PDR, Malaysia, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka, Thailand and Vietnam



- Asia Pacific Region has 18% of world's forest totaling 655 million ha, south Asia share is 76.6 mha (12 % of Asia pacific region)
- The region has 4 billion people which is 60% of world's population.
- Although forestry sector is a major source of GDP in many countries, the region is net importer of timber.

Status of Forests in the Region

The region is characterized by -

- Low per capita of forest (0.2 ha), outside region (1.1 ha), South Asia (0.1 ha)
- Large forest dwelling population and still larger depending on forests for their living.
- Rapid decrease in forest area due to population pressure. Around 4 million ha is lost or depleted every year.
- Forestry sector provides employment for poor people living in areas adjoining forests.

Plantation Forestry in the Region

- Asia Pacific region has around 113 m ha plantation which is 61% of forest plantation in the world. It also has the highest rate of planting around 3.4 m ha/ yr.
- South Asia has 34.6 m ha of plantation with the highest rate of planting in the Asia Pacific region at 1.6 m ha a year
- Six out of 10 countries with the largest plantation area are in the Asia Pacific Region (China, India, Indonesia, Japan, Thailand and Vietnam).
- Forest plantations are compensating loss / depletion of natural forests and generate employment opportunities to people.
- Large scale planting particularly short-rotation species, promise high returns for investments in tree improvement.

Major Plantation Species

Acacias

Casuarinas

Eucalypts

Gmelina

Hevea

Pinus

Swietenia

Teak

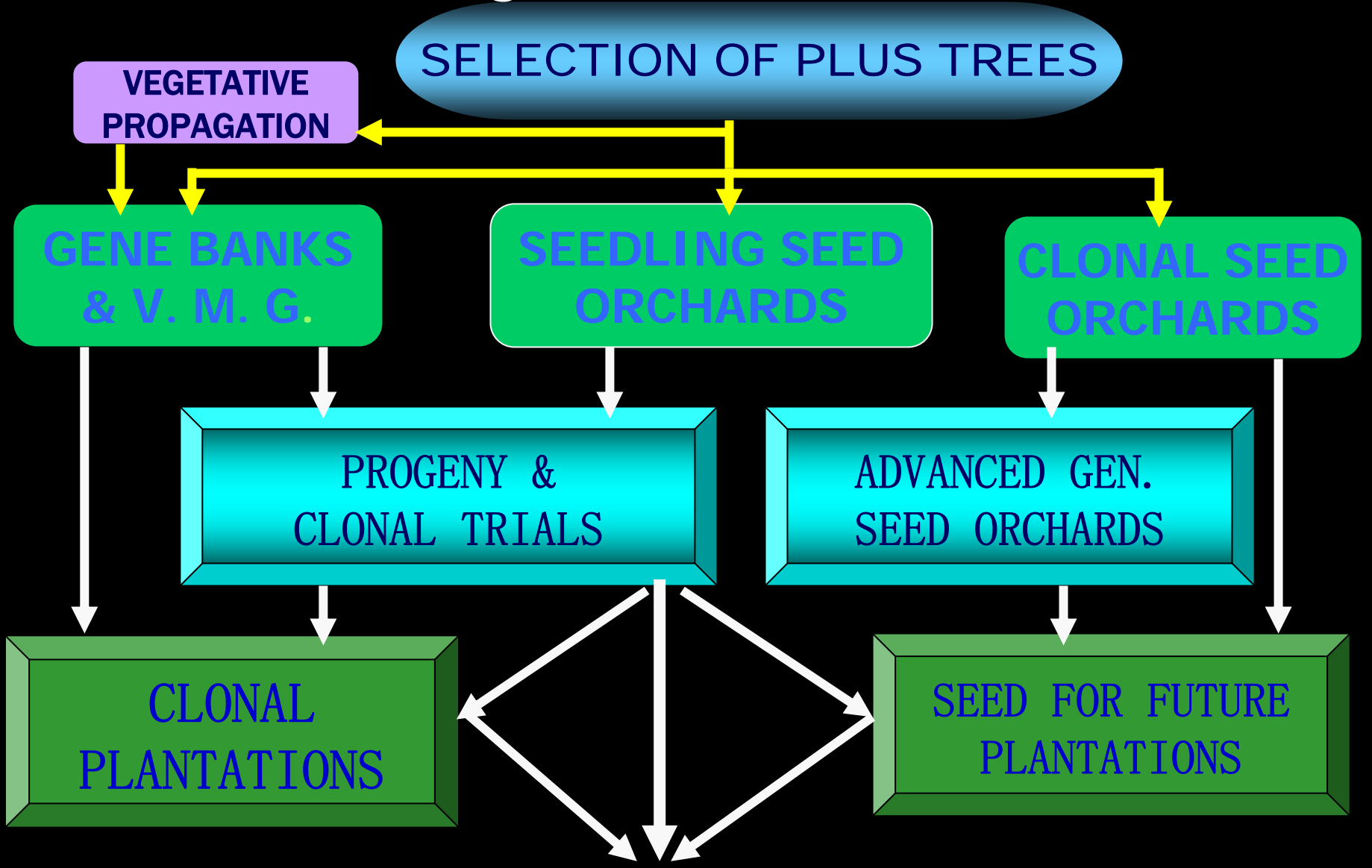
Poplar

- These species constitute 75% of total forest plantations.
- Most of them are exotic to the region.

Tree Improvement

- Forest genetics & tree improvement has highest potential for increased productivity
- Applied tree improvement aspects developed rapidly in early 1950s
- Factors responsible for these developments
 - Recognition of the importance of forest tree parentage
 - Recognition of fact that improvement in growth and quality can be brought about by breeding and parental control

Logical Framework



HYBRIDIZATION FOR NEW RECOMBINANTS

Crop Improvement: Productivity (India)

(yield in mt)

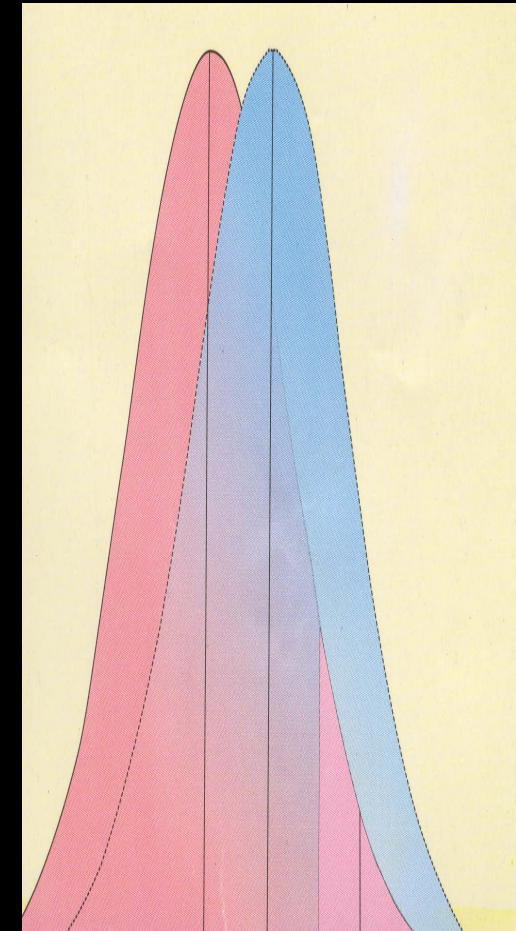
Crop	1950-51	1970-71	2000-01
Rice	20.58	42.20	88.30
Wheat	6.46	23.83	75.50
Pulses	8.41	11.82	13.50
Oilseeds	5.16	9.63	22.80
TOTAL	50.82	108.00	208.80

Tree Improvement: Productivity

SPECIES	INDIA (m³ha⁻¹yr⁻¹)	ABROAD (m³ha⁻¹yr⁻¹)
<i>Eucalyptus tereticornis</i>	16-20	40-50
<i>Tectona grandis</i>	2-3	10-12
<i>Populus deltoids</i>	20-25	45-50

Genetic Gain

Means	Predicted Genetic Gain (%)
Provenance	5
Plus Trees	5-7
Seed Production Area	5-10
Clonal Seed Orchards	15-20
Seedling Seed Orchards	10-15
Clones	25-30



Provenance Testing

- Conducted in majority of the species
- Best provenance need to be utilized in plantation program
- Land race need to be developed and utilized
- **Beyond provenance research**



Progeny Testing

- An essential component of tree improvement

- Limited to few species

- *Eucalyptus tereticornis*
- *Gmelina arborea*
- *Casuarina equisetifolia*
- *Tectona grandis*
- *Acacia mangium*



- Research concentrated only with half sibs

- Full sib development should be an essential component and to be taken up systematically

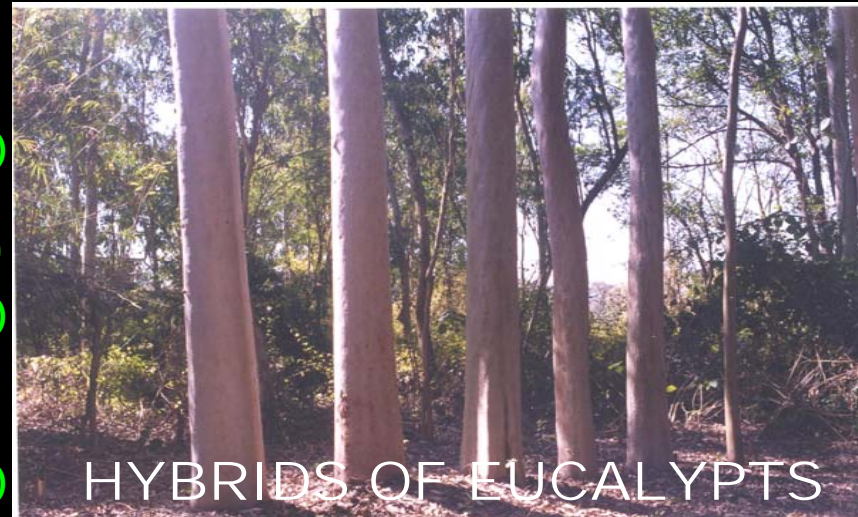
Hybridization

- **A technique for creating new recombinants and variation**
- **Undertaken only in eucalypts and poplar**
 - **Artificial hybrids developed**
 - **Natural hybrids identified**
- **Need for developing hybrids in all species with biological advantages**



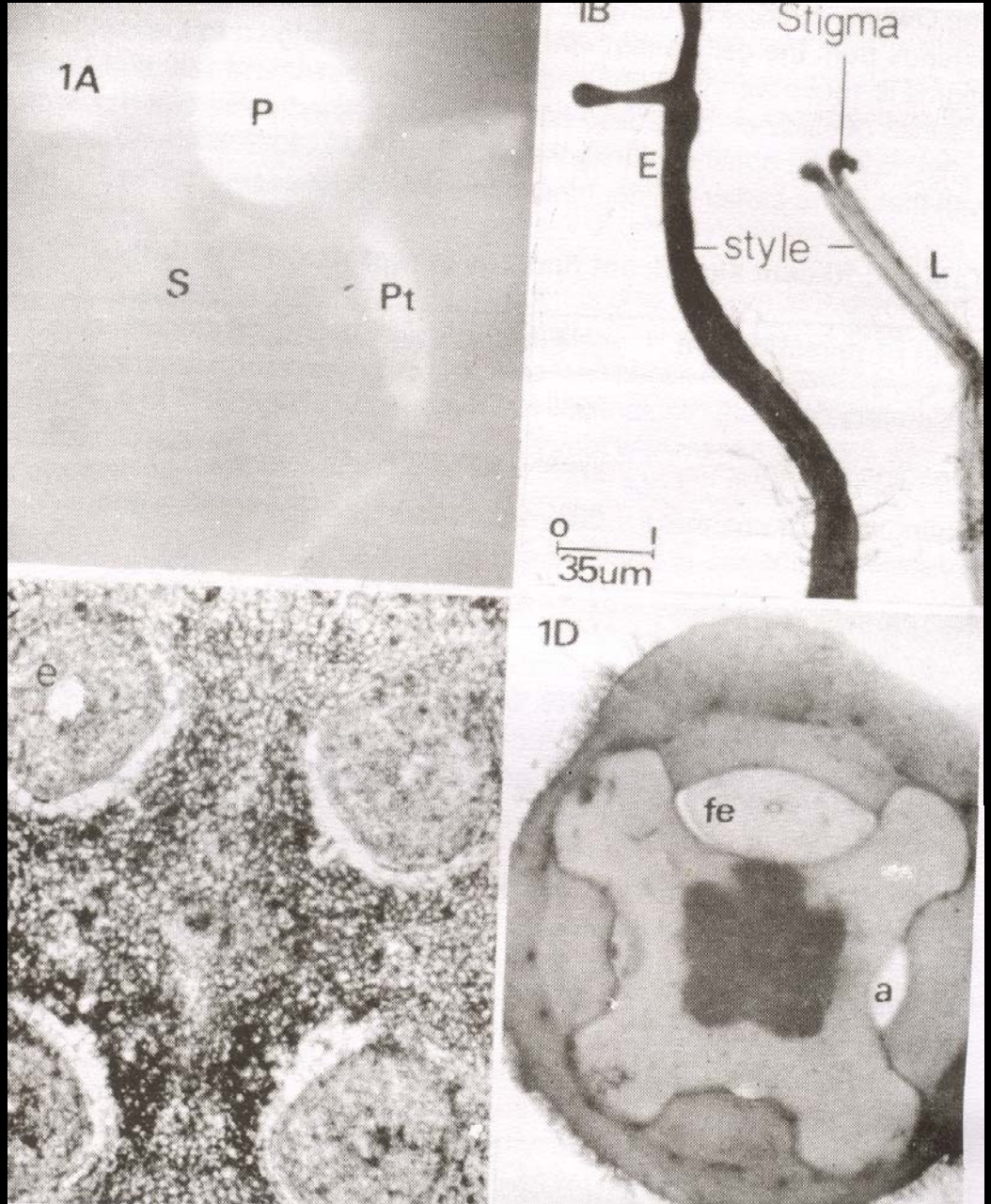
List of Hybrids

- **FRI 2, 3, 4 (A)** 1966-70
 - (*E. tereticornis* x *E. camaldulensis*)
- **FRI 5 (N)** 1970
 - (*E. camaldulensis* x *E. tereticornis*)
- **FRI 6, 7, 9 (A)** 1966-70
 - (*E. tereticornis* x *E. grandis*)
- **FRI 10 (N)** 1974
 - (*E. grandis* x *E. tereticornis*)
- **FRI 13 (A)** 1976
 - ((*E. tereticornis* x *E. camaldulensis*) x *E. grandis*)
- **FRI 14, 15 (N)** 1976
 - (*E. torelliana* x *E. citriodora*)
- **FRI 16 (A)** 1997
 - (*E. camaldulensis* x *E. tereticornis*)



Reproductive Biology

- Pre-requisite for undertaking controlled hybridization.
- Information available only on teak, few species of *eucalypts*, *Tamarindus indica*, *Gmelina arborea*.



Breeding Population

- Breeding population established only with half-sib families (teak, casuarinas, eucalypts)
- 2nd / advanced generation breeding population need to be established

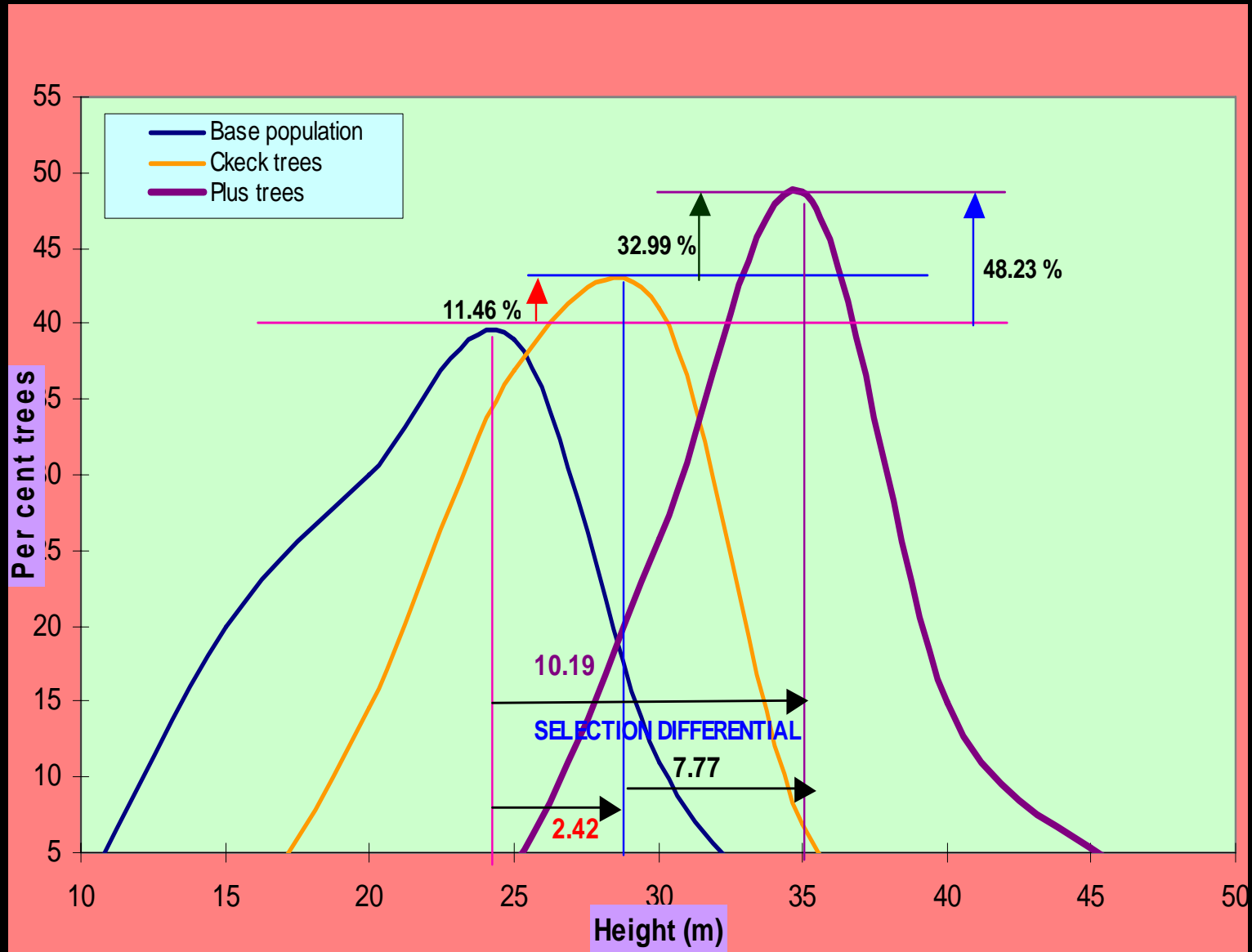


Production Population

(SPA, CSO, SSO, VMG)

- Established for many species
- Need better management and maintenance
- Seed from the production populations to be used for raising the new plantation programmes
- Advanced generation production populations need to be established
- Beyond production population?

Improvement through Selection



Teak

- A high priority species both in terms of timber value and extent of plantations in the region.
- Most studied tropical timber species for biology and ecology.
- Extensive phenotypic selections (“plus trees”) for raising clonal seed orchards and progeny tests.
- Low seed production in seed orchards is a bottleneck in teak improvement.
- Improved nursery and vegetative propagation techniques have addressed the problem of planting stock quality in recent years.
- The breeding objective needs to move from quantity (growth) to quality (wood traits) for maximizing returns from plantations. Breeding strategies to be reworked to capture genetic diversity in breeding and production populations.

Eucalypts

- Most widely planted species in the region for fuel wood, pulpwood, construction and essential oil needs.
- Domestication and breeding has seen rapid progress in the past two decades.
- Extensive testing of native provenances showed their superiority over the local landraces. Productive seed orchards exist in most countries.
- Clonal forestry has increased plantation productivity significantly. Clones of different interspecific hybrids are now preferred over pure species.
- Systematic breeding needs to be continued with adequate genetic diversity in each generation to take care of problems like gall insect attack.
- While embarking on production of interspecific hybrids, sufficient populations of pure species have to be preserved.

Acacias

- *Acacia auriculiformis*, *A. crassicarpa* and *A. mangium*
- One of the major plantation species in Indonesia, Malaysia and Thailand and in India to a limited extent.
- Native provenances from PNG and Australia have replaced low productive local landraces after extensive field testing. Seed orchards are the source of most of the seed demand.
- Interspecific hybrids of *A. auriculiformis* and *A. mangium* are replacing the pure species in plantations.
- The timber of *A. auriculiformis* has been found to be a worthy substitute for high value species like Teak.

Other Species

- Casuarinas and poplars are important plantation species in the region.
- It meets requirement for fuel, pulp and poles.
- Play a vital role in environmental protection especially in coastal region.
- Both the countries pursue active breeding programmes for Casuarinas.
- *Gmelina*, *Swietenia* and tropical pines are the other species found in plantations in a limited scale.

Utilizing Indigenous Forest Genetic Resources

- Only a small portion of potentially useful tree species is managed in tree planting programmes and most of them are exotics.
- In Asia, less than 100 species are included in testing and breeding programmes although close to 2000 species with high potential for different end uses have been reported.
- The species diversity in plantation regimes has to be increased by initiating domestication for high priority native species. Their use in plantations will strengthen efforts to conserve them.

Priority Species

Alstonia scholaris
Aquilaris crassna
Shorea spp.

Dalbergia species
Dipterocarpus species
Hopea species

Melia dubia
Pterocarpus species
Pinus merkusii

Biotechnological Interventions

- **Molecular markers has enhanced our understanding of population structure and breeding systems.**
- **Marker assisted breeding techniques (QTL) are useful in breeding for specific traits in Eucalypts and Acacias.**
- **Genetic engineering is actively pursued only for Eucalypts to improve papermaking quality. Other species where such work can be undertaken are salt tolerance in Casuarina, herbicide resistance in Poplar**
- **Considering the status of domestication of other species this approach may not be suitable for them at present.**
- **Costly proposition – need to be used with caution.**

Tree Genetics and Climate Change

- Plantations raised with improved planting stock will have high potential for carbon sequestration.
- All future plantations need to be established with improved planting stock only.
- Efforts need to be made for optimisation between goods (timber, pulp, etc.) and environmental services (carbon sequestration, abatement of noxious gases and noise pollution).

Regional Collaboration for Tree Improvement

- **Many indigenous and exotic species are economically or otherwise important in more than one country in the region.**
- **Researchers may benefit from exchanging experiences and germplasm available with each other for tackling shisham mortality, gall insect problem in eucalypts, utilization of wood in eucalypts, causuarina and rubber and climate change.**
- **Regional networking activities taken up during early 1990s have not been sustained and fresh initiatives are needed.**
- **Species-specific networks (like TEAKNET) needs to be strengthened and supported.**
- **Efforts should also be made to make the region importer to exporter of timber.**

THANK YOU