The expected and observed characteristics of several oil palm (*Elaeis guineensis* Jacq) clones

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Abstract:

Ortets were selected from excellent progenies studied at the La Mé and Aek Kwasan research stations. The clones obtained from these ortets were evaluated in direct or indirect comparative trials with their original cross and with sexual crosses from new breeding cycles. The observations made so far show that the clones present the same characteristics as the ortets in terms of mesocarp/fruit, oil/mesocarp and, to a lesser extent, fruit/bunch. The production of FFB at a young age was not as good as that of the ortets : that can be due to low heritability. However, given the low selection pressure and limited heritability, FFB yield seems to be similar for clones and the original crosses. The clones' level of production seems to improve after 6 years. Nevertheless, some clones had exceptional production characteristics.
Are these clones really the exact replica of the original ortets? The observations showed that the trees were apparently normal and presented no visibly discernable "mantled" or vegetative anomalies. However, it is possible that there were epigenetic modifications as a result of the process of *in vitro* culture, which could have affected other parts of the genome. An example is given for one clone in which the recloning of two individuals produced two theoretically identical groups of palms: there bunches had significantly different characteristics, such as average weight and percentage of fruit on the bunch. In general, the low production of bunch and the percentage of fruit on the bunch (although relative), could be due to "silent" epigenetic anomalies. The method and the strategy of cloning are also questionable.

Key words: *Elaeis guineensis*, clones, anomaly, ortet, genetic progress

INTRODUCTION

The development of *in vitro* culture techniques (Smith and Jones, 1970; Rabéchault *et al*., 1970) enabling vegetative propagation of the oil palm (*Elaeis guineensis* Jacq.) has been a technological advance in the improvement of the species. Indeed, as it is a cross-fertilizing plant with a long development cycle, substantial heterogeneity always exists in commercial planting material, which can be taken advantage of by vegetatively propagating the best palms of good crosses.

Clonal material obtained from such palms is considered to give more uniform plantations with higher yields (Noiret, 1981). The potential value of the progress achieved has been estimated, depending on the authors, at 30 p.100 by Hardon *et al.* (1982), 12 p.100 by Soh (1986) and 13 p.100 by Soh *et al*. (1988). For their part, Noiret *et al.* (1985) and Meunier *et al.* (1988) estimated the progress made by the best clones to be at least 20-25 p.100 and 30 p.100, highlighting the problems raised by the choice of candidates for cloning, given that the traits on which palm selection is based are strongly influenced by the environment, even though some techniques, such as smoothing, make it possible to reduce the effects (Baudouin *et al*., 1987).

Starting in 1983 in Ivory Coast, and 1985 in Malaysia and Indonesia (Durand-Gasselin *et al*., 1990), comparative field trials were set up with clones obtained by the procedure developed by ORSTOM/CIRAD in the 70s and 80s. The Unilever company itself planted its first clonal trial in 1977 and 22 trials were in place by the end of 1981(Corley, 1981). The first results reported were encouraging: uniformity of the palms planted (Corley *et al*., 1977; Duval *et al*., 1988), clonal planting material that was more homogeneous than crosses (Choo *et al*., 1981; Corley *et al.*, 1982; Durand-Gasselin *et al.*, 1990), immature palms producing more oil than palms grown from seeds marketed by CIRAD (Le Guen *et al*., 1991). However, in 1986, Corley *et al.* reported abnormalities in floral development, responsible for the existence of mantled fruits, and sterility in some clones, an observation that was confirmed by Durand-Gasselin *et al*. (1995), who pointed out that the frequency and severity of the abnormality varied from one clone to the next.

For the performance of mature clonal palms, the results obtained by Donough *et al.* (1995), Cochard *et al.* (1999) and Soh *et al*. (2001) showed that it is difficult to select ortets for their oil yield, due to the low heritability of the extraction rate, linked to the heritability of the fruit/bunch and oil/pulp components. Moreover, the existence of genotype x environment interactions considerably jeopardize the chances of identifying exceptional clones in clonal trials (Corley *et al*., 1995; Soh *et al*., 1995).

This paper sets out to present the production results for clones planted at Aek Loba Timur (North Sumatra – Indonesia) and at La Mé (Ivory Coast). The comparative performance of the ortets, original crosses and clones will be described and discussed in relation to the expected results and to the conditions under which the ortets were chosen. Lastly, the factors responsible for the observed results will be examined, as will ways of improving the ortet selection method.

MATERIAL AND METHODS

1. The experimental sites

The trials examined in this paper are located at two different sites:

- the La Mé Station (CNRA La Mé) in Ivory Coast, where the clonal trials are planted on tertiary sand or peat soils in a climate with a water deficit amounting to around 300 mm/year,
- the Aek Loba Timur station in Indonesia (SOCFINDO, North Sumatra), which benefits from a very suitable climate (deep loamy sand, low water deficit and good sunlight).

2. The trials

Ortet-clone comparisons are being made through two sets of trials:

- 12 trials planted at the La Mé plantation (CNRA La Mé), in Ivory Coast,
- 1 trial planted at the Aek Loba estate (SOCFINDO), in Indonesia.

All the trials are planted in statistical designs.

2.1 Trials in Ivory Coast

Twelve trials planted from 1985 to 1992 are being used to compare 12 clones with the cross from which they originally came, grown from seed (Table 1). Apart from clone LMC 133 (Deli x Yangambi), all these clones originated from Deli x La Mé crosses between parents from the first reciprocal recurrent selection cycle. They were obtained by the ORSTOM/CIRAD procedure used in the *in vitro* culture laboratory at the La Mé station (CNRA, Ivory Coast).

Table 1 Clone-Cross pairs studied in the trials in Ivory Coast

Clone	Original cross	Trial	Planting date	Design
LMC 20	DA 8 D x LM 2 T	LMGP78	06/1986	Fisher blocks, 6x4
LMC 22	DA 115 D x LM 2 T	LMGP111-116-117	5/91 ; 5/92 ; 5/92	Fisher blocks, 6x13;6x19;6x27
LMC 27	DA 8 D x LM 2 T	LMGP71	06/1985	Fisher blocks, 6x11
LMC 39	DA 17 D x LM 10 T	LMGP78	06/1986	Fisher blocks, 6x4
LMC 51	DA 8 D x LM 2 T	LMGP76-77	06/1986	Fisher blocks, 6x16 & 6x48
LMC 56	DA 10 D x LM 2 T	LMGP93	07/1988	Fisher blocks, 6x4 to 16
LMC 68	LM 404 D x LM 2 T	LMGP100	06/1989	Fisher blocks, 6x16
LMC 88	DA 28 D x LM 10 T	LMGP77	06/1986	Fisher blocks, 6x48
LMC 103	DA 118 D x LM 10 T	LMGP85	05/1987	Fisher blocks, 6x16
LMC 111	DA 28 D x LM 10 T	LMGP88	02/1988	Lattices, 5x5
LMC 133	DA 128 D x LM 239 T	LMGP108	05/1990	Fisher blocks, 6x24
LMC 163	LM 404 D x LM 2 T	LMGP100	06/1989	Fisher blocks, 6x16

2.2. Clonal trial at Aek Loba

23 clones were planted in 1995 in trial ALGP05 at the Aek Loba Timur estate. Those 23 clones were propagated from ortets selected from 13 Deli x La Mé crosses from the second reciprocal recurrent selection cycle assessed in six different trials of SOCFINDO's Aek

Kwasan experimental block (Table 2). The clones were produced by the ORSTOM/CIRAD procedure used in the SOCFINDO laboratory at Bangun Bandar (Indonesia).

Table 2 Trials and the original crosses of the ortets at Aek Kwasan propagated by cloning

Trial	Cross	Origin	Number of ortets
AKGP03	LM 3360 D X LM 1574 P	LM 404 D Self x LM 2 T Self	1
	LM 2345 D X LM 1571 P	DA 115 D Self x LM 2 T Self	1
AKGP06	LM 3466 D X LM 2246 P	(LM404D x DA10D) x LM 2 T Self	4
	LM 2935 D X LM 3943 T	(LM404D x DA10D) x LM 2 T Self	3
AKGP08	LM 3038 D X LM 1571 P	(DA 5 D x DA 3 D) x LM 2 T Self	1
	LM 3604 D X LM 2255 P	(DA 5 D x DA 3 D) x LM 2 T Self	1
	LM 3037 D X LM 2256 P	(DA 5 D x DA 3 D) x LM 2 T Self	1
AKGP11	LM 2750 D X LM 1595 P	(DA10D x DA3D) x LM2T Self	3
	LM 3258 D X LM 3943 T	LM 404 D Self x LM 2 T Self	3
	LM 2781 D X LM 2256 P	(DA10D x DA3D) x LM2T Self	2
AKGP12	LM 2509 D X LM 2255 P	DA 115 D Self x LM 2 T Self	1
	LM 2536 D X LM 2448 T	DA 115 D Self x LM 2 T Self	1
AKGP19	LM 1949 D X LM 2951 P	DA 5 D Self x LM 5 T Self	1

3. Traits measured

Oil production and its components have been studied in accordance with the principles described by Le Guen *et al*. (1991). We shall focus mainly on the following points:

- individual bunch weight recording as soon as the palms start bearing,
- bunch composition analysis on a sample of bearing palms in each treatment, multiplying the end result by 0.855 to approach the industrial extraction rate,
- calculation of oil yields based on 95% of bearing palms per hectare, i.e. 135 palms for an effective density of 143,
- exclusion of any palms with mantled fruits, irrespective of the degree of the abnormality.

4. Reminder of the cross and ortet selection method

The selected ortets from which the studied clones were produced were a sample of all the clones that had been chosen to make optimum use, by vegetative propagation, of part of the first cycle experimental block at La Mé (called "block 500") set up from 1959 to 1966, and of the second cycle experimental block at SOCFINDO's Aek Kwasan station, planted from 1975 to 1979 (Baudouin *et al*., 1994).

At both sites, the ortets were selected in two stages:

4.1 Selection of crosses

First of all, high-yielding crosses were selected, based on oil production/ha/year observed over a period (6-9 years or 7-10 years) that was representative of the long-term production of the oil palm.

Due to the absence of an experimental design in block 500 at the La Mé station, it was not possible to optimize selection, and it is not possible to effectively estimate the value of the selected crosses with regard to a common frame of reference.

The situation is different for the experimental block at Aek Kwasan, where it has been possible to identify the best crosses in each trial, and to connect the trials with each other through crosses that are common to the 16 trials in the experimental block. In order to compare materials from different trials, the value of the crosses has been estimated in relation to reference cross LM2T x DA10D. That estimation was carried out directly wherever the control existed in the trial. In the other cases, the estimation was made via crosses that are common to the different trials.

In comparison with that reference cross, table 3 (row a) gives the average value of the principal production components for the crosses from which the clones in trial ALGP05 were produced. For oil production per hectare at 6-9 years, the potential of those crosses is, on average, 15% better than the control, i.e. 10% better than the experimental block average at Aek Kwasan, which is representative of seed production potential at the time.

4.2 Selection of within-cross ortets

The second stage set out to identify the best *tenera* palms within the chosen crosses. That selection, which was based on bunch production and bunch quality data, was the trickiest, due to possible confusion, on a palm level, between environmental and genetic values. It was necessary to limit the role of the environment in individual data calculations. When estimating the extraction rate components, that was achieved by multiplying the analyses, which amounted, on average, to 6 at La Mé and more than 10 at Aek Kwasan, per ortet candidate. For bunch production, geostatistics (Baudouin et al, 1987) were used to smooth the fertility factor which, in some of the trials at Aek Kwasan, amounted alone to half the environmental effects. However, smoothing was only carried out in the most heterogeneous trials at Aek Kwasan. Lastly, the effects of competition between palms were taken into account: thus, only ortet candidates with 6 neighbours were chosen; field visits were made systematically to check that the ortet candidates were not benefiting from over-favourable environmental conditions; in the Aek Kwasan trials comparing materials with heterogeneous development, the choice went to the least dominant palms for equivalent yields (dominance was assessed by measuring the differences in height of the candidates compared to their neighbours).

At Aek Kwasan, within-cross selection pressure was low (between 20% and 40% depending on the crosses) in some second cycle crosses, where the average CV was estimated to be 0.2, and within-family heritabilities (H^2w) were between 0.05 and 0.2 (before smoothing). Under those conditions, in comparison with the crosses, the average progress expected for yield ($R\% = i*CV*H^2w$ according to Falconer's formula (1960), where i=1.4 and i=1 for 20% and 40% selection respectively) was only 1 to 6% depending on the crosses. After smoothing and after taking environmental effects into account, progress of around 8% was hoped for, through a substantial improvement in heritability (H^2w=0.3). Greater progress (>20%) was expected for 10% of the clones after evaluation in trials (Meunier et al, 1988).

At La Mé, within-cross selection pressure was largely the same, but it was exerted in more variable first cycle crosses, but the absence of an experimental design prevented any evaluation of H^2w values. No figure was put on the progress expected when compared to the crosses, but given the greater variance, it could have been slightly more than that obtained in the Aek Kwasan block, though the fact that environmental effects were not taken into account meant that, ultimately, it might be lower.

Table 3 (row b), for Aek Kwasan, and table 4 (row a), for block 500 at La Mé, show the average differences between the ortets and their original crosses. These values are raw phenotypic values without smoothing. For oil production at 6-9 years, they are an average of 12% higher at Aek Kwasan and 28% at La Mé, than the average value for their original crosses. The differences between the two sites tally with the fact that within-cross variance is lower for the second cycle material tested at Aek Kwasan than for the first cycle material tested at La Mé.

Table 3 (row c), also gives the average value of the ortets in comparison to cross LM2T x DA10D at Aek Kwasan. The average genetic value of the Aek Kwasan ortets, and therefore the expected value of the clones, lies between the average values of the crosses (+15% compared to the control) and the average phenotypic values (+28.5%).

5. Ortet-Clone comparison methods

The same sets of observations have been carried out on the ortets and clones in the trials. They focused on:

- bunch analyses (F/B%, M/F%, O/M%, and OER%),
- bunch production on immature palms (BN, ABW, FFB),
- bunch production on mature palms.

At Aek Loba, trial ALGP05 was studied from 3 to 9 years. The measurements carried out, and the observation periods, were the same as for the ortets in the trials of the Aek Kwasan block. The trial does not contain reference cross LM2T x DA10D. However, that cross is present in different trials of the Aek Loba Timur experimental block, and the existence of common treatments between ALGP05 and those trials means that all the clones in the trial can be compared to the reference cross. However, given the different planting dates, that basis of comparison can only be used, for the moment, for the 3-7 year period. The observations carried out at Aek Kwasan and Aek Loba make it possible to:

- study ortet-clone correlations and regression for observations over the 3-9 year period,
- estimate the value of the ortets and clones in comparison to the same frame of reference, cross LM 2 T x DA 10D, and use those estimations to compare the ortets and their clones for the 3-7 year period.

At La Mé, the measurements on immature palms (3-5 or 4-6 years) were only carried out on 8 clone-cross pairs. Observations on mature palms were carried out on 12 clone-cross pairs, but at different periods ranging, depending on the trials, from 6-9 years to 10-13 years. The absence of common observation periods and bridges between block 500 and the clonal trials means that ortet-clone regression cannot be studied. However, it is possible to compare ortets with clones by estimating their respective values compared to the original crosses.

RESULTS

1 Ortet/clone regression

This study was only carried out on the clones studied in trial ALGP05 at Aek Loba Timur.
For all the production components, for the 3-5 year and 6-9 year periods, table 5 gives the coefficients of correlation between, on the one hand, the values of the ortets in the Aek Kwasan trials and, on the other hand, the values of the clones in trial ALGP05. For the ortets, the different values have been corrected via the control cross, to take into account differences between the trials in the Aek Kwasan block. This table also indicates the broad sense heritability calculated by the ortet-clone regression. It should be noted that the between–ortet variations embrace both within-cross variations and between-cross variations.

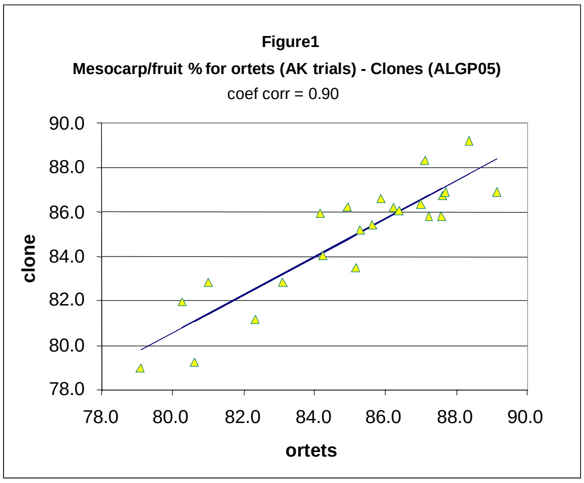
Table 5: Correlation between the ortets in the AKGP trials and the clones in trial ALGP05. Ortet/Clone coefficient of regression

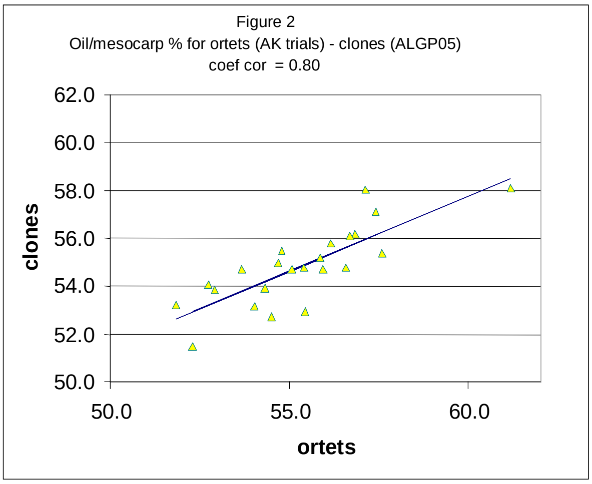
Trait	Ortet/clone correlation	h^2
F/B%	0.50*	0.51
M/F%	0.90**	0.84
O/M%	0.80**	0.63
OER%	0.53**	0.49
BN 3-5	ns	0.29
ABW 3-5	0.64**	0.81
FFB 3-5	0.52*	0.60
Oil 3-5	ns	0.34
BN 6-9	ns	0.00
ABW 6-9	ns (1)	0.36
FFB 6-9	ns (2)	0.10
Oil 6-9	ns	0.00

(1) 0.69** without trial AKGP12
(2) 0.68* on smoothed values (for 12 clones)

1.1 Bunch analyses.

The level of these correlations shows very clearly that by carrying out more than 10 bunch analyses per ortet candidate, it is possible to carry out quality selection based on the extraction rate components, particularly for the mesocarp/fruit percentage (figure 1) and the mesocarp oil content (figure 2). It is a little less true for the fruits/bunch percentage, as that trait is highly dependent upon environmental factors. However, even for that parameter, the correlations are significant, and a substantial improvement in the fruits/bunch percentage can be expected by selecting the best individuals for that parameter. It is indirectly likewise for the extraction rate.





The ortet-clone regressions go the same way as the correlations. In particular, they indicate high (broad sense) heritabilities for the mesocarp/fruit percentage and for the oil/mesocarp percentage.

1.2 Bunch production

The correlations are much lower for bunch production. Significant correlations are only found for the 3-5 year period (Table 5). Those correlations disappear for the 6-9 year period. This lack of correlation for the raw data is not surprising given the extent of the environmental and competition factors. By taking into account those factors, it is possible to substantially improve the ortet-clone correlations. For instance, in the trials were the palms were chosen after smoothing the bunch production data, there is a significant correlation of 0.68* with smoothed values (for 12 clones) for FFB 6-9 years. It should also be noted that the correlations for the average bunch weight at 6-9 years are highly significant (0.69**) if the data for trial AKGP12 are not taken into account, as that trial is characterized by very strong competition effects between materials with very different growth and bulk (Nouy et al, 1990).

The value of the production parameters is greatly influenced by the age and development of the palms. Over the immature and mature periods, the two sets of clone and ortet data can be out of phase. Under such conditions, regression barely accounts for ortet-clone relations. However, these regressions indicate that the average bunch weight is more heritable than the bunch number, and even more so for the immature data than the mature data.

2 Comparative clone-ortet values

2.1. Trial ALGP05

Table 3 (rows d, e and f) indicates the value of the clones in the trials, compared to the original cross and to the control, along with the number of clones better than the original cross. The need to compare the clones to the control means that the mature period is 6-7 years, rather than 6-9 years for the values of the ortets at Aek Kwasan.

For the extraction rate, compared to the original crosses, the clones display lower values for the fruit/bunch %, and slightly higher values for the mesocarp/fruit % and the oil/pulp %. Although the estimations are fairly imprecise, as shown by the slight superiority of the clones compared to the ortets for two parameters, the gains of the clones compared to the crosses tally with the regressions and therefore reflect a better choice for the most heritable traits.

For bunch weight. For immature palms, the clone values are well below those of the initial ortets. They are even well below the average value for the original cross. That inferiority is due both to the bunch number and the average bunch weight. Over the 6-7 year period, there is still no gain in production provided by the clones, but their production has almost reached that of the original crosses.

For oil production. On average, ortet selection has provided no progress, but it can be seen (Table 6) that 3 out of 23 clones have 10% better production than their original cross and that the best clone displays 15% progress compared to the original cross.

Table 6: Oil production at 6-7 years for the clones and their original cross

Clone	Oil production 6-7 years		
	Clone value Tonnes/ha/yr	**Cross value (1) Tonnes/ha/yr**	**% clone/cross**
SOC 1708 LM 3360 D X LM 1574 P	7.09	8.61	82.4
SOC 1806 LM 3038 D X LM 1571 P	8.47	8.40	100.1
SOC 2004 LM 3604 D X LM 2255 P	8.53	7.94	107.4
SOC 2106 LM 2345 D X LM 1571 P	7.86	7.87	99.9
SOC 2503 LM 3037 D X LM 2256 P	8.41	7.95	105.8
SOC 2704 LM 3466 D X LM 2246 P	8.46	7.83	108.0
SOC 2706 LM 3466 D X LM 2246 P	8.03	7.83	102.5
SOC 2708 LM 3466 D X LM 2246 P	9.07	7.83	**115.7**
SOC 2710 LM 3466 D X LM 2246 P	7.74	7.83	98.8
SOC 2803 LM 2935 D X LM 3943 T	7.68	8.23	93.3
SOC 2805 LM 2935 D X LM 3943 T	7.34	8.23	89.1
SOC 2807 LM 2935 D X LM 3943 T	9.17	8.23	**111.4**
SOC 2901 LM 2750 D X LM 1595 P	8.51	8.47	100.4
SOC 2910 LM 2750 D X LM 1595 P	7.05	8.47	83.3
SOC 2919 LM 2750 D X LM 1595 P	7.62	8.47	90.0
SOC 3001 LM 3258 D X LM 3943 T	7.95	8.18	97.2
SOC 3003 LM 3258 D X LM 3943 T	8.19	8.18	100.1
SOC 3004 LM 3258 D X LM 3943 T	8.21	8.18	100.4
SOC 3201 LM 2781 D X LM 2256 P	7.82	7.67	101.9
SOC 3202 LM 2781 D X LM 2256 P	8.32	7.67	108.4
SOC 3406 LM 1949 D X LM 2951 P	7.12	8.68	82.0
SOC 3703 LM 2509 D X LM 2255 P	8.72	7.92	**110.1**
SOC 3801 LM 2536 D X LM 2448 T	8.47	8.25	102.8
Average	8.08	8.13	99.6
Estimation % SC	7.06		

(1) estimation via the control, LM2T x DA10D

2.2 Clonal trials at La Mé

Table 4 (row b) gives the clone values compared to the original crosses studied in the same trials.

For the extraction rate, contrary to what can be seen in trial ALGP05, on average there is no progress for the extraction rate, whereas the "added value" of the ortets compared to the cross was relatively larger (+13%). The only (and slight) improvement is provided by the M/F%, but it is counterbalanced by the drop in F/B%.

For bunch production. There is very weak progress for the clones compared to the original crosses for FFB, but the potential of the clones is well below the phenotypic value of the ortets. Unlike ALGP05, the relative values of the clones compared to the crosses are largely the same in immature and mature palms. The change in the FFB components is surprising, with young clones bearing a smaller number of bunches and larger bunches than the crosses grown from seed, with the opposite occurring for mature clones.

For oil production. On average, ortet selection has only provided very slight progress (2%), but, as shown in table 7, 3 out of 11 clones have 10% higher production than their original cross and one exceptional clone, LMC111, exceeds its original cross by 40%, through progress that is equally distributed over bunch production and the extraction rate.

Table 7 Mature oil production for clones and their original cross

Clone	Mature oil production		
	Clone value Tonnes/ha/yr	Cross value Tonnes/ha/yr	% clone/cross
LMC 20 : DA 17 D x LM 10 T	3.88	3.54	109.7
LMC 22 : DA 115 D x LM 2 T	2.57	2.36	**111.6**
LMC 39 : DA 17 D x LM 10 T	3.87	3.54	109.3
LMC 51 : DA 8 D x LM 2 T	3.51	4.22	83.9
LMC 56 : DA 10 D x LM 2 T	3.14	3.64	86.3
LMC 68 : LM 404 D x LM 2 T	3.31	3.82	86.6
LMC 88 : DA 28 D x LM 10 T	3.71	3.56	104.2
LMC 103 : DA 18 D x LM 10 T	3.18	4.07	78.1
LMC 111 : DA 28 D x LM 10 T	5.54	3.91	**141.7**
LMC 133 : DA 28 D x LM 239 T	3.93	3.08	**127.6**
LMC 163 : LM 404 D x LM 2 T	3.16	3.82	82.7

DISCUSSION

In two different contexts, the oil production of mature clones appears, on average, to differ little from that of the crosses from which they came. These results, which might seem surprising given the quality of the ortet-clone correlations for several parameters, are nonetheless compatible with the low estimated within-family heritability (before smoothing), and especially with the low selection pressure exerted within the crosses. Remember that with heritability values between 0.05 and 0.2, CV values of 20% and low selection pressure between 20 to 30%, the expected gains are between 1 and 6% (Meunier et al, 1988). Such small differences might not be detected with conventional experimental designs, where treatments are evaluated on average with a precision of 7 to 12%. That is even more the case with a trial such as ALGP05, where comparisons are made indirectly via common crosses and a common control.

The frequency with which high-yielding clones are observed (3 out of 23 at Aek Loba and 3 out of 11 at La Mé are more than 10% better than their cross) is slightly under the expected frequency (around 30%) for a heritability of 0.2 and 20% selection pressure. These figures are almost equivalent to those observed by Soh *et al*. (2001) in trials BCT4-89 and BCT9-91 planted by AAR (2 out of 12 clones and 3 out of 10 clones respectively). The very high value for clone LMC111 compared to its cross is more surprising and is no doubt located at the limit of the gains that can be expected, even from a cross with high variability.

However, these results indicate that the methodology adopted for improving the appraisal of candidates (multiplication of analyses, data smoothing) has not led to any substantial improvement in heritability (a H^2w of 0.3 was hoped for), or consequently in the average quality of the clones (R of 8% hoped for). These results tally with those reported by Soh *et al.* (2001) who showed that, for oil production, environmental effects mask the genetic differences between individuals, making phenotypic selection inefficient.

In addition, the results for the clones in trial ALGP05 raise another problem in that the best clones produce less than the best crosses assessed in nearby trials connected to the same genetic block at Aek Loba Timur. In fact, like the Aek Kwasan block, the Aek Loba Timur block is testing crosses from the second reciprocal recurrent selection cycle, but over a wider genetic base than the Aek Kwasan block. It is difficult to imagine that this additional selection of second cycle parents has provided greater progress than the best clones derived from the best crosses in the Aek Kwasan block. We believe that the insufficient clone results can be explained by the selection of too large a number of crosses of insufficient value. That low family selection would have led to limited progress.

In terms of clonal strategy, these results suggest that:

- selection must first and foremost be based on the choice of elite crosses, whose exceptional value has been proved in trials,
- within-family selection is not very appropriate, particularly in crosses with low variance, such as the second cycle crosses. For this type of material, we can, as recommended by Soh (1986), clone virtually all the palms of the best progenies, whilst eliminating obviously mediocre palms, or reproduce the average of the cross by cloning embryos,
- it is possible to create clones with a greater potential than the original cross. The progress is at least 10-15% for uniform crosses (where either one or both parents are derived from selfs). It can be over 20% in crosses between more heterozygous parents. In all cases, the identification of high-yielding clones requires an evaluation phase in trials. As recommended by Soh *et al.* (2003), the efficiency of selection within the highest yielding families will be improved by working on large numbers of individuals.

However, a few observations carried out in trial ALGP05 raise some questions:

- How can the low bunch production levels seen for immature palms, be it for the bunch number or the average bunch weight, be explained? Why do production levels catch up in mature palms?

- Observations of male inflorescence production in the Aek Loba trials showed that the clones were far more feminine in the early years than the material grown from seed (Jacquemard, personal communication).

Is clone performance related to the abnormalities induced by *in vitro* culture? It was checked in trial ALGP05 that there is no relation between the frequency of the mantled abnormality of a clone and its bunch production level (calculated on abnormality-free palms), and in production trends between immature and mature palms. However, that absence of a direct relation with the mantled abnormality does not mean the absence of any other abnormalities that might affect floral biology and would be less visible than changes affecting the development of the stamens and staminodes of male and female flowers. For instance, is it possible that epigenetic abnormalities also affect the sex ratio and inflorescence size and that, like the mantled abnormality, their incidence decreases over time?

A few observations carried out in the Aek Loba experimental block are, in that respect, worrying. One clone, BC 68, was created in the IRD laboratories in Bondy from a nursery plant of DA115D self x LM2T self origin. Two ramets of that clone BC 68 were thus recloned by SOCFINDO's Bangun Bandar laboratory. The new clones, BC68-1 and BC68-2, were planted side by side in the same plot at Aek Loba Timur. Molecular analyses have confirmed that those two clones have the same genotype. Observations (Table 8) of bunch analyses show that those clones have identical values for the extraction rate components, but there are some significant differences between the clones from the recloning, notably for average bunch weight, average fruit weight, and average kernel weight. Those clones were planted without a statistical design, but no fertility gradient has been noticed, or the existence of any other sources of heterogeneity that might be responsible for the differences. Are the differences due to "discreet" variations that cannot be detected in clonal trials with the evaluation methods traditionally used?

Table 8 Comparison of bunch analyses for two clones derived from the recloning of 2 ortets of clone BC68

Variable	BDC681	BDC682	F	p(F)
Average bunch weight (kg)	14.1	12.8	20.973***	0.0001
Average fruit weight (g)	6.248	6.691	11.624***	0.0025
Average kernel weight (g)	0.729	0.591	19.815***	0.0002
Fruits / Bunch %	65.57	66.10	0.994^{ns}	0.3295
Mesocarp / fruit %	77.79	77.84	0.036^{ns}	0.8508
Oil / mesocarp %	54.57	54.25	2.595^{ns}	0.1250
CPO %	23.813	23.897	0.127^{ns}	0.7250
Kernel %	5.068	5.058	0.015^{ns}	0.9045

CONCLUSION

These results show that cloning can lead to a notable improvement in production, but as knowledge stands at the moment, it is still difficult to define a veritable cloning strategy.

More generally, it is regrettable that it is still impossible to:

- clearly establish that clones without the mantled abnormality reproduce, on average, exactly the agronomic value of the crosses produced by seed from which they came,
- put a precise figure on the progress that cloning can provide. For instance, we do not have any estimation of within-family variance, parameter by parameter, for the different types of crosses that are being tested in recurrent reciprocal selection programmes, or in pedigree selection programmes, be they:
    - crosses between two parents derived from selfing,
    - or crosses between two parents derived from a recombination.

These answers might be provided by methodological trials comparing crosses and sets of clones that ought to be set up as quickly as possible. In order to assess within-family genetic variance, it will be necessary to clone at least 40 genotypes per cross. In addition, in order to compare the average value of the clones with the value of the cross from which they came, with sufficient precision of 2 to 4%, at least 700 palms will have to be planted. As far as possible, several planting sites representative of different environments should be envisaged, as genotype x environment interactions exist (Corley *et al*., 1995; Soh *et al*., 1995; Soh *et al*., 2001).

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Table 3

Difference compared to the control (as % of the control) for ortets and clones in ALGP5
23 clones derived from 13 crosses studied in 6 different trials

				F/B %	M/F %	O/M %	**OER**	BNi	ABWi	**FFBi**	**Oili**	BNm	ABWm	**FFBm**	**Oilm**
Trials AK (1)	a	Crosses	as a % of control	6.1	7.5	3.4	**17.9**	5.7	-2.9	**2.8**	**21.0**	-0.5	-0.3	**-2.3**	**15.1**
	b	Ortets	as a % of crosses	4.8	-0.3	0.7	**5.8**	1.6	0.2	**1.6**	**7.3**	5.0	0.1	**5.9**	**11.8**
	c	Ortets	as a % of control	11.2	7.2	4.1	**24.7**	7.6	-2.6	**4.4**	**29.8**	4.4	-0.1	**3.2**	**28.5**
ALGP05 (2)	d	Clones	as a % of crosses	-2.4	1.9	3.6	**2.4**	-11.8	-5.2	**-16.6**	**-14.9**	1.4	-4.0	**-1.6**	**-0.4**
	e	Nb clones > Cross		3/23	16/23	20/23	18/23	2/23	8/23	2/23	1/23	12/23	8/23	10/23	14/23
	f	Clones	as a % of control	3.6	9.5	7.0	**20.7**	-6.9	-7.8	**-14.0**	**3.2**	0.4	-4.5	**-4.1**	**14.4**

(1) estimation %SC via common crosses, immature period 3-5 years or 4-7 years; mature period 6-9 or 7-10 years
(2) estimation %SC via common crosses, immature period 3-5 years; mature period 6-7 years

Table 4

Difference compared to the crosses (as a % compared to the cross) in the La Mé trials

			F/B %	M/F %	O/M %	**OER**	BNi	ABWi	**FFBi**	**Oili**	BNm	ABWm	**FFBm**	**Oilm**
Block 500	a	Ortets as a % of crosses	2.2	4.2	6.4	**13.0**	na	na	**na**	**na**	1.7	7.2	**13.1**	**28.0**
Clonal trials	b	Clones as a % of crosses	-2.1	1.5	0.3	**-0.3**	-7.3	12.4	**3.7**	**2.8**	7.7	-3.8	**1.0**	**2.0**
	c	Nb clones > Cross	4/12	8/12	6/11	**4/11**	2/8	4/8	6/8	4/8	7/12	5/12	4/12	6/11