QUALITY CONTROL AND MASS PRODUCTION OF TEAK CLONES FOR TROPICAL PLANTATIONS

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High variability within teak population

For growth traits

For form/morphology

For wood properties

There is a evident potential for improving teak raw material and producing high quality varieties for the different traits

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Performance of seed sources of teak established in YSG/BHD experimental trials in Sabah: first steps towards the genetic improvement programme

Objectives of the seed introduction:
- Testing seed sources from different origins in Sabah condition
- Selecting clones for varietal output
- Starting a genetic improvement programme

13 Seed sources from India
2 Seed sources from Thailand
2 Seed sources from Solomon Islands
1 Seed sources from Papua New Guinea
2 Seed sources from Malaysia

56 Seed sources from Ivory Coast collected in seedling seed orchard (different geographic origins)

86 seed sources, 20 true provenances, 15 provenances from natural area
26 seeds sources common for 2 sites (Taliwas, Luasong)
TALIWAS: Distribution of individuals for the different traits measured at 92 months

- marked variability between individuals for the growth traits measured
- high proportion of trees with forks
- high proportion of trees with no fluting
- high proportion of trees with good form
- high proportion of trees important branching

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LUASONG: evolution of trait expression and trait variability

Height from 13 to 106 months

Stem straightness from 49 to 106 months

High variability within provenance in growth

Percentage of trees with a good stem straightness increases with age

DBH from 13 to 106 months

Fork from 49 to 106 months

Percentage of trees with fork increases with age

High level of variability maintained with age for growth traits

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Analysing the correlation between growth and form based on the seed sources data

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High correlation between growth traits based on mean seedlot performance

Low correlation between growth and morphological traits based on mean seedlot performance

High correlation between fork and branching

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Analysing the distribution of seed source on a multi-trait approach

Seed source with a high potential for selection: good growth and good morphology
Seed from seed orchard of Ivory Coast

Seed source with a low potential for selection: bad growth and bad morphology
Seed from India

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Genotype * Environment interactions

Interaction not significant for growth  Interaction significant for fork  Interaction significant for stem straightness
Conclusion on first results from field trials

A high variability is observed in the teak population introduced in YSG trials of Taliwas and Luasong

Material introduced from Ivory Coast shows a better potential compared to provenances from the natural range

After the clonal strategy improvement (1989-1997), a significant genetic gain can be achieved through
- Recurrent programme and two types of varieties: improved seeds or clones,
- Integrated approach using tools and facilities (field trials, nursery, wood lab, molecular lab,....)

Cirad imputs
Part I - DNA molecular genetics: quality control, property right, improve the genetic improvement strategy
Part II - Wood trait assessments: introduce wood traits in selection scheme
Part III - Mass clonal propagation: mass production, improve plantation production, clone commercialisation

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Part I - DNA molecular genetics

- Clonal identification
- Property rights
- Genetic origin assessment
- Genetic relatedness

Plantations in tropical area (Malaysia)

Genetic laboratory of Cirad in France

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DNA molecular markers application: Fingerprinting and Origin

166 individuals from natural area, 15 SSR markers

(Fofana et al, in prep; Ofori et al in prep)
DNA molecular markers application: **Fingerprinting and Clones**

**Identifying commercial clones**
- Leaves from first ortets in the field (Luasong Foreste Center)
- 12 SSR markers sufficient for clonal characterisation
- Repeatability: leaves from **two ortets in two locations**

Good repeatability of the technic (microsatellite markers)

The clones can be easily differentiated with the markers such as microsatellites

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## Part II - Wood trait assessments

### Relevant properties

- Sapwood percentage
- Dimensional stability (shrinkages)
- Figure (colour, grain, structure)
- Natural durability

### Wood technological characteristics

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</tbody>
</table>

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Clonal characterisation and selection based wood traits

Despite they look similar, these clones are significantly different quality wise

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Heartwood / sapwood ratio variability

**Age effect**

**Provenance variability**

**Location effect**

Site 1  Site 2
A non-destructive sampling for rapid wood trait assessments

Near InfraRed Spectroscopy (NIRS): calibration/prediction principle

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NIRS for prediction of wood quality

- Lignin, cellulose, basic density, extractive contents, …

- Teak wood natural durability (= weight loss after fungi attack during 16 weeks /reference)

Relative masse loss $x<0.15 = \text{class 1}$: highly durable
$0.15<x<0.3 = \text{class 2}$: very durable
$0.3<x<0.6 = \text{class 3}$: Durable
$0.6<x<0.9 = \text{class 4}$: Moderately durable
$x>0.9 = \text{class 5}$: Non durable
Results of prediction teak wood properties by NIRS on core samples

- Radial variability of heartwood:
Variability of natural durability

22-35 years

10 years

30-40 years

Very durable clones at 10 years

COUNTRY
- Ghana
- Malaysia
- Togo

TREE

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Conclusions wood technology parts

Large type of technology using by CIRAD and new tools development

To explore the huge diversity for shape and wood properties for teak

To select clones and variety based on commercial values (wood properties) and yield

To define new selection traits based on wood properties

To develop genomics for wood properties

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Part III - Mass clonal propagation of Teak
Seed vs vegetatively produced planting stock
Biological constraints of seeds

i) Insufficient availability of seeds, genetic improvement quality in open pollinated seed orchards

ii) The longer the clear bole produced and thus the higher the commercial value, the later the onset of fruiting

iii) Seed germination rates highly variable, low overall (20 à 30%) and unpredictable

iv) High variability among individuals, even when genetically related, affecting traits of major economical importance

v) Lack of information regarding the genetic control of most of the economically important traits and of the genetic gain that can be expected from sexual reproduction (seeds)
Mass clonal propagation using nursery techniques

1st Step: Getting the first generation of vegetative copies: the « mobilization phase » - by grafting
1st Step: Getting the first generation of vegetative copies: the « mobilization phase » - by cuttings

- Directly from the mature tree « in situ »
- From sticks set under mist system conditions
In Malaysia - average rainfall of 2000-2500mm/yr - in absence of distinct dry season
450 to 500 rooted cuttings are produced annually per m² of stock plants from mature selected teak genotypes
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Requisites

i) Reliable and good quality « mist system » automatically controlled

ii) Container-grown stock plants intensively managed - adapted pruning

iii) Stockplant and rooting areas sheltered by shade cloth and windbreaks

iv) Committed and experienced staff
Mobilisation and mass production of clones by *in vitro* technique

Teak is one of the rare forest species that can be easily micropropagated *in vitro* at an industrial scale.
Microcuttings

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Meristem culture and microcuttings

Exponential multiplication rate: $3^n$

$n$: number of subcultures every 6-8 weeks

Rooting in nursery conditions under mist-system > 95%

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Meristem culture-issued teak tree

18 months after planting

7 yr after planting  (Girth: 55cm, Height: 25m)
Requisites

1. Tissue culture laboratory adapted to the local context and to the objectives (which can be used also for other species…)

2. Suitable human resources and budget for ensuring a good utilization

But the most suitable solution combining the advantages of two options

- Earlier mass production from mature selected genotypes
- Reduced nursery operations: stockplant management,…
- To use the *in vitro*-derived plants locally - mist-system needed for acclimatization -, or for oversea markets - plantlets are germ-free and hence are not subject to any phytosanitation measure
Possible back-up from Cirad as regards

The most advisable selection and propagation strategies adapted to the context and the objectives

The most suitable facilities and equipment depending on the context, the propagation strategy (nursery, \textit{in vitro}, combined…), and the production targets

Staff proper training
Suitably selected Teak clones can be attractive to land owners providing:

- Productivity can be increased
- Rotations can be shortened, (part of the crop can be harvested earlier)
- Losses can be reduced
- Wood quality improved
- It can be combined to other crops (agroforestry systems)

Silviculture adapted to:

- The clones (new genetic materials)
- The rotation
- The type of culture
ICSB/CIRAD Teak Clone Characteristics

Species: Tectona grandis
Origin: Solomon Island
Identity: ICSB/CIRAD Clone TG2

Available in the form of:

- Ready for planting cuttings (for local market)
- In vitro-derived microcuttings (for international market)

Packed and delivered under contamination-free conditions to meet foreign country phytosanitary requirements

Form more information:

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Narrow-crowned and clear bole clones suitable for intercropping with cash crops such as oil palm

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