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Agronomical Performances of Angolan Natural Oil Palm Accessions and Interests for Oil Palm Selection in Côte d'Ivoire

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Abstract

In Côte d'Ivoire, Deli populations, descendants of four oil palms, constituted Group A of the recurrent reciprocal selection. Their genetic base was narrow, an obstacle to long-term genetic progress. Therefore, Angolan oil palm accessions were acquired to broaden Group A's genetic base. Angola selfed and Deli × Angola progenies were tested via Angola selfed × La Mé and (Deli × Angola) × La Mé intergroup hybrids for bunch and oil production, height growth, and tolerance to *Fusarium* in two progeny trials; one in La Mé (Côte d'Ivoire) and the other one in Bangun Bandar (Indonesia). On average, bunch yield (183 kg/palm/year) and oil yield (5.34 t/ha) were close to those of the control. The best 5 hybrids represented 104-112% of the control all traits put together. In addition, Angolan origin has transmitted tolerance to *Fusarium* to its progenies (*Fusarium* index = 80-90). [(Deli × Angola)'s LM 5448 T] × La Mé hybrids yielded 241.4 kg/palm/year of bunch and 7.30 t/ha of palm oil. Their mean height was comparable to that of the control and the *Fusarium* index low (82). Therefore, LM 5448 T was selected for further crop improvements. The modalities of its use were proposed.

Keywords: bunch production, genetic evaluation, genetic resources, oil palm, oil yield, Côte d'Ivoire

1. Introduction

Plant genetic resources, including those of oil palm, are a vital component of plant breeding without which plant improvement is impossible (Acquaah, 2007). At the oil palm research station of La Mé (Côte d'Ivoire), the improvement of productivity and other agronomic characteristics of oil palm uses the recurrent reciprocal selection scheme (RRS) (Meunier & Gascon, 1972). RRS exploits the complementarity of two groups A and B of oil palms: group A made up of oil palm populations with a small number of large bunches and group B of oil palm populations with a large number of small bunches.

Group B assembles a considerable number of palms from different African origins including La Mé (Côte d'Ivoire), Pobè (Benin), Lobé and Widikum (Cameroon), Yangambi (DR Congo), Sibiti (Congo), Calabar and Cowan (Nigeria) to name but a few. Group A is solely comprised of Deli provenance. It consists of *dura* type palms descended from four *dura* oil palms introduced into the Botanical Garden of Bogor (Indonesia) in 1848 (Hartley, 1977). The Deli *dura* used in oil palm breeding at La Mé are descendants of the third and fourth generations of selection.. The resulting populations are considered to have a narrow genetic base (Rosenquist, 1990). In fact, the frequency of genes related to traits of interest to the industry (bunch production) has been increased to the detriment of that of traits not directly related to production. However, the long-term effectiveness of a genetic improvement programme depends on the wide variability of available genetic resources (Gallais, 1990). Therefore, introductions of oil palm materials from new sources, including accessions from sub-spontaneous palm groves, are undertaken before each new selection cycle (Adon et al., 1993, Adon et al., 1998, Bakoume et al., 2001). It is in this context that Angolan natural oil palm accessions from the localities of Salazar and Novo Redondo Nhime were introduced in the Oil Palm Research Station of La Mé (Côte d'Ivoire) in 1971. A first stage of evaluation of the said palms was carried out by crossing them with genitors from Deli

(Asia), La Mé (Côte d'Ivoire), Yangambi (Democratic Republic of Congo) and by crossing them with each other as well. In the latter case, Angola × Angola populations were created (Adon, 1995, Adon et al., 1998). The first evaluation led to selecting Angolan genitors. Unfortunately, their mean total fresh bunch weight, average bunch weight, fruit to bunch ratio, and mesocarp to fruit ratio did not allow them to be directly introduced into the general oil palm improvement scheme despite their good tolerance to Fusarium wilt.

The present study that corresponds to the second stage of evaluation of Angola's oil palm materials, seeks to improve the frequency and the stability of characters of agronomic interest through selfing of candidate Angola genitors and combinations with well renowned Deli Dabou *dura*. Progeny trials were planted at La Mé (Côte d'Ivoire) in 1985 and Bangun Bandar (Indonesia) in 1986. The aim was to select Angola or Angola × Deli genitors with good general combining ability for bunch production, oil production, low height growth, and tolerance to *Fusarium oxysporum elaeidis*. In fact, the economic life of an oil palm plantation depends on the height growth rate. Slow growing oil palms have a long economic life. *Fusarium oxysporum elaeidis* is a causal agent of a fungal disease of the same name *Fusarium* which is endemic to African palm groves. Selected genotypes will be integrated into Group A to enrich it and increase its genetic variability.

2. Materials and Methods

2.1 Planting Material

Progenies evaluated were hybrids resulting from crosses between Deli × Angola or Angola selfed (Group A) and La Mé selfed and La Mé × La Mé partners (Group B). A total of 17 genitors of Deli × Angola or Angola selfed origin and 2 Deli *dura* (LM 5489 D, LM 5885 D) genitors (forming group A) were tested with 13 partners from La Mé selfs and 8 La Mé × La Mé intra-origin crosses within Group B. The ancestries of La Mé genitors and Angola-derived parents are shown in Figures 1 and 2.

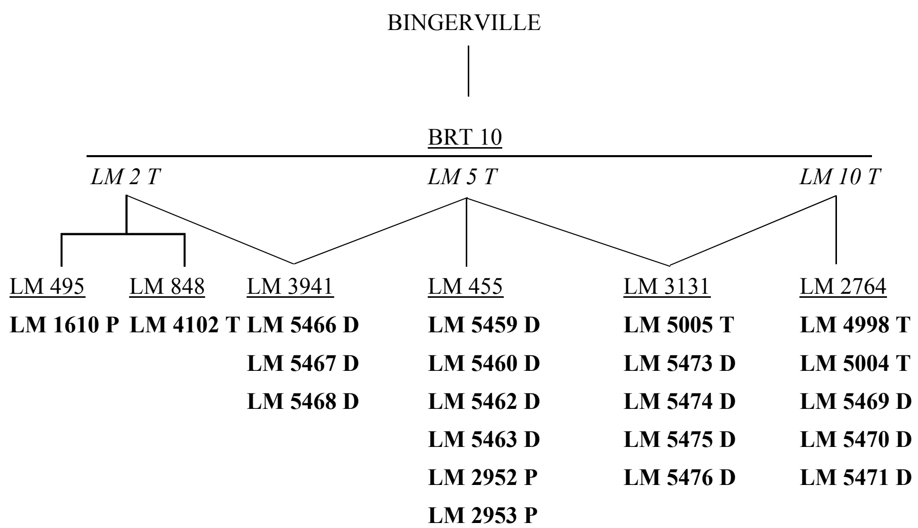

Figure 1. Genealogy of La Mé genitors

Note. Progenies are underlined. Genitors of first selection cycle are in italics. Genitors of the second cycle of selection tested are in bold.

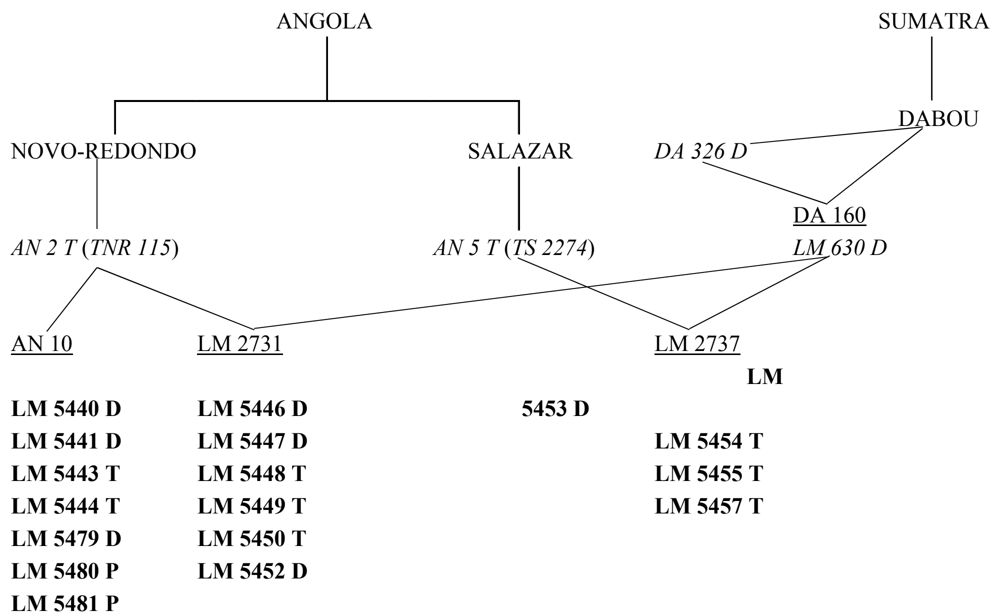

Figure 2. Ancestry of Angola-derived genitors of the second cycle of selection

Note. Progenies are underlined. Genitors of first selection cycle are in italics. Genitors of the second cycle of selection tested are in bold.

A total of 35 progenies were field tested in La Mé (24 progenies) and Bangun Bandar (12 progenies). Four progenies were common to the two trials notably the control (LM 2 T × DA 10 D) and progenies LM 11720, LM 12231, and LM 12281 derived from Angola × La Mé or (Angola × Deli) × La Mé crosses. The control cross (LM 2 T × DA 10 D)-derived progeny was labelled LM 11380 and LM 12649 in the La Mé trial and Bangun Bandar trial, respectively. In fact, the progeny from LM 2 T × DA 10 D cross was one of the best progenies of the first selection cycle. The second selection cycle used it as a control) (Table 1). The four common progenies subsequently served as a bridge (or link) between the two trials. The La Mé (Côte d'Ivoire) trial was laid in 1985 whereas the Bangun Bandar (Indonesia) progeny trial was established in 1986. La Mé oil palm research station is located in the retreat of the Gulf of Guinea, at 5°26′ N latitude and 3°50′ west longitude (Quencez, 1996). It is within an ombrophilic sector and benefits from a transitional tropical climate. The rainfall is abundant, very unevenly distributed throughout the year, and in decreasing trend with an average of 1740 mm/year (Quencez, 1996). The average annual water deficit is about 350 mm. The soil was formed on ferrallitic tertiary sediments and was considered poor in organic matter (Ollagnier et al., 1978). The average sunshine is 1,800 h/year. The Bangun Bandar oil palm research station is situated on volcanic soil (Tampubolo et al., 1990). Rainfall is abundant and well distributed throughout the year. Hence, there is no water deficit and the palm trees benefit from a shallow water table. Sunshine is more than 2,000 h/year. The experimental design was a Fisher block with 6 replicates and 12 palm trees per elementary plot, *i.e.*, 72 trees per progeny. The planting density was 143 palm trees per hectare.

Table 1. Crosses of provenance of hybrid progenies tested in trials LM GP56 and BB GT25

Progeny	Cross type	Progeny serial number in the trial
Trial LM GP 56		
Control: La Mé × Deli		
LM 11380	LM 2 T × DA 10 D	1
(Deli × Angola Novo-Redondo) × La Mé		
(LM 630 D × TNR 115) × La Mé		
LM 11622	LM 5447 D × LM 5005 T	2
LM 11413	LM 5460 D × LM 5449 T	3
LM 11407	LM 5468 D × LM 5449 T	4
LM 11603	LM 5470 D × LM 5450 T	5
LM 11772	LM 5446 D × LM 4102 T	6
(Deli × Angola Salazar) × La Mé		
(LM 630 D × TS 2274) × La Mé		
LM 12231	LM 5453 D × LM 4998 T	7
LM 11503	LM 5462 D × LM 5455 T	8
LM 11725	LM 5471 D × LM 5455 T	9
LM 11720	LM 5457 T × LM 5459 D	10
Angola Novo-Redondo selfed × La Mé		
TNR 115 selfed × La Mé		
LM 11839	LM 5440 D × LM 2953 P	11
LM 11353	LM 5441 D × LM 1610 P	12
LM 11821	LM 5441D × LM 2952 P	13
LM 11494	LM 5441 D × LM 5004 T	14
LM 12281	LM 5443 T × LM 5467 D	15
LM 11856	LM 5443 T × LM 5475 D	16
LM 11964	LM 5463 D × LM 5444 T	17
LM 11749	LM 5444 T × LM 5466 D	18
LM 11319	LM 5473 D × LM 5444 T	19
LM 11548	LM 5470 D × LM 5479 D	20
LM 11225	LM 5474 D × LM 5479 D	21
LM 11623	LM 5471 D × LM 5480 P	22
LM 11442	LM 5476 D × LM 5480 P	23
LM 11633	LM 5469 D × LM 5481 P	24
Trial BB GT25		
Control: La Mé × Deli		
LM 12649	LM 2 T × DA 10 D	1
(Deli × Angola Novo-Redondo) × La Mé		
(LM 630 D × TNR 115) × La Mé		
LM 12283	LM 5448 T × LM 5463 D	2
LM 12273	LM 5467 D × LM 5448 T	3
LM 12293	LM 5476 D × LM 5448 T	4
LM 12433	LM 5452 D × LM 5335 P	5
(Deli × Angola Salazar) × La Mé		
(LM 630 D × TS 2274) × La Mé		
LM 12231	LM 5453 D × LM 4998 T	6
LM 11406	LM 5473 D × LM 5454 T	7
LM 11720	LM 5457 T × LM 5459 D	8
LM 11337	LM 5468 D × LM 5454 T	9
Angola Novo-Redondo selfed × La Mé		
TNR 115 selfed × La Mé		
LM 12281	LM 5443 T × LM 5467 D	10
LM 12334	LM 5469 D × LM 5445 T	11
LM 11440	LM 5440 D × LM 2042 T	12

Note. LM GP 56: La Mé’s 56th genetic trial; LM: La Mé; T: tenera; DA: Dabou; D: dura; P: pisifera; BB GT25: Bangun Bandar’s 25th genetic trial.

2.2 Parameters Measured

Bunch production was recorded for each palm for seven years from 3 years after planting. The period 3-6 years after planting was the juvenile period and the period 9-10 years the adulthood.

The characteristics of the bunch and the fruit were determined by carrying out 2 series of physico-chemical analyses of bunches, at 5 and 6 years of age, on a sample of 30 to 40 bunches harvested from *tenera* palms from each progeny. Analyses led to determining (i) percentage of fruit per bunch (F/B), (ii) percentage of pulp (or mesocarp) per fruit (P/F), (iii) oil to pulp ratio (O/P), and (iv) palm oil extraction rate (OER). OER has been deducted from F/B, P/F and O/P using the following arithmetic formula:

$$OER = F/B \times P/F \times O/P \times 0.855 \tag{1}$$

Where, 0.855 is a coefficient that takes into account the various losses during the extraction of palm oil from the fresh fruit bunch.

Palm tree height was measured at 6 and 9 years of age according to the method described by Jacquemard (1979). It corresponded to the distance between the soil surface and the axil of the leaf 33, which generally bears a ripe and harvestable fresh fruit bunch or a rotten male inflorescence. Data recorded were used in the estimates of the vertical growth rate.

Progenies were tested for tolerance (or resistance) to *Fusarium* according to the method described by Renard et al. (1972). The Fusarium index (FI) of a progeny was the ratio of the number of *Fusarium*-infected individuals in the progeny to the average number of plants attacked in the test multiplied by 100. The Fusarium index 100 was attributed to the mean number of Fusarium-infected palms in the test. Any value lower than the index corresponds to a more tolerant (or resistant) progeny.

2.3 Data Analysis

An analysis of variance was carried out for total bunch weight, oil yield, and height growth for the periods of 3-6 years and 9-10 years after planting. Emphasis was put on progeny effect and progeny × station interaction. The analysis of variance model used was as follows:

$$\mu = m + D + S \tag{2}$$

where, μ is the mean of the station progeny, m is the overall mean, D is the downfall effect, S is the station effect.

An analysis of variance was also carried out for total bunch weight, oil yield and height growth for the periods of 3-6 years and 9-10 years after planting in a search of Angolan origin, La Mé origin and Angolan genitors effects. The statistical model used was as follows:

$$\mu = m + \text{Origin La Mé} + \text{Parent Angola} + \text{Origin Angola} \tag{3}$$

where, μ is the progeny mean, m is the overall mean, La Mé origin is La Mé origin effect, Parent Angola is the Angola parent effect, origin Angola is the Angola origin effect.

The comparison of mean values of the different progenies for each of the parameters measured was carried out using Tukey's test However, only mean values of height of progenies from the genetic trial planted in La Mé (Côte d'Ivoire) whose heights were measured were compared.

3. Results

3.1 Progeny Effect and Progeny × Station Interaction

The analysis of variance detected a highly significant difference between the progenies tested, for bunch production and its components at 3-6 years after planting as well as at 9-10 years' period, and oil yield. Difference was also found for tree height between 6 and 9 years. On the other hand, the analysis detected an absence of progeny × station interaction (Table 2). In the absence of progeny × station interaction, means were adjusted for each of the progenies studied for the components of bunch production and oil yield, over the periods of 3-6 years and 9-10 years after planting.

Table 2. Analysis of variance for bunch production and its components and height

	NR 3-6 years	TBW 3-6 years	ABW 3-6 years	NR 9-10 years	TBW 9-10 years	ABW 9-10 years	GR 6-9 years	Oil yield
Station	58.6**	69.21 **	O.4O ns	2.23 ns	10.98 **	9.43*	55.5 **	6.99*
Progeny	8.14**	2.42 **	18.5 **	5.30 **	1.59 *	10.45 **	7.35 **	4.65 **
Station × Progeny	0.89 ns	1.21 ns	1.07 ns	0.49 ns	1.19 ns	0.61 ns	-2.09 ns	

Note. BN: bunch number; TBW: total bunch weight; ABW: average bunch weight; GR: height growth rate.

3.2 Effects Angola Origin, La Mé Origin, and Angola Parents

No difference was observed between La Mé origin (selfs and crosses), Angola origin (Angola selfed and Angola × Deli combinations) and Angola parents as well, for all the variables studied viz BN, TBW, and ABW at 3-6 years and 9-10 years and vertical growth rate at 9 years after planting (Table 3).

Table 3. Analysis of variance of origins and Angola parent for bunch production and its components and height

Source of variation	NR 3-6 years	TBW 3-6 years	ABW 3-6 years	NR 9-10 years	TBW 9-10 years	ABW 9-10 years	GR
La Mé Origin	0.74 ns	1.61 ns	2.27 ns	0.00 ns	0.44 ns	0.42 ns	11.07 ns
Angola Parent	4.36 ns	1.28 ns	20.30 ns	1.28 ns	0.83 ns	2.53 ns	8.51
Angola Origin	0.59 ns	1.49 ns	6.35 ns	0.19 ns	1.02 ns	0.67 ns	5.08

Note. BN: bunch number; TBW: total bunch weight; ABW: average bunch weight; GR: height growth rate.

3.3 Mean Values of Hybrids Tested

On average, hybrids tested produced 130 kg/tree (17 t/ha/year) of fresh fruit bunches at 3-6 years of age and 190 kg/tree (26 t/ha/year) at 9-10 years after planting. The fresh fruit bunches production of the different types of hybrids tested was comparable to that of the control (LM 2 T × DA 10 D) (Table 4). The number of bunches and average bunch weight were also comparable to that of the control. Within each of the hybrids (LM 630 D × TNR 115) × La Mé, (LM 630 D × TS 2274) × La Mé, and TNR 115 AF × La Mé the variability was moderate for the bunch number (8-12%) and average bunch weight (5-15%) and relatively low for total bunch weight of (4-6%).

Table 4. Mean values of bunch production and its components at young age and maturity of different types of hybrids tested

	Types of hybrids tested					
	(LM 630 D × TNR 115) × La Mé (8)		(LM 630 D × TS 2274) × La Mé (7)		TNR 115 AF × La Mé (16)	
	Mean	CV	Mean	CV	Mean	CV
BN (3-6 years)	23.4	10 %	23.5	4 %	23.1	7 %
TBW (3-6 years)*	128	6 %	126	5 %	128	5 %
ABW (3-6 years)*	5.6	9 %	5.3	5 %	5.7	15 %
BN (9-10 years)	14.7	12 %	14.8	8 %	14.5	10 %
TBW (9-10 years)*	191	6 %	187	4 %	183	6 %
ABW (9-10 years)*	13.5	11 %	13.1	8 %	13.0	10

Note. ( ): number of hybrids' progenies; BN: bunch number; TBW: total bunch weight; ABW: average bunch weight; *: mean expressed in kg/year.

Oil extraction rates (OER) ranged from 20.8 for hybrids (LM 630 D × TS 2274) × La Mé to 21.9% for hybrids (LM 630 D × TNR 115) × La Mé (Table 5). Extraction rates were comparable to that recorded for the control (20.5%). CV value, an indication of the variability existing within each of these different types of hybrids, ranged from 5% to 7%.

Table 5. Mean values of oil extraction rates and oil yields of the different types of hybrids tested at young and mature periods

	Types of hybrids tested					
	(LM 630 D × TNR 115) × La Mé (8)		(LM 630 D × TS 2274) × La Mé (7)		TNR 115 AF × La Mé (13)	
	Mean	CV	Mean	CV	Mean	CV
OER *	21.9	7 %	20.8	7 %	20.8	5 %
Oil (3-6 years)**	3.78	10 %	3.50	9 %	3.57	5 %
Oil (9-10 years) **	5.64	10 %	5.26	9 %	5.13	7 %

Note. OER: oil extraction rate; ( ): number of hybrids' progenies; CV: coefficient of variation; *: mean expressed in %; **: mean given t/ha/year.

Hybrids' oil yields at 3-6 years and 9-10 years were close to those of the control cross (Table 5). The variability in the hybrids (LM 630 D × TS 2274) × La Mé and (LM 630 D × TNR 115) × La Mé was 10%. Vertical growth rates of the different hybrids were around 50 cm/year (Table 6). They were similar to the control in height. In addition, hybrid types tested showed a coefficient of 10% for this vegetative trait. The best 5 progenies' bunch number, fresh fruit bunch yield, average bunch weight and palm oil yield represented 104-to 112% of the trial control and 100-109% of the trial mean all parameters put together at maturity (6-9 years after planting). Three of the 5 best progenies share a common Angola-derived parent LM 5448 T (Table 7).

Table 6. Average growth rate of the different types of hybrids tested at 6-9 years of age

	Types of hybrids tested					
	(LM 630 D × TNR 115) × La Mé (8)		(LM 630 D × TS 2274) × La Mé (7)		TNR 115 AF × La Mé (13)	
	Mean	CV	Mean	CV	Mean	CV
Height growth rate 6-9 years	51	11 %	48	7 %	53	9 %

Note. ( ): number of hybrids' progenies; CV: coefficient of variation; *: mean expressed in cm/year.

Table 7. Performances of 5 best progenies in BB GP25

Progeny	Cross type	BN	TBW (kg/palm/year)	ABW (kg)	Oil (t/ha)	Height (m)
LM 12283	**LM 5448 T** × LM 5463 D	22.7	233.28	10.40	7.31	1.92
LM 12273	LM 5467 D × **LM 5448 T**	22.6	245.73	11.00	6.80	1.93
LM 12293	LM 5476 D × **LM 5448 T**	22.2	245.15	11.33	7.78	1.82
LM 12433	LM 5452 D × LM 5335 P	21.6	238.90	11.25	6.87	1.98
LM 12334	LM 5469 D × LM 5445 T	23.0	248.68	10.95	6.92	1.98
5 best progenies' mean		22.4	242.35	10.99	7.14	1.93
Trial mean		21.7	234.16	11.00	6.55	1.90
Control		21.6	232.38	10.93	6.35	1.80

Note. BN: bunch number; TBW: total bunch weight; ABW: average bunch weight.

3.4 Resistance to Fusarium Wilt

The average Fusarium indices recorded were less than 100 on average (Table 8). Hybrids (LM 630 D × TS 2274) × La Mé revealed the lowest index for this trait (IF = 83).

Table 8. Average Fusarium wilt index of different types of hybrids tested

	Types of hybrids tested		
	(LM 630 D × TNR 115) × La Mé (8)	(LM 630 D × TS 2274) × La Mé (7)	TNR 115 AF × La Mé (13)
Mean Fusarium index	97 (14: 15)	83 (22: 10)	90 (20: 14)

Note. ( ): number of hybrids' progenies; (14: 15) 14 tests with FI < 100 against 15 tests with FI > 100.

4. Discussion

4.1 Comparison of Progenies and Value of Progeny of Angolan Origin

Analysis of variance revealed a highly significant difference between progenies for bunch production and its components both at juvenile period (3-6 years) and at mature stage (9-10 years) as well as for height at 9 years. It also showed the absence progeny × station interaction. In the absence of progeny × station interaction. The two genetic trials were merged into one trial. Data were adjusted with reference to the trial planted in Bangun Bandar (Indonesia) whose mean values of the different parameters were relatively high. In fact, the four progenies common to two trials served as bridges and were used in the estimates of the adjustment factors. The 5 progenies that ranked first in the comparison of mean values (Table not shown) have produced 8.16 to 21% more oil than the control at 9-10 years after planting. Their oil yields were comparable to those of oil palm commercial fields planted Deli × La Mé materials of the second cycle of RRS represented by the control. However, they can be selected for improvement for future utilization as seed trees. They should be reproduced for seed supply to farmers. Four (4) progenies have recorded a lower height growth rate (44 cm/year, on average) than the control at 9 years after planting-period. In fact, the period is considered that of the exponential growth phase in oil palm (Baudouin & Jacquemard, 1987).

The second analysis of variance revealed the absence of an effect of each of the La Mé origin, Angola origin, and Angola parent. However, the 3 progenies that ranked among the 5 best in oil production per unit area had one common parent, *i.e.*, LM 5448 T a descendant of (LM 630 D × TNR 115) cross. In fact, LM 5448 T has demonstrated a good GCA for this trait. Therefore, it is possible to disseminate planting material derived from Angola origin with moderate height growth rate than the Deli × La Mé seeds that are currently supplied to oil palm growers. It should be considered a genetic progress on the trait since Angolan origin was characterised in the ‘wild’ state as high vertical growth rate material (Adon et al., 1998).

4.2 Mean Values of Hybrids From Angola origin-Contributed Crosses

Fresh fruit bunches production of Angola origin-derived hybrids have 130 kg/tree at 3-6 years of age (17 t/ha) and 190 kg/tree (26 t/ha) at 9-10 years. The values are very close to the potential yield of planting materials of the second cycle of RRS currently supplied to oil palm growers by the French PalmElit considered the producer of high potential bunches and oil yields planting materials for the African oil palm climates and soils. The relatively high bunch production of the Angolan origin-contributed progenies was due to their high bunch number (23 bunches per tree at 3-6 years and 15 at 9-10 years) of medium size (6 kg/bunch and 13 kg/bunch, respectively). The performances obtained were comparable to those the control LM 2 T × DA 10 D which is one of the best crosses of the first selection cycle in bunch production. In fact, it is not common to identify Deli × La Mé seeds from the second cycle of RRS that are currently more productive than the LM 2 T × DA 10 D control. It can be argued that the hybrids (Deli × Angola) × La Mé and Angola selfed × La Mé had a satisfactory bunch production per hectare. The performance obtained indicated the efficiency of the selection made in the accessions from Angola natural oil palm groves. Indeed, a 10% improvement in bunch production was recorded in the second stage of evaluation of this material compared to the one obtained in the first stage (Adon, 1995).

Oil extraction rates varied from 20.8% to 21.9% for hybrids contributed by the Angolan origin. OER values were comparable to that of the control (20.5%) which was recognised as poor performer for this trait. This characteristic of Angolan oil palm genotypes, which was already detected in the first stage of their evaluation by Adon et al. (1998), would be a consequence of a low percentage of pulp on fruit and a low oil content of the pulp. Okwagwu (1985) explained the low percentage of pulp to fruit by the presence of a large kernel. In fact, this trait is said to be governed by a gene related to the sh^{-}(*tenera*) gene of the 2 ancestors TNR 115 and TS 2274 of Angolan origin.

Mean oil yields of the hybrids derived from Angola origin were around 3.5 t/ha at 3-6 years and 5.3 t/ha at 9-10 years. Yields were comparable to those of the control, which were 3.5 t/ha and 5.5 t/ha, respectively, for the same periods. However, yields were relatively lower than those of the Deli × La Me seeds supplied to oil palm growers, which are producing 15-25% more oil than the LM 2 T × DA 10 D control. Angolan origin-based hybrids can be considered less productive in oil. However, the existence of considerable variability for this trait especially in the hybrids (LM 630 D × TNR 115) × La Me (CV = 10%) would allow the selection of progenies with a performance comparable to that of the current Deli × La Mé planting materials. They showed a vertical growth rate of about 50 cm/year recorded from two measures made one at 6 years and the other one at 9 years. The value was close to that of the control. Some of the progenies grew slower than the control, which was considered as a low vertical growth rate progeny (about 50 cm/year) in La Mé (Jacquemard & Baudouin, 1987). This characteristic was a pitfall in using Angolan materials in the first stage of evaluation, where Angola ×

Angola progenies averaged 117% of the control (Adon, 1995). In fact, oil palm planting materials must represent at most 100% of the control in terms of plant height. There was a genetic progress in reducing the vertical growth rate.

The Fusarium index, which is an indicator of oil palm tolerance, was less than 100 showing that Angolan origin-based hybrids were tolerant to Fusarium wilt. The tolerance to Fusarium observed in the Angolan origin in the first stage of evaluation was preserved. This character is an asset for the material of Angolan origin (Durand-Gasselin et al., 2000). Thus, the Angolan source material provides a new source of tolerance to Fusarium that would eventually lead to the distribution of seeds to susceptible areas.

4.3 Introgression of Angola Origin Genitors in Main Breeding Programme

In the long term, there is the possibility of genetic progress with selected oil palms of Angola origin in combination with the Deli origin. It would be possible, on the one hand, to increase the genetic basis of Group A of the reciprocal recurrent selection, which until now has consisted solely of Deli *dura* (sh^+ gene) materials, and on the other hand, to introduce there the *tenera* (sh^-gene present in the Angola origin). In addition, intra-group A recombinations between Angolan genitors selected in this work and Indonesian genitors acquired from an oil palm materials exchange programme between the Centre National de Recherches Agronomiques (CNRA) of Côte d'Ivoire and the Indonesian Oil palm Research Institute (IOPRI) would constitute a phase of the third cycle of RRS.

A genitor of Angola origin (LM 5448 T) has distinguished itself by its good general combining ability for agronomic performance, notably the tolerance to Fusarium, low vertical growth rate, and a decumbent architecture. Selected genitor deserves to be integrated as a priority in recurrent populations. There are two ways to use it. The first aims to test certain trees from LM 5448 T AF with partners from Group B. The production of Angola × La Mé seeds' objective is to identify better genotypes than their ancestors. The second is to integrate LM 5448 T into the Group A's populations, which will be broaden and enriched with the Angola origin.

5. Conclusion

The main objectives of introducing Angolan oil palm materials in Group A were, on the one hand, to enrich the genetic base of Group A for the selection scheme and, on the other hand, to introduce the sh^-(*tenera*) gene. The genitor of Angola origin LM 5448 T and the descendants from its selfing offered new genes for bunch production and tolerance to Fusarium to Group A. Recombinations involving Angola's *tenera* and *pisifera* of Deli × Angola crosses are means of transferring the sh^-gene into Group A (which initially consisted only of *dura* (sh^+ gene). Eventually, it will be possible to make crosses of the *pisifera* type of Group A × Group B *dura*. This inversion of the traditional direction of crosses, *i.e.*, Group A *dura* × Group B *pisifera* would make it possible to avoid problems of insufficient pollen on the *pisifera* of Group B which are rather too female. However, the low average bunch weight of Group B materials consisting of *tenera* and *pisifera* would result in the production of small bunches which leads to a reduced number of fruits per bunch. Therefore, seed producers will expect less seeds for supply to growers. Therefore, seed production should take the average bunch weight of Group B material into account.

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Abbreviations

AN 2 T: Second genitor of *tenera* type and of Angolan origin selected at La Mé; BB: Bangun Bandar (Indonesia); D: *Dura* palm; DA 10 D: 10th genitor of *dura* type selected at Dabou; LM: La Mé (Côte d'Ivoire); T: *tenera* palm; P: *pisifera* palm.

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