Breeding of Acacia spp. for timber products and Plant variety registration

2015. September

Osamu CHIGIRA

Forest Tree Breeding Center
Forest and Forest Products Research Institute
JAPAN
Contents of Lecture

• Distinctive features of breeding for timber products
  • Recurrent Mass selection based on population genetics
  • Example of Acacia spp. Breeding by Mass selection
  • Clonal cultivar of Japan cedar (Cryptomeria japonica)

• Examples of Clonal forest by genetically improved stock (Hybrid Acacia)
  • Important trait for interspecific hybrid of Acacia and their parent species
  • Naturally occur interspecific hybrid of Acacia
  • Breeding of interspecific hybrid Acacia by Artificial crossing

• Plant variety Registration of hybrid Acacia clones in Sabah Malaysia
  • Background
  • Important characteristic to distinct clone varieties each other
Distinctive features of breeding for timber products

- Recurrent Mass selection based on population genetics (low heritability)
  - Majority of timber product tree are allogamous species
  - Higher yielding (quantitative trait), Better quality, better adapted is objective of breeding
- Prefer genetic variation rather than uniformity! except breeding objective

1st Gen. Seed Orchard

- Propagate selected trees (Seedling, Grafting etc.)
- Seed production for operational planting (plant variety from 1st gen. seed orchard)

2nd Gen. Seed Orchard

- Propagate selected trees (Seedling, Grafting etc.)
- Seed production for operational planting (plant variety from 2nd gen. seed orchard)

Natural stand etc.

- Propagate selected trees (Seedling, Grafting etc.)
- Difficult to distinct from another population (variety of geographical features, large scale, long life crop)
Distinctive features of breeding for timber products

• Example of Acacia spp. Breeding by Mass selection

  • Seed were corrected from superior tree in natural stand
  • Breeding population is consist of several sub-populations
  • Each sub-pop. Consist of 30 to 60 families (strain)
  • Each fam. Planted in 4 tree Line plot with 6 to 10 replication
  • After felling, Best tree in each plot were left for operational seed production
  • For most families, Best tree in all replication were selected to collect seed for next generation. Culling inferior fam. At the same time.

1st Gen. seedling seed orchard of Acacia mangium in Java, INDONESIA
Distinctive features of breeding for timber products

- Clonal cultivar of Japan cedar (Cryptomeria japonica)

PICK BEST TREES UP AMONG BREEDING POPULATION AND DEVELOP NEW PLANT VARIETY AFTER CLONAL TEST
Examples of Clonal forest by genetically improved stock (Hybrid Acacia)

- Important trait for interspecific hybrid Acacia and their parent species
- Hybrid Acacia is Reciprocal hybrids between *A. auricuriformis* and *A. mangium*

<table>
<thead>
<tr>
<th>Features</th>
<th><em>A. auriculiformis</em></th>
<th><em>A. mangium</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Growth</td>
<td>Moderate to fast growth</td>
<td>Fast growth</td>
</tr>
<tr>
<td>Adaptation to soil</td>
<td>Tolerant to highly acidic and alkaline soils</td>
<td>Good in Acidic to weekly acidic soils</td>
</tr>
<tr>
<td>Drought tolerant</td>
<td>4 to 6 month</td>
<td>3 to 4 month</td>
</tr>
<tr>
<td>Pest and Disease resistance</td>
<td>Pests and diseases damage is minor. root rot damage in India <em>(Ganoderma lucidum)</em></td>
<td>Susceptible to hart rot, root rot and die-back</td>
</tr>
<tr>
<td>Stem form</td>
<td>Crooked</td>
<td>Straight</td>
</tr>
<tr>
<td>Wood density</td>
<td>Higher than mangium</td>
<td></td>
</tr>
<tr>
<td>Strength of wood</td>
<td>Stronger than mangium</td>
<td></td>
</tr>
<tr>
<td>Productivity of rooted cutting</td>
<td>Well</td>
<td>Well until 2-3 years</td>
</tr>
</tbody>
</table>

Breeding objective of Hybrid Acacia

- Fast growing
- Adaptation
- Disease resistance
- Straight stem form
- Wood density
- Wood color
- Strength of wood
- High productivity of scion for rooted cutting
- High success rate of rooted cutting

Legend; table above are created based upon from “characteristic of tropical tree species for reforestation 1 &2”, N. Mori et al, 1996 & 1997
Examples of Clonal forest by genetically improved stock

• Naturally occur interspecific hybrid Acacia in Sabah, Malaysia

• Natural interspecific hybrid discovered at *A. mangium* stand in Ulu-Kukut, Saba in 1970, among Mission Beach provenance, Queensland.

• 40 plus trees were selected at the stand.

• 30 plus trees are planted in scion garden ready to operational planting

• Clone trial was established at Karamatoi Saba in 2003 By private company

N.B.; A part of Information above are summarized from “Seed sources establishment and tree improvement project, Sabah, Malaysia”, 1982, FAO/UNDP-MAL/78/009 consul-tant’s report no 8. FAO, Rome.
Examples of Clonal forest by genetically improved stock

• Naturally occur interspecific hybrid Acacia in Vietnam

• Occasional hybrid individuals identified in young A. mangium plantations in Vietnam in 1992
• Six clones from clonal tests in 1990s, were approved by MARD (Ministry of Agriculture and Rural Development) for commercial use in the year 2000
• Hybrid Acacia plantations was estimated at 232,000 ha in Vietnam in 2009

N.B.; Information above are summarized from “Growth and wood density of acacia hybrid clones at three locations in Vietnam” Le Dinh Kha et al, 2012, New Forests 43:13-29
Examples of Clonal forest by genetically improved stock

- Breeding of interspecific hybrid Acacia by Artificial crossing

Development of artificial crossing technique

**Pollen collection & artificial pollination**

**Pollen storage at -20C**

**Check pollen viability**

**Sound seed rate in different mating time**

**Seed pod formation rate In artificial cross (%)**

**Pollen storage period (days)**

- Female: A. auriculiformis
- Female: A. mangium
Examples of Clonal forest by genetically improved stock

- Breeding of interspecific hybrid Acacia by Artificial crossing
- Development of artificial crossing technique

![Graph showing percentage of pod formation](Image)
Plant variety Registration of hybrid Acacia clones in Sabah Malaysia

• Background
  • SAFODA (Sabah Forest Development Authority) had discovered Natural interspecific hybrid *A. mangium* stand in Ulu-Kukut, Sabah in 1970
  • 30 clones out of 40 plus trees are conserved in scion garden
  • Clone trials of these clone were established in Sabah in 2003 By a private company
  • 19 better performed clone were registered as plant variety of Malaysia by SAFODA in cooperation with the private company and FTBC

N.B. ; A part of Information above are summarized from “Seed sources establishment and tree improvement project, Sabah, Malaysia”, 1982, FAO/UNDP-MAL/78/009 consultant’s report no 8. FAO, Rome.
Plant variety Registration of hybrid Acacia clones in Sabah Malaysia

- Important characteristic to distinct clone varieties each other
- 23 characteristic could be evaluated out of 40 characteristics
- “Color of bark” were gave up

<table>
<thead>
<tr>
<th>Category</th>
<th>Characteristic</th>
</tr>
</thead>
<tbody>
<tr>
<td>General appearance</td>
<td></td>
</tr>
<tr>
<td>Shape of tree crown</td>
<td>Color of tree crown</td>
</tr>
<tr>
<td></td>
<td>Geotropism of branches</td>
</tr>
<tr>
<td></td>
<td>D.B.H.</td>
</tr>
<tr>
<td>Trunk</td>
<td></td>
</tr>
<tr>
<td>Trunk form</td>
<td>Trunk taper</td>
</tr>
<tr>
<td></td>
<td>Shape of stem cross section</td>
</tr>
<tr>
<td>Wood</td>
<td></td>
</tr>
<tr>
<td>Color of heartwood</td>
<td>Color of sapwood</td>
</tr>
<tr>
<td></td>
<td>Specific gravity</td>
</tr>
<tr>
<td>Bark</td>
<td></td>
</tr>
<tr>
<td>Color of bark</td>
<td>Pattern of tree bark cracks</td>
</tr>
<tr>
<td></td>
<td>Thickness of bark</td>
</tr>
<tr>
<td>Branch</td>
<td></td>
</tr>
<tr>
<td>Size of branch</td>
<td>Length of branch</td>
</tr>
<tr>
<td></td>
<td>Angle of branch</td>
</tr>
<tr>
<td></td>
<td>Density of branch</td>
</tr>
<tr>
<td>Shoot</td>
<td></td>
</tr>
<tr>
<td>Shape of cross section</td>
<td>Edge of cross section</td>
</tr>
<tr>
<td>Phyllode</td>
<td></td>
</tr>
<tr>
<td>Length of phyllode</td>
<td>Width of phyllode</td>
</tr>
<tr>
<td></td>
<td>Bend of phyllode</td>
</tr>
<tr>
<td></td>
<td>Shape of phyllode base</td>
</tr>
<tr>
<td></td>
<td>Shape of phyllode tip</td>
</tr>
<tr>
<td></td>
<td>fork position of vein</td>
</tr>
<tr>
<td></td>
<td>Color of petiole</td>
</tr>
<tr>
<td>Pod</td>
<td></td>
</tr>
<tr>
<td>Shape of cross section</td>
<td>length of pod</td>
</tr>
<tr>
<td></td>
<td>Width of pod</td>
</tr>
<tr>
<td></td>
<td>Crookness of pod</td>
</tr>
<tr>
<td></td>
<td>Length of stalk</td>
</tr>
<tr>
<td></td>
<td>Color of stalk</td>
</tr>
<tr>
<td>Seed</td>
<td></td>
</tr>
<tr>
<td>Length of ovule stalk</td>
<td>Color of ovule stalk</td>
</tr>
<tr>
<td></td>
<td>Color of seed</td>
</tr>
<tr>
<td></td>
<td>Color of flower</td>
</tr>
<tr>
<td></td>
<td>Length of inflorescence</td>
</tr>
<tr>
<td>Fruiting</td>
<td></td>
</tr>
<tr>
<td>quantity of fruit</td>
<td>Age start fruting</td>
</tr>
<tr>
<td>Rooting</td>
<td></td>
</tr>
</tbody>
</table>
Plant variety Registration of hybrid Acacia clones in Sabah Malaysia

- Important characteristic to distinct clone varieties each other
  - Some characteristic seems difficult to judge subjectively
  - Coincidence ratio between evaluator was quite low in “shape of crown form”

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Code correspond to each Characteristics</th>
<th>combination of evaluator</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>General appearance</td>
<td>Shape of tree crown</td>
<td>conical</td>
</tr>
<tr>
<td>Trunk</td>
<td>Trunk form</td>
<td>straight</td>
</tr>
<tr>
<td></td>
<td>Shape of stem cross section</td>
<td>circular</td>
</tr>
<tr>
<td>Bark</td>
<td>Pattern of tree bark</td>
<td>smooth</td>
</tr>
<tr>
<td>Phylloide</td>
<td>Bend of phylloidal leaf</td>
<td>less bended</td>
</tr>
<tr>
<td></td>
<td>Shape of phylloidal tip</td>
<td>acuminate</td>
</tr>
<tr>
<td></td>
<td>fork position of vein</td>
<td>base</td>
</tr>
</tbody>
</table>

Note; 51 trees were observed as sample
Plant variety Registration of hybrid Acacia clones in Sabah Malaysia

• Important characteristic to distinct clone varieties each other
• Data analyzed to estimate repeatability for Part of trait

<table>
<thead>
<tr>
<th>Category</th>
<th>Characteristic</th>
<th>Repeatability</th>
</tr>
</thead>
<tbody>
<tr>
<td>General appearance</td>
<td>Shape of tree crown</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>Color of tree crown</td>
<td>0.07</td>
</tr>
<tr>
<td></td>
<td>D.B.H.</td>
<td>0.30</td>
</tr>
<tr>
<td>Trunk</td>
<td>Trunk form</td>
<td>0.32</td>
</tr>
<tr>
<td></td>
<td>Shape of stem cross section</td>
<td>-0.07</td>
</tr>
<tr>
<td>Bark</td>
<td>Pattern of tree bark cracks</td>
<td>0.12</td>
</tr>
<tr>
<td>Branch</td>
<td>Angle of branch</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td>Density of branch</td>
<td>-0.04</td>
</tr>
<tr>
<td>Phyllode</td>
<td>Length/Width of phyllode</td>
<td>0.41</td>
</tr>
<tr>
<td></td>
<td>Bend of phyllode</td>
<td>0.34</td>
</tr>
<tr>
<td></td>
<td>Shape of phyllod base</td>
<td>0.56</td>
</tr>
<tr>
<td></td>
<td>Shape of phyllod tip</td>
<td>0.22</td>
</tr>
<tr>
<td></td>
<td>fork position of vein</td>
<td>0.16</td>
</tr>
</tbody>
</table>

Note: 51 trees were observed as sample. 5 phyllode from each trees were observed.

Phyllode of A. mangium (above) and A. auriculiformis (below) Continuous variation were observed in Phyllode of Hybrid.
Plant variety Registration of hybrid Acacia clones in Sabah Malaysia

- Important characteristic to distinct clone varieties each other
  - 23 characteristic could be evaluated out of 40 characteristics
  - 7 characteristic is not effective to distinct varieties

<table>
<thead>
<tr>
<th>Category</th>
<th>Characteristic</th>
</tr>
</thead>
<tbody>
<tr>
<td>General appearance</td>
<td>Shape of tree crown</td>
</tr>
<tr>
<td>Trunk</td>
<td>Trunk form</td>
</tr>
<tr>
<td>Wood</td>
<td>Color of heart-wood</td>
</tr>
<tr>
<td>Bark</td>
<td>Color of bark</td>
</tr>
<tr>
<td>Branch</td>
<td>Size of branch</td>
</tr>
<tr>
<td>shoot</td>
<td>Shape of cross section</td>
</tr>
<tr>
<td>Phyllode</td>
<td>Length of phyllode</td>
</tr>
<tr>
<td>Pod</td>
<td>Shape of cross section</td>
</tr>
<tr>
<td>Seed</td>
<td>Length of ovule stalk</td>
</tr>
<tr>
<td>Fruiting</td>
<td>quantity of fruit</td>
</tr>
<tr>
<td>Rooting</td>
<td>Rooting</td>
</tr>
</tbody>
</table>