Silviculture – Foundation and Practices:

Tree Genetics: an Over view

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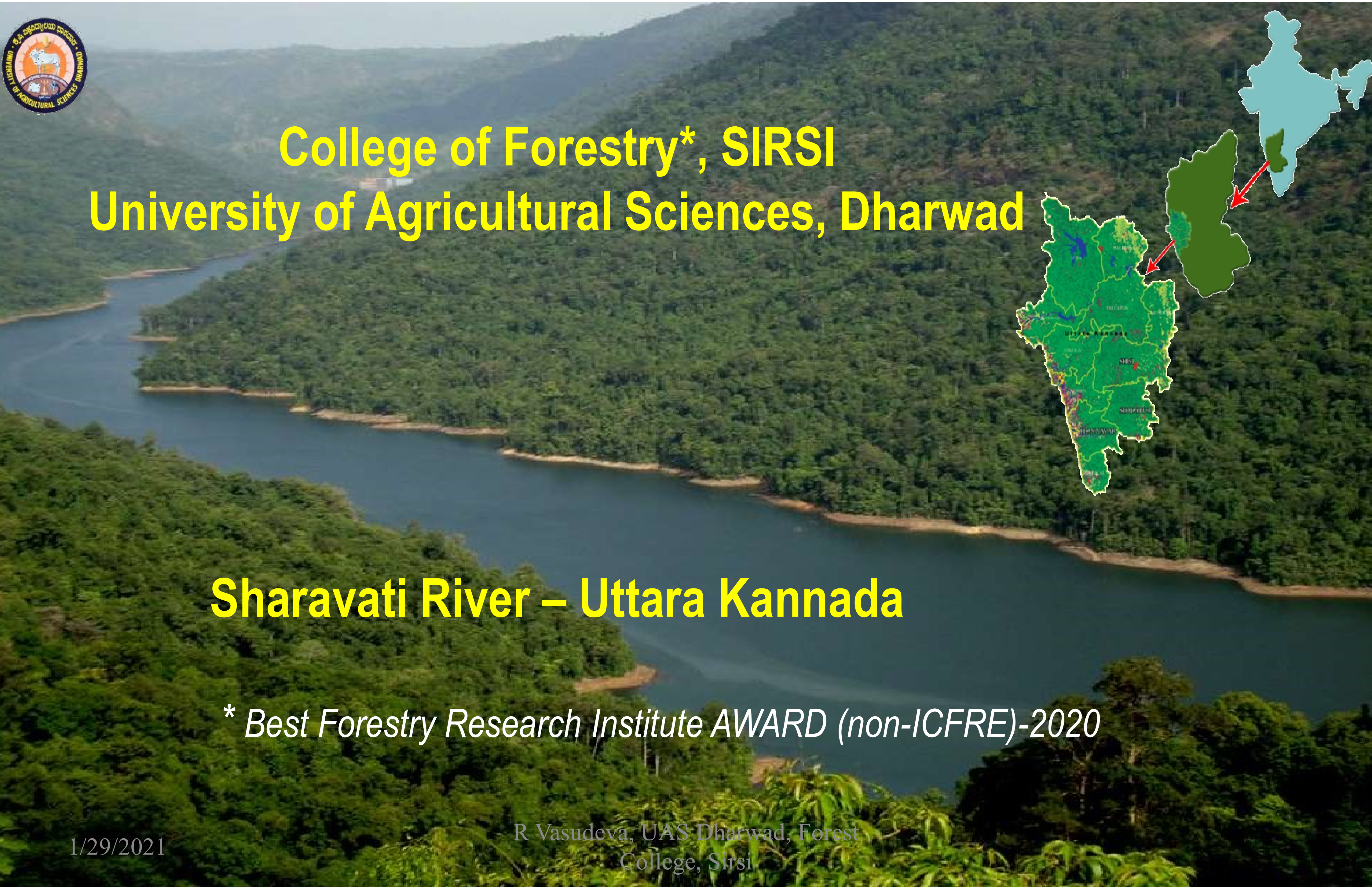

College of Forestry*, SIRSI
University of Agricultural Sciences, Dharwad
Sharavati River – Uttara Kannada
* Best Forestry Research Institute AWARD (non-ICFRE)-2020

How old is the
Art of Tree Improvement ?

Assyrian Sculpture- Fertility Ritual

All most 3000 years Before Present 883-859 B.C.E.

A bas- relief sculpture found at the Palace of Nimrod, `near the Trigris river

Present Day IRAQ

Winged Genie performing a Fertility Ritual to the Date Palm tree.

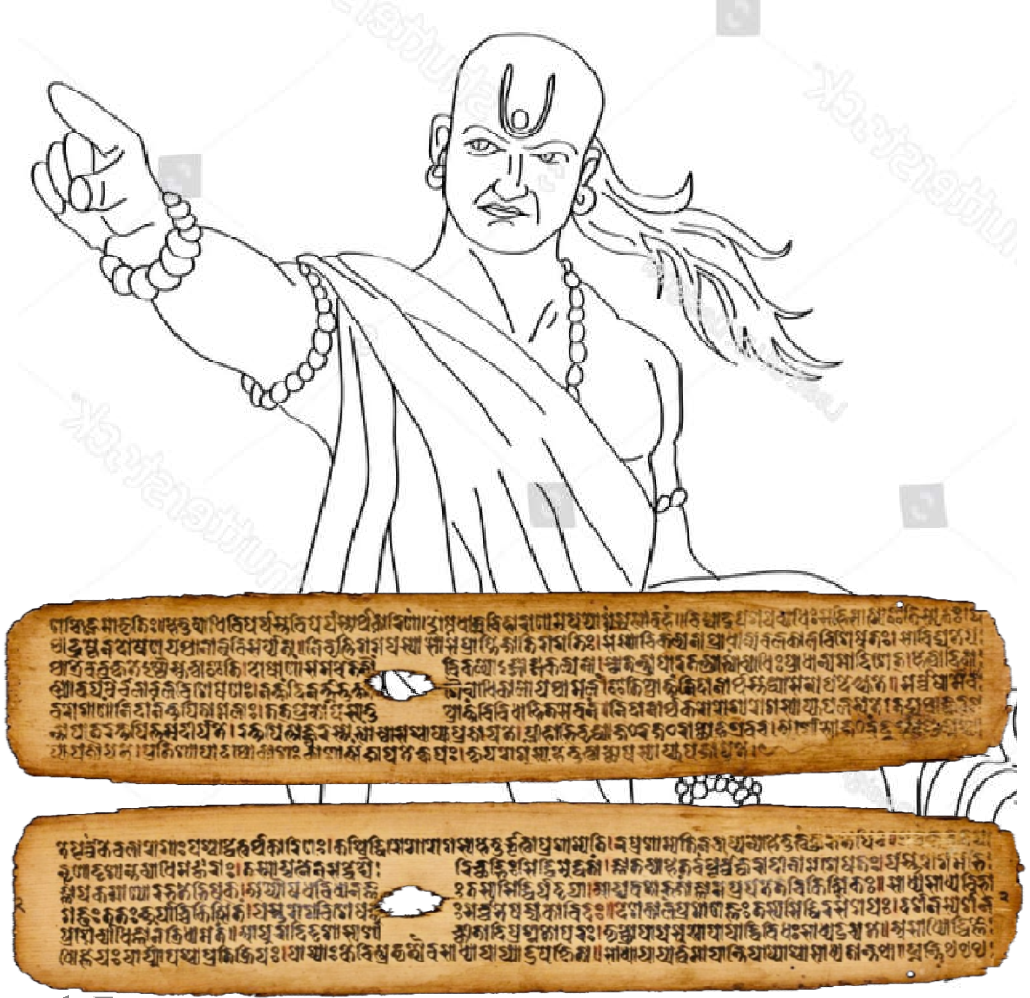
ASSYRIANS KNEW ABOUT:

- The sexuality of Date Palm
- Pollination system
- Maturity Period
- Tree Selection and use of Pollen
- Control of Parentage

Belief is that the YIELD & QUALITY dates would improve

Chanakya, the Prime Minister of **Chandra Gupta Mourya**

- 150 AD ; ArthaShasthra
- Has given a detailed account on How **Different Provenances of Sandal Wood**, to be categorized based on the Aroma and Colour
- **Perhaps the first description of the Provenance Diversity in a tree**



GREEKS maintained OLIVE TREE GROOVES for seed Collection for Planting Purposes

Believed that some SACRED trees were the bounty given by the GODS

4000 yeas before present; Syrian Coast

Tree Domestication and
Tree Improvement
started with
Human Civilizations

- Egypt
- 1500 years back
- Huge Earthen Olive Jars
- Fruits Edible FIG that were Cultivated
- These tree were Selected as food trees for desert travel

What is Tree Improvement ?

THREE REALTED TERMS

- **Forest Genetics**
- **Forest Tree Breeding**
- **Forest Tree Improvement**

Forest Genetics

Activities restricted to Basic studies:

Answering the questions:

- **What is the genetic basis of flower colour?**
- What is the chromosome number of different tree species?
- **What is the genetic diversity in a population?**

Forest Tree Breeding

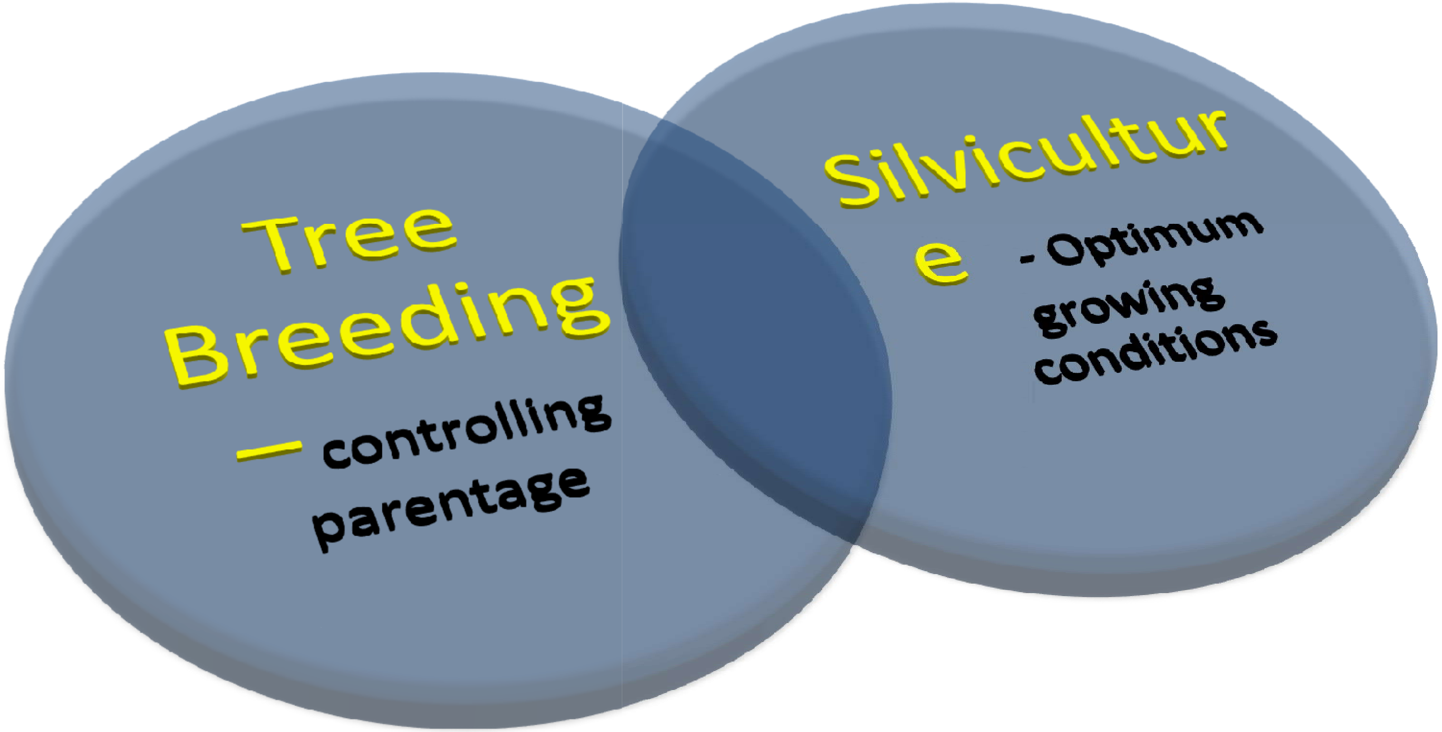
Activities that are more of Applied in nature, uses the principles of Forest Genetics:

- **Development of a Hybrid**
- **Development of pest-resistant genotypes**
- **Improving the Wood Quality of the trees**

Genetic Tailoring of Tree species for the needs of the Human

Forest Tree Improvement* ?

Combination of both the Tree Breeding Skills and Management Skills to improve the overall yield and quality of the products from forestlands



**Term introduced by Professor Scott S. Pauley 1953*

Overall Goal of
Forest Tree Improvement

Production of:

- ***Desired-quality*** *timber (or any product)*
- *in* ***Maximum amounts***
- *in the* ***Shortest Period of Time*** *(it is the non-commercial input)*
- *at a* ***Reasonable Cost***

Steps in Tree Improvement Programme

Step 1
- A Determination of the species, or the geographic source that should be used in a given area

Step 2
- A determination of the amount, kind and causes of variability within the species

Step 3
- A packing of the desired qualities into improved individuals, such as to develop trees with combinations of desired characters

Step 4
- Mass production of improved individuals for operational level planting

Step 5
- Developing and maintaining a genetic base population broad enough in advanced generations

Step 1
- Which Species /Which Provenance ?

Step 2
- What is the Level of Variability ?

Step 3
- How to get All-in-One ?

Step 4
- How to Mass Produce?

Step 5
- How to Secure Future ?

STEP 1 Determination of the species, or the geographic source that should be used in a given area

- **Which species should be focused for genetic improvement?**
  - Teak, Sandal, Sal, Eucalyptus, Bamboo
  - Bio fuel yielding trees?
  - High Value drug yielding trees?
- **Which geographic source should be focused for planting?**

STEP 1 Determination of the species, or the geographic source that should be used in a given area

A flowering branch of one of the species of *Cinchona* used commercially to produce quinine. A strip of bark, harvested from the stem of the tree, is shown at the upper left. It is this bark that is the source of quinine used in pharmacy.

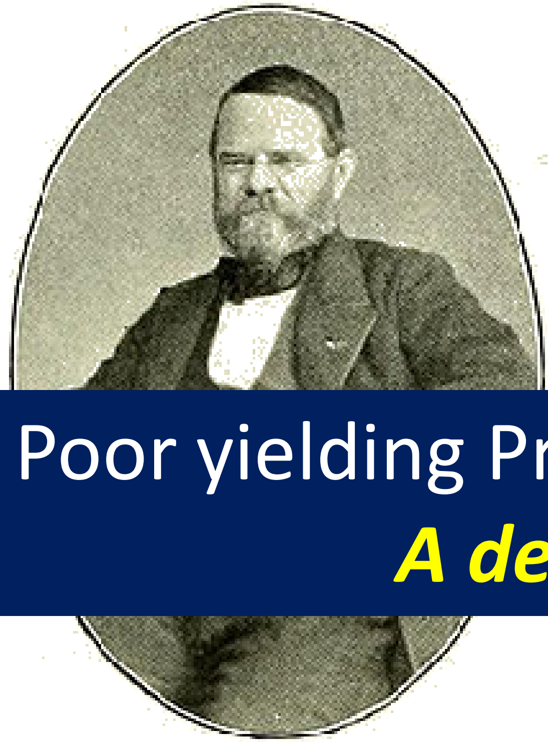
Story of the Identification of TRUE Cinchona tree!

Story of the Identification of Quinine

- More European and US soldiers were dying **because of Malaria** than the **Bullets in the War**
- **Quinine was supplied only by Columbia**
- It was strategic to grow Cinchona outside Columbia
- **But the Columbian government had put an embargo on the export of this; no seed material was allowed to go out of the country**
- SO SMUGGLE OUT

STEP 1 Determination of the species, or the geographic source that should be used in a given area

Story of the Identification of Quinine



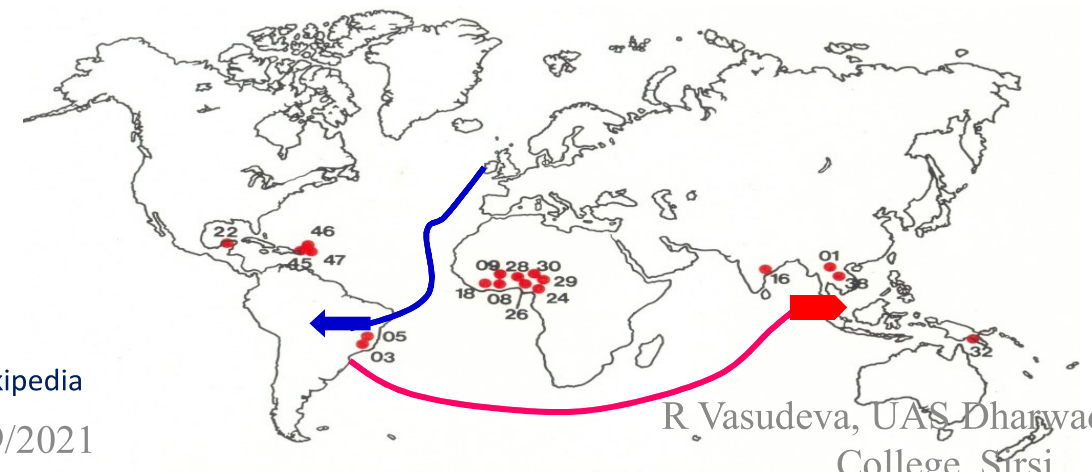
- The Dutch government at JAVA commissioned the Director of Botanical Garden to smuggle

A Poor yielding Provenance / Seed Source was grown!

A decade of Testing wasted

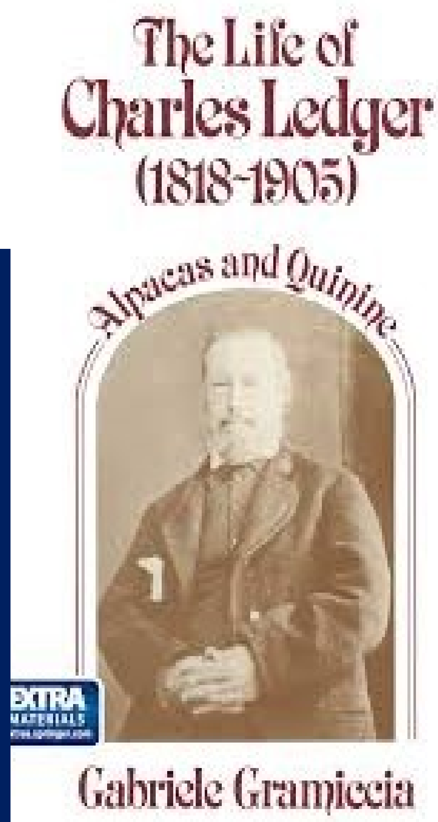
- **21 box loads of seeds and seedlings of Cinchona was exchanged with one bag full of gold coins from South America**
- They were brought to Java to grow; **Unfortunately when the trees matured, the yield of Quinine was very low!**

Source: The Wise Articles



source: Wikipedia

Story of the Identification of Quinine



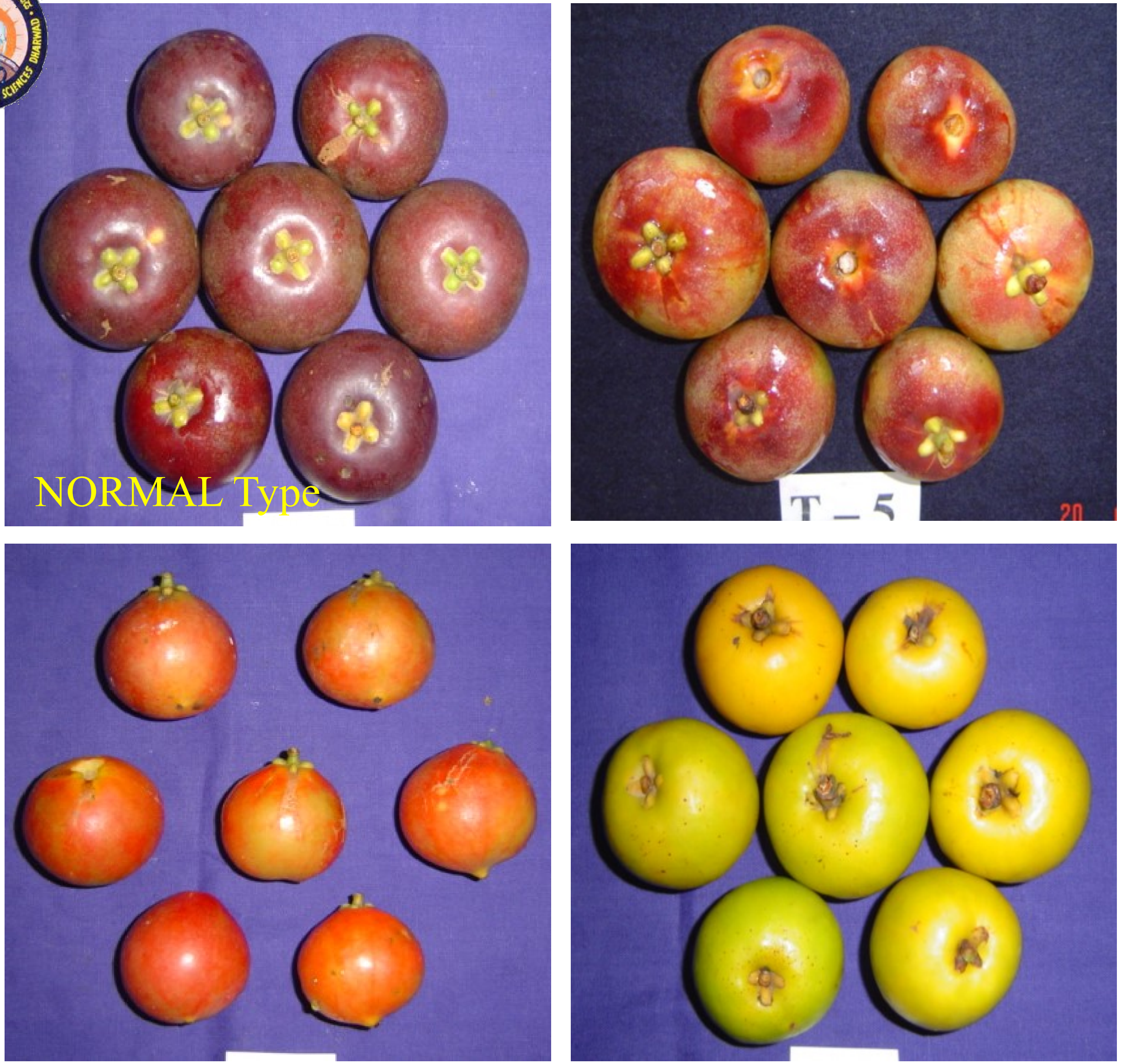
Dutch had the monopoly & produced 97% world's quinine by 1930

One GOOD Provenance Changed the Entire Course of NATION!!

(for an investment of 20 $!!)

Cinchona ledgeriana

- **Australian Sailor: C**
- He prevailed on a T
- **Manuel Incra show**
- The Seeds were sol
- **Manuel Incra was tortured to death**
- The Plantation raised out of that seed material had maximum Quinine



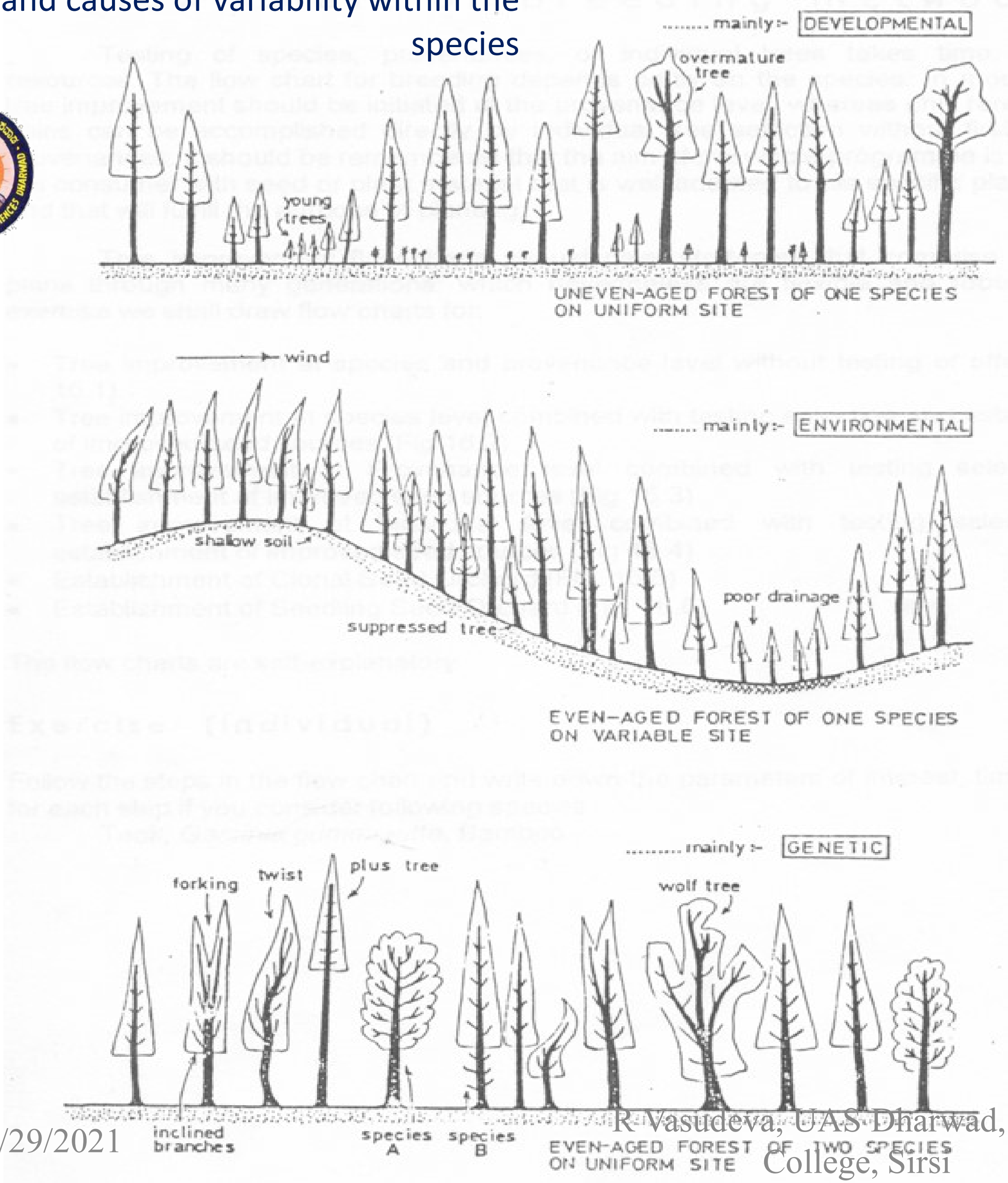
Genetic variation in Murugalu (Kokam) *Garcinia indica*

Step 2 : A determination of the amount, kind and causes of variability within the species

- We may wish to have a teak genotype which grows @ 15 cm DBH increment per annum, but does such an individual available in the natural conditions?
- **Even if such a trait is recognized, the variability may not be genetically controlled**
- Yield traits are quantitatively controlled. They need a different statistical treatment

Step 2 : A determination of the amount, kind and causes of variability within the species

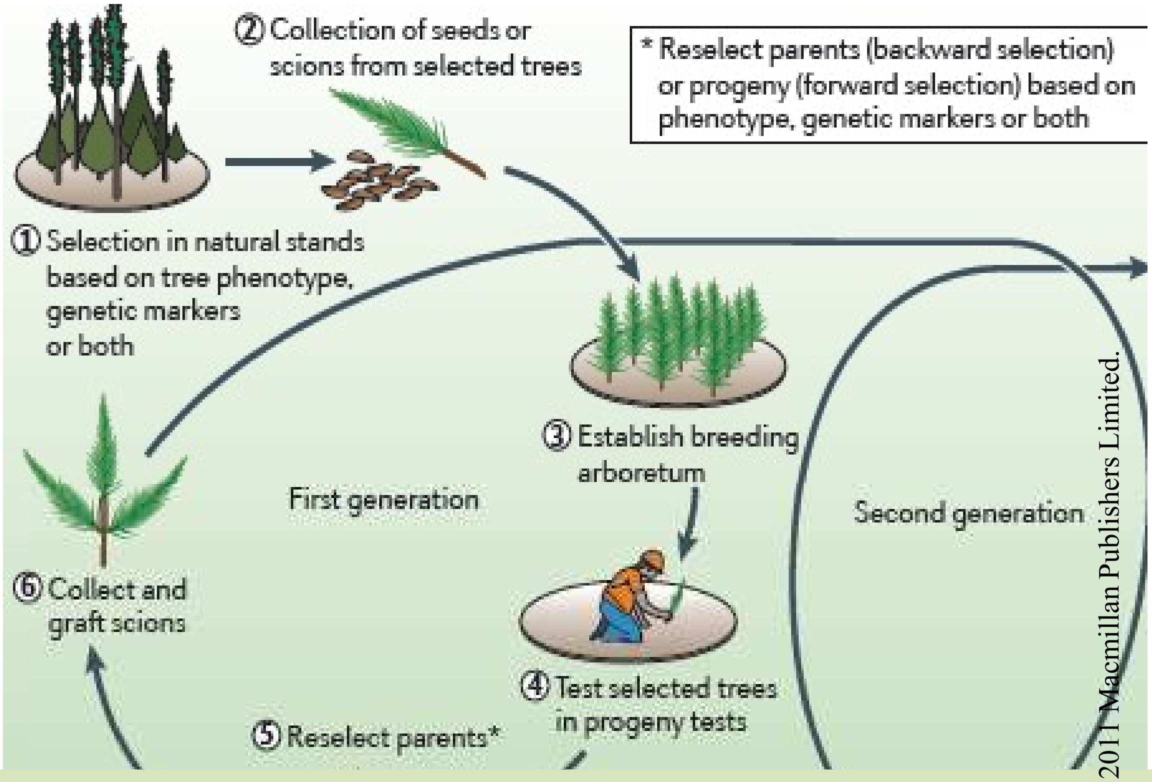
Sources of variation



- **Genetic variation is the basis for tree improvement**
- Understanding this natural variation and controlling it forms the basis of Tree Improvement
- **It must be distinguished from the developmental and environmental variation**

Common Garden Experiments

- There is a long tradition of provenance testing in forest tress, primarily as a tool to determine optimal seed sources for reforestation.
- **Extensive seedling nursery comparisons or growth chamber and field common-garden experiments**



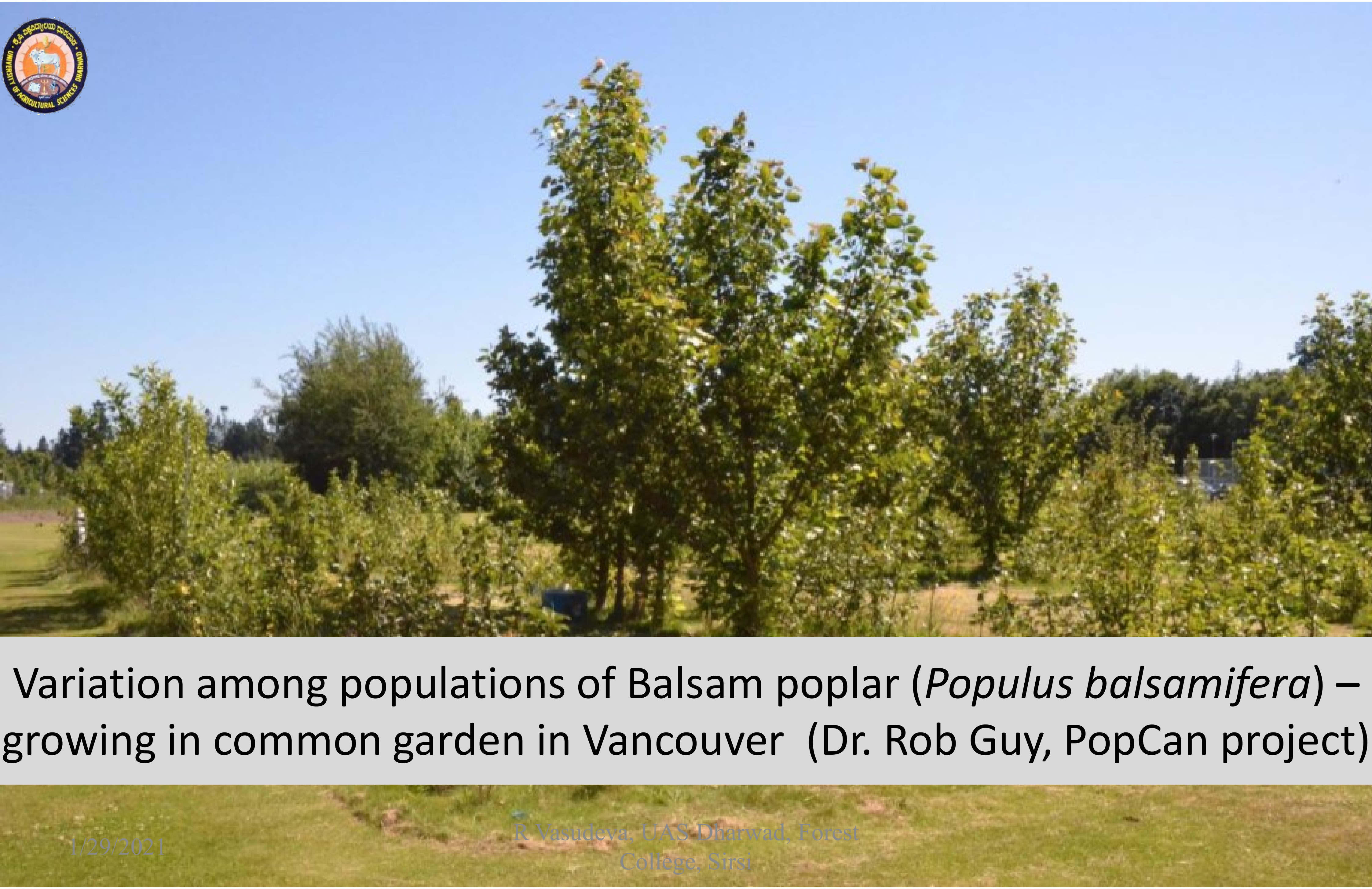
Common garden experiment is essentially a plantation in which tree populations corresponding to different geographical origins (provenances) are compared using statistical designs.

Provenance variation for early growth traits in *Dysoxylum binecteriferum*

North East Indian Provenance Western Ghats Provenance

Source: Vasudeva et al., 2015

Adaptation to climate in Sitka spruce: *Common Garden Experiment*



Variation among populations of Balsam poplar (*Populus balsamifera*) – growing in common garden in Vancouver (Dr. Rob Guy, PopCan project)

- Provenance Studies Help the breeders to match the seed sources to different target sites and achieve significant genetic gains
-

Step 3 A packing of the desired qualities into improved individuals, such as to develop trees with combinations of desired characters

- Individual which is phenotypically superior with respect to economic traits such as timber/ wood quality/ fruit quality/ chemical profile, *etc*. and GRADED
- **Plus tree Selection** (the starting the point of tree improvement programme)
- Individual which is phenotypically superior with respect to economic traits such as timber/ wood quality/ fruit quality/ chemical profile, *etc*.
- **Hybridization**

Selection Methods:
Natural Forest vs. Plantations

(no control over the age) vs. (complete control over the age)

Natural Forests:

- **Subjective Grading System**
- Mother Tree Selection
- **Regression Method of Selection**

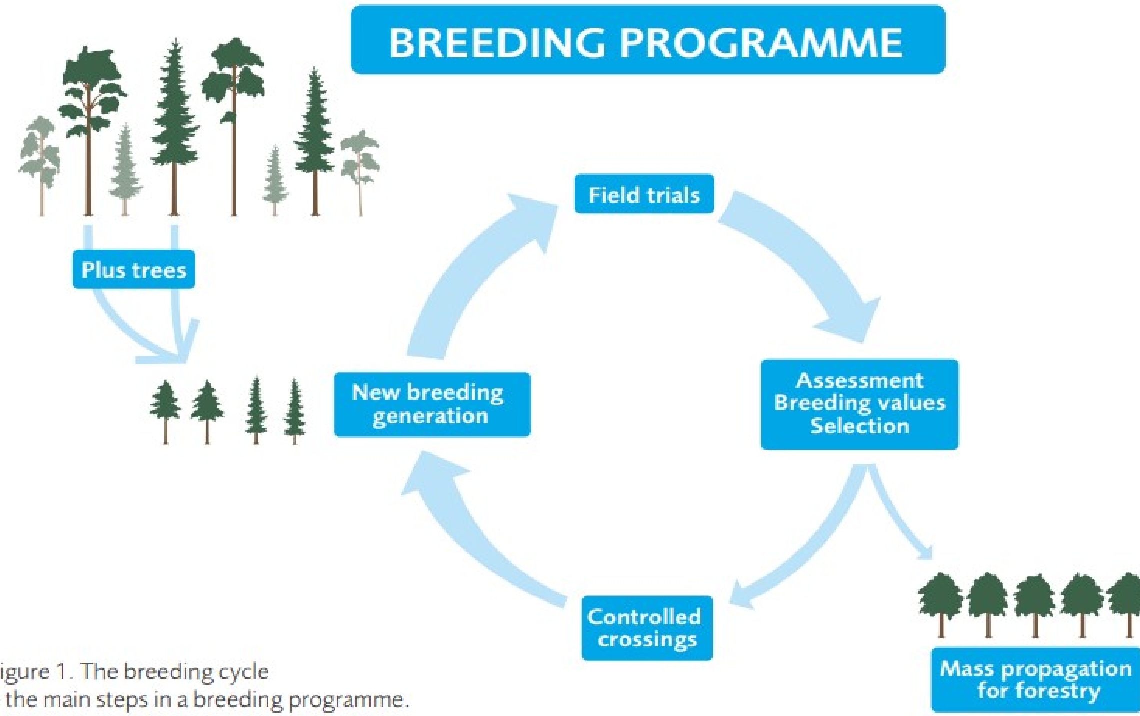
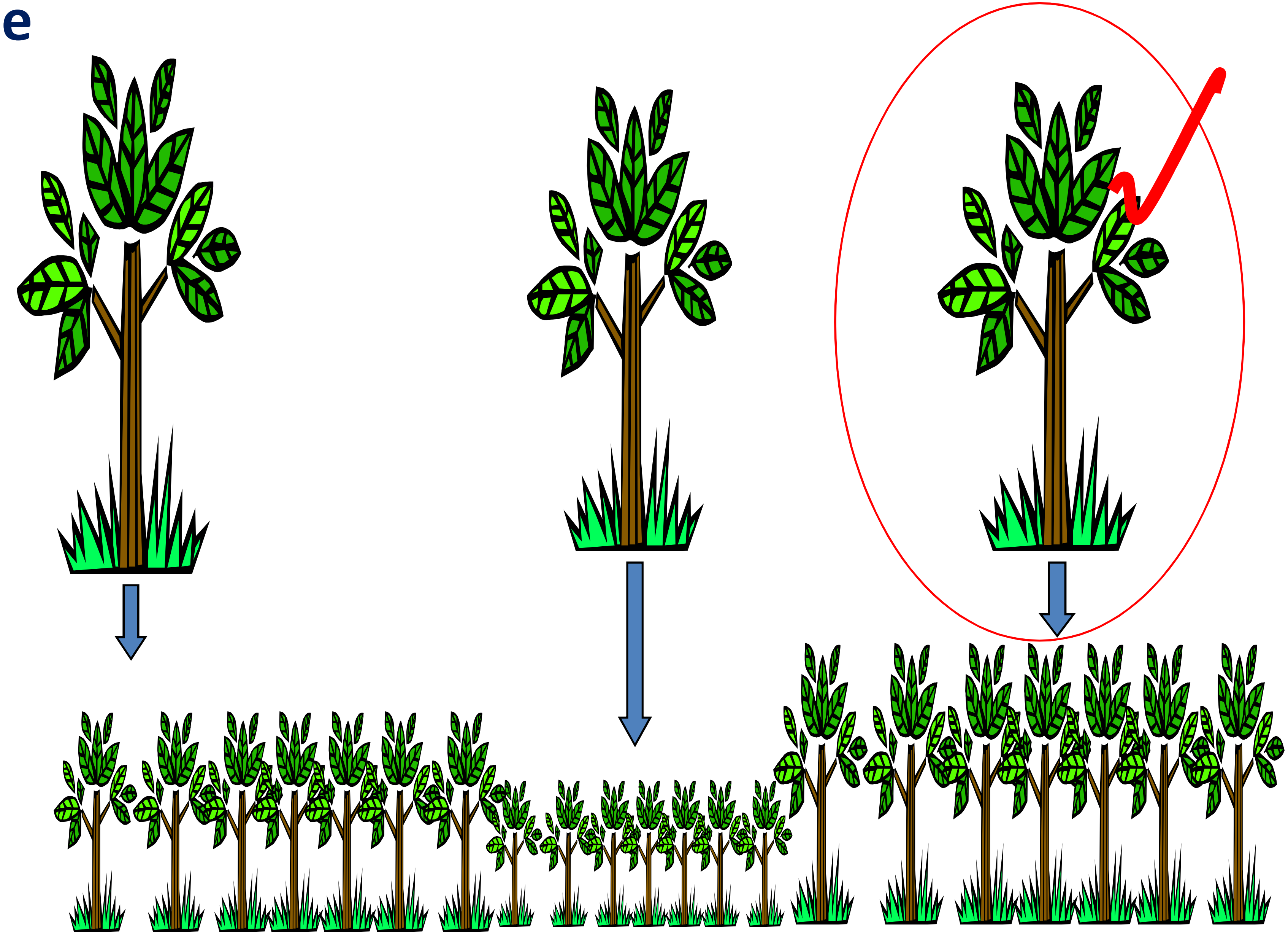


Figure 1. The breeding cycle
– the main steps in a breeding programme.

Subjective Evaluation Method

Mother Tree Selection : the Ultimate Way of Selecting a Tree

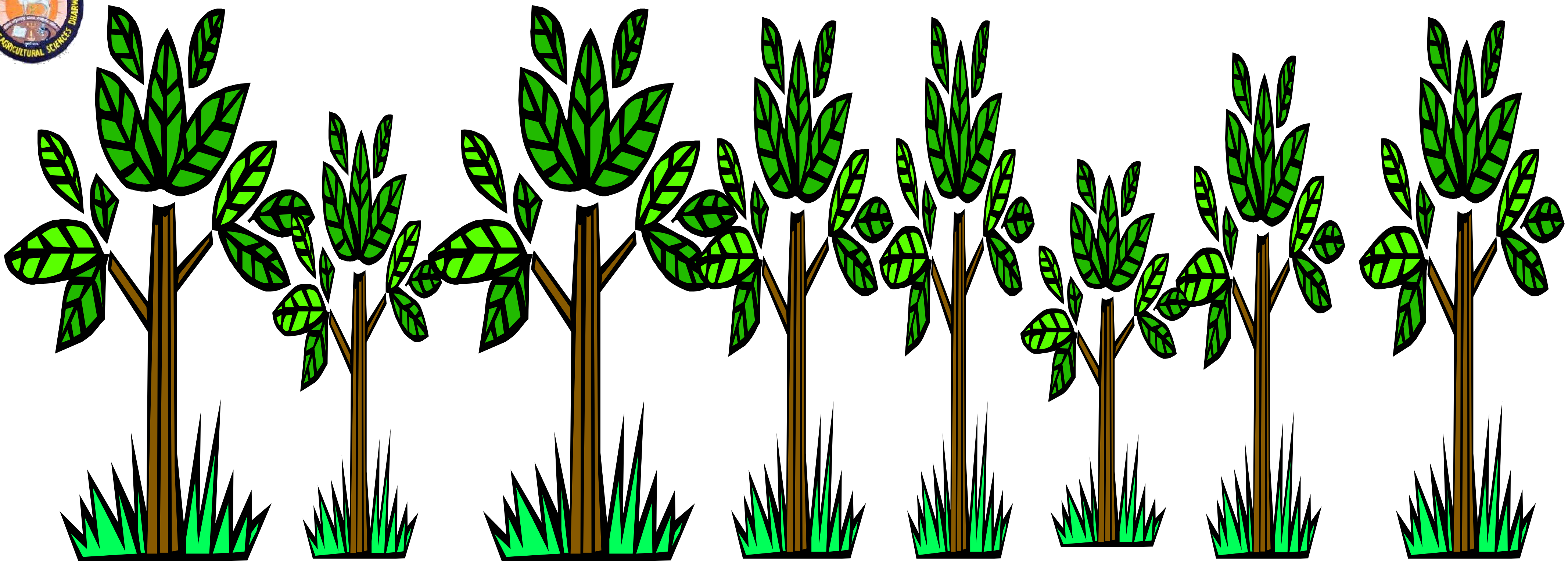


Mass Selected Trees

Evaluate Progenies for Half Rotation Period, and then select the mother trees based on the progeny performance

PROGENY TRIAL

Regression System of selection

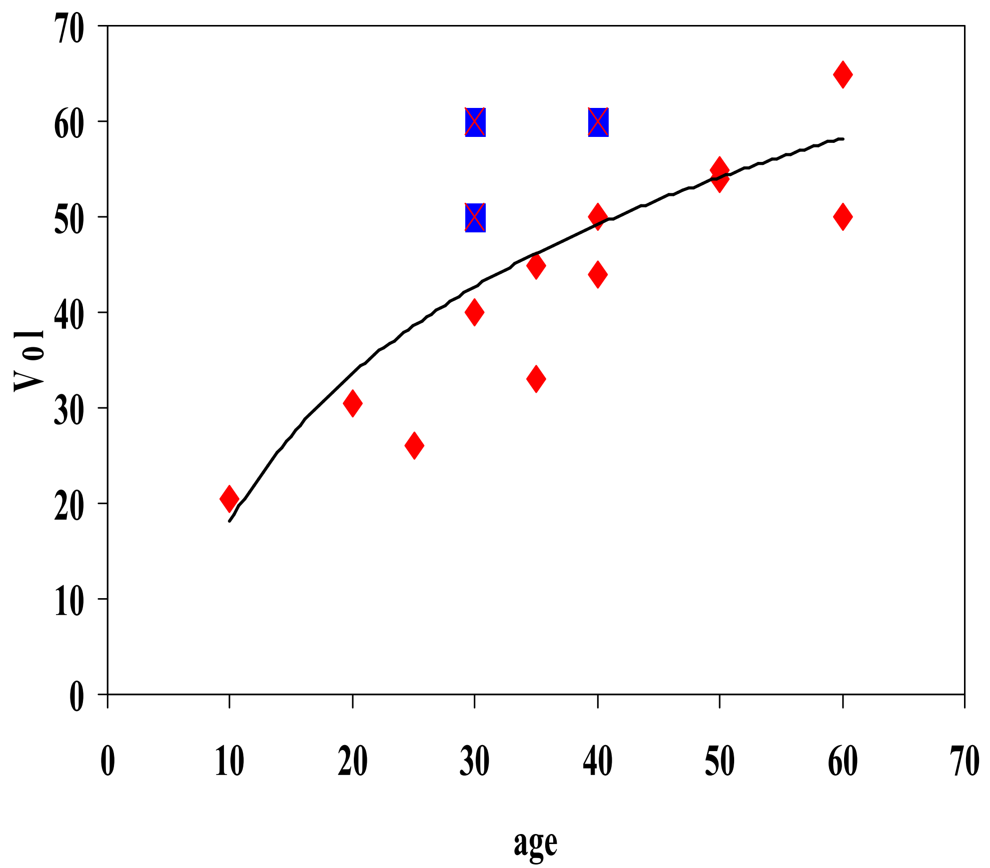


Different ages; different GBH

- Evaluate Performance of the trees and correct it for their age.
- Select the best ones which have yielded more in less age

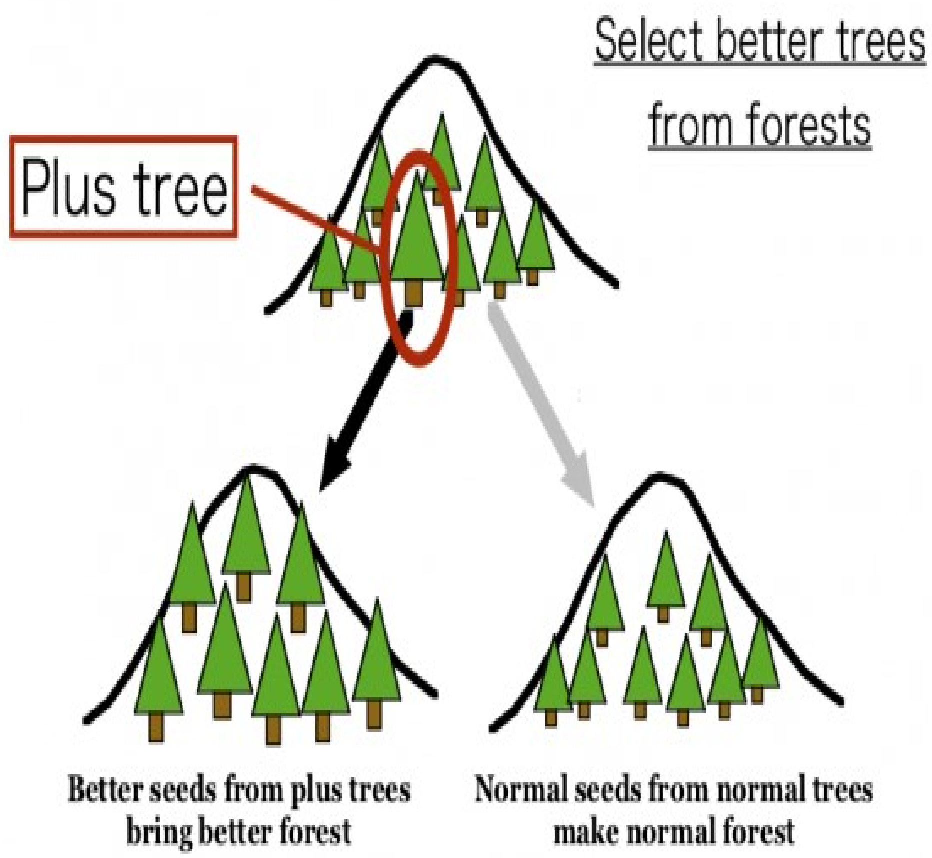
Regression Selection Method

- **Trees are sampled (50 to 100 nos.) for a particular character in a given area & then plotted against the age.**
- Regression curve is drawn
- **From candidate tree the particular character is recorded**
- If value of candidate tree falls above a specified distance from the regression curve, the candidate tree is selected
- **If value falls below the curve, the tree is rejected**
- *Reliable method if age of the trees are known.*

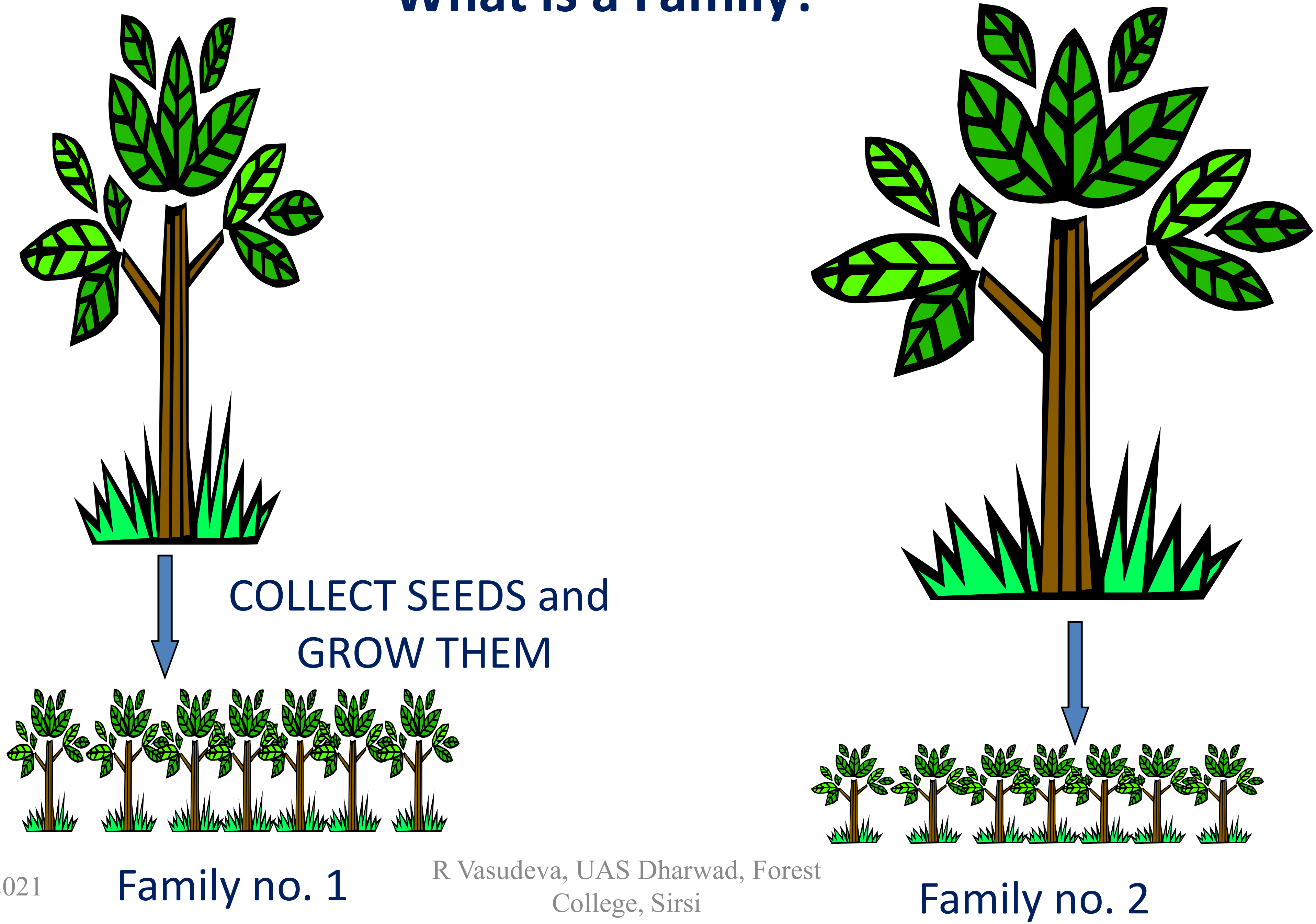


Selection of Trees in Plantations
(Even-aged Plantations)

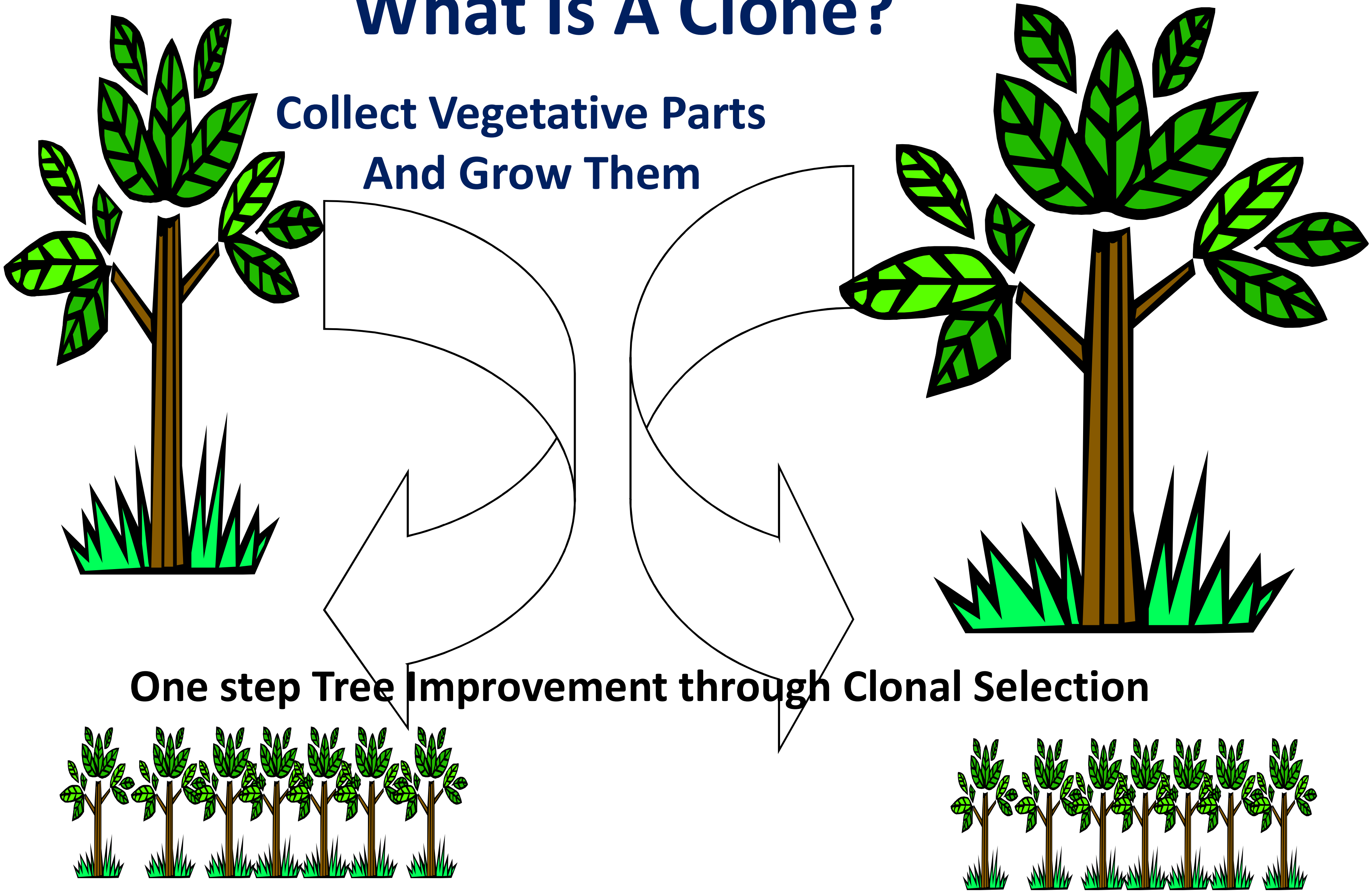
- Mass selection/Individual selection
- **Family selection**
  - Within Family selection
  - Family + Within Family selection
- **Sib-selection**
- Progeny testing



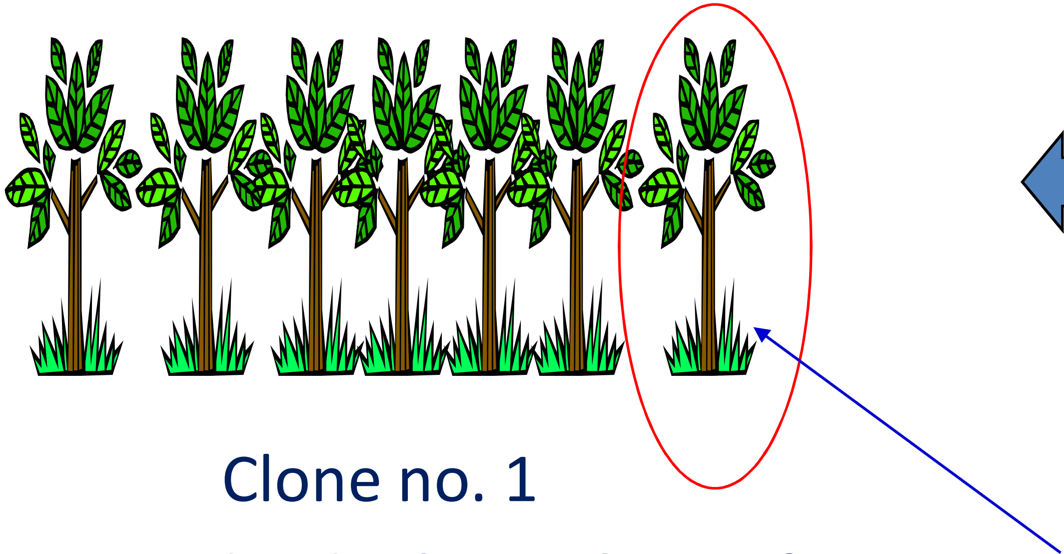
What is a Family?



What Is A Clone?

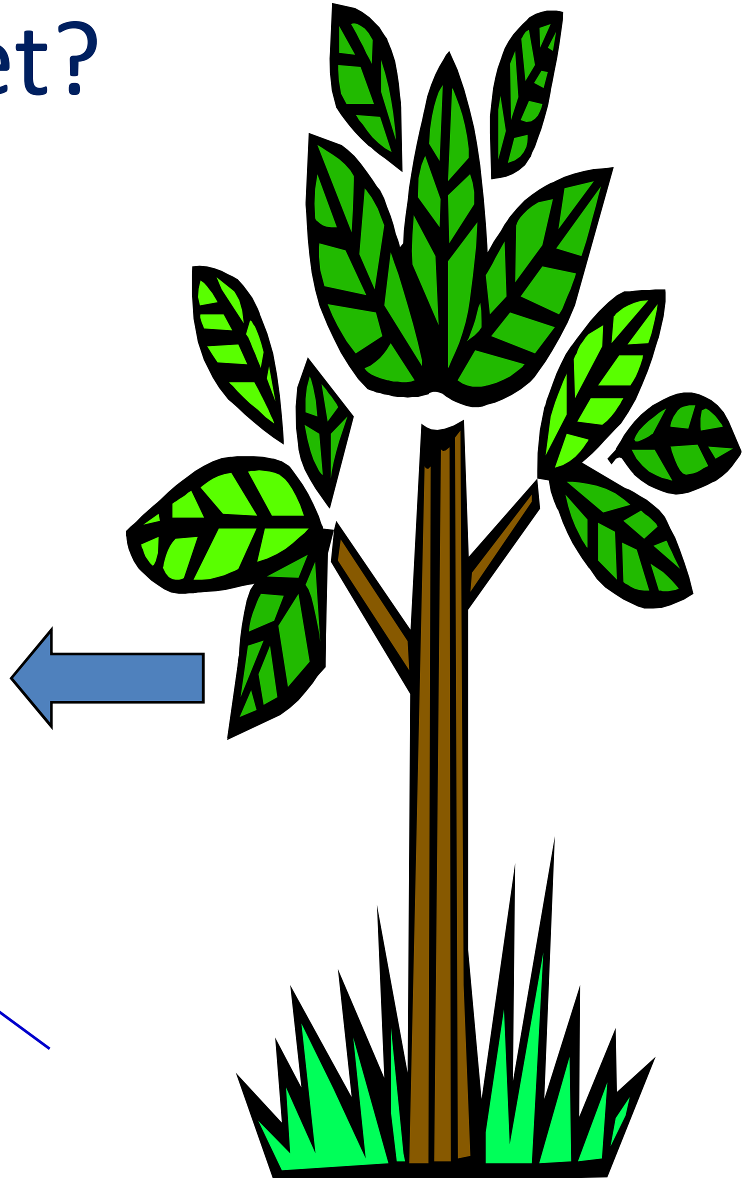


What is a Ramet?



Clone no. 1

Individual members of a clone is a Ramet



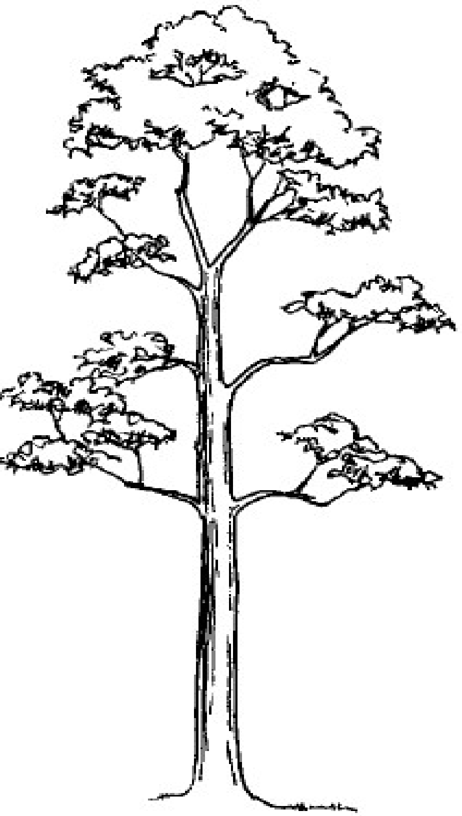
Ortat

Criteria for selection of Plus tree

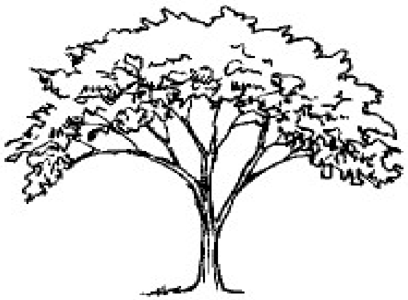
- The selection of plus tree involves a thorough screening of the plantation/ forest to choose the desired variability

- **The selection process involves-**
  - **Preliminary reporting of outstanding trees (Candidate trees/ Check trees)**
  - **Final phenotypically appraisal & approval as *Plus tree***

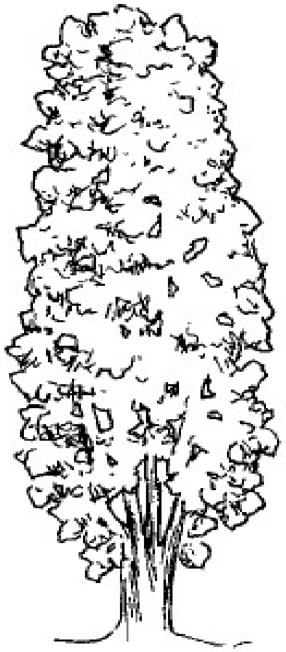
- Selection criteria varies with the end use It is always MULTI TRAIT SELECTION.



desirable timber form:
tall and straight
with few branches



short with many
branches; good for
fodder, not timber



trunk divides into several
vertical branches; good for
windbreak, not timber

poor bole form;
not useful for timber

Example-1: Timber Species

Teak, White Cedar, Artocapus hirsutus, etc.

Plus tree of White cedar

Important Characters considered are:

- Tree height
- Clear bole height
- DBH
- Crown diameter
- Straightness of stem
- Roundness of stem
- No forking
- Self-pruning
- Free from pest & diseases

Plus tree of Teak

Example-2: Pulp Wood Species

Eucalyptus, Poplar, Casuarinas, Mangium, etc

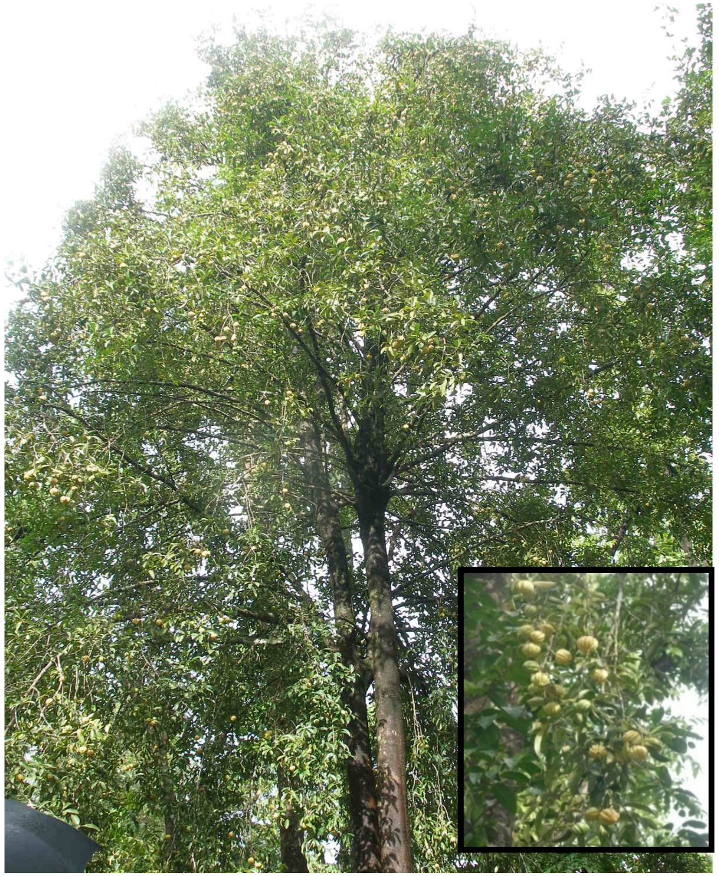
Plantation of *Acacia mangium*

Characters to be considered-

- **Specific gravity**
- **Lumen diameter**
- **Cell-wall thickness**
- **Fiber length**
- **Cellulose**
- **Hemicellulose**
- **Lignin**
- **Other extractives**

Example-3: NTFPs

Garcinia indica and *G. gummi-gutta*



Important characters-

***Fruit*- economic part**

- **Fruit yield**
- **Fruit size (Dia, weight, density)**
- **Pulp weight**
- **Rind weight**
- **Seed to pulp ratio**
- **Oil content (%)**
- **HCA content**

Step 3 A packing of the desired qualities into improved individuals, such as to develop trees with combinations of desired characters

Flacourtia montana

Emblica officinalis

Example-4: Tropical fruits

- Fruit yield
- Fruit size
- Fruit colour
- Fruit tastiness
- Fruit ingredients
  - Protein
  - Sugar content
  - Carbohydrates

Artocarpus hirsutus

Syzizium cumini

Example-5: Medicinal plants

Important traits:

- Tree height
- Bark thickness
- Chemical profile-alkaloid
- Seed yield per tree

Mammea suriga

Step 3 A packing of the desired qualities into improved individuals, such as to develop trees with combinations of desired characters

Example-6: Aromatic plants

Important traits:

- **Flowers yield**
- **No. of main branches**
- **Flowers with sweet aroma**
- **Aromatic Oil yield (%)**

Step 3 A packing of the desired qualities into improved individuals, such as to develop trees with combinations of desired characters

Example-7: Tree Borne Oil species

Jatropa curcus, Pongamia pinnata, Neem

Plus tree of Neem

Fruits from Plus tree of Jatropa

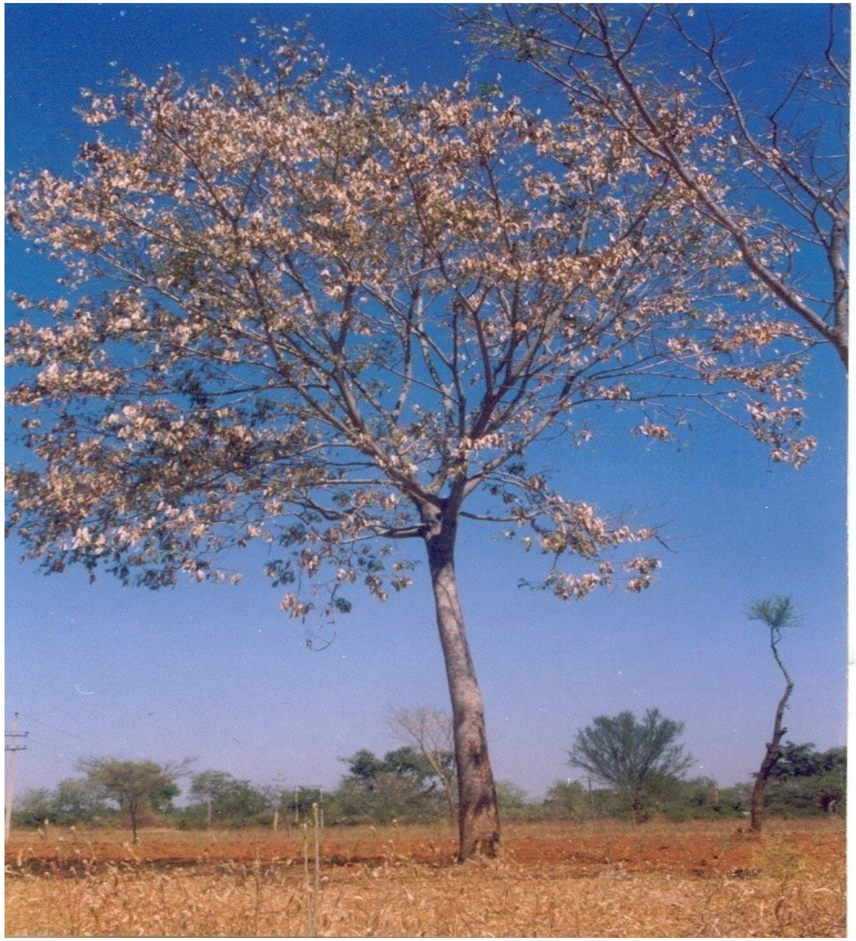
Important traits:

- High flowering capacity
- High fruit set
- Fruit / pod yield
- No. of branches
- Larger crown
- Fruit size & density
- Fruit moisture content,
- Fruit oil yield (%)
- Resistance to drought/ stress

Pongamia

Plus tree of Madhuca

Example-8: Fodder Tree species



Albizia lebbek, Prosopis julifera, Dalberiga sisoo

Important traits:

- **Higher leaf biomass**
- **More branches**
- **Highly palatability and digestibility of fodder**
- **Nutrient content**

Step 3 A packing of the desired qualities into improved individuals, such as to develop trees with combinations of desired characters

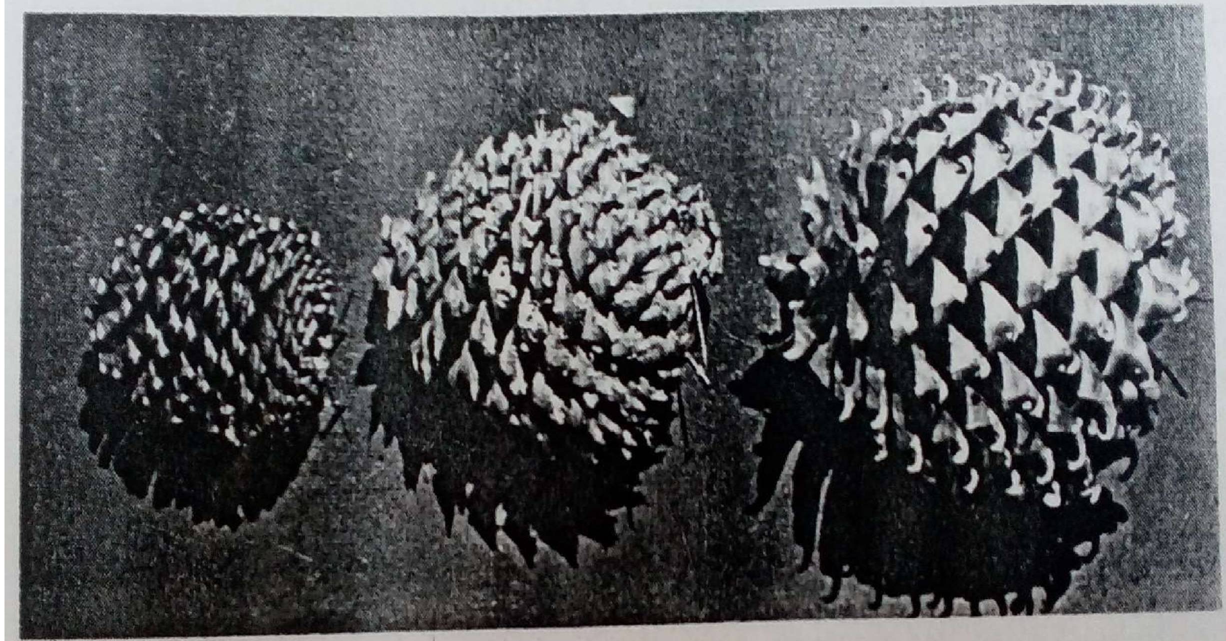


FIGURE 11.1 /

Shown are mature cones of *P. coulteri*, *P. jeffreyi*, and the natural hybrids between the two. Note the intermediacy in size and conformation of cone scales of the mature cones, with Jeffrey pine at the left, Coulter pine at the right, and the hybrid in the center.

Hybridization

Occasionally, closely related species can hybridize, that is fertilize each other and produce offspring that have a mixture of genes from both parent species.

Natural Hybrid:
Pinus coulteri x P. jeffreyi

•**Hybridization naturally occurs between shortleaf pine and loblolly pine.**

• **About 4% of shortleaf pine trees grown from seed collected in the 1950s had significant hybrid character**

An F1 hybrid occurs when a shortleaf pine and loblolly pine cross.

When an F1 hybrid crosses with a parent species, the resulting offspring are considered to be backcrossed.

Loblolly Pine ✖ Shortleaf Pine

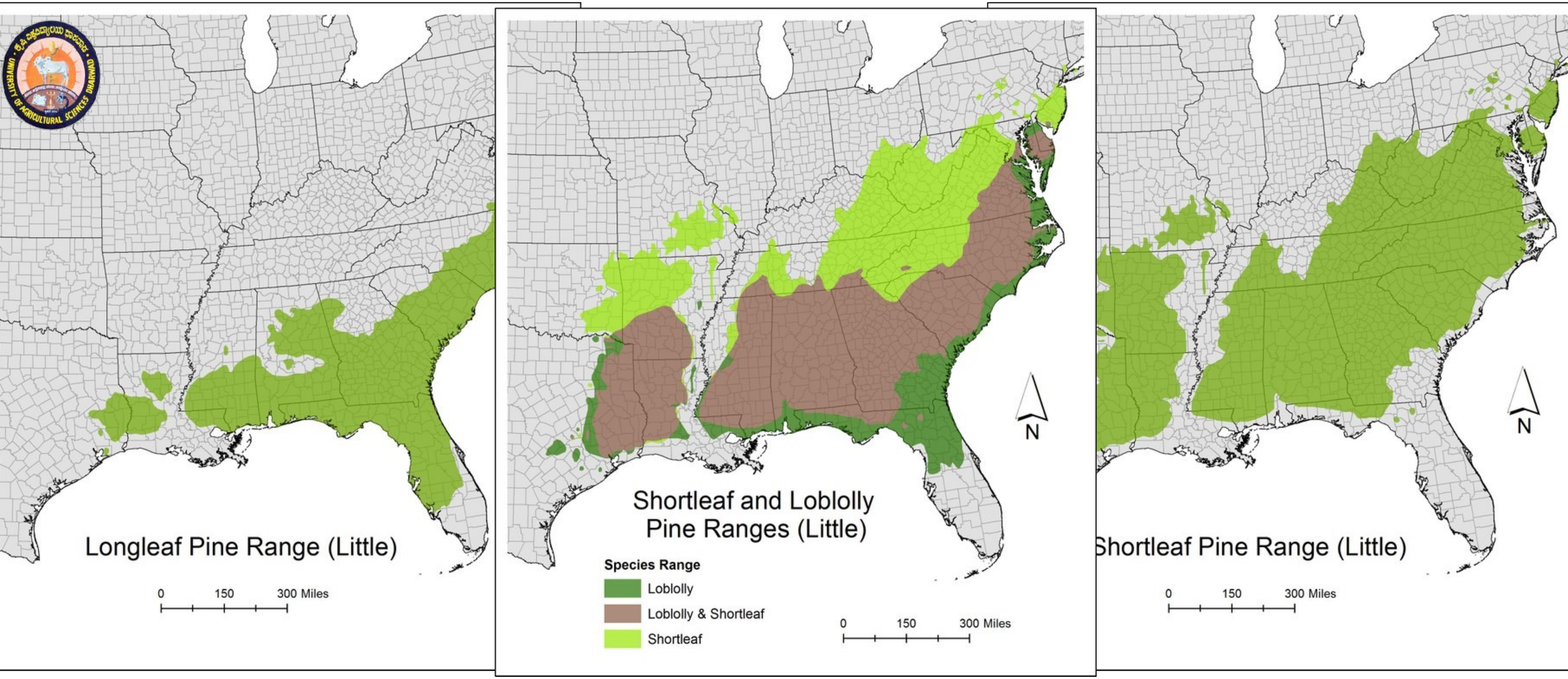
↓

F1 Hybrid
50% Loblolly
50% Shortleaf

✖ Shortleaf Pine

↓

Hybrid Backcrossed into Shortleaf Pine
25% Loblolly
75% Shortleaf

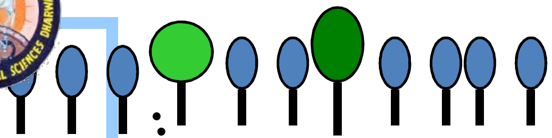

Longleaf Pine Range (Little)
0 150 300 Miles
Shortleaf and Loblolly Pine Ranges (Little)
Species Range
Loblolly
Loblolly & Shortleaf
Shortleaf
0 150 300 Miles
N
Shortleaf Pine Range (Little)
0 150 300 Miles
N

Natural Hybrids

- *Pinus coulteri x P. jeffreyi*
- *Acacia mangium x A. auriculiformis,*
- *Eucalyptus torrelliana x E. citriodora,*
- *E. urophylla x E. alba and*
- *E. tereticornis x E. grandis*
- *Terminalias?? = OPEN QUESTION*

Vietnam : 2,20,000 hectares of clonal acacia hybrid (*Acacia mangium × auriculiformis*),

- Vietnamese scientists led by Professor Le Dinh Kha
- **Fast-growing acacia plantations provide industrial wood for Vietnam's wood-processing and pulp and paper industries, woodchip exports and household fuelwood supplies in rural areas.**
- Acacia plantations are nitrogen-fixing and the acacia litter provides an effective litter layer,
- **Vietnamese plantations are predominantly grown on small forest**



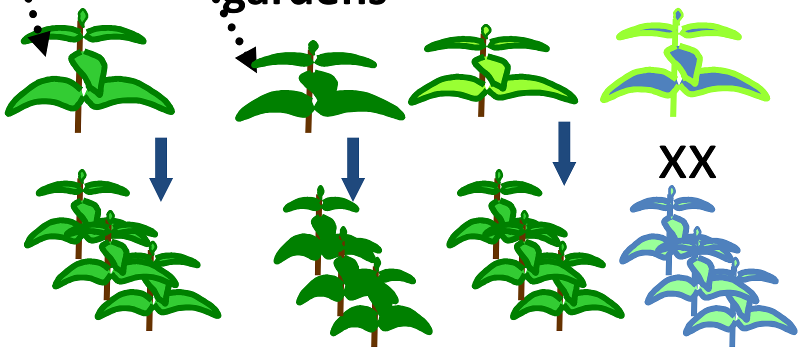
Select 30 outstanding F_1 hybrid ortets in 3-year-old *A. mangium* plantations

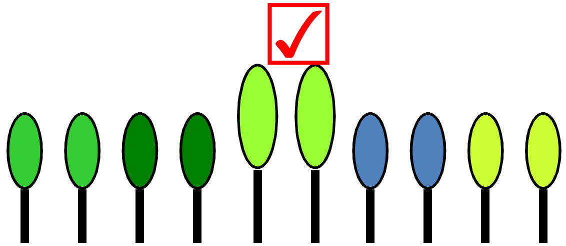
1992

Fell candidates, propagate from coppice shoots, plant hedge gardens

Study wood properties of felled trees

Tissue-culture to maintain juvenility





1993 **First clone trials screening 20 clones**

1996 **Proving trials of best clones and controls**

Nurseries for clonal propagation

1998 **Operational planting of best clones**

Development of new series of hybrid clones

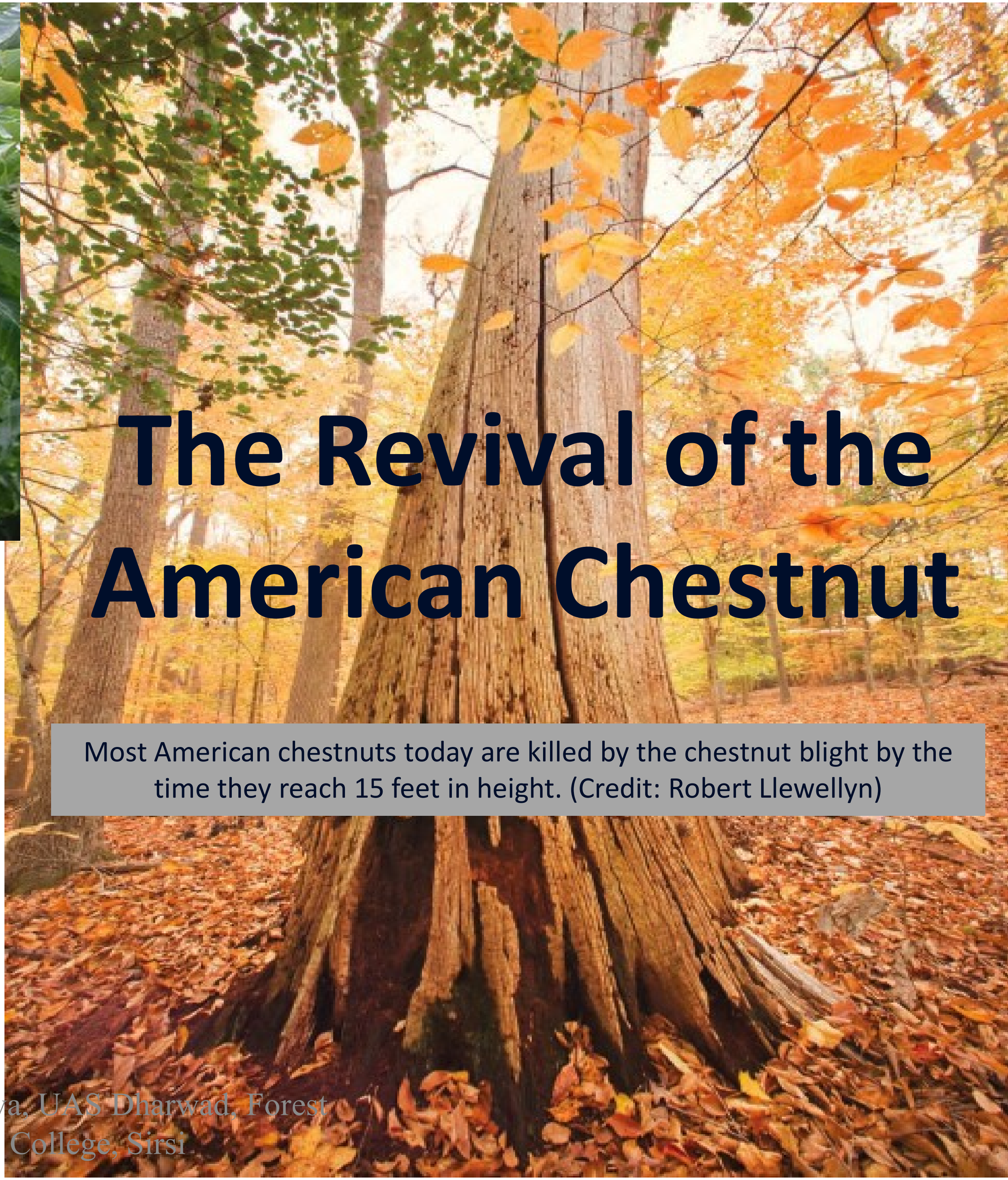
Source: Research Centre for Forest Tree Improvement, Forest Science Institute of Vietnam

2009 **Over 200,000 hectares of plantations established (about 10 production clones)**

Artificial Hybridization and selection

The Revival of the American Chestnut

- American chestnuts sometimes made up half the trees in a given forest.
- At their peak, they numbered as many as 4 to 5 billion from Maine to Georgia.
- But today, the species is nearly wiped out.
- Chestnut Blight
- Since about 1900, the American chestnut has been attacked relentlessly by a fungus that was introduced when Americans first imported Chinese



Most American chestnuts today are killed by the chestnut blight by the time they reach 15 feet in height. (Credit: Robert Llewellyn)

- **Failed methods:**
  - Chemical
  - Fire
  - Quarantine
- **First inter-specific Hybrid: in 1931**
  - Japanese Chestnut x American Chestnut
- **Thirteen species of Chestnut available**
  - Large variations are found

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How to Revive it?

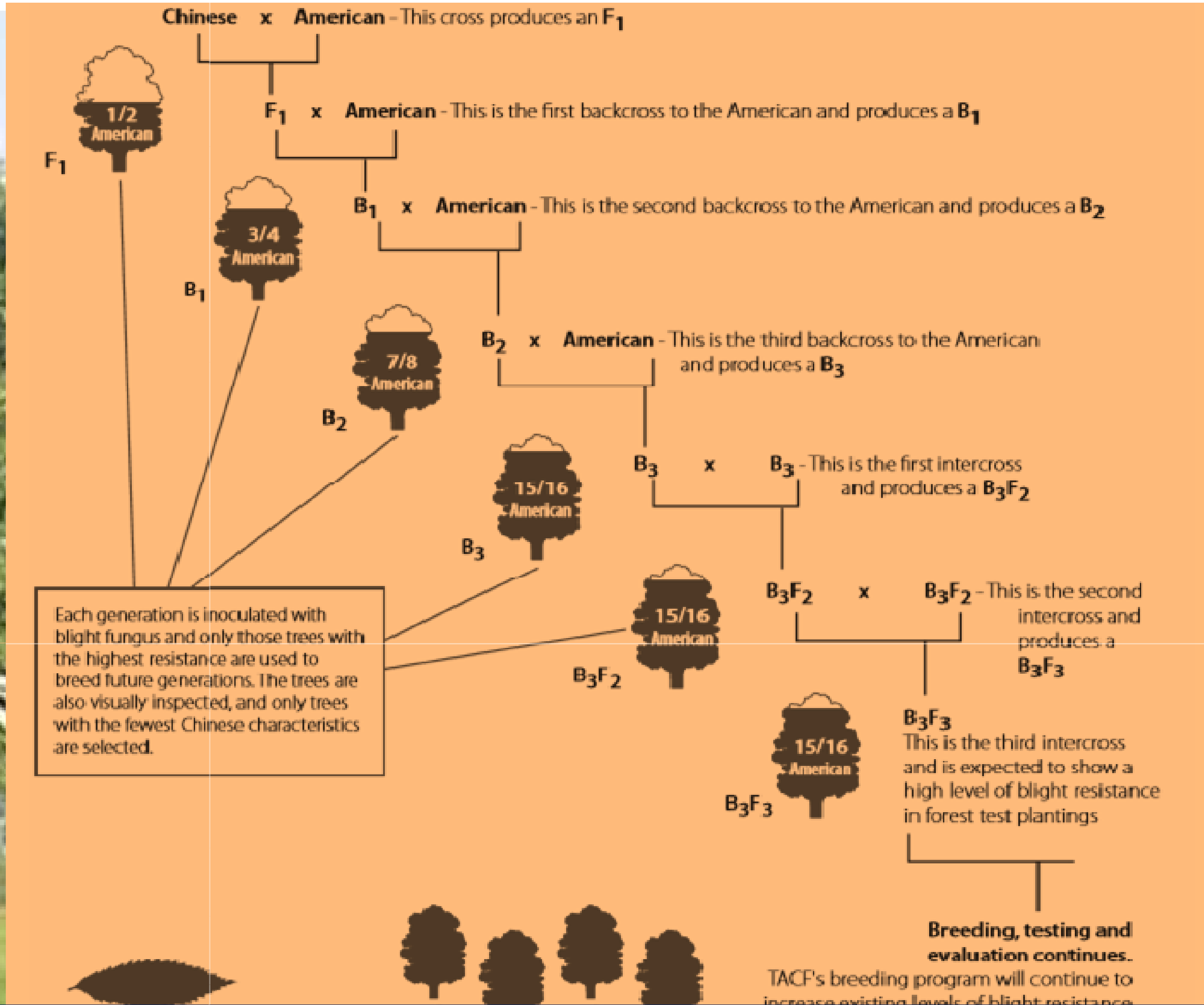
Backcross Hybrid

The **American chestnut**'s distinctive leaves, burs, and **nuts.** (Credit: American Chestnut Foundation)

Susceptible to Blight

A **pure Chinese chestnut**, resistant to the blight. (Credit: American Chestnut Restoration Foundation/USDAFS)

Resistant to Blight



Note that at each step the backcross is selected for resistance through the process of inoculation and for American characteristics by visual observation

Step 4

Mass production of improved individuals for operational level planting

SEED ORCHARDS
SEED PRODUCTION AREA

R Vasudeva, UAS Dharwad, Forest College, Sirsi

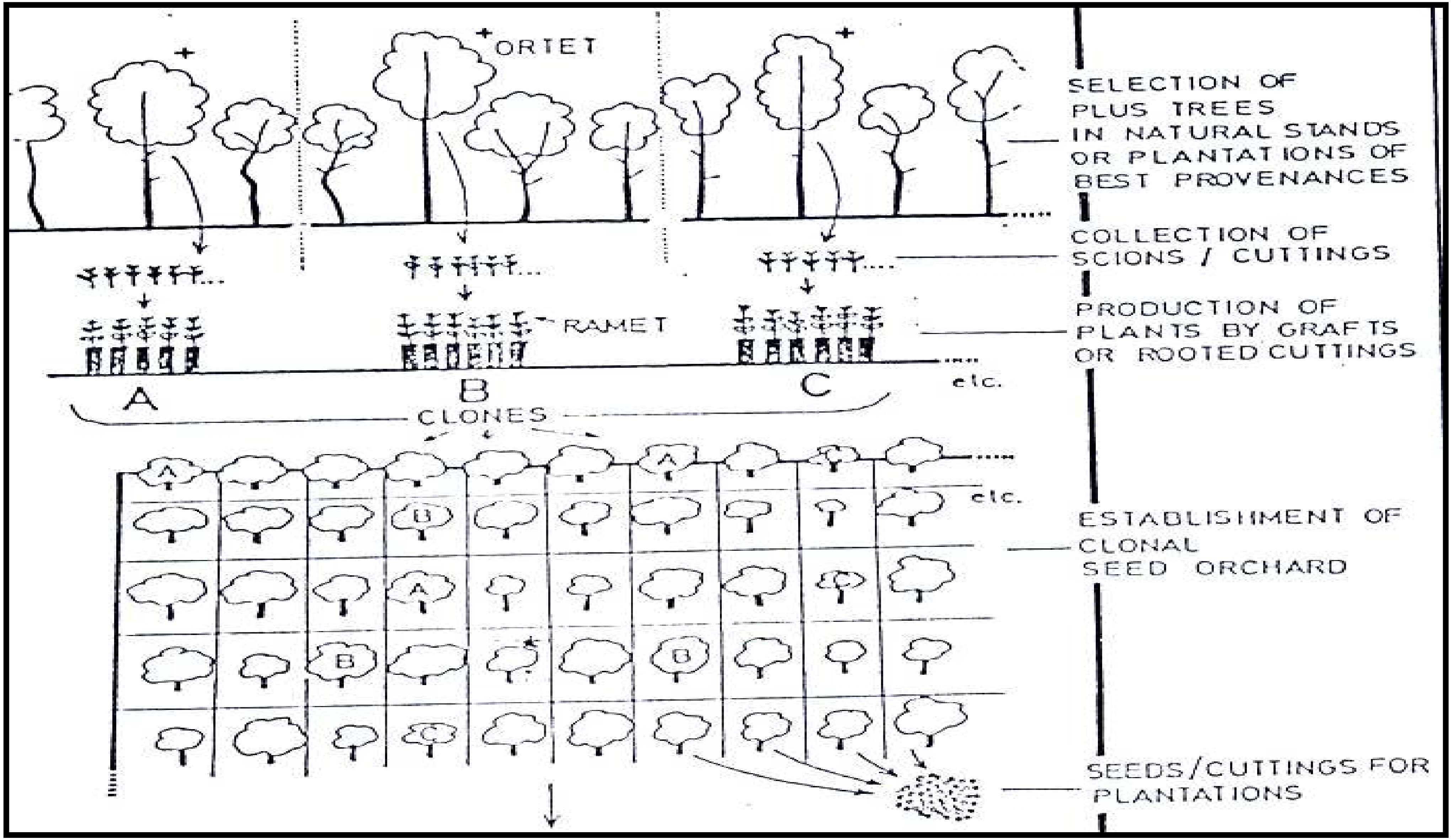
Mass Multiplication

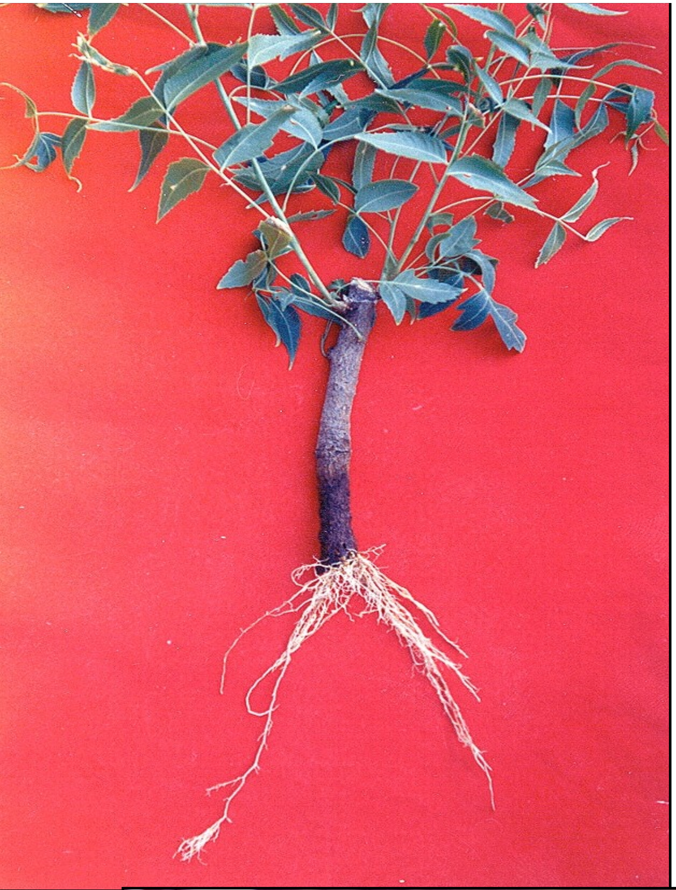
Mass quality seedling production

Micro propagation

Macro clonal propagation

Clonal Seed Orchard





Clonal Propagation

Establishment of base population

What is a Seed Orchard ?

Seed orchard is a plantation of genetically superior trees, isolated to reduce pollination from genetically inferior outside source, and intensively managed to produce frequent, abundant, easily harvested seed crops (Zobel *et al*., 1950)

To supply sufficient seeds to produce seedlings for large scale afforestation programmes.

Good planting material from good quality seed

History of seed orchards

First proposed by F.A.L. Burgsdorf of Germany (1787) using vegetative propagules.

N. Sylven (1918) suggested seed orchards with seed origin.

Horticulture crops

First in *Cinchona ledgeriana in* Java, 1880 (Sehreiner, 1962)

***Heavea brasiliensis* in Malaya, 1919 (Keiding, 1972)**

Forest tree seed orchard

– In Scotland European Larch and hybrid by Serymgeour Wedderburn in 1931 (Falkner, 1965)

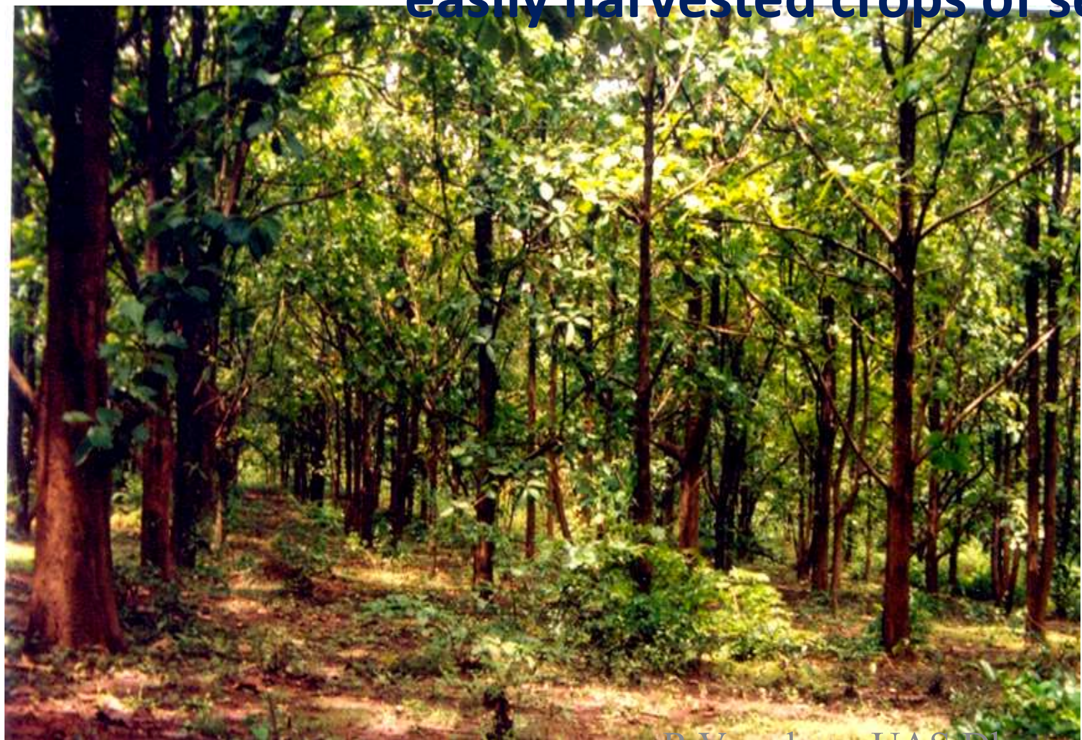
In India

Tectona grandis – 1971

Casuarina equisetifolia - 1985

Seed Orchards

Seed orchard is a plantation of genetically superior trees, isolated to reduce pollination from genetically inferior (foreign) outside source (pollen), and managed to produce frequent, abundant, easily harvested crops of seed.



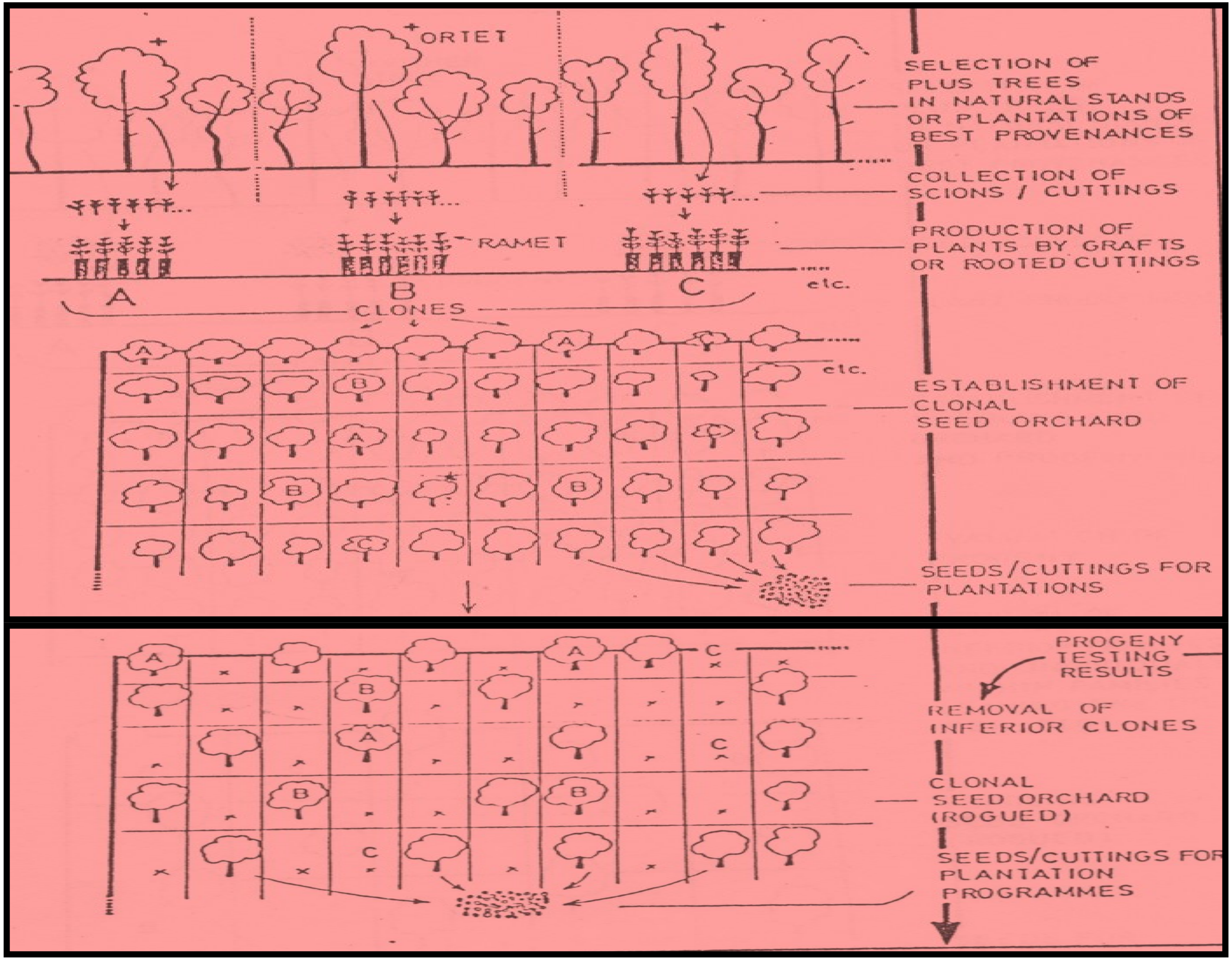
There are two major types of seed orchards:

- Clonal seed orchard
- Seedling seed orchard.

1. Clonal Seed Orchards

- Most commonly adopted world wide.
- Raised through vegetative propagation.
- Grafts are most commonly used, but incompatibility problems.
- Maximum crown development for good seed production

Steps in establishment of CSO



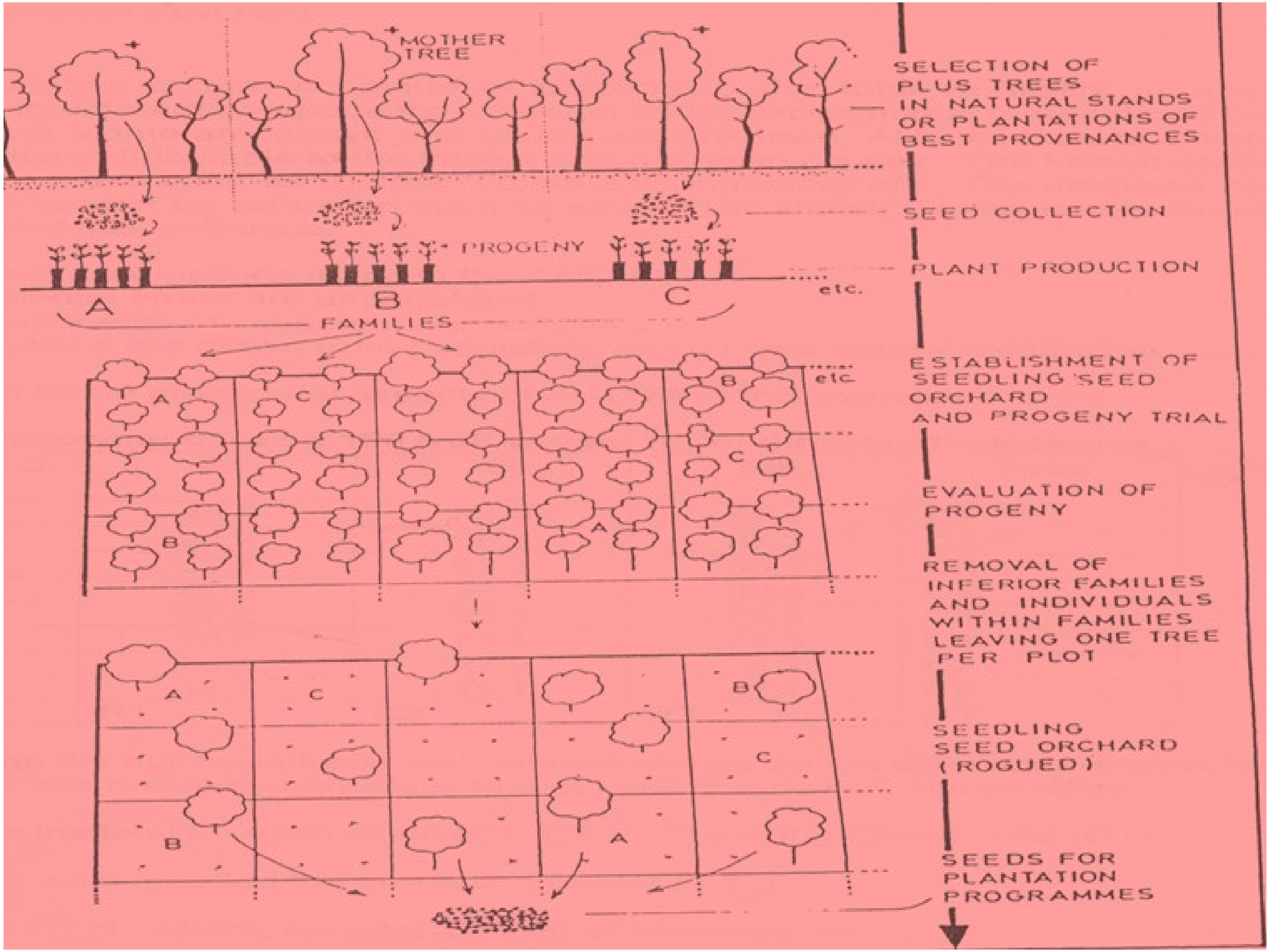
Seedling Seed Orchards

Using seeds of open or controlled pollinated selected phenotypes.

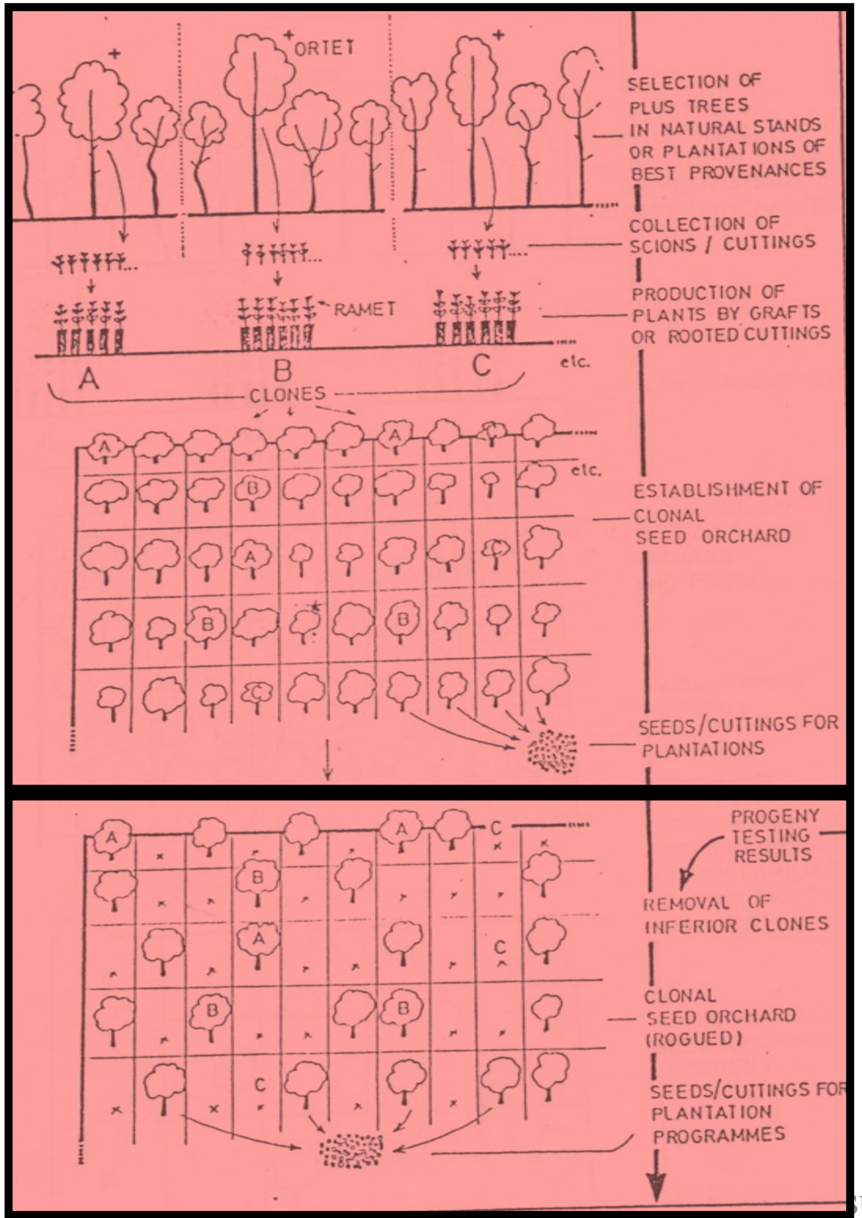
Identity of families maintained.

Thinning or rouging done before seed production starts.

Steps in establishment of SSO

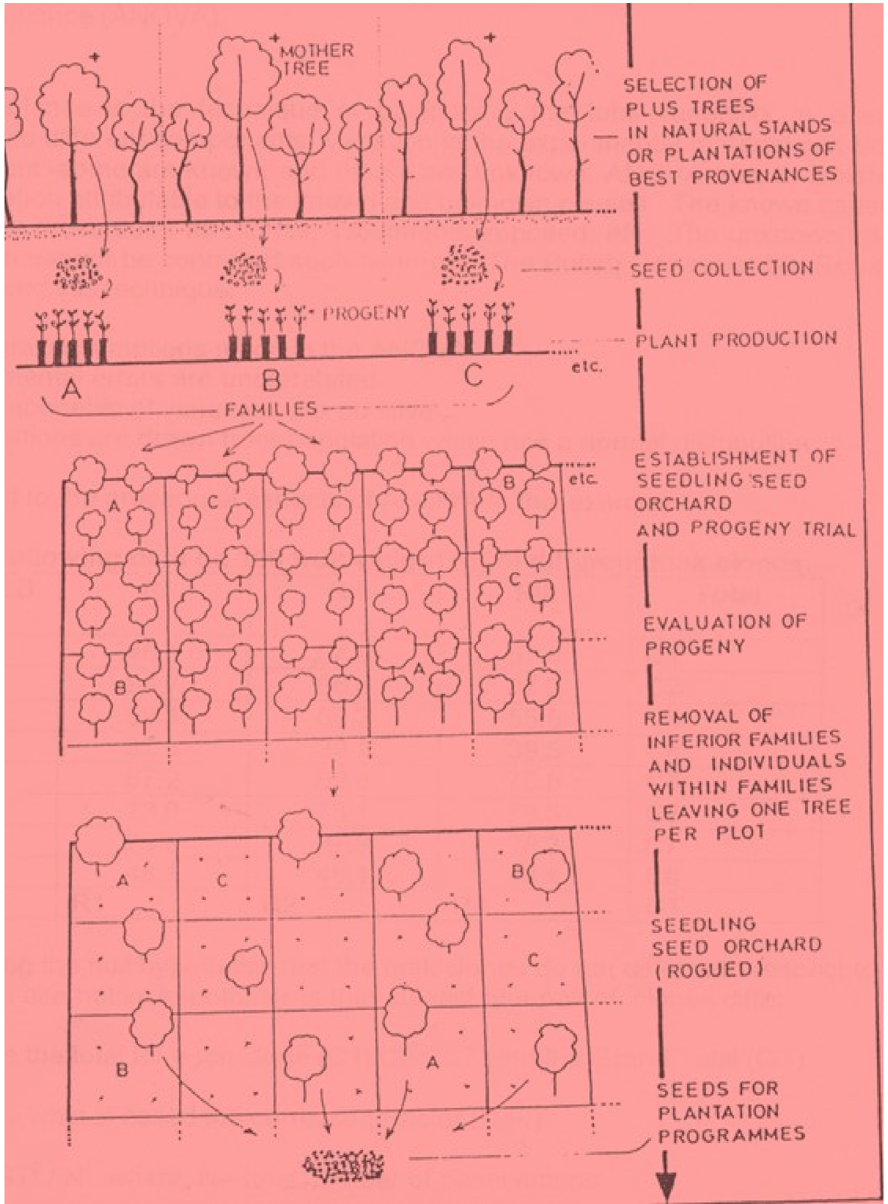


CSO

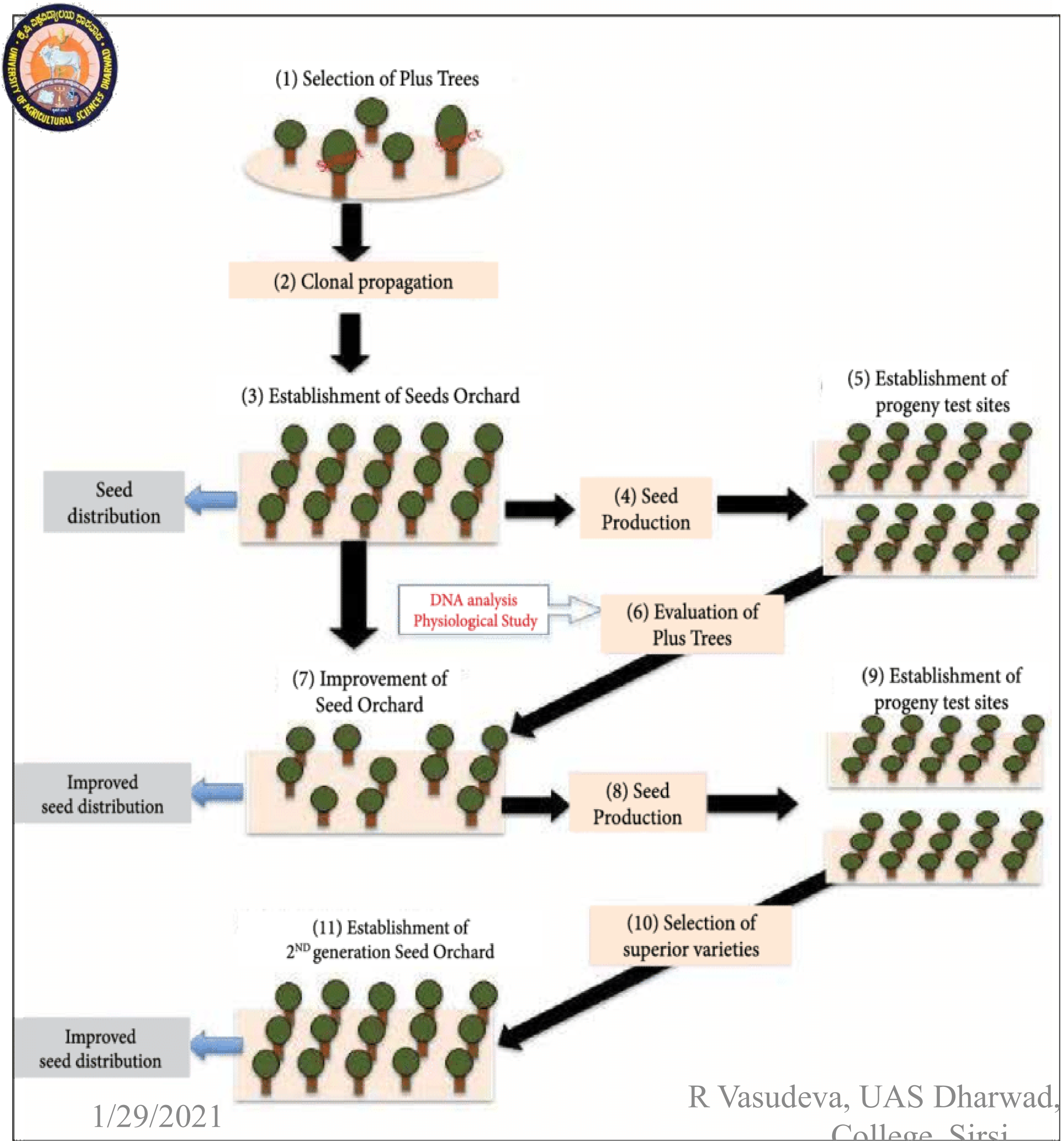


ORTET
SELECTION OF PLUS TREES IN NATURAL STANDS OR PLANTATIONS OF BEST PROVENANCES
COLLECTION OF SCIONS / CUTTINGS
RAMET
PRODUCTION OF PLANTS BY GRAFTS OR ROOTED CUTTINGS
A
B
C
etc.
CLONES
ESTABLISHMENT OF CLONAL SEED ORCHARD
SEEDS/CUTTINGS FOR PLANTATIONS
PROGENY TESTING RESULTS
REMOVAL OF INFERIOR CLONES
CLONAL SEED ORCHARD (ROGUED)
SEEDS/CUTTINGS FOR PLANTATION PROGRAMMES

SSO



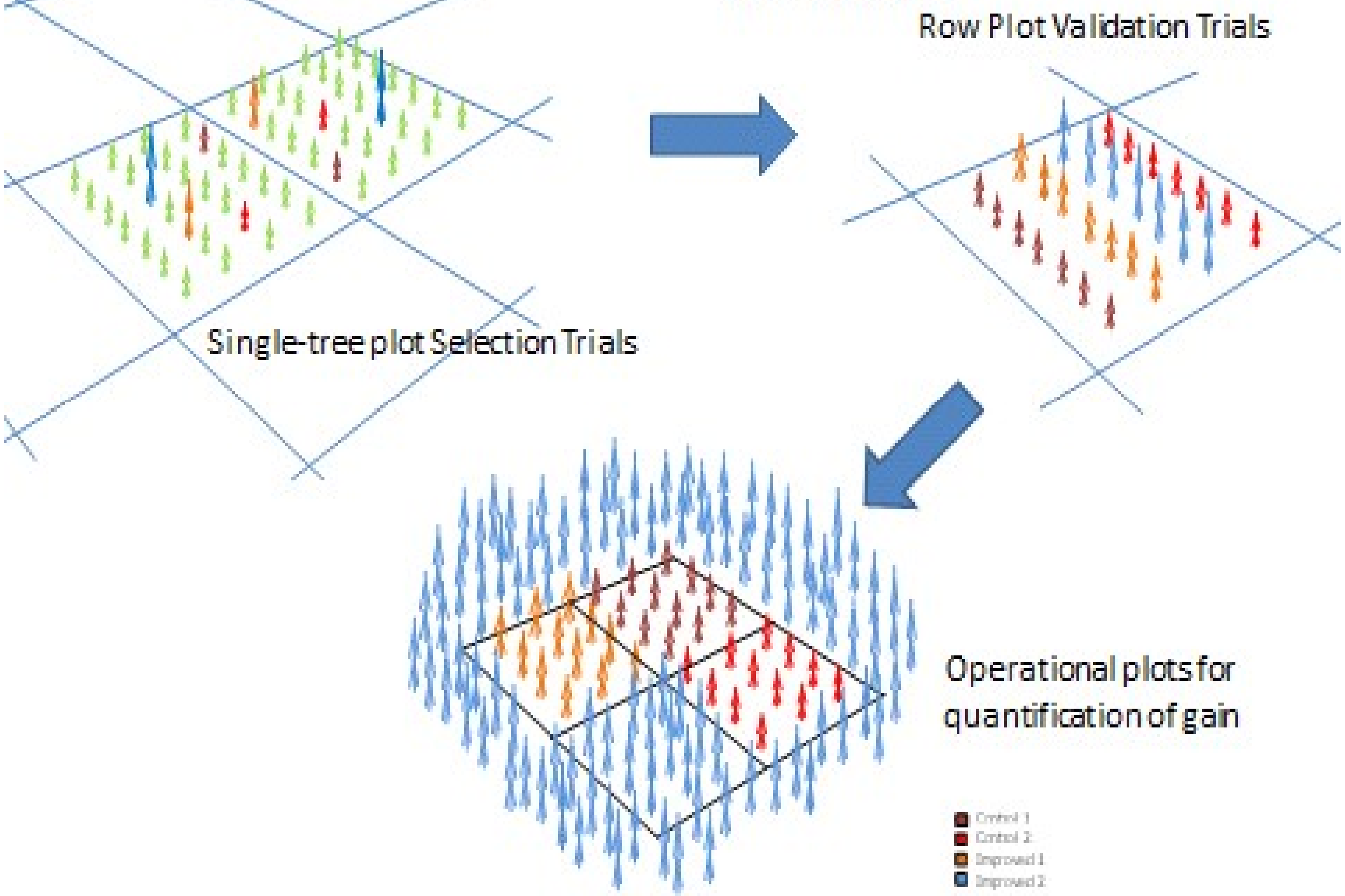
MOTHER TREE
SELECTION OF PLUS TREES IN NATURAL STANDS OR PLANTATIONS OF BEST PROVENANCES
SEED COLLECTION
PROGENY
PLANT PRODUCTION
A
B
C
etc.
FAMILIES
ESTABLISHMENT OF SEEDLING SEED ORCHARD AND PROGENY TRIAL
EVALUATION OF PROGENY
REMOVAL OF INFERIOR FAMILIES AND INDIVIDUALS WITHIN FAMILIES LEAVING ONE TREE PER PLOT
SEEDLING SEED ORCHARD (ROGUED)
SEEDS FOR PLANTATION PROGRAMMES



Seed orchards have to be constantly improved through the results of Progeny Trials

Every Cycle of Selection and Testing would improve the genetic gain

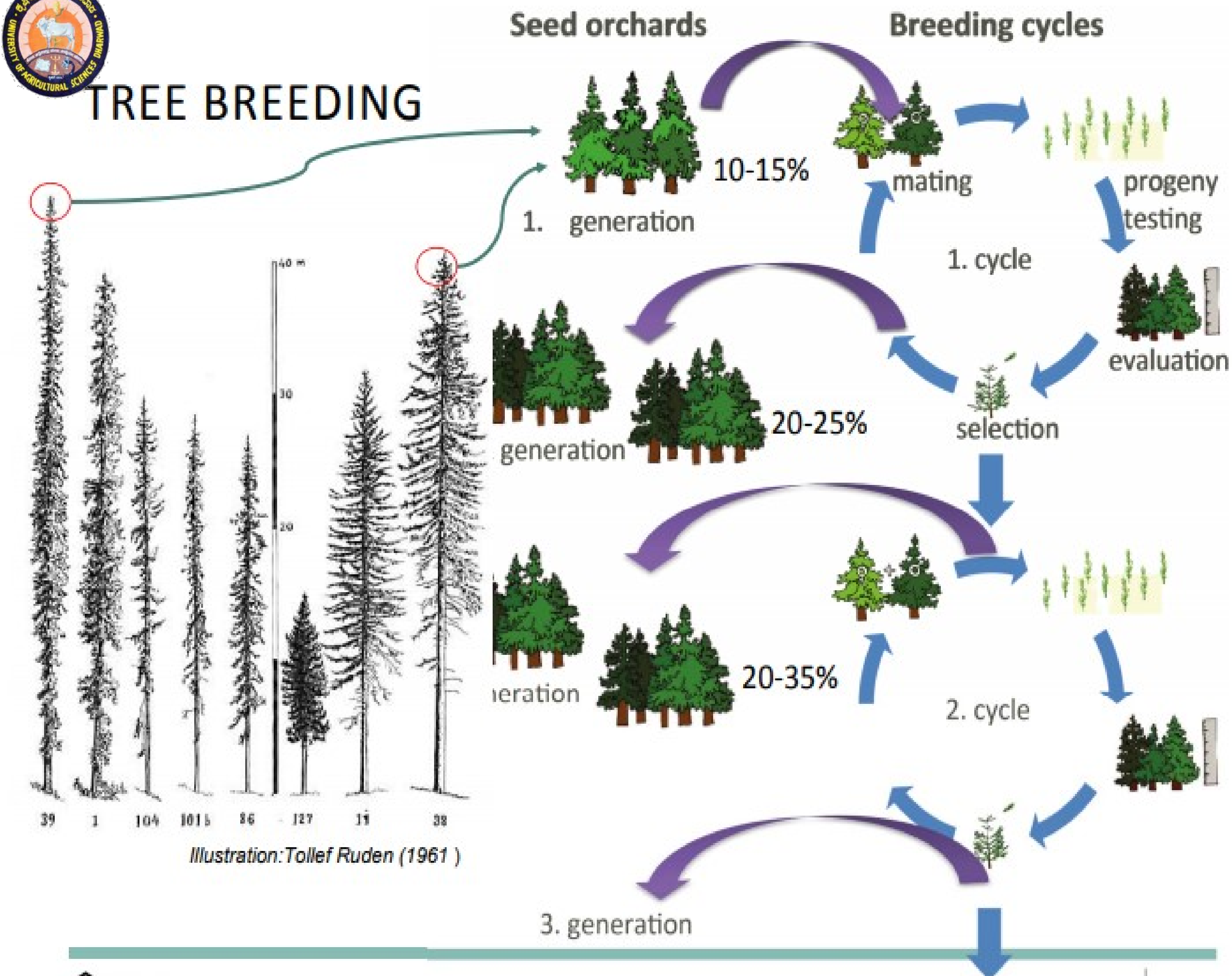
Genetic Testing, Selection & Validation



Problems associated with flowering and fruiting in seed orchards

1. Delayed flowering/ long juvenile period
2. Sparse flowering.
3. Alternate flowering / infrequent flowering.
4. Non synchronized flowering of different clones.
5. Non synchronization of male and female flowers.
6. Absence of enough fruit set due to pollinator deficiency.
7. Incompatibility between clones for grafting.
8. Incompatibility between clones for cross pollinati
9. Fruit and flower damage by pests and diseases.
10. Pollen contamination.
11. Fruit and seed maturity and collection problems.

TREE BREEDING



At every cycle of selection, Progeny Testing and seed orchard maintenance, the genetic gain would increase upto 35 %

Step 4 : Mass production of improved individuals for operational level planting

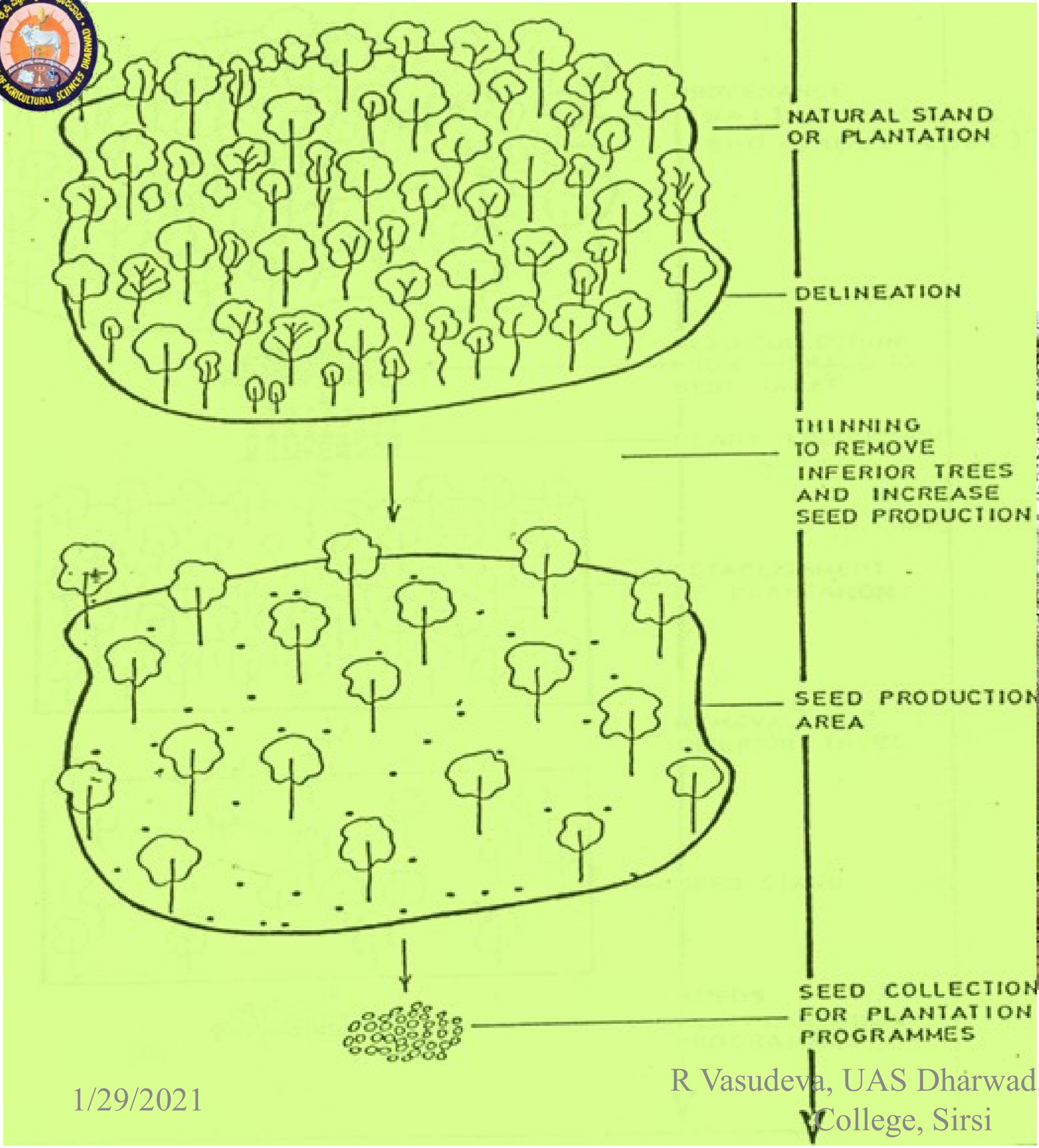
Seed Production Area (SPAs) are existing stands of natural or plantation origin of a tree species that are selected for phenotypic superiority and managed for production of known genotypic origin and parentage

A view of teak SPA (Source: Rajesh P. Gunaga)

Purpose

1. Seed production on Interim basis until seed orchards comes into full production
2. To utilize genetic material from superior provenance for improvement
3. Providing seeds for minor species having small planting programs

Steps involved in selection of SPAs



GENOMIC APPROACHES

- To identify the local adaptations to climate change and to match the future climate

Genomic research in forest trees is driven by two major goals.

- The first goal is the breeding and genetic improvement of a few species for **short rotation crops that can be grown under intensive cultivation regimes**. Research towards this goal seeks to develop a sustainable supply of wood fibre products for human use.

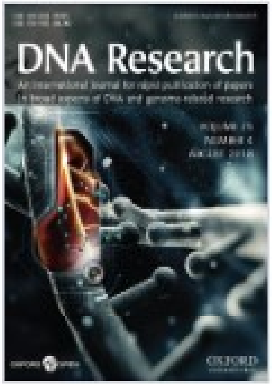
- The second goal is the **management of largely undomesticated and long-lived forest populations**, and this goal will be reached by deciphering the distribution and evolution of adaptive diversity in an ecological and evolutionary context.

- Both goals have several priority objectives, many of which are shared between domesticated and undomesticated populations

Major objectives of forest tree genomics research

- **Understanding the structure of tree genomes**
- We need to develop a comprehensive understanding of the structure of tree genomes in an evolutionary and comparative framework. This will be accomplished by full-genome sequencing, which is now underway for a few tree species but will develop rapidly with advanced generation sequencing technologies and comparative genomics.
- **Understanding genotype–phenotype relationships**
- We also need to develop an understanding of the function of genes and how each relates to phenotypes, with an emphasis on the genes that determine a long-lived, perennial and woody habit. This work is important and will be done only by members of the woody plant community. Highly efficient genetic transformation techniques remain to be developed for nearly all forest tree species.
- **Monitoring adaptive gene diversity**
- **Another important objective will be to measure and characterize the genetic diversity in domesticated and natural populations of forest trees and determine how this diversity relates to the massive phenotypic diversity that is found in trees. Forest geneticists have had a long-standing interest in this research area, but now, with full-genome scans, geo-referencing of large population samples and rich geographical information system (GIS) and ecological databases, this area of research will develop rapidly. This information is needed to manage forest tree populations in the face of a changing climate.**
- **Developing genomics-based tools**
- Finally, we need to develop genomics-based tools to assist in the genetic improvement of production populations and for the stewardship of natural populations. There is still a great need to meet the human demand for forest tree products (solid wood, paper, food and energy), and genomics-based breeding approaches can greatly accelerate traditional approaches that are based solely on the phenotype.

DNA Research



Volume 25, Issue 4
August 2018

This article was originally published in DNA Research

Draft genome of a high value tropical timber tree, Teak (*Tectona grandis* L. f): insights into SSR diversity, phylogeny and conservation

Ramasamy Yasodha ✉, Ramesh Vasudeva, Swathi Balakrishnan, Ambothi Rathnasamy Sakthi, Nicodemus Abel, Nagarajan Binai, Balaji Rajashekar, Vijay Kumar Waman Bachpai, Chandrasekhara Pillai, Suma Arun Dev Author Notes

DNA Research, Volume 25, Issue 4, August 2018, Pages 409–419, https://doi.org/10.1093/dnares/dsy013

Published: 24 May 2018 **Article history** ▾

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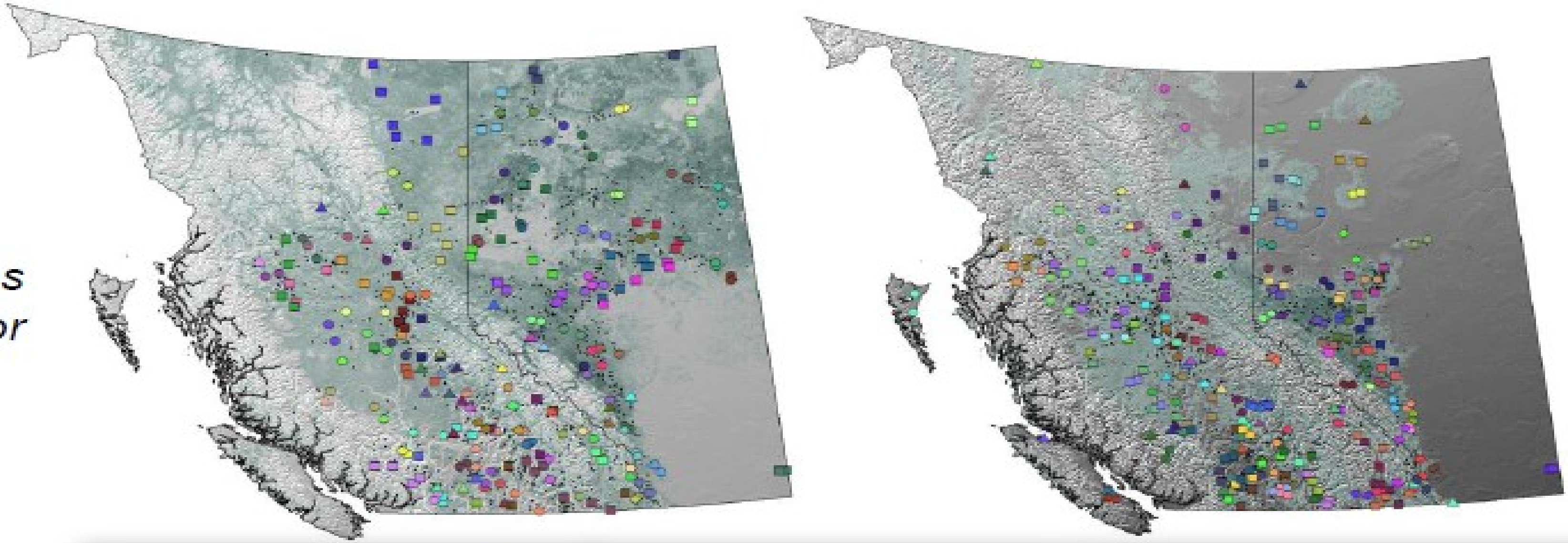
Three Important Questions:

1. **How many genes govern the traits related to local adaptations?**
2. **What is the distribution of their effect sizes?**
3. **What is the distribution of the relevant genes within the genome?**

Despite great interest in recent years, a clear picture of genomic basis of locally adaptive traits in Forest Trees remains ELUSIVE.

Experiments with >250 populations (Lodgepole Pine) linking genomic, climatic and trait variations

Populations sampled for AdapTree

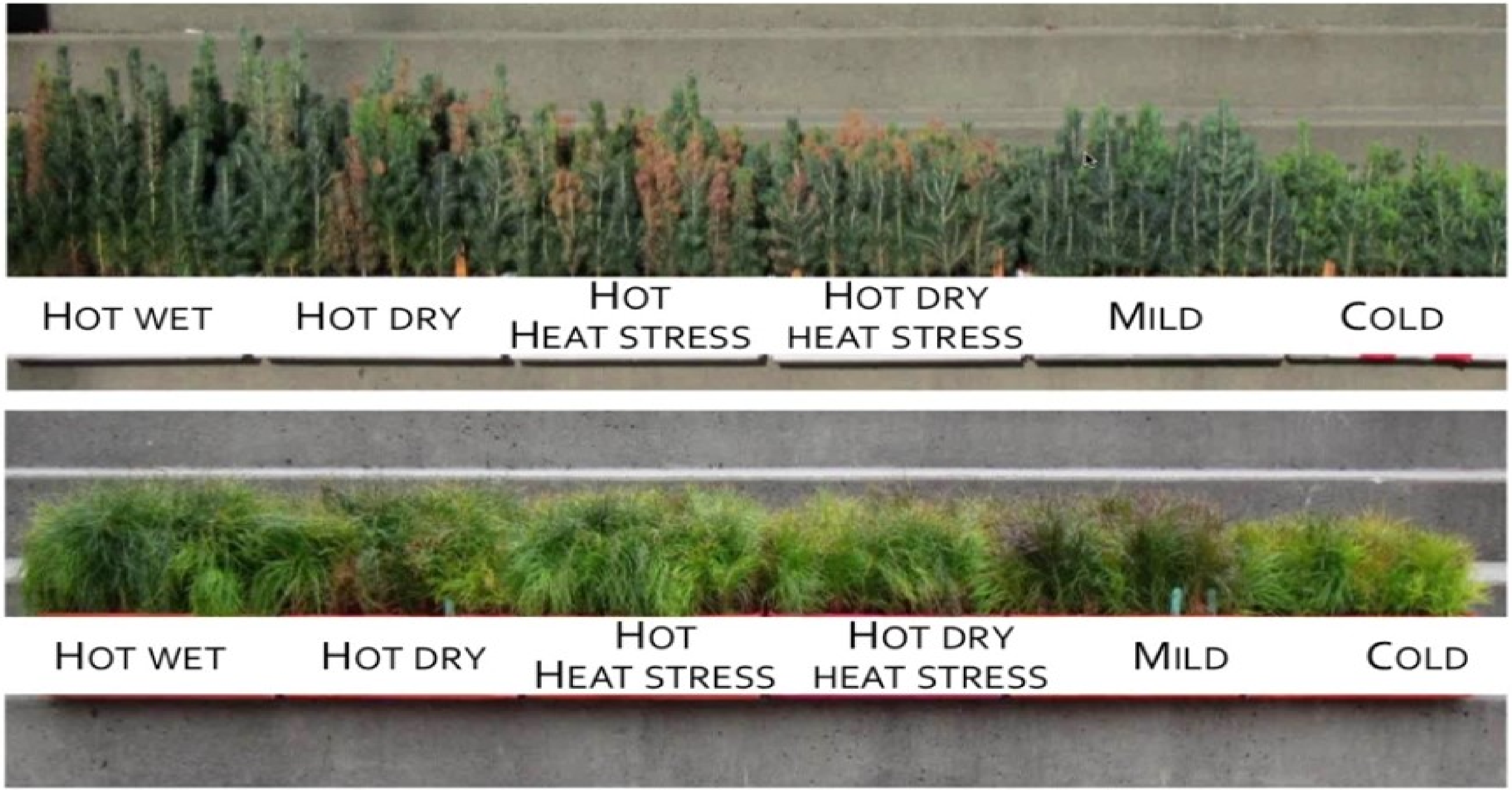


Short-term growth chamber experiments

Mean annual temperature (MAT) 1°C   MAT 6°C   MAT 11°C

Source: Adaptree

Seedlings grown under simulated climates show plasticity and genetic adaptation to historic climates



Source: Adaptree

www.ncbi.nlm.nih.gov

Test many seedlings for climate-related traits in controlled environments

- Heat, drought and cold tolerance
- Growth rates
- Timing of growth & dormancy
- Sample DNA to assess climate-related variation in genes

Source: Adaptree

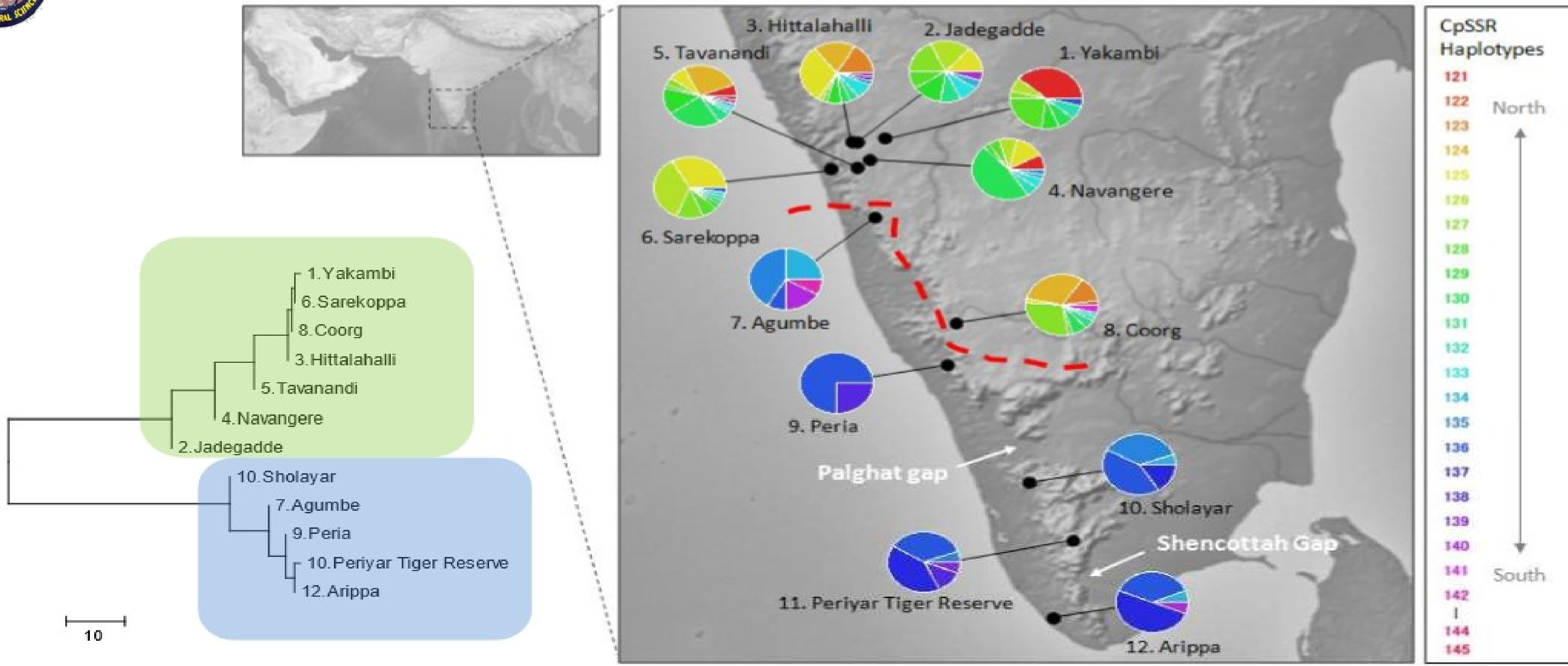
www.ncbi.nlm.nih.gov

What comes next? Field testing for validating genomic predictions

Source: Adaptree

www.ncbi.nlm.nih.gov

The distribution of chloroplast DNA haplotypes



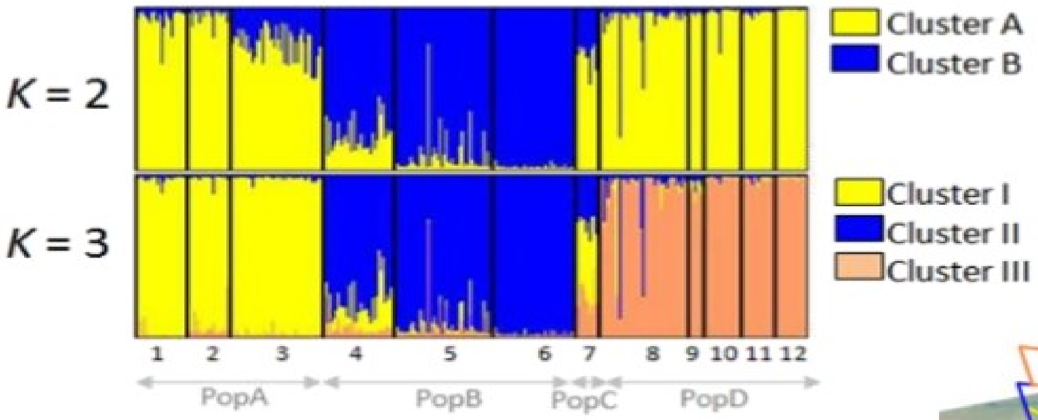
Allelic richness is higher in the Northern populations

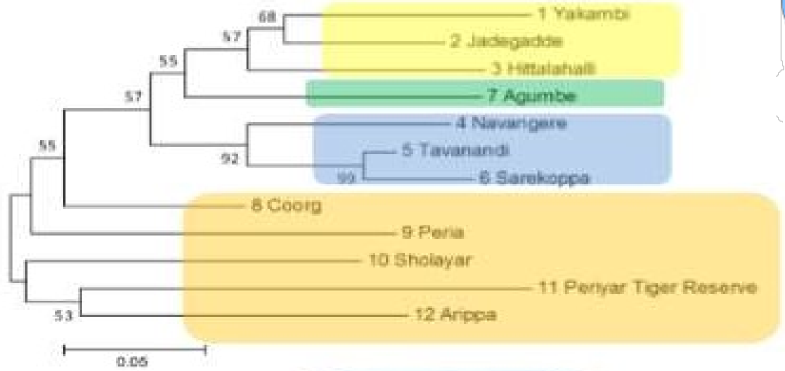
Two groups were detected High genetic differentiation (G'ST = 0.87)

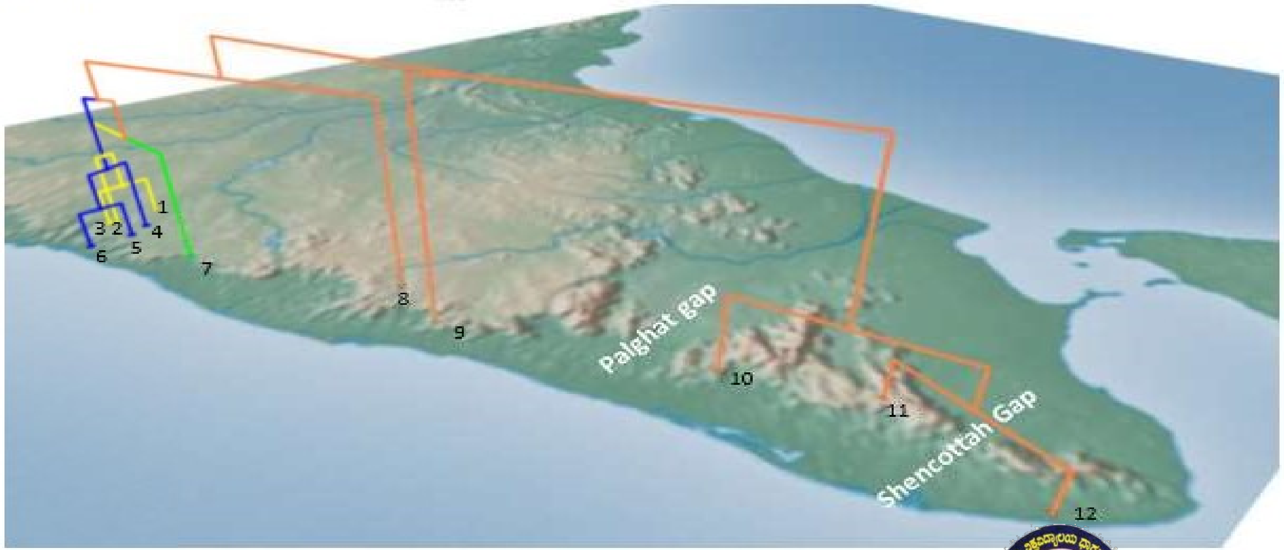
No impact of geographic gaps

Tsuda et al., 2016

The distribution of nuclear DNA







- Three groups were detected with admixed populations
- Moderate genetic differentiation (G’ST = 0.33)
- No impact of geographic gaps

Yoshiaki Tsuda, Sascha A Ismail, Sofia Bodare, Ravikanth G, Mohana Kumara Patel, Ilaria Spanu, **R Vasudeva,** R Uma Shaanker, Giovanni Giuseppe Vendramin, Martin Lascoux

Tsuda et al., 2016

Step 5 : Developing and maintaining a genetic base population broad enough in advanced generations

Level of improvement →

Gene Conservation through increased Utilization

Wild population

No improvement

Continued harvest from the wild

Gene erosion coupled with quality

Decrease in utilization

Increased pressure on wild populations

Improved material

Increased utilization

Increased access to planting material

Reduced pressure on wild

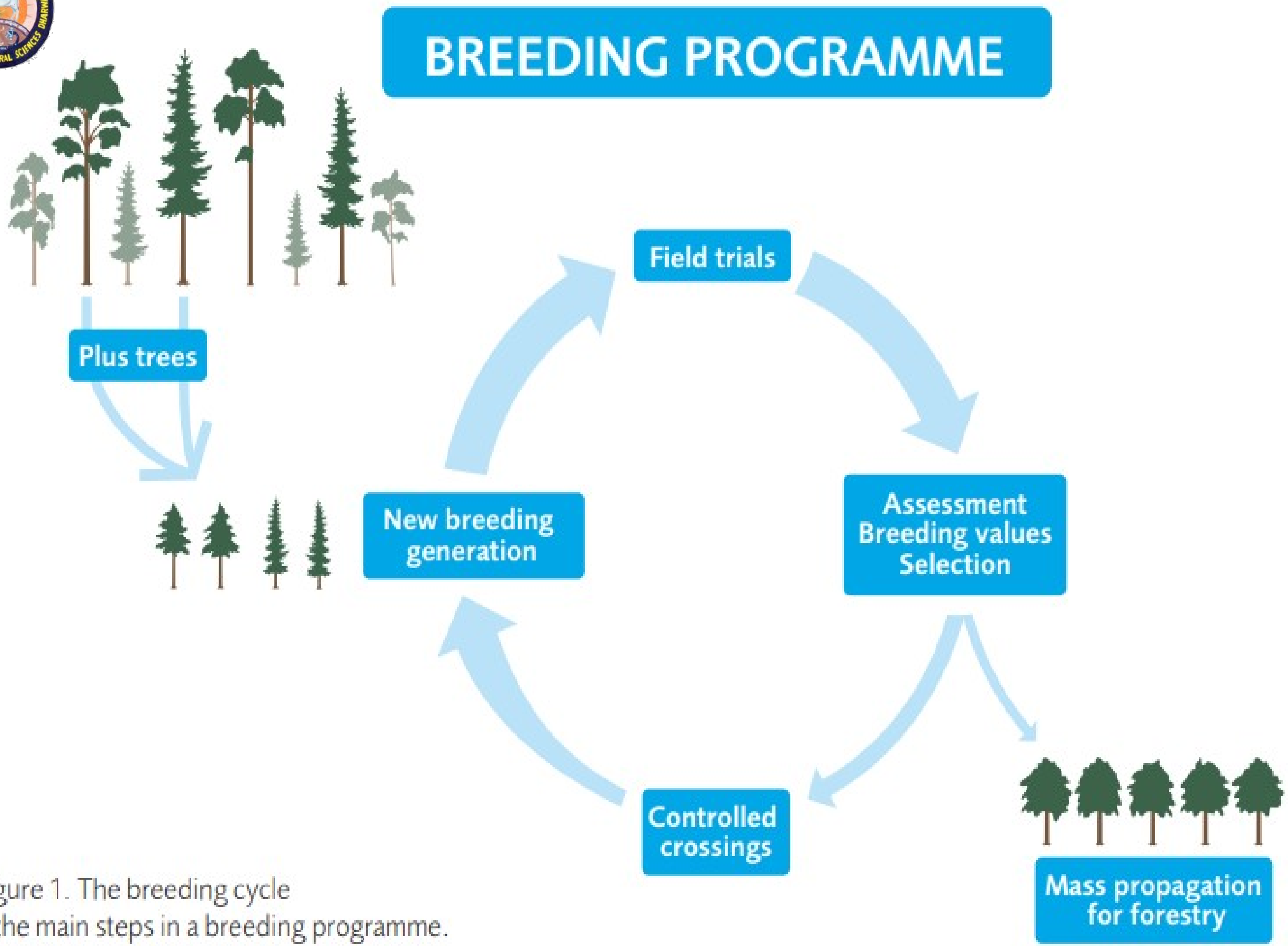


Figure 1. The breeding cycle
– the main steps in a breeding programme.

Dismal status of Tree Improvement in India

Even after completed almost half a century

Sl/No.	Item	No of Species	Exotic	Native
1	Species actively managed for productive aims	**272**	30	242
2	Genetic Variability evaluated	**104**	14	90
3	Tree Improvement program	**145**	30	115
4	Commercial seeds produced	**27**	21	6
5	Some form of *Ex situ* Conservation attempted	**154**	22	132

THANK YOU

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Genetic gain achieved in Teak production

- Classified seed stands over plantations = 8% higher value
- Through Clonal Seed Orchard = 12 % higher than plantations
- 17% through best clones

- Cost benefit analysis has revealed that 10% gain is sufficient for breeding programmes to be economically viable