Palm Oil yield potential of oil palm (*Elaeis guineensis*) seeds developed by CIRAD and its partners.

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2 P.T. Socfindo, Medan, Indonesia.
3 INRAB CRA-PP Station de Pobè, Bénin.
The main challenges
Oil and fat requirements

- 135 million tonnes of oils and fats consumed in 2005, including 115 million of vegetable origin.
- Oil palm supply around 37 million tonnes, Soybean around 34 Mt.
- In world average terms, oil palm yields are 6 to 10 times > soybean: 3 to 3.5 t/ha/year
- Oil and fat requirements are growing by 4.4% per year.
- Palm oil production is growing by 5.6%.
- The contribution made by genetic improvement amounts to 1,2 %/ year (Cirad seeds).
- The rest comes from extensions, agronomic improvement and rehabilitation.

... and bio diesel.
Value of Oil Palm seeds developed by CIRAD and its partners

The most important height vegetable oils.
Breeders and global context

To partly meet these challenges:

⇒ **Sustainable intensification** of production over several cropping cycles will help to limit pressure on uncultivated areas, notably tropical forest. It will also have a positive economic impact for growers.

⇒ One of the prerequisites for achieving high yields is to provide growers with:

1 – high-yielding planting material.
2 – resistance to main deseases.

*In this presentation we will focus on yield.*
Breeding and seed production strategy

1 - SSR

A Group
Deli, Angola

Parent choice

Progeny trials

D x P Seeds
(other scheme)

B Group
(La Mé, Yang, SP540,)

Parent choice

Improved A Group

Improved B Group

One cycle = 20 years; 3rd cycle on progress
Value of Oil Palm seeds developed by CIRAD and its partners

2 – Scheme for D x P Seeds production: One cycle based on pedigree

- **Parent 1** (Dura)
  - Selfing I
    - ~ xx palms (100)
  - Selfing II
    - ~ xx palms (100)

- **Parent 2** (tenera)
  - Selfing I
    - ~ xx palms (100)
  - Selfing II
    - ~ xx palms (100)

Comparative progeny tests

- **D x P seeds**
  - Additional yield = +12 %
  - High homogeneity

15 to 20 years
Breeding and seed production strategy (cont…)

Selection and evaluation of parents

2 phases

1/ Pre-selection of parents for their inherent value

Only for heritable traits:

Dura & Tenera Parents: growth rate  
% mesocarp/fruit  
% oil/mesocarp

Pisifera Parents: growth rate

2/ Selection of parents for their general combining ability (GCA)

Assessment of the average value of each parent when crossed with the parents of the other group for yield and growth rate.
## Breeding and seed production strategy

General mating designs to evaluate GCA of parents

<table>
<thead>
<tr>
<th>Group A parents</th>
<th>Group B parents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Origin A1</td>
<td>A11</td>
</tr>
<tr>
<td>Origin A1</td>
<td>A12</td>
</tr>
<tr>
<td>...</td>
<td>A1n</td>
</tr>
<tr>
<td>Origin A2</td>
<td>A21</td>
</tr>
<tr>
<td>Origin A2</td>
<td>A22</td>
</tr>
<tr>
<td>...</td>
<td>A2n</td>
</tr>
<tr>
<td>Origin Am</td>
<td>Am1</td>
</tr>
<tr>
<td>Origin Am</td>
<td>Am2</td>
</tr>
<tr>
<td>...</td>
<td>Amn</td>
</tr>
</tbody>
</table>

| Origin B1       | B11             |
| Origin B1       | B12             |
| ...             | B1n             |
| Origin B2       | B21             |
| Origin B2       | B22             |
| ...             | B2n             |
| ...             | ...             |
| Origin Bm       | Bm1             |
| Origin Bm       | Bm2             |
| ...             | Bmn             |

### A genetic block

(set of progeny tests)

- 20 trials x 20 progenies = 400 crosses = 300 ha
- 130 parents tested per group
- Each is tested three times …
Value of Oil Palm seeds developed by CIRAD and its partners

Field design

Group B parents

Group A parents

Origin A1

Origin A2

Origin Am

Origin Amn

Origin B1

Origin B2

Origin Bm

Origin Bmn

Origin B2n

Origin Bn

Origin B

Origin B1n

Origin B1

Origin B2

Origin Bm

Origin Bmn

Origin B2n

Origin Bn

Origin B

Origin B1n

Origin B1

Origin B2

Origin Bm

Origin Bmn

Origin B2n

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Origin B

Origin B1n

Origin B1

Origin B2

Origin Bm

Origin Bmn

Origin B2n

Origin Bn

Origin B
Breeding and seed production strategy

Example Aek Loba Timur Genetic Block
(P.T. Socfindo in Indonesia)

- Favourable ecological conditions
- 28 trials set up from 1995 to 2000 (25 prog test -3 clonal)
- 420 DxT or DxP crosses between
  - 114 Dura Deli parents
  - 112 Tenera or Pisifera parents (La Mé & Yangambi origins)

⇒ We will comment early data for 17 trials that have attained 8 years, 254 progeny, 83 Dura Deli and 104 LM ou YA palms
## Origins tested in trials at Aek Loba Timur

### A GROUP
- DA 5 D x DA 3 D (*)
- DA 10 D x DA 3 D
- DA 10 D x DA 115 D
- DA 115 D self
- DA 115 D self (*)
- DA 115 D x DA 3 D
- DA 300 D x DA 128 D
- DA 551 D x DA 767 D
- LM 269 D x DA 115 D
- LM 269 D x DA 128 D
- LM 404 D self
- LM 404 D x DA 3 D
- LM 404 D x DA 10 D

### B GROUP
- LM 2 T self
- LM 2 T self (*)
- LM 2 T x LM 5 T
- LM 2 T x LM 9 T
- LM 2 T x LM 10 T (*)
- LM 2 T x SI 10 T (*)
- LM 5 T self
- LM 5 T x LM 10 T
- LM 5 T x LM 311 P
- LM 9 T x LM 13 T
- LM 10 T self
- LM 13 T self
- LM 238 T x LM 511 P
- LM 718 T self
- LM 718 T x LM 238 T

(*) + one cycle of pedigree selection
RESULTS
Preliminary comments

FFB: the effective planting density is 143 palms/ha but we consider only 135 palms (road and non value palms)

$$FFB = \text{observed yield} \times 0.944 \quad (1)$$

OER: to estimate OER we consider mill loses and bias when sampling the bunches:

$$\text{OER} = \frac{O}{B} \times 0.855 \quad (2)$$

$$(1) \times (2) = 0.807 \Rightarrow -20\%$$

10.5 t/oil/ha observe in trials = 8.5 t/oil/ha effective in plantation
Mean of Aek Loba genetic block

After 2005 season

1 - Bunch analyses at 5 and 6 years (360 crosses)

<table>
<thead>
<tr>
<th>% Fruit/Bunch</th>
<th>% Mesocarp/Fruit</th>
<th>% Oil/Mesocarp</th>
<th>Oil/Bunch Lab.</th>
<th>OER</th>
</tr>
</thead>
<tbody>
<tr>
<td>66.5%</td>
<td>82.5%</td>
<td>56.1%</td>
<td>30.8%</td>
<td>26.4%</td>
</tr>
</tbody>
</table>

2 - Yield of young and mature palms

<table>
<thead>
<tr>
<th>Period</th>
<th>Crosses</th>
<th>BN x ABW</th>
<th>FFB t/ha/yr</th>
<th>Oil t/ha/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-5 years</td>
<td>360</td>
<td>28.3 x 5.8</td>
<td>21.4</td>
<td>5.65</td>
</tr>
<tr>
<td>6-8 years</td>
<td>254</td>
<td>18.8 x 12.0</td>
<td>29.1</td>
<td>7.73</td>
</tr>
</tbody>
</table>
Aek Loba genetic bloc: extreme values (variability)

1 - Crosses tested (6-8 year period)

<table>
<thead>
<tr>
<th>Number</th>
<th>OER</th>
<th>FFB</th>
<th>OIL</th>
</tr>
</thead>
<tbody>
<tr>
<td>254 crosses classed</td>
<td>from 20.0 % to 31.6%</td>
<td>from 23.2 to 33.6</td>
<td>from 6.15 to 9.45</td>
</tr>
</tbody>
</table>

2 - GCA of parents tested (6-8 year period)

<table>
<thead>
<tr>
<th>Number</th>
<th>OER</th>
<th>FFB</th>
<th>OIL</th>
</tr>
</thead>
<tbody>
<tr>
<td>65 dura classed</td>
<td>from 23.6% to 29.8%</td>
<td>from 25.0 to 31.5</td>
<td>from 6.48 to 8.65</td>
</tr>
<tr>
<td>79 T or P classed</td>
<td>from 21.8 % to 29.5%</td>
<td>from 23.0 to 32.9</td>
<td>from 6.47 to 9.11</td>
</tr>
</tbody>
</table>
# Aek Loba genetic bloc:
## Selection of progenies

<table>
<thead>
<tr>
<th>6-8 year period</th>
<th>Ind. OER</th>
<th>FFB t/ha/yr</th>
<th>Oil t/ha/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean of ALT</td>
<td>26.4</td>
<td>29.1</td>
<td>7.73</td>
</tr>
<tr>
<td>Selected best 16 % (40 crosses)</td>
<td>27.6</td>
<td>30.8</td>
<td>8.63</td>
</tr>
<tr>
<td>% improvement</td>
<td>+ 4.6%</td>
<td>+6.0%</td>
<td>+11.6%</td>
</tr>
<tr>
<td>Selected best 8 % (20 crosses)</td>
<td>28.0</td>
<td>31.2</td>
<td>8.85</td>
</tr>
<tr>
<td>% improvement</td>
<td>+ 6.1%</td>
<td>+7.3%</td>
<td>+14.5%</td>
</tr>
</tbody>
</table>
### Value of Oil Palm seeds developed by CIRAD and its partners

#### Aek Loba genetic bloc: Selection of best parents based on GCA for Oil production

<table>
<thead>
<tr>
<th>6-8 year period</th>
<th>Ind. OER</th>
<th>FFB t/ha/yr</th>
<th>Oil t/ha/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean of parents</td>
<td>26.2</td>
<td>29.1</td>
<td>7.76</td>
</tr>
<tr>
<td>GCA of the 16% best Dura (10 palms)</td>
<td>+1.1 (27.3)</td>
<td>+1 (30.1)</td>
<td>+0.59 (8.35)</td>
</tr>
<tr>
<td></td>
<td>+4.1%</td>
<td>+3.6%</td>
<td>+7.7%</td>
</tr>
<tr>
<td>GCA of the 16% best T/P (13 palms)</td>
<td>+1 (27.2)</td>
<td>30.6</td>
<td>+0.76 (8.52)</td>
</tr>
<tr>
<td></td>
<td>+3.9%</td>
<td>+5.6%</td>
<td>+10.0%</td>
</tr>
<tr>
<td>16% best D x 16% best T/P</td>
<td>28.3</td>
<td>31.7</td>
<td>9.13</td>
</tr>
<tr>
<td>% improvement</td>
<td>+8.0%</td>
<td>+9.2%</td>
<td>+17.7%</td>
</tr>
</tbody>
</table>

**Reminder:** 11.6% -> 14.5% -> 17.7%
**AL bloc : Selection of best parents based on GCA for Oil production**

The expected value of crosses between selected palms for GCA on Oil production is attainable as we have observed:

<table>
<thead>
<tr>
<th>6-8 year period</th>
<th>Ind. OER</th>
<th>FFB t/ha</th>
<th>Oil t/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>PO 3360 D x PO 4982 P</td>
<td>29.6 %</td>
<td>31.5</td>
<td>9.45</td>
</tr>
<tr>
<td>PO 3174 D x PO 2766 P</td>
<td>29.1 %</td>
<td>31.1</td>
<td>9.22</td>
</tr>
<tr>
<td>PO 3600 D x PO 2762 P</td>
<td>30.5 %</td>
<td>29.8</td>
<td><strong>9.21</strong></td>
</tr>
</tbody>
</table>

(Expected : 9.13)
## Correlations (R² : 0.9)

<table>
<thead>
<tr>
<th>Cross</th>
<th>Rank</th>
<th>Observed values Oil t/ha/yr</th>
<th>Calculated values from GCA Oil t/ha/y</th>
</tr>
</thead>
<tbody>
<tr>
<td>PO 3360 D x PO 4982 P</td>
<td>1</td>
<td>9.45</td>
<td>9.52</td>
</tr>
<tr>
<td>PO 3174 D x PO 2766 P</td>
<td>2</td>
<td>9.22</td>
<td>9.02</td>
</tr>
<tr>
<td>PO 3600 D x PO 2762 P</td>
<td>3</td>
<td>9.21</td>
<td>9.25</td>
</tr>
<tr>
<td>PO 2580 D x PO 2980 T</td>
<td>25</td>
<td>8.53</td>
<td>8.41</td>
</tr>
<tr>
<td>PO 3052 D x PO 2761 P</td>
<td>50</td>
<td>8.28</td>
<td>7.75</td>
</tr>
<tr>
<td>PO 3062 D x PO 4740 P</td>
<td>75</td>
<td>8.06</td>
<td>8.10</td>
</tr>
<tr>
<td>PO 3170 D x PO 3636 P</td>
<td>100</td>
<td>7.90</td>
<td>7.92</td>
</tr>
<tr>
<td>PO 2995 D x PO 3277 T</td>
<td>125</td>
<td>7.72</td>
<td>7.33</td>
</tr>
<tr>
<td>PO 3064 D x PO 3253 T</td>
<td>150</td>
<td>7.60</td>
<td>7.60</td>
</tr>
<tr>
<td>PO 4840 D x PO 2972 T</td>
<td>175</td>
<td>7.45</td>
<td>7.61</td>
</tr>
<tr>
<td>PO 4844 D x PO 3351 P</td>
<td>200</td>
<td>7.31</td>
<td>7.21</td>
</tr>
<tr>
<td>PO 3127 D x PO 4799 P</td>
<td>225</td>
<td>7.12</td>
<td>7.37</td>
</tr>
<tr>
<td>PO 3971 D x PO 3660 P</td>
<td>250</td>
<td>6.78</td>
<td>6.74</td>
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</tbody>
</table>
### Genetic progress

- Both FFB and OER are moving:

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</tr>
</thead>
<tbody>
<tr>
<td>OER %</td>
<td>21,5</td>
<td>23,5</td>
<td>25,8</td>
<td>27,8</td>
<td>+ 29,3 %</td>
</tr>
<tr>
<td>FFB t/ha</td>
<td>24,1</td>
<td>25,5</td>
<td>27,1</td>
<td>29,9</td>
<td>+ 24,1 %</td>
</tr>
<tr>
<td>Oil t/ha</td>
<td>5,2</td>
<td>6,0</td>
<td>7,0</td>
<td>8,3</td>
<td>+ 59,6 %</td>
</tr>
</tbody>
</table>
Evolution of Genetic Productivity

- Nord Sumatra (no water deficit)
- Côte d'Ivoire (-340 mn/an)

1.2%/year
55 kg/year
Conclusion: what production can be expected under Aek Loba-type ecological conditions?

- **FFB:** 30 to 32 t/ha/yr  
  (31 to 34 t/ha/yr in trials)
- **Oil Extraction Rate:** 26 to 29%  
  (30 to 34% in the lab.)
- **Yield:** 8 to 9 t CPO/ha/yr  
  (10 to 11 t/ha/yr in trials)
- **Reasonable ABW:** 22 to 24 kg for mature palms
- **First harvest** at 2 years
- **Slow vertical growth:** 40 to 60 cm/yr
- **Iodine value over 55**
Conclusion

- The scheme proposed here allows an overall exploitation of the results.
- Value of crosses is estimated with high precision.
- It enable GCA calculations for the parents: this is of strategic importance as for the seed gardens and the recombinations for the next cycle.
- We estimate a greater genetic progress (> 17%)
- Ongoing progress is a (welcome) result of our work.
Thank you for your attention