II CONGRESO PALMERO C//PAL
22 AL 24 DE AGOSTO DE 2016
SANTO DOMINGO DEL CERRO
LA ANTIGUA GUATEMALA
Genetic progress for oil palm planting material:

Reality, perception and future

Tristan Durand-Gasselin
Increase in oilpalm Yield

400 kg of oil for wild material in the Nigerian grove
16 tones (obs) in the best conditions in Guatemala.

Three main reasons to get such progress:
1. Soil & Climatic conditions
2. Agronomic progress
3. Genetic progress

Is it possible to separate the effects of agronomical progress from genetic progress?

Yes: we are able to plant the same cross in different location and to repeat it over time: for example one cross has been planted 91 times from 1959 to 2000, in Asia and Africa.
What is genetic progress?

Genetic progress = to accumulate “good” genes.

- One gene (or few) with “big” effect:
  - breakthrough innovation.
  - Very evident effects.

- Many genes with “small” effect:
  - incremental innovations.
  - Or quantitative improvement.
  - Almost imperceptible.

Dura X pisifera (one gene) = tenera

Yield (many genes):
  - small progress every year.

Nord sumatra (no water deficit)
Côte d’Ivoire (-340 mn/an)

![Graph showing yield progress over decades](https://example.com/graphics/graph.png)
SH gene (1)

End of 1930’s Understanding how the Shell gene works (Beirnaert, INEAC Congo):

Dura = double Sh +
Pisifera = Double sh-
→ Tenera = Sh+ x sh-

Full implementation: end of 1950’s…

100 % include in planter’s knowledge
Genetic resources (2)

Experience Internationale 1947-1957 (IRHO)

La Mé  Nigeria  Yangambi  Sibiti  Deli
Genetic resources (2)

- Considerable within-population variability and heredity of main characters (Bunch Nb/W)

- **Inter origin crosses > intra origin crosses**
  (Example: Yangambi x LM is better than la Mé x la Mé or Yangambi x Yangambi)  
  *Heterosis*

- **Deli x others > all others crosses**
  (Example: Deli x LM or Deli x Yangambi are better than la Mé x Nigeria or Yangambi x la Mé)

Full implementation: **beginning of 1960’s…(?)**

→ **breakthrough innovation.**
Breeding Schema (3)

Breeding Schema : end of 1950’s

➢ Recurrent- Reciprocal Selection. (IRHO, 1957)
➢ Family / Individual Selection (unilever)

The former, adapted from Comstock et al., 1949, is the most widely spread: very efficient to take advantage of inter origin crosses [Heterosis], and for seed production.

Idea : to take advantage of hererosis (Deli x Africa)

→ Two groups : not because of dura and pisifera but because of genetic origin.
This schema has lead to decades of Incremental innovation.
Recurrent Reciprocal schema(3)

OER has been improved dramatically

Same for FFB....
Recurrent Reciprocal schema(3)

Yield (FFB + OER) improvement:

Yield potential of one seed can’t be taste.

Difficulties to perceive Incremental innovation
One gene controls the endogenous lipase activity (Cirad/PalmElit 2010’s).

Material with **zero** endogenous lipase activity will lead to **reduced FFA** (free fatty acid) content (1/3).

→ **breakthrough innovation.**
Resistance to diseases

Researcher needs to combine knowledge resulting of:

- breakthrough innovation: identification of a pathogen, development of early screening test
- incremental innovation: we have to cumulate many “good” genes linked to quantitative resistance (Partial resistance).
Resistance to Fusarium wilt (5)

IRHO starts in the 70’s, then Cirad and PalmElit have continuously improved the resistance.

→ Incremental innovation
Resistance to Fusarium wilt (5)

IRHO Dabou Plantation 4 000 ha (Côte d'Ivoire)

After 30 years of continuous efforts Fusarium wilt has almost “disappear” in Africa… as long as one use resistant material.

A Challenge = to achieve the same for *Ganoderma* and Bud rot (Pudricion del cógollo).
Resistance to *Ganoderma* (6): field observation

Mata Pao Estate (Indonesia) : 17 years old plantation
Resistance to *Ganoderma* (6)

Innovation (technical) : 
Early screening test (prenursery test) achieved by Cirad/palmElit in the 2000’s.

It allows to test more than 120 000 palms per year. (Cirad in the 2000’s)

→ Incremental innovation
## Resistance to *Ganoderma* (6):

**Field result**

<table>
<thead>
<tr>
<th>Origins</th>
<th>Deli x La Mé</th>
<th>Yambi IRHO A</th>
<th>La Mé B</th>
<th>Nigeria A</th>
<th>Nigeria B</th>
<th>Yangambi Socfin A</th>
</tr>
</thead>
<tbody>
<tr>
<td>D Dabou A</td>
<td>18</td>
<td>10,4</td>
<td>8</td>
<td>4</td>
<td>10,2</td>
<td>Intermediate resistant</td>
</tr>
<tr>
<td>D Dabou B</td>
<td>0</td>
<td>16,7</td>
<td>10</td>
<td>6</td>
<td>Intermediate to resistant</td>
<td></td>
</tr>
<tr>
<td>D Dabou C</td>
<td>14,6</td>
<td>7,3</td>
<td>9,1</td>
<td>12,1</td>
<td>10,2</td>
<td>Intermediate resistant</td>
</tr>
<tr>
<td>D Dabou D</td>
<td>15,3</td>
<td>7,4</td>
<td>6,3</td>
<td>3,4</td>
<td>9,1</td>
<td>Resistant</td>
</tr>
<tr>
<td><strong>D Dabou E</strong></td>
<td><strong>31,3</strong></td>
<td><strong>8,3</strong></td>
<td><strong>12,9</strong></td>
<td><strong>13,2</strong></td>
<td><strong>22,9</strong></td>
<td>Susceptible</td>
</tr>
<tr>
<td>D Nifor A</td>
<td>17,6</td>
<td>9</td>
<td>9</td>
<td>6</td>
<td>Intermediate resistant</td>
<td></td>
</tr>
<tr>
<td>D Nifor B</td>
<td>22</td>
<td>9</td>
<td>4</td>
<td>13</td>
<td>16</td>
<td>Intermediate resistant</td>
</tr>
<tr>
<td>D Socfin A</td>
<td>16,7</td>
<td>2,1</td>
<td>0</td>
<td>12,5</td>
<td>13,4</td>
<td>Resistant</td>
</tr>
<tr>
<td>D Socfin B</td>
<td>6,2</td>
<td>14,6</td>
<td>15</td>
<td>Intermediate resistant</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Partial resistance to *Ganoderma* is intermediate: one can not expect (yet) to have “zero” disease.

- Resistant x Resistant genitors → Resistant progeny (2,1%)
- Susceptible x Susceptible genitors → Susceptible progeny (22,9%)
- Susceptible x Resistant genitors → intermediate progeny (8,3% - 13,4%)
First solution to Bud rot (PC) : Interspecific Hybrids (7)

Crosses between two different species : *E. oleifera* and *E guineensis*

- First planted in the 60’s but real development took place in the 70’s (research) and 80’s (commercial)

IRHO then Cirad/Palmelit has been a pioneer for breeding and our partners Haimé Group and Hacienda la Cabaña pioneer for cultivation
First solution to Bud rot (PC)  
Interspecific Hybrids (7)

• Important to find the good combination between origins (**oleifera** as well as **guineensis**):

  – **Oleifera**: Amazonian basin and Guyana are the best oleifera' s (other from central america (costa rica Nicaragua, panama …). Among them **Coari, Manicoré and “Mangenot”** are by far the best. Guyana is very promissing.

  – **Guineensis**: **la Mé** is the best origin to be combined with oleifera ; some **specific Yangambi** are (not all)
First solution to Bud rot (PC) : Interspecific Hybrids (7)

• Yield of Interspecific Hybrids is year after year improved... (Quantitative improvement !)

→ OER : 18 % in the 1980’s 23-24 % today ; it will be soon > 27 % ! Because of oleifera and guineensis

→ Incremental innovation (Again difficult to taste...)

<table>
<thead>
<tr>
<th>ORIGIN</th>
<th>E. oleifera</th>
<th>E. guineensis</th>
<th>OER</th>
</tr>
</thead>
<tbody>
<tr>
<td>MANGENOT</td>
<td>LM 2 T self II</td>
<td>24,3%</td>
<td></td>
</tr>
<tr>
<td>MANICORE</td>
<td>LM 2 T self II</td>
<td>24,8%</td>
<td></td>
</tr>
<tr>
<td>MANGENOT</td>
<td>LM 2 T self II</td>
<td>25,2%</td>
<td></td>
</tr>
<tr>
<td>MANGENOT</td>
<td>LM 2 T self II</td>
<td>25,6%</td>
<td></td>
</tr>
<tr>
<td>MANICORE</td>
<td>LM 2 T self II</td>
<td>25,8%</td>
<td></td>
</tr>
<tr>
<td>MANICORE</td>
<td>LM 2 T self II</td>
<td>26,4%</td>
<td></td>
</tr>
<tr>
<td>MANICORE</td>
<td>LM 2 T self II</td>
<td>26,7%</td>
<td></td>
</tr>
<tr>
<td>MANGENOT</td>
<td>LM 2 T self II</td>
<td>27,0%</td>
<td></td>
</tr>
<tr>
<td>MANICORE</td>
<td>LM 2 T self II</td>
<td>27,1%</td>
<td></td>
</tr>
<tr>
<td>MANICORE</td>
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<td></td>
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Other solution for bud rot (PC) (8)  
Pure *E. guineensis*

- Field evidences  
  Commercial, plt 1980’s  
- To confirm and improve  
  Results: Danec & PalmElit in 2000’s
Other solution for bud rot (PC) (8)

Pure *E. guineensis*

Evaluation in many places:
- Oriente : Ecuador
- San Lorenzo : Ecuador
- Tumaco : Colombia
- Magdalena medio : Colombia
- Rio Maniti : Peru
- Belem : Brazil
- Uraba : Colombia

To improve the best material:
Challenge : to move from from 50% to 25% infection

Palmelit/Cirad & Groupo Danec & La Cabaña

→ Incremental innovation

→ Already a security for some location
Clonal propagation (9)

Idea:

Within a cross some excellent palm does exist.
Clonal propagation (9)

Sampling → Callogogenesis → Suspension in liquid media

→ Transfer to nursery → Root formation → Germination

Achieved by a few teams in the late 1970’s (Unilever, IRHO/Cirad) improved in 1990’s (liquid suspension by Cirad)
Clonal propagation (9)

Problem of quality (a few % of sterile palms, but unevenly spread)

• Discovery of the « Def » gene in oil palm (Cirad end of 1990’s)
• Understanding of “def” gene behavior (MPOB, 2010’s)

→ This new knowledge will, very likely, lead to a better quality control of clones

→ breakthrough innovation
Clonal propagation (9)
Results

Idea: to clone palms from an outstanding cross (above average seed value) (Namely PO3174D x PO4747P)

• FFB: 30.6 tonnes / ha (industrial)
• OER: 27.5 % (industrial, 32.2 % in the lab)
• Oil yield: 8.7 tonnes / ha

The cross is 5 % above seed value. How much can we get from the best clones?

Two trials were planted:
• One in Guatemala (Hame group) (11 clones)
• One in Ecuador (Danec group) (20 clones)
Clonal propagation (9)

Results

Trial HAGP1 (Guatemala)
Oil Production of best clone

- FFB = 46.3 t/ha
- EOR = 29.2%

Increase of +19%
Perception of yield is difficult

• Yield in young age is poorly connected to adult age yield.
• Appearances at one moment are not a prediction of the future.

Example: size of the bunches and “nice looking palms”.
Yield perception:
Small or big bunches

Many

Small bunches

Few

Big bunches
(nice looking)

Big crop

Low crop
Yield perception: 1934 Beirnaert (Congo)

<table>
<thead>
<tr>
<th>Nombre de régimes</th>
<th>Production en Kgs régl.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Kgs 50</td>
</tr>
<tr>
<td>1-2</td>
<td>44</td>
</tr>
<tr>
<td>3 - 4</td>
<td>177</td>
</tr>
<tr>
<td>5 - 6</td>
<td>147</td>
</tr>
<tr>
<td>7 - 8</td>
<td>72</td>
</tr>
<tr>
<td>9 - 10</td>
<td>39</td>
</tr>
<tr>
<td>11 - 12</td>
<td>15</td>
</tr>
<tr>
<td>13-14</td>
<td>3</td>
</tr>
<tr>
<td>15 - 16</td>
<td>10</td>
</tr>
<tr>
<td>17 - 18</td>
<td>2</td>
</tr>
<tr>
<td>19 - 20</td>
<td>1</td>
</tr>
</tbody>
</table>

Moyenne de rég. par classe de production: 5, 8, 10, 13

Higher yield if more bunches

1934... Bunch number
Yield perception: 2000’s Cirad

Indonesia: Trial ALGP 29
FFB yield 6 to 9 year:

Big Bunches

Progeny (cross) nb & name

High
FFB Yield

Low bunch number

+ 50 %

 Nb 19 & 8 high bunch number

FFB Yied

Low bunch number

N 19 & 8
Small bunches

Low crop

Nb 24 & 16
Big bunches

High crop

Yield perception: 2000’s Cirad
Yield perception: 2000’s Cirad

Average bunch weight and FFB yield (Adult age : N7 to N10)
Futur innovation

For sure: incremental innovation will continue!
  • for Yield
  • for resistance to diseases

New technology are available
  • Sequence of oil palm Genome (MPOB, Cirad, other..)
  • Gene Identification (Sh by Mpop, Def by cirad, LL by Cirad, virescent by Mpop, …)

  • Genetic transformation: **Crispr** (*Clustered Regularly Interspaced Palindromic Repeats*) using Cas9 protein.
Future innovation

One will be able to take advantage of individual gene. But do not expect it will be easy: they are 15,000 and interactions are numerous... field testing will be a key.
Conclusion

➢ Relationship between planters and seed producers are based on long term trust: this trust is a treasure that can be squandered.

➢ Researchers have to explain their work

➢ Planters should be demanding much more.
Gracias