Development of New Oil Palm Cultivars in Malaysia with Special Reference to Protocols in Developing and Releasing a New Cultivar

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Malaysian Palm Oil Board (MPOB)
Oil Palm Centres of Origin

7. West African Centre: *Elaeis guineensis*

9. North-South American Centre: *E. oleifera*
Initial Planting Materials

Early commercial plantings utilized the thick-shell, thin-mesocarp *dura* planting materials.
Single Gene Inheritance

Experiment of Beirnaert & Vanderweyen (1941) – The single gene inheritance

Phenotypic ratio 3:1

Genotypic ratio 1:2:1

Current planting materials

**Dura**
- *Sh+ Sh+
- Shell: present
- S/F: 30%
- K/F: 10%
- M/F: 60%
- O/B: 18%
- Fibre ring: absent

**Tenera**
- *Sh+ Sh-
- Shell: present
- S/F: 10%
- K/F: 5%
- M/F: 85%
- O/B: 20%
- Fibre ring: present

**Pisifera**
- *Sh- Sh-
- Shell: absent
- S/F: 0%
- K/F: 5%
- M/F: 95%
- O/B: 0%
- Fibre ring: present

Sh+ Sh+
Sh+ Sh-
Sh+ Sh-
Sh+ Sh-
Sh+ Sh-

100%

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Deli *Dura* Breeding Population

- 1848: Four *dura* seedlings introduced to Bogor Botanical Garden
- 1870s: Seeds from Bogor were planted along avenues long bungalows in Deli, Sumatra for decorative purposes
- Superior materials unconsciously mass selected for several generations for more avenue plantings
- 1920s: Formal breeding and selections carried out in Indonesia (Marihat Baris) and Malaysia (Elmina & Serdang)
- The population became known as *Deli dura* population with uniform performance, big bunches and good fruit traits with high mesocarp
- Deli dura sub-populations in Malaysia (Serdang Avenue, Elmina, Dumpy E206, Ulu Remis and Johore Labis) are considered Breeding Populations of Restricted Origin (BPRO)
Tenera/Pisifera Breeding Populations

- Pisiferas generated from
  - Tenera x Tenera (TxT) = 1D:2T:1P
  - Tenera x Pisifera (TxP) = 1T:1P
  - Pisifera x Pisifera (PxP) = 1P

- Some common pisiferas
  - Yangambi, AVROS, Serdang 27B, NIFOR, La Me, Derived Pisifera

- Cultivated Variety (Cultivar)
  - Common DxP planting material
  - Deli dura x AVROS pisifera

AVROS pisifera palm, MPOB Kluang, Malaysia
Oil yield potential of oil palm

<table>
<thead>
<tr>
<th>Category of Production</th>
<th>Oil Yield (tonne/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>African groove</td>
<td>0.18</td>
</tr>
<tr>
<td>African plantations (national)</td>
<td>1.6</td>
</tr>
<tr>
<td>Malaysian plantations (national)</td>
<td>2</td>
</tr>
<tr>
<td>Malaysian commercial plantations</td>
<td>3.8</td>
</tr>
<tr>
<td>Best experimental plot</td>
<td>5</td>
</tr>
<tr>
<td>Selected progeny</td>
<td>6</td>
</tr>
<tr>
<td>Individual palm</td>
<td>8.6</td>
</tr>
<tr>
<td>Maximum theoretical yield</td>
<td>12.2</td>
</tr>
<tr>
<td></td>
<td>13.6</td>
</tr>
<tr>
<td></td>
<td>18.2</td>
</tr>
</tbody>
</table>
Oil Palm Breeding Objectives

To increase oil yield

To reduce palm height

To increase oil quality

Tolerance to pests and diseases

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Oil Palm Genetic Base

- The oil palm has a narrow genetic base
  - 4 Bogor Palm (1848)
  - Limited Sources of *Pisiferas* (AVROS, La Me, Yangambi)
    - Commercial DxP seeds
      - Deli x AVROS
Activities of MPOB Oil Palm Genebank

• Collections at centres of diversity
• Establishment, evaluation and selection of elite materials
• Progeny testing of elite materials
• Distribution of elite materials to the industry
• Screening germplasm for genetic variability (quantitative, molecular, biochemical)
Germplasm Collections
Elaeis guineensis

Africa

Nigeria '73
Senegal '93
Gambia '93
Guinea '94
Sierra Leone '94
Ghana '96
Cameroon '84
Zaire '84
Angola '91/'10
Tanzania '86
Madagascar '86
Germplasm Collections
Elaeis oleifera

Honduras '82
Nicaragua '82
Costa Rica '82
Panama '82
Colombia '82 & '04
Ecuador '04 & '06
Peru '04
Suriname '82
Brazil '04

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Improvement Programmes

**Dura**
- Cycle 0
  - Selection on own merit
  - Bunch yield
  - Bunch and fruit characteristics

**Tenera/Pisifera**
- Cycle 0
  - Selection based on tenera sibs
  - Bunch yield
  - Bunch and fruit characteristics

**DxP / DxT Progeny Test**
- Mating design e.g. NCMI

**DxP Seed Production**
- Heterosis GCA, SCA

**New Introductions (e.g. germplasm)**

**Repeat**

**Modified Reciprocal Recurrent Selection (MRS) in Oil Palm Improvement Programme in Malaysia**
North Carolina Model I (NCM I) Breeding Design

• Females / within Males (nested)

Key
F : Female (Dura)
M : Male (Pisifera)

North Carolina Model I.
The progenies include both full-sibs and half-sibs. Each set of families with the same father in common constitutes a half sib family group and a set of families with both parents in common constitutes a full-sib family
Timeframe to Develop MPOB PS1.1 DxP Cultivar (high yield, short palm)

- 1973: Germplasm collection
- 1975/76: Field planting
- 1994: Second generation germplasm
- 1994: Deli dura
- 2004: DXP progeny testing
- 2013: MPOB PS1.1

Deli dura X
Oil Palm Breeding Objectives

To increase oil yield

To increase oil quality

To reduce palm height

Tolerance to pests and diseases

Breeding for specialty traits

PS Series
- PS1 – slow height increment
- PS2 – high iodine value
- PS3 – high kernel
- PS4 – high carotene *Elaeis oleifera*
- PS5 – thin shell *tenera*
- PS6 – large fruit *dura*
- PS7 – high bunch index
- PS8 – high vitamin E
- PS10 – long stalk
- PS11 – high carotene *E. guineensis*
- PS12 – high oleic
- PS13 – low lipase

Elaeis oleifera

*tenera*

*dura*

*E. guineensis*
<table>
<thead>
<tr>
<th>Breeding Populations</th>
<th>Specialty Traits</th>
<th>PS</th>
<th>Current DxP</th>
</tr>
</thead>
<tbody>
<tr>
<td>• PS1</td>
<td>Dwarf palm (height increments)</td>
<td>40cm/yr</td>
<td>50 – 75cm/yr</td>
</tr>
<tr>
<td>• PS1.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• PS2</td>
<td>High Iodine value</td>
<td>56</td>
<td>52</td>
</tr>
<tr>
<td>• PS3</td>
<td>Large kernel (K/F)</td>
<td>10-15%</td>
<td>5-7%</td>
</tr>
<tr>
<td>• PS4</td>
<td>High carotene <em>E. oleifera</em></td>
<td>&gt; 3,000ppm</td>
<td>500 – 700ppm</td>
</tr>
<tr>
<td>• PS5</td>
<td>Thin shell <em>tenera</em> (S/F)</td>
<td>2.80 – 7.40%</td>
<td>&gt;10%</td>
</tr>
<tr>
<td>• PS6</td>
<td>Large fruit <em>dura</em> (weight)</td>
<td>24g – 34g</td>
<td>10g</td>
</tr>
<tr>
<td>• PS7</td>
<td>High bunch index</td>
<td>0.6</td>
<td>0.3</td>
</tr>
<tr>
<td>• PS8</td>
<td>High vitamin E</td>
<td>1,300 – 2,500ppm</td>
<td>600 – 1000ppm</td>
</tr>
<tr>
<td>• PS9</td>
<td><em>Bactris gasipae</em></td>
<td>Not oil palm</td>
<td></td>
</tr>
<tr>
<td>• PS10</td>
<td>Long stalk</td>
<td>20 – 30cm</td>
<td>10-15cm</td>
</tr>
<tr>
<td>• PS11</td>
<td>High carotene <em>E. guineensis</em></td>
<td>2000 – 2474ppm</td>
<td>500 – 700ppm</td>
</tr>
<tr>
<td>• PS12</td>
<td>High oleic</td>
<td>48 – 52.5%</td>
<td>37 – 40%</td>
</tr>
<tr>
<td>• PS13</td>
<td>Low lipase (FFA cold activation)</td>
<td>1 – 10%</td>
<td>22 – 73%</td>
</tr>
</tbody>
</table>
Selection

PS1.1 Dwarf palm

PS1.1 palm

Control (normal DxP)
Selection

PS1 and PS1.1 Dwarf palm
PS2 High iodine value
PS3 Large kernel
Carotene extract
Carotene capsules
PS4 dan PS11 High carotene
PS5 Thin shell tenera
PS6 Large fruit dura
PS10 Long stalk

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Clonal Seeds

- An alternative to clones
- Parents with good Specific Combining Ability (SCA)
Planting Materials

1. **DxP seeds**
   - General Combining Ability (GCA)
2. **Clonal DxP seeds**
   - Specific Combining Ability (SCA)
3. **Clones**
   - Individual palms

**Breeding Programmes**

- **DxP Seeds**
- **Clones**
- **Pollination**
- **Seeds**
- **Nursery**
- **Ex-plant**
- **Polyembroid**
- **Rooting**

**Duration from field to nursery**
- **DxP**: 9 months
- **Clone**: 2 – 5 yrs

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Cloning of Palms with Special Traits

Palms with special traits were cloned, examples:

- High bunch index
- High vitamin E
- High carotene
- Long stalk
- Low height increment

High-bunch index 0.68 *dura*

High bunch index (0.58) *tenera*

Long stalk *tenera* (35.5cm)

High carotene (4000ppm) *E.oleifera* ramets

High vitamin E *dura* (1551ppm) & *tenera* (1392ppm)

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Molecular Markers for Quality Control

- Exploitation of "omics" technologies for isolation of biomarkers
- Continuous effort in identification of new markers
- Characterization and functional analyses of potential markers
- Small scale testing
- Large scale testing of potential markers (involvement of industry crucial)
- Incorporation of validated markers into tissue culture process
- Conversion of biomarkers into an improved version for routine assay applications

Biomarker discovery
Biomarker verification
Biomarker validation
Biomarker application
Biomarker improvement

Diagnostic tool for CLONAL AMENITY AND CONFORMITY
Genomics-guided Breeding

Classical Breeding

- 10 – 12 year selection cycle
- Large land requirement
- High cost in conducting breeding trials

Genomics-guided Breeding

MARKER APPLICATION

- Genomics guided decisions
- Short breeding cycle
- Reduced cost of trials
- Tools for QC & selection of traits

TYPES OF MARKERS

- Simple Sequence Repeats (SSRs)
- Single Nucleotide Polymorphisms (SNPs)

Improved Planting Material
• >34,802 Genes
• Oil Palm Genome and SHELL gene published *(Nature, 2013)*
Convention on Biological Diversity (CBD)

• CBD is a UN treaty formally adopted in Rio de Janeiro, Brazil in 1992
• CBD recognizes biological resources as sovereign rights of nations
• Malaysia, being a party to CBD deposits equal portion of oil palm germplasm collection in the host country
Plant Breeders Right (BPR)
Test Guidelines for New, Distinct, Uniform and Stable (DUS)

New plant varieties are registered based on the International Union for the Protection of New Varieties of Plants (UPOV)

Oil palm DUS test guidelines (TG) developed under the purview of the Department of Agriculture, Malaysia

Harmonized DUS TG of oil palm involved Malaysia (chair), Indonesia & Thailand under the East Asia Plant Variety Protection Forum (EAPVPF), Japan

CRITERIA FOR PROTECTING A PLANT VARIETY
The plant variety must be:
- **Distinct:** A variety should be clearly distinguishable by at least one essential characteristic from existing or commonly known varieties in any country at the time of filing of the application.
- **Uniform:** A Variety must be sufficiently uniform in its essential characteristics.
- **Stable:** Essential characteristics of a variety must be stable after repeated propagation or in the case of a particular cycle of propagation at the end of each cycle.
MALAYSIAN STANDARD

• The Department of Standards Malaysia (STANDARDS MALAYSIA) is the national standardisation and accreditation body.

• Malaysian Standards are developed through consensus by committees which comprise of balanced representation of producers, users, consumers and others with relevant interests.

• To the greatest extent possible, Malaysian Standards are aligned to or are adoption of international standards.

• Approval of a standard as a Malaysian Standard is governed by the Standards of Malaysia Act 1996 (Act 549).

• Malaysian Standards are reviewed periodically.

• The use of Malaysian Standards is VOLUNTARY except in so far as they are made mandatory by regulatory authorities by means of regulations, local by-laws or any other similar ways.
MALAYSIAN STANDARD

MS 157  Oil Palm Seeds for Commercial Planting: Specification
MS 2099  Oil palm Clones for Commercial Planting. Specification for Ortet Selection
Malaysian Standard MS157

Oil Palm Seeds for Commercial Planting

• **B1. Materials of both known pedigree and performance**
  • B1.1 minimum requirements for the *tenera* in the progeny test.
  • B1.2 minimum requirements for the *dura* parent palms.

• **B2. Materials of unknown pedigree but known performance**
  • B2.1 minimum requirements for the *tenera* in the progeny test.
  • B2.2 minimum requirements required for the *dura* parent palms.

• **B3. Materials of known pedigree but unknown performance**
  • B3.1 minimum requirements for *tenera* in the progeny test
  • B3.2 minimum requirements for the *dura* parent palms.

• **B4. Materials of both unknown pedigree and performance**
  • Materials of both unknown pedigree and performance shall not be used for commercial $D\times P$ seed production.
Selection requirements of parental palms for commercial DxP seed production

MS157:2005

<table>
<thead>
<tr>
<th>Traits</th>
<th>Dura</th>
<th>Tenera</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh fruit bunch (kg/p/yr), min.</td>
<td>150</td>
<td>170</td>
</tr>
<tr>
<td>Mesocarp to fruit (%), min.</td>
<td>55</td>
<td>-</td>
</tr>
<tr>
<td>Shell to fruit (%), max.</td>
<td>35</td>
<td>-</td>
</tr>
<tr>
<td>Kernel to bunch (%), min.</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td>Oil to dry mesocarp (%), min.</td>
<td>75</td>
<td>-</td>
</tr>
<tr>
<td>Oil to bunch (%), min.</td>
<td>18</td>
<td>25</td>
</tr>
</tbody>
</table>

Yield records: Mean of four consecutive years,
Bunch analysis: Minimum of three bunches/palm
Legal Requirements

• Producers of oil palm planting materials must obtain license to produce, store and move the planting materials.

• Producers must be a registered company, financially sound and has a competent breeder.

• Seeds, clones and seedlings for commercial sale must fulfill the requirements of Malaysian Standard MS157 (seeds) or MS2099 (clones).

• The seeds and clones shall in all aspects comply with the requirements of the legislations currently in force in Malaysia.
License for Oil Palm Seeds and Clones for Commercial Planting

Related Legislation:

- Malaysian Standards are voluntary according to the Department of Standards Malaysia (STANDARDS MALAYSIA)

- However, MS 157 (seeds) and MS 2099 (clones) are MANDATORY standards imposed by MPOB on producers regulated under the Malaysian Palm Oil Board (Licensing) Regulations 2005

- The industry in general is very well regulated and any revisions to improve the standards will immediately be imposed on producers

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Conclusion

- Development of new oil palm cultivars owes a great deal to the work and dedication initiated by early breeders.
- Science, laws and regulations facilitate development and release of new cultivar and healthy growth of the industry.

Introduction of germplasm
Genetic diversity

Breeding objectives
Yields, specialty traits

MS 157 (seeds)
MS 2099 (clones)

Register for protection

Malaysian laws
MPOB licence

Oil palm area
in Malaysia
5.84 mil ha
(June 2018)

Legal Requirements
(mandatory)

Commercial Sale & Planting

Plant Breeders Right
(optional)

Malaysian Standard

Breeding & Selection

Genetic Materials

Development of new oil palm cultivars owes a great deal to the work and dedication initiated by early breeders.

Science, laws and regulations facilitate development and release of new cultivar and healthy growth of the industry.

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Malaysia

- Science, laws and regulations facilitate development and release of new cultivar and healthy growth of the industry.
Thank You

See You at PIPOC 2019

19 - 21 November 2019
Kuala Lumpur Convention Centre,
Kuala Lumpur, Malaysia

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