Genetic gain and projected increase in stand volume from two cycles breeding program of *Acacia mangium*: implications to plantation productivity and sustainable forestry in Indonesia

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Introduction

**STATUS OF PULP INDUSTRY IN INDONESIA**

2009

- 8 million tons pulp / yr
- 33 million m³ wood / yr
- 200,000 ha / yr

2020

- 16 million tons pulp / yr
- 67 million m³ wood / yr
- 390,000 ha / yr

**Demand (Road Map MOF)**

- 50 %

**Supply Capacity**
S-O-L-U-T-I-O-N

• INTENSIVE FOREST PLANTATION ESTABLISHMENT

Strategy I → MAI increase 30% (35 m³/ha/yr)
wood property increase 28%

Strategy II → MAI increase 50% (40 m³/ha/yr)
wood property increase 18%

Breeding strategy adopted by CFBTI
• seedling seed orchard using open pollinated families
• seedling seed orchard population - sub-lining system

Concepts of successive generation in sub-lining system

<table>
<thead>
<tr>
<th>PAPUA NEW GUINEA</th>
<th>FAR NORTH QUEENSLAND</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st generation</td>
<td></td>
</tr>
<tr>
<td>Sub-line A</td>
<td>Sub-line B</td>
</tr>
<tr>
<td>selection</td>
<td>selection</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>2nd generation</td>
<td></td>
</tr>
<tr>
<td>Sub-line A</td>
<td>Sub-line B</td>
</tr>
<tr>
<td>selection</td>
<td>selection</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>n+1 generation</td>
<td></td>
</tr>
<tr>
<td>Sub-line A</td>
<td>Sub-line B</td>
</tr>
<tr>
<td>selection</td>
<td>selection</td>
</tr>
</tbody>
</table>

Seed production orchard
Seed Orchard Establishment

- 12 seed orchards F-1 at 4 locations in 1994
- 32 seed orchards F-2 at 9 locations in 2002

<table>
<thead>
<tr>
<th>Seed Orchard Number</th>
<th>Total Area (ha)</th>
<th>Seed Production Capacity (kg/year)</th>
<th>Plantation (ha/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F-1 Generation</td>
<td>12</td>
<td>24.52</td>
<td>1.200</td>
</tr>
<tr>
<td>F-2 Generation</td>
<td>32</td>
<td>48.58</td>
<td>2.400</td>
</tr>
<tr>
<td>Total</td>
<td>44</td>
<td>73.10</td>
<td>3.600</td>
</tr>
</tbody>
</table>

Purpose of this study

- To verify realized genetic gain and stand volume projection brought by the two cycles breeding of *A. mangium*
- To observe the implications of gain to plantation productivity and sustainable forestry

Observed genetic gains in the trials

- Gain trial was established at Jonggol -West Java in 2010
- 4 SSO bulk (2 PNG and 2FNQ) and 1 land race were tested in 10 x 10 tree plots with 4 replications
Measurement and data analysis

- Measurement
  - 1, 2 and 3 years age (height and dbh)
  - stem volume: \( v = 0.000058806 \times D^{1.71772} \times H^{1.0809} \)
  - stand volume per hectare:
    \[ \text{stand volume on plot} \times 10000 \div \text{area of plot in square meter} \]

- Realized genetic Gain:
  - percentage increase of improved seed (seed orchard) to unimproved seed (seed stand)

- Stand volume projection
  - Gains in height converted to the increase in Site index
    \[ H_t = h_1(t_i) + [\text{SI} - h_1(8)] \times \frac{h_2(t_i)}{h_2(8)} \]

<table>
<thead>
<tr>
<th>Functions for site index curve</th>
<th>Functions with parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guide curve for height growth</td>
<td>( h_1(t) = 33.946 \times (1 - \exp(-0.1164^t))^{1.0272} )</td>
</tr>
<tr>
<td>CV curve for height growth</td>
<td>( h_2(t) = 3.859 \times (1-\exp(-0.1548^t)) )</td>
</tr>
</tbody>
</table>

Realized genetic gain

- Additional gains of improve seed:
  - height: 6-17%
  - dbh: 3-27%
  - stem volume: 26-60%

- Across the two cycles breeding, gain increased with ages for height, but it decreased for dbh and stem volume
Predicted increase in stand volume by Genetic Improvement

• Stand volume for F-1 reached 290 m³/ha.
• While stand volume for F-2 reached 325 m³/ha.
• 8 years’ rotation could be shortened by 1.5 and 2 years with the use of F-1 and F-2 improved trees, respectively.

• 30% to 50% of increase in stand volume is likely achieved from two cycles breeding (F-1 and F-2) of A. mangium
• Improved seed from F-2 provided 13% additional gain over the F-1

Implications

• 30%-50% more stand volume at rotation indicated that the impacts of tree improvement on plantation forest productivity had been substantial from the two cycles breeding of A. mangium.
• With the annual planting at around 200,000 hectares, a total of 55 million m³ – 63 million m³ of wood would be produced from these improved A. mangium.
• Additional improvement from wood quality traits could be expected to be other source to increase pulp yield production through reducing wood consumption per ton pulp.
• With fully supplied by wood harvested from improved plantation, it will significantly reduce the logging pressures on natural forest.
• Therefore to achieve these goals, it is recommended to multiply the seedling seed orchards from this two cycles breeding in mass scale (up to 100 hectares) to meet the demand of genetically improved seed for the targeted plantation in Indonesia.
Thank you