**Journal of Applied Biosciences 186: 19705- 19720**
**ISSN 1997-5902**

# Evaluation of the vertical growth rate of oil palms (*Elaeis guineensis* Jacq.) derived from recombinations of Yocoboué progenitors in the 3rd cycle of reciprocal recurrent selection.

**FOFANA Vamara Paterne[1, 2*], KONAN Jean Noël[1], FOFANA Inza Jésus[2], NIAMKETCHI Gilles Léonce[1], SOUMAHORO Mêgbê[1, 3]**

[1]Centre National de Recherche Agronomique (CNRA), Station de Recherché de La Mé - 13 BP 989 Abidjan13, Côte d'Ivoire

[2]Unité de Formation et de Recherche (UFR) des Sciences Biologiques, Département Biochimie-Génétique, Unité Pédagogique et de Recherche (UPR) de Génétique, Université Peleforo Gon Coulibaly, BP 1328 Korhogo, Côte d'Ivoire

[3]Laboratoire de l'amélioration de la production végétale, UFR Agroforesterie, Université Jean Lorougnon Guédé, BP 150 Daloa, Côte d'Ivoire

* Auteur correspondant: E-mail: fofni10@gmail.com / Tel: (+ 225) 0759918006

Submission 13th April 2023. Published online at https://www.m.elewa.org/Journals/ on 31st July 2023. **https://doi.org/10.35759/JABs.187.3**

## ABSTRACT

*Objective:* The present study aims to determine the vertical growth characteristics of the progeny of the 3rd cycle resulting from recombinations involving the genitors of the Yocoboué population.

*Methodology and results:* The study was carried out at Ehania/PALMCI (Côte d'Ivoire), using a square lattice design, measurements were made on the height of stem of 2402 trees belonging to eighteen oil palms progenies and three popularised controls. Vertical growth rates expressed in cm/year were calculated and reported as a percentage of control 1 (LM 2 T x DA 10 D) in order to link the progenies of each trial. The results showed that eight progenies evaluated expressed growth rates statistically lower than those of the three controls. These were LM 22179, LM 22259, LM 22349, LM 22363, LM 23163, LM 24201, LM 23658 and LM 24040 that averaged 87.29% of the LM 2 T x DA 10 D control.

*Conclusion and application of results:* The low growth rate expressed by these progenies resulted in a reduction in growth rate of up to 14% compared to control 1, up to 6% compared to control 2 and up to 9% compared to control 3. These results can be used by the breeder to continue improving the oil palm.

**Key words:** Selection, Growth, Oil palm, 3rd cycle of RRS, Yocoboué

## INTRODUCTION

The improvement of oil palm (*Elaeis guineensis* Jacq.) in Côte d'Ivoire began in the 1920s and continues to this day (Tano *et al*., 2020; Adon, 2021a). This improvement of plant material based on selection criteria follows a reciprocal recurrent selection (RRS) scheme involving two groups (group A, composed of the Deli and Angola populations, and group B, composed of other African populations including Côte d'Ivoire, Benin, Cameroon.) with complementary characteristics (Meunier and Gascon, 1972; Adon, 2021b). Among the selection criteria is the reduction of the vertical growth rate of oil palms to extend the economic life of the plantations (Darkwah *et a*l., 2020). The economic life of a farm can be as long as 25 to 30 years for slow-growing material with a vertical growth rate of 45 to 50 cm per year. Whereas a material with a vertical growth rate of 55-65 cm per year must be felled after 18 to 20 years (Cochard *et al*., 2001, Konan *et al*., 2014). The selection carried out in Côte d'Ivoire on recurrent oil palm populations has considerably reduced vertical growth rate of the material distributed. This Deli x La Mé type material has an average growth rate that varies between 40 cm/year and 45 cm/year (CNRA, 2006), compared to the Deli x Yangambi and Deli x Avros types, with average growth rates of 55 cm/year and 63 cm/year respectively (Cochard et al., 2001). This strong selection pressure on recurrent populations during the two previous cycles has limited oil palm improvement to mostly related progenitors (Allou, 2008; Ataga, 2012; Noumouha, 2015). To ensure the efficiency of the breeding scheme and to establish long-term genetic progress, several genotypes of oil palm populations resulting from surveys or exchanges between research institutes were introduced into the breeding scheme (Noumouha *et al*., 2014; Adon, 2022). Thus, broodstock from the Yocoboué population were integrated into the oil palm breeding scheme following a survey conducted in Côte d'Ivoire in 1968 (Meunier, 1969; Adon, 1995; Bakoumé *et al*., 2001). This population differs from that of La Mé in that its fruit is of better quality with a high percentage of pulp and its bunches are relatively larger. These palms were therefore introduced into the selection scheme to improve the oil extraction rate of the La Mé material and to broaden the variability of the Côte d'Ivoire origin (Adon, 1995). During the evaluation of this material, it was found that in addition to these characteristics (large bunches and high pulp percentage), two broodstock from this population stood out for their low vertical growth. These were the broodstock YO 3 T and YO 9 T, which expressed average growth rates of 49 cm/year and 43 cm/year respectively (Bakoumé *et al*., 2001). These broodstock were therefore selected and introduced into group B in recombinations at the end of the 2nd cycle. These recombinations (La Mé x La Mé) x (Yocoboué x La Mé) and (La Mé x La Mé) x (Yocoboué x Yocoboué) were intended to diversify the material base for a 3rd cycle of oil palm breeding in Côte d'Ivoire. The work carried out by Assouma *et al* (2019) made it possible to determine the vertical growth characteristics of some progenies of the 3rd cycle resulting from these recombinations. Eight (8) progenies from recombinations involving the Yocoboué introduction expressed a lower growth rate (42.75 cm/year) than the control from the first selection cycle LM 2 T x DA 10 D (47.86 cm/year), and a growth rate equivalent to the second control from the 1st cycle LM 2 T x DA 115 D. However, the vertical growth characteristics of some progenies of 3rd cycle from these recombinations are still undetermined. The objective of the study is to determine the vertical growth characteristics of the progeny of the 3rd cycle resulting from recombinations involving the broodstock of the Yocoboué population and to estimate the contribution of these broodstock to the reduction of vertical growth rate.

## MATERIALS AND METHODS

**Plant material:** The plant material is essentially composed of eighteen (18) oil palms hybrids progenies from the 3rd cycle of recurrent selection in Côte d'Ivoire. These progenies were obtained from crosses involving group B progenitors resulting from 4-way recombinations between two populations of Côte d'Ivoire origin tested with group A progenitors (Deli and/or Deli progenitors with Angola progenitors) (Table I). These are crosses of the type [(DELI x DELI) x (DELI x DELI)] x [(LA MÉ x LA MÉ) x (YOCOBOUÉ x YOCOBOUÉ)] and [(ANGOLA AF) x (DELI x DELI)] x [(LA MÉ x LA MÉ) x (YOCOBOUÉ x YOCOBOUÉ)]. These progenies were evaluated for vertical growth rate and compared in the trials to three (3) popularised controls. These controls were the reference crosses LM 2 T x DA10 D and LM 2 T x DA 115 D from the 1st selection cycle and the cross LM 2 T AF x DA 115 D AF from the 2nd cycle.

**Experimental design:** The trials studied were planted between 2002 and 2003 on the PALMCI Integrated Agricultural Unit (IAU) in Ehania, Côte d'Ivoire. This site is located in the south-east of Côte d'Ivoire, at 5°19' north latitude, 2°46' west longitude and 12 m altitude. It hosts the genetic block for the 3rd cycle of reciprocal recurrent selection experiments, which covers 375 ha (Kablan, 2020). This area benefits from an equatorial climate (Atean climate) characterised by bimodal rainfall with two wet periods and two dry seasons. Annual rainfall varies between 1276 and 2007 mm, with an average temperature of about 27°C and an average atmospheric humidity estimated at 85% each year (Kaman, 2013). The study focused on four genetic trials of Ehania, namely EH-GP 02, EH-GP 04, EH-GP 05 and EH-GP 06. The EH-GP 02 trial was set up in a balanced square lattice design with 4 x 4 and 5 replications with experimental plots comprising 14 trees, i.e. 70 oil palms per progeny. For the other three trials, a 5 x 5 balanced square lattice design with six replications was adopted with experimental plots containing 16 trees, i.e. 96 oil palms per progeny. In the end, 2402 oil palms were planted in all these trials at a standard density of 143 oil palms per hectare.

**Measuring method:** The measurements carried out consisted of measuring the height of stem in the trials as described by Jacquemard (1980). This method consists of measuring the height of stem from the base of the leaf insertion to ground level (Figure 1). In practice, the measurement is made with a metal square attached to a wooden pole and a double decameter. The zero point of the double decameter is placed at the bottom of the horizontal leg of the square. The branch is placed in the axil of leaf 33, located at the level of the wall diets (Assouma *et al.*, 2019). The height of the stem is then read at ground level. The vertical growth rates of different progenies were estimated according to the following formula:

$$\mathbf{VC} = \frac{\mathbf{H}}{\mathbf{N - 3,75}}$$

With**:**

- **VC**: Vertical growth rate (cm/year)
- **H**: Height of stem
- **N**: The age of the tree expressed in years
- **The value '3.75'** corresponds to the age at which vertical growth begins, since before this age the palm grows transversely to ensure good root bulb anchorage.

**Data statistical analyses:** The data collected on the progenies of the 3rd cycle on vertical growth rates were subjected to a series of statistical analyses. A verification of the

Kolmogorov-Smirnov normality hypothesis, necessary for the use of parametric tests, was carried out. The parameters of the descriptive statistics (mean, standard deviation and coefficient of variation) were used to assess the performance of the eighteen (18) progenies in the trials. Next, analysis of variance (ANOVA) or Kruskal-Wallis test, depending on whether the data have a normal distribution or not, was performed to assess the discriminatory power of each of the studied offspring at the 5% threshold. A post-hoc test named Student Newman Keul test or a Duncan test was then performed to classify the statistical units into a homogeneous group (Dagnelie, 2012). Progenies with a statistically significantly lower average growth rate than a control were used to express genetic progress. The genetic progress obtained in this study was defined through the reduction in vertical growth rate of the progenies compared to the different controls. Control 1 (LM 2 T x DA 10 D), being present in all trials, was used to link the different trials by expressing the mean values of the progenies as a percentage of it. Hierarchical ascending classification (HAC) was used to group the progenies into classes.
All these analyse were carried out by XLSTAT software version 2019.

**Figure 1:** Measuring the vertical growth of an oil palm from base to leaf 33.

**Table 1:** Genetic origins of the progenies evaluated in the study for vertical growth rate.

| Trials numbers | Progenies | Crossing | Type of crossing | Number of oil palms |
|---|---|---|---|---|
| 02 | LM 22363 | LM13009D X LM13011T | [(DE x DE) x (DE x DE)] x [(LM x LM) x (YO x YO] | 70 |
| | LM 22306 | LM13011T X LM12894D | [(DE x DE) x (DE x DE)] x [(LM x LM) x (YO x YO] | 70 |
| | LM 23750 | LM13031D X LM13011T | [(DE x DE) x (DE x DE)] x [(LM x LM) x (YO x YO] | 70 |
| | LM 22349 | LM13009D X LM13015T | [(DE x DE) x (DE x DE)] x [(LM x LM) x (YO x YO] | 70 |
| | LM 22596 | LM13015T X LM13016D | [(DE x DE) x (DE x DE)] x [(LM x LM) x (YO x YO] | 70 |
| | LM 23163 | LM13010T X LM13031D | [(DE x DE) x (DE x DE)] x [(LM x LM) x (YO x YO] | 70 |
| | LM 22179 | LM13831T X LM13009D | [(DE x DE) x (DE x DE)] x [(LM x LM) x (YO x YO] | 70 |
| | LM 22259 | LM13832T X LM13016D | [(DE x DE) x (DE x DE)] x [(LM x LM) x (YO x YO] | 70 |
| | LM 24201 | LM12905D X LM13832T | [(DE x DE) x (DE x DE)] x [(LM x LM) x (YO x YO] | 70 |
| 04 | LM 24506 | LM13888D × LM13014T | [(ANG AF) x (DE x DE)] x [(LM x LM) x (YO x YO] | 96 |
| | LM 24306 | LM13905D x LM13013T | [(ANG AF) x (DE x DE)] x [(LM x LM) x (YO x YO] | 96 |
| | LM 24392 | LM13905D x LM13831T | [(ANG AF) x (DE x DE)] x [(LM x LM) x (YO x YO] | 96 |
| | LM 24730 | LM13907D x LM13010T | [(ANG AF) x (DE x DE)] x [(LM x LM) x (YO x YO] | 96 |
| 05 | LM 23967 | LM13908D x LM13011T | [(ANG AF) x (DE x DE)] x [(LM x LM) x (YO x YO] | 96 |
| | LM 23658 | LM13908D x LM13934P | [(ANG AF) x (DE x DE)] x [(LM x LM) x (YO x YO] | 96 |
| | LM 24378 | LM13995D x LM13010T | [(ANG AF) x (DE x DE)] x [(LM x LM) x (YO x YO] | 96 |
| | LM 24576 | LM13996D x LM13015T | [(ANG AF) x (DE x DE)] x [(LM x LM) x (YO x YO] | 96 |
| 06 | LM 24040 | LM13906D x LM13935P | [(ANG AF) x (DE x DE)] x [(LM x LM) x (YO x YO] | 96 |
| 02; 04, 05; 06 | Control 1* | DA10D X LM2T | Control (T1*) | 358 |
| 02; 05 | Control 2* | LM2T X DA115D | Control (T2*) | 166 |
| 04; 05; 06 | Control 3* | DA115D AF x LM2T AF | Control (T3*) | 288 |

*DE: Deli, ANG: Angola, AF:* Self-fertilisation, *LM: La Mé, YO: Yocoboué*

## RESULTS

The Kolmogorov-Smirnov normality test performed on the vertical growth rate data showed that, with the exception of the EH GP 05 trial (D = 0.058; p = 0.047), the distribution of data in the genetic trials followed the normal distribution (Figure 2). The mean value of vertical growth rate varied from trial to trial (Table2). This vertical growth rate was lowest in the EH GP 02 trial with an average of 39.19 cm/year and a standard deviation of 5.75. Within this trial, the growth rate varied from 21.33 cm/year to 60.76 cm/year in terms of individual palm oil performance. The highest vertical growth rate was recorded in the EH GP 05 trial with an average of 56.44 cm/year with a standard deviation of 9.68. The individual values of the oil palms in this trial varied between 12.92 and 91.69 cm/year. The variability observed (CV between 10 and 20%) was average in all the trials analysed. The performance of the progenies evaluated is recorded in Table 3. In the EH-GP 02 trial, the mean value of vertical growth rate of the progenies ranged from 37.14 cm/year (LM 23163) to 43.27 cm/year (LM 2 T x DA 10 D). Six of the nine progenies (LM 22179, LM 22259, LM 22349, LM 23163, LM 22363 and LM 24201) tested in the trial expressed a lower growth rate than the two controls in the trial, while the other three progenies (LM 22306, LM 22596 and LM 23750) were only lower than Control 1 (LM 2 T x DA 10 D). For the EH-GP 04 trial, variations in the mean value of vertical growth rate of progenies ranging from 43.09 cm/year (LM 24730) to 52.31 cm/year (LM 24306) were obtained. Three progenies (LM 24392, LM 24506 and LM 24730) out of four tested in the trial showed a lower vertical growth rate than the two controls. As for the performance of all progenies in the EH-GP 05 trial, the mean value of vertical growth rate ranged from 52.67 cm/year (LM 23658) to 59.98 cm/year (LM 2 T x DA 10 D). The progenies LM 24378, LM 23658 and LM 24576 expressed a lower growth rate than the three controls. The progeny LM 23967 had a lower mean value of vertical growth rate than the control 1 (LM 2 T x DA 10 D). In the EH-GP 06 trial, the mean value of vertical growth rate of the progenies ranged from 43.88 cm/year (LM 24040) to 49.98 cm/year (LM 2 T x DA 10 D). The progeny LM 24040 expressed a lower vertical growth rate than the two controls in the trial.

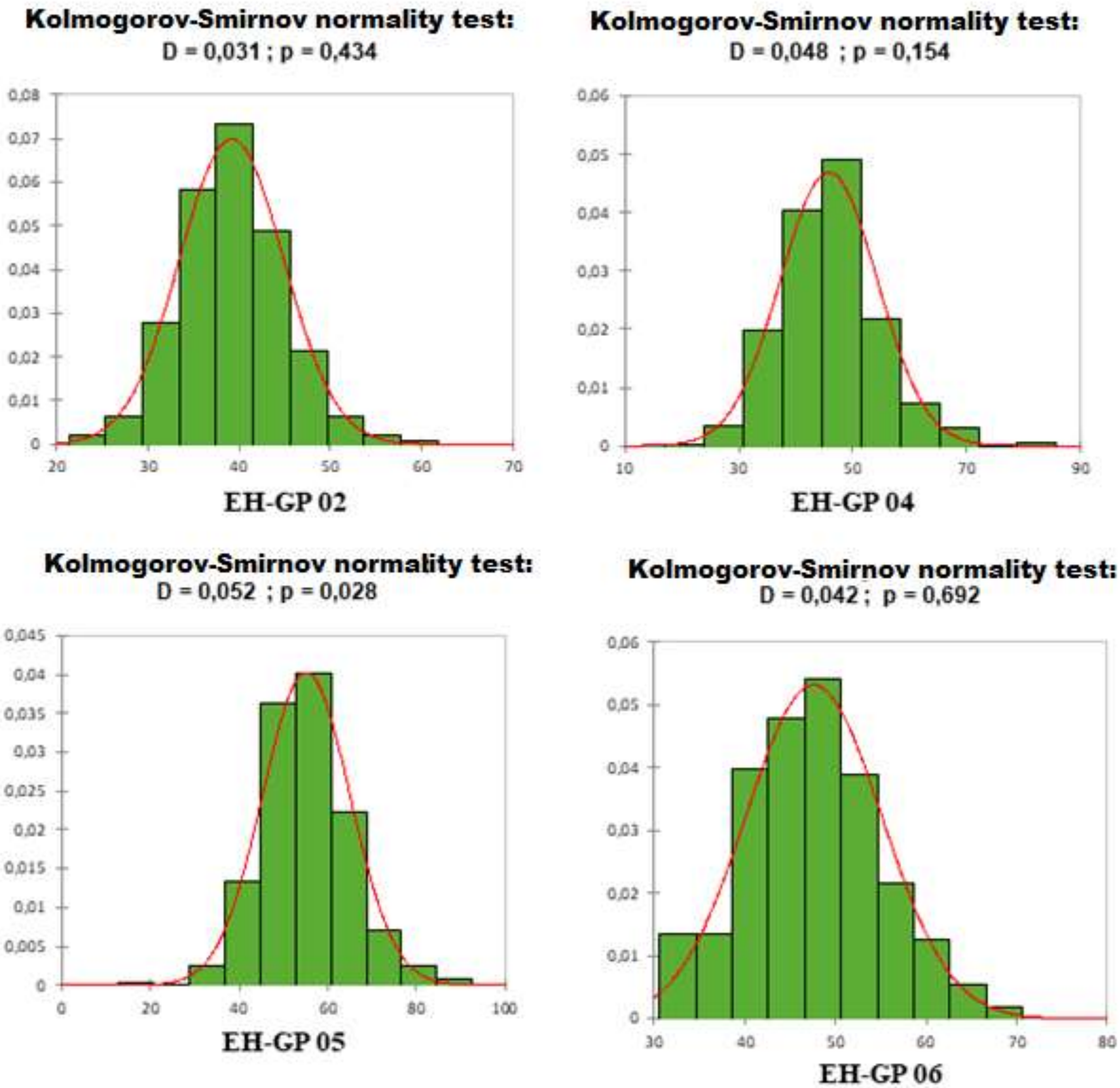


**Figure 2.** Distribution of oil palms in relation to vertical growth rates

**Table 2**: Mean value, standard deviation, minimum, maximum and coefficient of variation (CV) of the trials studied

| Trials | minimum | maximum | Mean | standard deviation | CV (%) |
|---|---|---|---|---|---|
| EH GP 02 | 21.33 | 60.76 | 39.19 | 5.75 | 14.67% |
| EH GP 04 | 17.18 | 84.71 | 45.8 | 8.56 | 18.68% |
| EH GP 05 | 12.92 | 91.69 | 56.44 | 9.68 | 17.15% |
| EH GP 06 | 30.59 | 69.65 | 47.60 | 7.51 | 15.79% |

**Table 3:** Performance of the progenies tested according to the trials studied.

| Trials | Progenies | Mean | Standard deviation (n) | CV (%) |
|---|---|---|---|---|
| EH-GP 02 | $T_1$* | 43.27 | 6.04 | 13.97% |
| | $T_2$* | 39.1 | 4.89 | 12.50% |
| | LM 22179 | 37.49 | 5.23 | 13.94% |
| | LM 22259 | 38.22 | 5.33 | 13.96% |
| | LM 22306 | 41.84 | 5.59 | 13.35% |
| | LM 22349 | 37.6 | 4.50 | 11.97% |
| | LM 22363 | 37.44 | 4.99 | 13.32% |
| | LM 22596 | 40.42 | 5.92 | 14.65% |
| | LM 23163 | 37.14 | 5.32 | 14.33% |
| | LM 23750 | 40.21 | 6.53 | 16.24% |
| | LM 24201 | 38.28 | 4.85 | 12.67% |
| EH-GP 04 | $T_1$* | 45.81 | 7.45 | 16.27% |
| | $T_3$* | 45.79 | 6.23 | 13.60% |
| | LM 24306 | 52.31 | 9.54 | 18.23% |
| | LM 24392 | 44.13 | 7.91 | 17.92% |
| | LM 24506 | 43.52 | 7.00 | 16.09% |
| | LM 24730 | 43.09 | 8.12 | 18.85% |
| EH-GP 05 | T1* | 59.98 | 11.49 | 19.15% |
| | T2* | 57.38 | 8.73 | 15.22% |
| | T3* | 56.21 | 9.51 | 16.93% |
| | LM 23658 | 52.67 | 7.74 | 14.70% |
| | LM 23967 | 58.76 | 8.7 | 14.80% |
| | LM 24378 | 54.96 | 8.72 | 15.87% |
| | LM 24576 | 55.07 | 10.42 | 18.92% |
| EH-GP 06 | $T_1$* | 49.98 | 7.74 | 15.46% |
| | $T_3$* | 48.47 | 6.679 | 13.78% |
| | LM 24040 | 43.88 | 6.71 | 15.30% |

***Control 1 ($T_1$*)**: DA10D x LM2T;*
***Control 2 ($T_2$*)**: LM2T x DA115D ;*
***Control 3 ($T_3$*):** DA 115 D AF x LM 2 T AF*

**Analysis of variance of progenies:** The analysis of variance (ANOVA at the 5% level) applied to the average growth rates revealed that there were significant differences between the progenies in each of the trials (Figure 2). Indeed, the ANOVA ($F = 9.531$; $p < 0.0001$) showed that it is possible to establish significant differences between progenies in the EH-GP 02 trial. The Newman-Keuls test revealed five homogeneous groups. The first group is composed of four progenies (LM 22179, LM 23163, LM 22363 and LM 22349) with a statically lower growth rate than the controls. In addition, the intermediate group is formed by the progenies LM 24201 and LM 22259, which recorded a statically lower growth rate than control 1. The ANOVA in the EH-GP 04 trial ($F = 16.278$; $p < 0.0001$) revealed a significant difference between the progenies. The first group, consisting of two progenies (LM 24506 and LM 24730) had the lowest static growth rates. The results of the Kruskal-Wallis test ($K = 14.067$; $p < 0.0001$) applied to growth rates showed a significant difference between progenies in the EH-GP 05 trial. Duncan's test showed three groups, of which the first group with the lowest growth rate was represented by progeny LM 23658. For the EH-GP 06 trial, ANOVA results ($F = 17.580$; $p < 0.0001$) showed statistical differences between progenies. The Newman-Keuls test was used to form two (2) homogeneous groups. The first of which was characterised by a statistically lower growth rate than the controls. This group is composed of the LM 24040 progeny.

**Genetic progress:** The genetic progress obtained through the reduction in growth rate of progenies in the 3rd selection cycle in each of the trials is recorded in Table 4. The gain obtained in the EH-GP 02 trial ranged from 3.31% to 14.17% compared to the 1st selection cycle control (LM 2 T x DA 10 D) for all progenies. However, the variation from the control LM 2 T x DA 115 D is 2.21% to 5.01% for the best 3rd cycle progenies (LM 22179, LM 22259, LM 22349, LM 23163, LM 22363 and LM 24201) in the trial. The improvement in vertical growth rate in the EH-GP 04 trial for the best progenies in the 3rd cycle (LM 23750 and LM 24201) ranged from 4.96% to 5.91% over the LM 2 T x DA 10 D control and from 4.93% to 5.90% over the LM 2 T x DA 115 D control. The best progeny (LM 23658) in the EH-GP 05 trial showed a reduction in growth rate of about 12.19% compared to Control 1, 6.3% compared to Control 2 (LM 2 T x DA 115 D) and 8.21% compared to Control 3 (LM 2 T AF x DA 115 D AF). Also, progenies LM 24378 and LM 24576 expressed a reduction in growth rate of about 8% compared to control 1, about 2% compared to control 2 (LM 2 T x DA 115 D) and 4% compared to control 3 (LM 2 T AF x DA 115 D AF). The gain in the EH-GP 06 trial is around 12.20% and 9.45% respectively in relation to Controls 1 and 3 for the best progeny (LM 24040) in the 3rd cycle of the trial.

**Progenies classification:** The hierarchical ascending classification applied to the average growth rate of the different progenies expressed as a percentage of control 1 (LM 2 T x DA 10 D) revealed three distinct classes according to their degree of dissimilarity (Figure 4). The first class (C1) contains eight progenies, i.e. 38% of the total number of progenies evaluated. It is composed of the progenies LM 22349, LM 22363, LM 24201, LM 24551, LM 24040 and LM 25688. The second class (C2) represents 28% of the total with six progenies including the control 2 and the progenies LM 23750, LM 24392, LM 24506, LM 24730, LM 24378 and LM 24576. Finally, the third class (C3) is made up of seven progenies (i.e. 34% of the total) including controls 1 and 3 and progenies LM 24306, LM 24545, LM 24870, LM 24874, LM 24894, LM 24954, LM 24980, and LM 26077. The characteristics of these different classes are recorded in Table 5. The first class is characterised by an average vertical growth rate of 87.29% of control 1 with a standard deviation of 0.947. It is the best class with the progenies expressing the lowest speed compared to the different controls equivalent to a percentage reduction in growth speed of more than 10% compared to control 1. C2 is characterised by an average of 92.99% of control 1 with a standard deviation of 1.28. It represents the intermediate class of progenies with statistically significantly lower growth rates than Control 1 and 3. C3 is 98.787% of Control 1 with a standard deviation of 1.40. It is essentially made up of the progenies with the highest growth rates in the series.

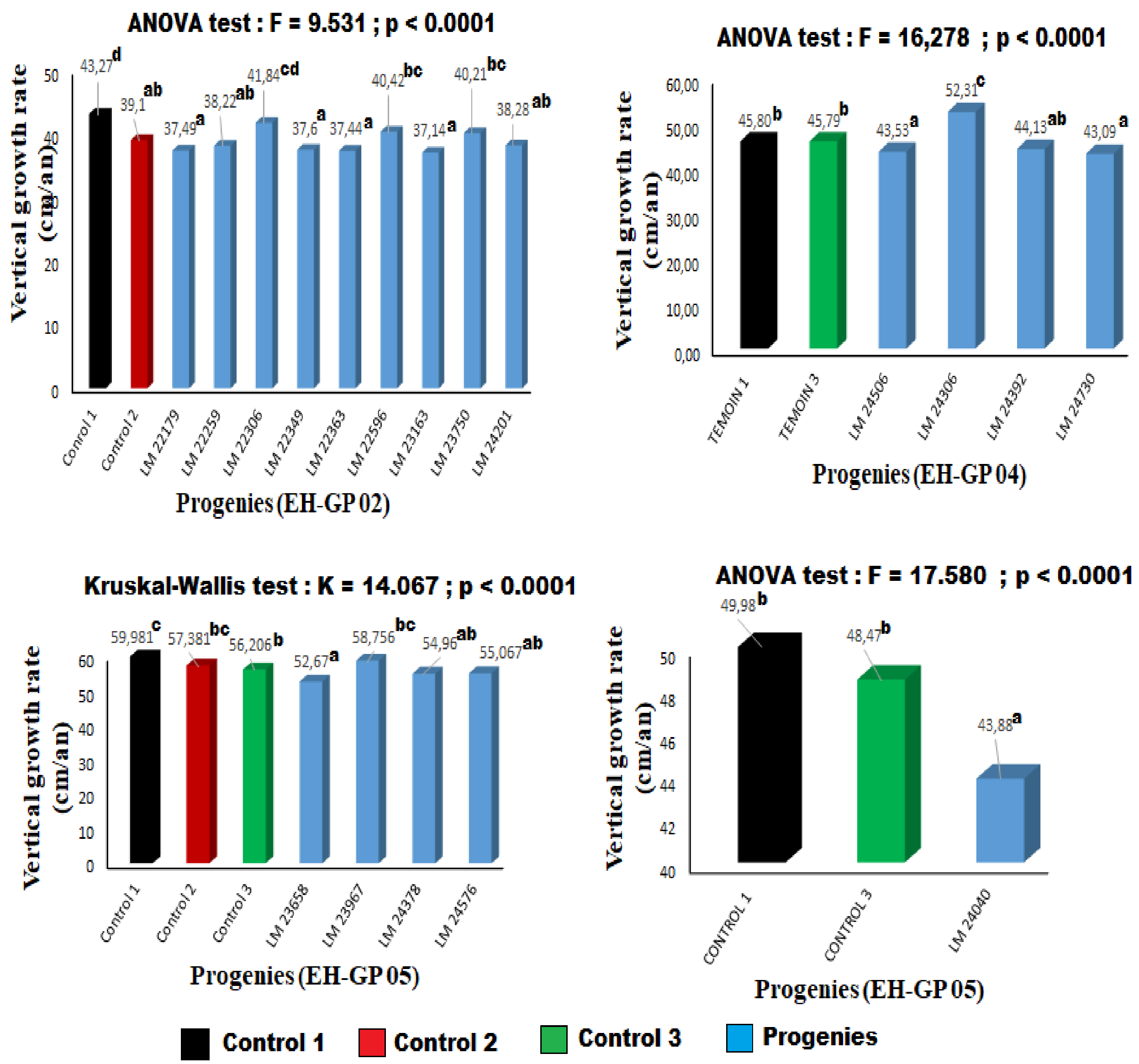


**Figure 3.** Analysis of variance in vertical growth rate of progenies in each trial

**Table 4:** Genetic progress expressed as a percentage reduction of the controls according to the trials

| Trials | Progenies | VC ($cm.an^{-1}$) | Reduction compared to control 1 (%) | Reduction compared to control 2 (%) | Reduction compared to control 3 (%) |
|---|---|---|---|---|---|
| EH-GP 02 | T1* | 43.27 | | | |
| | T2* | 39.1 | | | |
| | LM 22179 | 37.49 | 13.36 | 4.12 | |
| | LM 22259 | 38.22 | 11.67 | 2.25 | |
| | LM 22306 | 41.84 | 3.31 | - | |
| | LM 22349 | 37.6 | 13.10 | 3.84 | |
| | LM 22363 | 37.44 | 13.47 | 4.24 | |
| | LM 22596 | 40.42 | 6.59 | - | |
| | LM 23163 | 37.14 | 14.17 | 5.01 | |
| | LM 23750 | 40.21 | 7.07 | - | |
| | LM 24201 | 38.28 | 11.53 | 2.1 | - |
| EH-GP 04 | T1* | 45.8 | | | |
| | T3* | 45.79 | | | |
| | LM 24506 | 43.53 | 4.96 | 4.93 | - |
| | LM 24730 | 43.09 | 5.91 | 5.90 | - |
| EH-GP 05 | T1* | 59.98 | | | |
| | T2* | 56.18 | | | |
| | T3* | 57.38 | | | |
| | LM 23658 | 52.67 | 12.19 | 6.3 | 8.21 |
| | LM 23967 | 58.76 | 2.03 | - | - |
| | LM 24378 | 54.96 | 8.37 | 2.22 | 4.22 |
| | LM 24576 | 55.07 | 8.19 | 2.03 | 4.03 |
| EH-GP 06 | T1* | 49.98 | | | |
| | T3* | 48.47 | | | |
| | LM 24040 | 43.88 | 12.20 | | -9.45 |

***VC:*** Vertical growth rate ***; Control 1 ($T_1$*)****: DA10D x LM2T;****Control 2 ($T_2$*)****: LM2T x DA115D ;****Control 3 ($T_3$*)*** *: DA 115 D AF x LM 2 T AF*

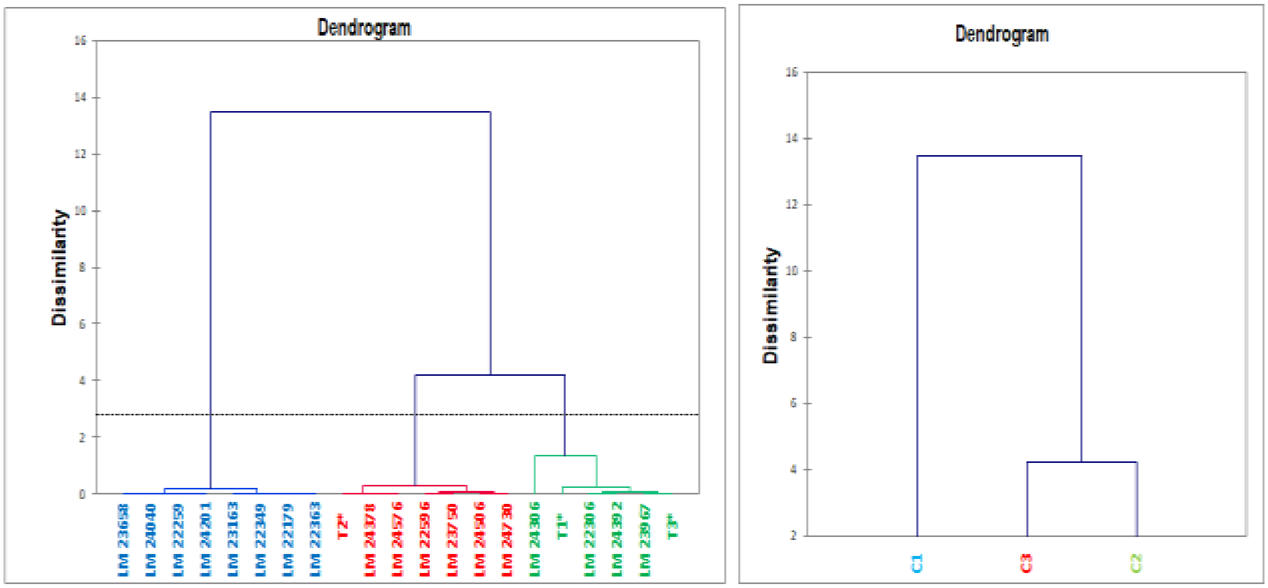


**Figure 4.** Classification of the tested progenies according to their performance expressed as a percentage of control 1.

**Table 5:** Characteristics of the different progeny classes for growth rate in height expressed as a percentage of the control 1.

| Class | 1 | 2 | 3 |
|---|---|---|---|
| Number of progenies | 8 | 7 | 6 |
| Mean (% of control 1) | 87.29[a] | 92.99[b] | 98.787[c] |
| Standard deviation | 0.947 | 1.28 | 1.40 |
| Intra-class variance | 0.896 | 1.630 | 8.656 |
| Mean distance to center of gravity | 0.813 | 1.020 | 2.205 |
| | LM 22179 | LM 22596 | LM 22306 |
| | LM 22259 | LM 23750 | LM 23967 |
| | LM 22349 | LM 24506 | LM 24306 |
| | LM 22363 | LM 24730 | LM 24392 |
| | LM 23163 | LM 24378 | **T1*** |
| | LM 24201 | LM 24576 | **T3*** |
| | LM 23658 | **T2*** | |
| | LM 24040 | | |

***Control 1 ($T_1$*)****: DA10D x LM2T;* ***Control 2 ($T_2$*)****: LM2T x DA115D ;* ***Control 3 ($T_3$*)*** *: DA 115 D AF x LM 2 T AF*

## DISCUSSION

In this study, the selection focus was on the slow-growth trait resulting from recombinations of the Yocoboué (YO 3 T x YO 9 T) progenitors at the level of the group B grandparents of the progenies studied. The results of the study showed that there is genetic variability both within progenies (intra-descendants) and between different progenies (inter-descendants). Indeed, the parameters of dispersion, i.e. the standard deviation and especially the coefficient of variation, which is between 10 and 20%, show that the growth rates are not stable and constant from one progeny to another. The disparity in the growth rate in height of the offspring could be explained by the fact that the progenitors used have different grandparental origins. The same observation has been made by various authors who have come to the conclusion that the vertical growth rate of oil palm does not only depend on the growing environment, but also on its genetic origin (Cochard *et al.*, 2005; Verheye, 2010; Tano *et al*., 2017). The progeny with the largest standard deviation is the most heterogeneous progeny (De Berchoux and Quencez 1980). The oil palm improvement scheme implemented at La Mé station (Côte d'Ivoire) exploits the hybrid vigour that results from crossing two groups A and B with complementary characteristics (Durand-Gasselin *et al*., 2009). The exploitation of this hybrid vigour between the two groups is always preceded by a recombination phase within the basic populations of high-performing genitors and the introduction of additional material (Konan *et al*., 2014). Thus, the 3rd round of reciprocal recurrent selection in Côte d'Ivoire was carried out with the aim of bringing new progress by exploiting recombinations of the best genitors from the 1st and 2nd rounds of selection and introductions (Noumouha, 2015). The results showed a vertical growth rate of 37.14 cm/year for the best hybrid progeny (LM 23163) in all trials. According to the hierarchical ascending classification, this progeny belongs to the best Class (C1) together with seven (7) other progenies that expressed a lower growth rate than all controls. This result confirms the studies conducted by Adon (1995) which showed that the progenitors YO 3 T and YO 9 T had in addition to the good diet and fruit characteristic a low growth in height. The heritability of certain traits in oil palm has highlighted the high heritability of the vertical growth rate in height trait (Durand-Gasselin et al., 2009). These progenitors (YO 3 T and YO 9 T) would therefore transmit this trait to their offspring. The low vertical growth rate of the C1 progeny has resulted in a significant genetic benefits, which is reflected in a reduction in vertical growth rate that varies from 11% to 14% compared to the first control in the 1st cycle; from 2% to 6% compared to the 2nd control in the 1st cycle and 9% compared to the control in the 2nd cycle. This genetic progress observed in the progeny of the 3rd cycle is considerable. Indeed, it is part of the dynamic of oil palm improvement by continuing the results obtained during the two previous selection cycles, in particular an average reduction of 20% vertical growth (De Touchet, 1991). Some progenies from crosses between the Yocoboué and Deli populations could be used to improve the slow-growth character of the oil palm (Bakoumé *et al*., 2001). The strategy put in place for the exploitation of the 3rd cycle trials by the recombinations of the 2nd cycle by integrating this introduction has therefore proved to be a good one, as confirmed by these results, since the performance of the progenies obtained is largely superior to that of the controls, which are considered to be small-sized material. The Yocoboué material introduced to diversify the Côte d'Ivoire material and improve the extraction rate of the La Mé material proved to be a real advantage in reducing growth rate through its two progenitors YO 3 T and YO 9 T.

## CONCLUSION AND APPLICATION OF RESULTS

Material of Yocoboué origin has been used in the reciprocal recurrent selection scheme for oil palm in Côte d'Ivoire as an introduction in group B to bring genetic diversity within this group and above all to improve selection parameters. The aim of the present work was to evaluate the contribution of the progenitors resulting from the Yocoboué x La Mé recombinations in reducing vertical growth rate of 3rd cycle progeny. It was found that most of the progenies evaluated had a lower average growth rate than the 1st cycle control

(LM 2 T x DA 10 D), which is considered in the selection scheme as a low-growth individual. These values obtained made it possible to classify the different progenies tested into three distinctly homogeneous classes. The best class is composed of eight (8) progenies that expressed an average growth rate in height of about 87.29% of the 1st cycle control (LM 2 T x DA 10 D). Also, the genetic progress obtained through the reduction of growth rate was the most important for these progenies. These results can be used by the breeder to continue the genetic improvement of the oil palm. In this way, he will be able to provide farmers with material combining several traits of interest.

## AUTHORS' CONTRIBUTIONS

All the authors contributed to the realization of this work, and FOFANA Vamara Paterne was the principal investigator. All of them contributed to the correction of the manuscript.

## ACKNOWLEDGEMENTS

The authors would like to thank the administrative directorate of the National Agricultural Research Centre at the La Mé Research Station for providing us with the trials EH-GP 02; EH-GP 04; EH-GP 05 and EH-GP 06.

## REFERENCES

Adon N B. 1995. Évaluation des introductions de palmier à huile (*Elaeis guineensis* Jacq.): Utilisation dans le schéma de sélection récurrente réciproque. Thèse 3e cycle, Université de Cocody-Abidjan, p34-52

Adon N B. 2022. Utilisation des accessions issues de la population subspontanée d'Angola pour l'amélioration du rendement en huile et de ses composantes chez le palmier à huile (*Elaeis guineensis* Jacq.) Thèse 3e cycle, Université de Cocody-Abidjan, 123p

Adon N B., 2021a. Selection of (Deli × Angola Novo-Redondo) Selfed × La Mé Progenies for Improved Oil Palm Productivity. Journal of Agricultural Science; Vol. 13(12) : pp. 51-60. ISSN 1916-9752, E-ISSN 1916-9760

Adon N B., 2021b. Agronomical Performances of Angolan Natural Oil Palm Accessions and Interests for Oil Palm Selection in Côte d'Ivoire. Journal of Agricultural Science ; Vol. 13(11) : pp. 64-73. ISSN 1916-9752 E-ISSN 1916-9760

Adon N B., Baudouin, L., Durand-Gasselin, T., & Kouame, B. (1998). Utilisation du matériel non amélioré pour la sélection du palmier à huile, l'origine Angola. Plantations, Recherche, Développement, 201-207

Allou D. (2008). Evaluation de la divergence génétique au premier et au second cycle de sélection récurrente réciproque du palmier à huile (*Elaeis guineensis* Jacq.) en Côte d'Ivoire: Cas des populations sélectionnées BRT 10 d'origines La Mé. Thèse de Doctorat de génétique et amélioration des espèces végétales. Université de Cocody-Abidjan, Côte d'Ivoire, 185 p.

Assouman D, Adon B, Konan J-N, Noumouha Epa G N ; Nguetta S-P, Konan E. 2019. Évaluation du matériel de la population YOCOBOUE pour la réduction de la vitesse de croissance en hauteur du palmier à huile (*Elaeis guineensis* Jacq.) dans le 3ème cycle de sélection récurrente réciproque en Côte d'Ivoire. Int. J. Biol. Chem. Sci. 13 (7): pp 3320-3331, Ataga C D, Hamza AM, Yusuf AO. 2012. Status of date palm (Phoenix dactylifera L.) genetic resources. Intl J Life Sci Pharma Res 2: pp46-51.

Bakoumé C, Adon B, Cochard B, Potier F, Durand-Gasselin T, Amblard P. 2001. Assessment of Yocoboué wild oil palm (*Elaeis guineensis* Jacq.) from Côte d'Ivoire. *Euphytica*, 121 (1) : p59-64. DOI:http://dx.doi.org/10.1023/A:1012076207543

Bakoumé C. (2016). Genetic diversity, erosion and conservation in oil palm. In M. R. Ahaja & S. Mohan Jain (Eds.), Genetic diversity and erosion in plants—Case studies. Springer International Publishing, AL, Zurich, pp. 1-31. https://doi.org/10.1007/978-3-319-25954-3_1

Centre National de Recherche Agronomique (CNRA). 2006. Bien cultiver le palmier à huile en Côte d'Ivoire. Fiche technique palmier n°1 CNRA / CTA, p 4.

Cochard B, Adon B, Kouamé K R, Durand-Gasselin T, AMBLARD P. 2001. Intérêts des semences commerciales améliorées de palmier à huile (*Elæis guineensis* Jacq.). *Oléagineux, Corps Gras, Lipides*, 8 (6): pp 654-658.

Cochard B, Amblard P, Durand-Gasselin T. 2005. Oil palm genetic improvement and sustainable development. OCL 12(2): 141–145.

Dagnelie P. 2012. Principes d'Expérimentation: Planification des Expériences et Analyses de leurs Résultats. Les Presses Agronomiques de Gembloux, passage des déportés, 2 : B- 5030 Gembloux, Belgique ; 413 p.

Darkwah D O, Blay E, Amoatey H, Sapey E, Bakoumé C, Agyei-Dwarko D. 2020. Genetic diversity and selection within natural *dura* oil palm accessions collected in Ghana for oil palm productivity improvement. BIODIVERSITAS, Vol. 21(8), pp. 3534-3538. ISSN: 1412-033X DOI: 10.13057/biodiv/d210815

De Berchoux C, Quencez P. 1980. Etude de la croissance en hauteur du palmier, Application pratique au problème de replantation. *Oléagineux*, 35 (10) : pp 431- 437. DOI : http://agritrop.cirad.fr/453559 .

Durand-Gasselin T, Cochard B, Amblard P, Nouy B. 2009. Exploitation de l'hétérosis dans l'amélioration génétique du Palmier à huile (*Elæis guineensis*). Le Sélectionneur Français" 2009 (60) : 91-100.pp.

Jacquemard J-C. 1980. Méthode d'observation de la taille des palmiers. *Oléagineux*, 35 (10): pp 439-442.

Kablan K A B M. 2020. Fusariose vasculaire du palmier à huile [*elaeis Guineensis* (Arecaceae)] cultive en Côte d'Ivoire : Sélection de descendances hybrides tolérantes et identification de marqueurs phénoliques. Thèse 3e cycle, Université Nangui Abrogoua - Abidjan, 170 p.

Kaman P. 2013. Rapport du Ministère de l'Environnement et du Développement Durable de Côte d'Ivoire. Analyse des vulnérabilités aux catastrophes et des capacités de réponse en Côte d'Ivoire, 65 p.

Konan J-N, Allou D, Diabate S, Konan E P, Koutou A. 2014. Évaluation de l'introgression du caractère croissance lente de quelques géniteurs Akpadanou (origine Bénin) chez quelques géniteurs améliorés de palmier à huile (E. guineensis Jacq.) de l'origine La Mé (Côte d'Ivoire). International Journal of Biological and Chemical Sciences, 8(5): pp 2015-2022.

Meunier J. 1969. Étude des populations naturelles d'*Elaeis guineensis* en Côte d'Ivoire. Oléagineux, 24 (4) : 195 – 201.

Meunier J. et Gascon J. P. (1972). Le schéma général d'amélioration du palmier à huile à l'I.R.H.O. *Oléagineux*, 27(1): 1-12.

Noumouha E. N. G, Allou D, Adon B, Konan J-N, Sékou D, konan K E, Nguetta S-P A. 2014. Assessment of Nigerian wild oil palm (*elaeis guineensis* jacq.) populations in crosses with deli testers. J. Plant Breed. Genet. Vol. 02 (02) : pp. 77-86

Noumouha N G. 2015. Évaluation en Côte d'Ivoire des introductions de palmiers à huile (*Elaeis guineensis* Jacq.) dans le schema de sélection récurrente réciproque : Cas des populations subspontanées et préalablement sélectionnées du Nigeria et du Cameroun. Thèse 3e cycle, Université Félix Houphouet – Boigny - Abidjan, 193 p.

Tano E K , Allou D , N'nan O A, Konan E K, N'guetta S P A. 2017. Evaluation of the height of some genitors of seed field Deli Dura of Oil Palm (Eleais Guineensis Jacq) planted in 1998 and 1999 at La Me Station. Agricultural Science Research Journal Vol. 7(10): pp 318 – 323

Tano E K, N'nan O A, Konan J-N, Konan E K, N'guetta S P A. 2020. Effet du système de reproduction des géniteurs sur les caractéristiques de qualité du régime et du fruit des descendances dura utilisées en production de semences de palmier à huile (*Elaeis guineensis* Jacq.). Agronomie Africaine 32(1): pp 101-112

Verheye W. 2010. Growth and production of oil palm. In: Verheye W, ed. Land Use, Land Cover and Soil Sciences. Encyclopedia of Life Support Systems (EOLSS). Oxford, UK: UNESCO-EOLSS Publishers. Available from http://www.eolss.net.