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Performance, Heritability and Genetic Advance for Oil Yield and some Economical Characters in Oil Palm (*Elaeis guineensis* Jacquin) of Cameroon

Penampilan, Heritabilitas dan Kemajuan seleksi pada karakter Produksi Minyak dan beberapa Sifat Ekonomi Kelapa Sawit dari Kamerun

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ABSTRACT

Knowledge of the magnitude of genetic variability, heritability and genetic advance in the selection of desirable characters could assist the plant breeders in ascertaining criteria to be used in the breeding programmes. Twenty three introgressed oil palm progenies were evaluated at the Specialized Centre for Oil Palm Research of Cameroon, from 2004 to 2014 to estimate performance, genetic variability, heritability and genetic advance of oil yield and some economic traits in terms to select new oil palm parent materials with the traits of interest. The results revealed high variability among oil palm population for all the characters. Moderate estimates of the phenotypic and genotypic coefficient of variations associated with high heritability and moderate genetic advance as percent of mean were obtained for characters of fresh fruit bunch, bunch number, oil yield, kernel to bunch, kernel to fruit, kernel yield and height increment. The results suggest the effectiveness of selection method for these traits and their improvement through their phenotypic performance. LM11087T x LM2749D and LM12960T x LM7409D were obtained as superior oil palm crossing parents with the potential production of 6.26 ton ha^{-1}yr^{-1} of crude palm oil; they can be exploited in seed production and further breeding program.

Keywords: genetic advance, heritability, introgressed progenies, oil yield, Phenotypic

ABSTRAK

Ketersediaan informasi parameter pemuliaan sangat penting untuk mendukung program pemuliaan kelapa sawit yang efektif. Penelitian ini bertujuan untuk mengetahui besaran keragaman genetik, heritabilitas dan tingkat kemajuan seleksi pada karakter-karakater yang menjadi target pemuliaan pada kelapa sawit dari Kamerun. Evaluasi dilakukan terhadap 23 progeni introgresi kelapa sawit di Specialized Centre for Oil Palm Research of Cameroon, mulai tahun 2004 hingga 2014, untuk parameter keragaman genetik, heritabilitas dan kemajuan seleksi pada karakter produksi minyak dan beberapa sifat lain yang memiliki nilai ekonomi. Hasil penelitian menunjukkan terdapat keragaman genetik yang tinggi diantara populasi yang dievaluasi untuk semua karakter yang diamati. Karakter bobot tandan segar, jumlah tandan, produksi minyak, nisbah kernel terhadap tandan, nisbah kernel terhadap buah, nisbah kernel terhadap produksi dan pertambahan tinggi tanaman memiliki koefesien keragaman genetik dan fenotifik yang moderat, dengan heritabilitas yang tinggi serta kemajuan seleksi yang moderat. Persilangan LM11087T x LM2749D dan LM12960T x LM7409D merupakan kombinasi tetua yang menghasilkan hasil persilangan superior dengan tingkat produksi minyak sawit rata-rata of 6.26 ton ha^{-1} per tahun sehingga dapat dilanjutkan ke produksi benih komersial atau digunakan dalam program pemuliaan di masa mendatang.

Kata kunci: fenotipik, heritabilitas, progeni introgresi, kemajuan seleksi

INTRODUCTION

Oil palm (*Elaeis guineensis* Jacq.) is a perennial tropical forest plant originated from the wild regions of West and Central Africa. The palms are currently produced in African, Southeast Asian and Central and South American countries. Oil palm fruits are exploited from mesocarp (crude palm oil: CPO) and endocarp (palm kernel oil: PKO) of fruits. It is the most productive and economically attractive vegetable crop for smallholders, companies and government of oil palm producer countries. Palm oil is used in diverse range of

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commercial products, ranging from margarine and cooking oils to animal feeds, cosmetics, plastics, surfactants, soaps, detergents, herbicides as well as biofuels and a broad range of agricultural chemicals (Colon-Ramos *et al.*, 2007; Ladeia *et al.*, 2008; Van Rooyen *et al.*, 2008). Thus palm oil demand is increasing tremendously (Jekayinfa and Bamgboye, 2008; Sumathi *et al*., 2008).

Oil palm is a cross-pollinated, perennial monocotyledon plant with 2n=32 chromosomes (Singh *et al*., 2013). Therefore, significant variability in oil palm population are reported (Okwuagwu *et al*., 2008; Noh *et al*., 2014). Heritability is one of important parameter in breeding program which indicates how strongly a particular character can pass on from parent to progeny. In oil palm genetic improvement, the heritability estimates and their contribution towards oil yield are important parameters. Noh *et al.* (2014) has reported the heritability of bunch quality component characters of oil palm.

The genetic advance estimate, associated to heritability, will give rise to selection effectiveness for useful promising lines in crop improvement. They are main key parameters for plant breeder in selection (Okwuagwu *et al*., 2008; Okoye *et al*., 2009; Jalal and Ahmad, 2012). The expected genetic advance is the gain produced by selection, which contributed to change the population mean. In quantitative genetic study the estimation of genetic progress from selection has been greatly contributed in plant breeding (Okwuagwu *et al*., 2008; Sungkono *et al*., 2009). In oil palm, the bunch component like fresh fruit bunch yield (FFB), which is a product of the number of bunches (BN) and average bunch weight (ABW), represents a major determinant of oil palm productivity (Okwuagwu *et al*., 2008). In this view, the selection effectiveness for heritable FFB components would rapidly advance the oil palm breeding program. Murphy (2009) has estimated the field CPO potential production (9-12 tons) of some oil palm Tenera varieties.

Cameroon is one of the most African provider countries of oil palm wild population and commercial oil palm elite material in the world. Unfortunately, Cameroon currently produces an estimated amount of 230,000 tons CPO per year from the plantation area of about 190,000 ha (Hoyle and Levang, 2012) and it is the World's 13th largest producer (USDA 2016). In Cameroon, palm oil accounts for about 90% of edible oil needs; Ngando *et al*. (2011) has reported the national palm oil consumption estimate of 80% of population. Under favourable agro-ecological conditions, oil palm plantation can produce up to 7.2 tons CPO ha^{-1} and 1.5 ton PKO ha^{-1} (Caliman, 2011). In fact, compare to estates in Southeast Asian countries, average yield is extremely low in Cameroon, i.e., 2.3 tons CPO ha^{-1}year^{-1} in the agro-industry and 0.8 ton CPO ha^{-1} year^{-1} in smallholdings (Hoyle and Levang, 2012).

Currently, new lands of about 500,000 ha were allocated by the government for the implementation of new oil palm estates to improve palm oil production. With an annual national production of about 2,500,000 of improved Tenera oil palm seed of the second cycle of selection, the current oil palm research center of Cameroon: CEREPAH and PAMOL which are in charged to provide oil palm seed to palm oil producer cannot satisfy the seed demand for such new lands. New oil palm yielding line parents are needed to improve the current low production of oil palm seeds. It is in that light that the 3rd cycle of selection of oil palm of CEREPAH breeding program was carried out. The promising oil palm parent crosses from the new progeny trials are expected to increase the number of the current oil palm parents used in the seed production department of CEREPAH. This paper highlights the performance and the estimation of genetic variability, heritability and genetic advance of some traits in the new oil palm breeding population of the Specialized Centre for Oil Palm Research of Cameroon, in terms to provide information for seed production of high palm oil yielding lines and for advancing the current population into the next generation.

MATERIALS AND METHODS

The oil palm experiment was carried out in 2004 at the government research center of Cameroon, namely Specialized Centre for Oil Palm Research (CEREPAH), (3^{o} 46′ - 4^{o} 01′N and 9^{o} 44′- 10^{o}04′ E, at less than 200 m above the sea level). The research region was located in the Guinean equatorial climate with four seasons. During the research activities, annual climate data were 2730.49 mm of mean rainfall, temperature 23.95 ^{o}C - 30.81 ^{o}C (average 27.36 ^{o}C) and 1334 hours of mean sunshine. The sandy clay soils were found in this region.

The trial was focused on progeny test and contained a total of 23 oil palm introgressed progeny population crosses from Deli *dura* x La Mé tenera (DxT). The Dabou *dura* materials family originating from the National Centre for Agronomic Research (CNRA) in Ivory Coast Breeding Programme was used as female parents. The male parents were the La Mé *tenera* family, the descendants of the crosses between Widikum from CEREPAH-Cameroon and La Mé. All the crosses of the progeny test are pesented in Table 1.

For the mean comparisons evidence, one of the current elite tenera commercial hybrid oil palm materials of CEREPAH was used as control oil palm material in this experiment. The randomized complete block design was applied with three replications in the experimental field. The oil palm trees with one year old were laid down in equilateral triangular planting system at 9 m apart with 12 palm plants per progeny in 3 replications. Thus a total of 864 oil palm trees (6 ha) were used for observation. The recommended agronomic practices were also used to raise a good crop stand. Oil palm foliar survey was carried out and fertilizers were applied at six year old after planting at the rate of 0.487 kg per palm of urea, 0.951 kg per palm of potassium chloride and 0.166 kg per palm of magnesium sulfate. The trait data were recorded from 2004 to 2014 on yield components, i.e., fresh fruit bunch weight (FFB), bunch number (BN), kernel to fruit ratio (K/F), kernel to bunch ratio (K/B), oil yield (OY) and kernel yield (KY), following the method of Mandal and Kochu (2008) (Table 2). The palm height increment (HT), was calculated by using the formula reported by Noh *et al*. (2014): Height

Table 1. Progeny tested oil palm D x T population planted in 2004-2014 at CEREPAH Cameroon

Progenies	Parents	Origin of tenera/pisifera	Origin of dura	Origin of grand parent Tenera/Pisifera	Origin of grand parent Dura
LM 21661	LM2T x DA115D	BRT10	Dabou		
LM 22478	LM5100D x LM11096T	DA2356	LM9838	DA115 D x LM269D	LM2T x WI 10T
LM 21761	LM11087T x LM2749D	LM9175	DA787	LM5T x WI 15T	DA10D x DA3D
LM 22099	LM11087T x LM7409D	LM9175	LM7899	LM5T x WI 15T	LM3257D AF
LM 22001	LM11088T x LM2531D	LM9175	DA507	LM5T x WI 15T	DA115D AF
LM 22527	LM11088T x LM2781D	LM9175	DA787	LM5T x WI 15T	DA10D x DA3D
LM 22534	LM11088T x LM7811D	LM9175	LM7899	LM5T x WI 15T	LM3257D AF
LM 21884	LM11089T x LM2749D	LM9175	DA787	LM5T x WI 15T	DA10D x DA3D
LM 21864	LM12963T x LM5100D	LM9175	DA2356	LM5T x WI 15T	DA115 D x LM269D
LM 22130	LM11091T x LM2749D	LM9287	DA787	LM5T x WI 1T	DA10D x DA3D
LM 21709	LM11091T x LM5100D	LM9287	DA2356	LM5T x WI 1T	DA115 D x LM269D
LM 21706	LM11097T x LM2531D	LM9927	DA507	LM5T x WI 10T	DA115D AF
LM 21787	LM11097T x LM5100D	LM9927	DA2356	LM5T x WI 10T	DA115 D x LM269D
LM 21839	LM11097T x LM7422D	LM9927	LM7899	LM5T x WI 10T	LM3257D AF
LM 21925	LM7422D x LM11091T	LM7899	LM9287	LM3257D x LM3257D	LM5T x WI 1T
LM 21728	LM12960T x LM5100D	LM9287	DA2356	LM5T x WI 1T	DA115D x LM269D
LM 21790	LM12960T x LM7409D	LM9287	LM7899	LM5T x WI 1T	LM3257D AF
LM 21881	LM12961T x LM2509D	LM9287	DA507	LM5T x WI 1T	DA115D AF
LM 22575	LM12961T x LM2749D	LM9287	DA787	LM5T x WI 1T	DA10D x DA3D
LM 21852	LM12961T x LM5155D	LM9287	LM2911	LM5T x WI 1T	LM269D x DA115D
LM 21886	LM12965T x LM2509D	LM9927	DA507	LM5T x WI 10T	DA115D AF
LM 21867	LM12965T x LM2749D	LM9927	DA787	LM5T x WI 10T	DA10D x DA3D
LM 21874	LM12967T x LM2781D	LM9927	DA787	LM5T x WI 10T	DA10D x DA3D
LM 21836	LM12967T x LM2509D	LM9927	DA507	LM5T x WI 10T	DA115D AF

increment/year = (height at year t) / (t - 2), where, t: is the age of the palm.

Analysis of variance of the recorded data was carried out using computer statistic R program software (3.3.1.Version). The Duncan Multiple Range Test was used to separate mean of each studied characters. The response to selection estimate, the genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were adopted in this study as suggested by Bello *et al.* (2012). The broad sense heritability (h^2_{bs}) estimate was the ratio of genotypic variance (σ^2_g) and phenotypic variance (σ^2_p). However the expected genetic advance (GA) as per cent of means with 10% of selection intensity, were estimated using the formula suggested by Bello *et al.* (2012).

RESULTS AND DISCUSSION

Analysis of Variance

The information from the analysis of variance showed significant different among the tested oil palm genotypes for fresh fruit bunch yield (FFB), number of bunches (BN), oil yield (OY), kernel to bunch (K/B), Kernel to fruit (K/F), kernel yield (KY) and height increment (HT) (Table 3). The result was indicating the presence of important variability among this breeding population. Thus it was inferring the feasibility of optimum selection process to release superior candidate with high oil palm commercial characters from these 23 progenies of the third cycle of selection in Cameroon. Similar findings were also suggested by Okwuagwu *et al*. (2008), Okoye *et al.* (2009) and Noh *et al.* (2012). The experimental coefficients of variation (CV %) were low for all the studied traits, suggesting the presence of little influence of the experimental error, i.e 8.4% for fresh fruit bunch yield, 7.3% for bunch number, 10.8% for oil yield, 15.5% for kernel to bunch, 12.3% for kernel to fruit, 17.7% for kernel yield and 14.7% for height increment. Okwuagwu *et al.* (2008) stated that, for perennial crops, the reasonable coefficient of variation values should not exceed 30%.

Genetic Parameters and Means of Traits

The statistical estimate of genetic parameters means and ranges of all the characters are combined in Table 4. The result revealed that for all the traits, the phenotypic coefficient

Table 2. Determination of oil palm physical bunch analysis parameters sheet (Mandal and Kochu, 2008)

Recorded data sheet formula			
			Code
Bunch weight (kg)			A
Stalk weight (kg)			B
Spikelet weight in 1/4 th Bunch (kg)			C
Fruit weight in 1/4 th Bunch (kg)			D
No. of fruits in 500g fruits			E
Weight of nuts in 500g fruits (g)			F
Drying of mesocarp for estimation of moisture content in mesocarp	Weight of container (petriplate) (g)		G1
	Initial weight (mesocarp + container) (g)		G2
	Dry weight of (mesocarp + container) (g)		G3
Weight of shell in 500g fruits (g)			H
Drying of kernel for estimation of moisture content in kernel	Weight of container (g)		I1
	Initial weight of (container + kernel) (g)		I2
	Dry weight of (container + kernel) (g)		I3
Mesocarp oil estimation	Weight of round bottom flask (g)		J1
	Weight of mesocarp (g)		J2
	Weight of round bottom flask + oil (g)		J3
Average FFB yield/palm/year (kg)			Y
OTHER PARAMETERS			
	Code	Formula	
Total spikelet weight (kg)	K	= A-B	
Spikelet/bunch (%)	L	= (K / N) x 100	
Fruit/spikelet (%)	M	= (D / C) x 100	
Fruit/bunch (%)	N	= (L x M) x 100	
Average fruit weight (g)	Not required	= 500/ E	
Mesocarp/fruit (%)	O	= [(500-F)/ 500] x 100	
Mesocarp/bunch (%)	P	= (O x N)/ 100	
Moisture in mesocarp (%)	Q	[(G2-G3)/ (G2-G1)] x 100	
Moisture in kernel (%)	R	[(I2-I3)/ (I2 -I1)] x 100	
Oil/dry mesocarp (%)	S	[(J3-J1)/J2] x 100	
Oil/fresh mesocarp (%)	T	[S x (100-Q)] / 100	
Oil/bunch (%)	U	(T x P)/ 100	
Oil yield/palm/year (kg)	Not required	U x Y	
Kernel/fruit (%)	V	= [(F-H)/500] x 100	
Kernel to bunch (%)	W	= (V x N)/100	
Kernel yield/palm/year (kg)	Not required	= W x Y	

of variation (PCV %) was moderately higher than their corresponding genotypic coefficient of variation (GCV %). Thus, the result was illustrating the relative consistent effect of the environmental factors on the expression of these traits for the studied oil palm breeding population. This assertion was determined also by the narrow difference between PCV and GCV estimates recorded for all these characters and suggesting their environmental factor tolerance potential for this oil palm population (Table 4). The same appreciation was reported by Okwuagwu *et al.* (2008), Bozokalfa *et al.* (2010), Ogunniyan and Olakojo (2015).

Heritability Estimate

High broad sense heritability estimates were obtained for most of the traits, i.e 78.33% for fresh fruit bunch yield,

Table 3. Compiled analyses of variance for fresh fruit bunch yield, number of bunches, oil yield, kernel to bunch, kernel to fruit, kernel yield, and height increment (HT) in the 3rd cycle of selection progeny test Deli x tenera oil palm breeding population in Cameroon

Sources of variation	Degree of freedom	Mean squares of traits						
		FFB	BN	OY	K/B	K/F	KY	HT
Replications	2	111.00	3.197*	1.273*	33.519	46.67	1.728	77.182**
Progenies	24	403.62***	8.717***	1.255***	206.53***	429.38***	8.311***	39.115**
Residuals	48	87.47	0.700	0.368	39.378	57.71	1.318	14.303
C.V (%)		8.40	7.400	10.800	15.500	12.30	17.700	14.700

Significant codes: *** 0.001; ** 0.01; * 0.05 ; fresh fruit bunch yield (FFB); number of bunches (BN); oil yield (OY); kernel to bunch (K/B); kernel to fruit (K/F); kernel yield (KY); height increment (HT)

91.97% for bunch number, 86.56% for kernel to fruit ratio, 80.93% for kernel to bunch ratio, 70.72% for oil yield, 84.14% for kernel yield and 63.43% for height increment. This result should be associated with the genotype variability observed in the studied breeding population. Similar findings have been reported by Okwuagwu *et al*. (2008). However, the presence of high broad sense heritability will not eventually signify favourable response to selection because it is related to non-additive gene effects. Therefore, the high estimate of broad sense heritability should be associated to high genetic advance as percent of means of traits for their improvement through selection (Jalata *et al*., 2011; Jalal and Ahmad, 2012).

Genetic Advance and Expected Genetic Advance as percent of mean

The estimates of expected genetic advance (GA) for fresh fruit bunch was 15.9 kg per palm per year indicating that whenever we select the best, 10% high performance crossings as parents, mean FFB of descendants could be improved by 15.9 kg per palm per year, that is, mean genotypic value of the new population for FFB will be improved from 109.48 to 125.38 kg per palm per year. In the same way, it will be 13.9, 6.3 ton ha^{-1}, 51.8%, 79.3%, 8.7 ton ha^{-1}, 21.7 cm for bunch number, oil yield, kernel to bunch, kernel to fruit, kernel yield and height increment respectively (Table 4). The estimates of expected genetic advance for all the plant traits were slightly high when calculated at 10% selection intensity, except for palm oil yield performance. However moderate genetic advance as percent of mean was recorded for all traits, inferring that in this studied oil palm breeding population, traits were controlled by additive genes. It revealed the feasibility of the selection for these characters and hence these traits can be improved through their phenotypic performance. The result of genetic advance also showed that selection for palm oil yield performance can be more promising by indirect selection of FFB and BN characters, but mainly for FFB than BN (15.9 kg per palm per year and 2.8 bunches respectively). High estimate of broad sense heritability being recorded and associated with moderate genetic advance as percent of mean for all the traits of these genotypes the characters can be improved through selection

Table 4. Genetic parameters of variation for the 7 studied characters in 23 DxT oil palm progenies of Cameroon

Traits	Mean	Range	GV	PV	GCV (%)	PCV (%)	Hbs (%)	GA	GA as % of mean	Control plant
Fresh fruit bunch (kg per palm per year)	109.48	90.33-146.3	105.38	134.54	9.38	10.59	78.33	15.9	14.56	129.30
Bunch number	11.13	8.07-13.53	2.67	2.91	14.68	15.31	91.97	2.8	24.72	13.53
Oil yield (ton ha^{-1})	5.52	4.38-6.35	0.30	0.42	9.86	11.72	70.72	0.8	14.55	6.29
Kernel to bunch (%)	40.02	27.56-56.14	55.72	68.84	18.65	20.73	80.93	11.8	29.45	44.98
Kernel to fruit (%)	61.09	43.54-85.5	123.89	143.13	18.22	19.58	86.56	18.2	29.75	69.85
Kernel yield (ton ha^{-1})	6.27	4.40-9.66	2.33	2.77	24.36	26.56	84.14	2.5	39.21	8.29
Height increment (cm)	25.69	21.41-35.78	8.27	13.04	11.20	14.06	63.43	4.0	15.65	25.08

Note: GV = genotypic variance; PV = phenotypic variance; GCV = genotypic coefficients of variation; PCV = phenotypic coefficients of variation; GA = genetic advance; H_{bs} = broad sense heritability based on the phenotypic expression (Akinwale *et al*., 2011). Okoye *et al*. (2009) reported high broad sense heritability and high genetic advance as percent of mean for the studied characters.

Oil Palm Population Performance

The results of 10 years of performance for the 23 oil palm crosses DxT for all the studied characters are presented in Table 5. The trial means for bunch number, fresh fruit bunch, kernel to fruit, kernel to bunch, oil yield, kernel yield and height increment were 11.133; 109.481 kg per year; 61.089%; 40.020%; 5.518 ton ha^{-1} per year; 6.268 ton ha^{-1} per year and 25,685 cm respectively. The information of progeny performance revealed that the palm oil yield was ranged from 4.38 ton ha^{-1} per year for LM21787 progeny to 6.35 ton ha^{-1} per year for LM21761 progeny. The recorded palm oil yield mean 5.52 ton ha^{-1} was remarkable high compared to the current Cameroon commercial variety (4.52 ton ha^{-1}; thus 122%) reported by Bakoume *et al.* (2010). The Duncan's new multiple range test (DMRT) further revealed that 3 progenies and the control genetic material were relatively comparable for high palm oil yield performance in the studied population. These progeny palms yielded more than 6 ton ha^{-1} per year of CPO and no significant difference was obtained among them. They were also relatively short with annual height increment value found from 21.41 to 27.66 cm compared to 39.4 -53.3 cm of the current commercial planting materials (Bakoume *et al*, 2010). However, the selection progress at 10% of the studied progeny entries allowed only LM21761 and LM21790 to be released as new highest yielding oil palm genetic material progenies in terms to select their self-crossing parents for seed production program with a potential production of 6.26 ton CPO ha^{-1} per year, that is 99,5% of the control. The world highest palm oil potential production was reported as 5.52 ton ha^{-1}, and 4.31 ton ha^{-1} for Indonesia and Malaysia respectively (MPOB, 2016).

Table 5. Mean performance of 23 oil palm introgressed progenies and the control for 7 traits in Cameroon

Progeny	FFB	BN	K/B	K/F	KY	OY	HT
LM 21761	122.3abc	12.4bc	33.73efg	51.64fghi	5.96cdef	6.35a	24.08c
LM 21661*	129.3a	13.53a	44.98abcd	69.85bcde	8.29ab	6.29a	25.78c
LM 21790	118.7bcde	13.45a	54.07ab	80.32ab	9.12a	6.16a	21.41c
LM 22534	118.1bcde	11.19cdefg	33.00efg	50.20ghi	5.53cdef	6.14a	27.66c
LM 21925	124.2ab	13.22a	52.81ab	78.06abc	9.39a	6.01b	26.82c
LM 22130	115.8bcde	12.56bc	40.94bcdef	64.21cdefg	6.80bcde	5.88b	24.20c
LM 22478	112.3bcdef	10.62defgh	36.48defg	55.13defghi	5.87cdef	5.83b	35.12ab
LM 21867	118.1bcde	13.14a	27.56g	43.54i	4.69def	5.83b	24.67c
LM 21728	120.4bcd	13.46a	56.14a	85.50a	9.66a	5.79b	35.78a
LM 21852	113.9bcde	10.29efgh	40.5bcdef	61.76cdefgh	6.62bcdef	5.79b	26.40c
LM 21709	117.1bcde	12.8ab	49.23abc	74.42abcd	8.25ab	5.77b	24.82c
LM 22527	113.2bcdef	12.04bcd	36.13defg	54.33efghi	5.88cdef	5.75b	26.62c
LM 22099	107.8cdef	10.65defgh	35.68defg	51.45fghi	5.45cdef	5.63bc	22.69c
LM 22575	108.2bcdef	11.56bcde	35.94defg	55.39defghi	5.54cdef	5.49bcd	21.80c
LM 22001	103.9def	11.07cdefg	31.31fg	49.14hi	4.64def	5.46bcd	21.65c
LM 21874	106.2cdef	9.75fgh	36.52defg	55.2defghi	5.55cdef	5.45bcd	27.11c
LM 21864	108cdef	10.36efgh	34.66efg	53.87efghi	5.32cdef	5.40bcd	24.30c
LM 21886	106.3cdef	11.34cdef	43.37abcde	65.84bcdef	6.60bcdef	5.20bcd	28.04c
LM 21884	104.7def	10.46defgh	29.48fg	46.44i	4.40f	5.29bcd	28.65bc
LM 21839	102.2def	10.16efgh	38.69cdefg	57.4defghi	5.61cdef	5.15bcd	21.46c
LM 21706	97.19ef	9.58ghi	36.01defg	57.93defghi	4.99cdef	4.87cd	22.77c
LM 21836	96.37ef	8.58ij	49.47abc	75.42abcd	6.81bcd	4.81cd	26.09c
LM 21881	92.52f	9.31hi	53.70ab	81.89ab	6.99bc	4.48d	25.09c
LM 21787	90.33f	8.07j	35.05efg	55.96defghi	4.53ef	4.38d	23.52c

Note: *control oil palm material; Numbers followed by the same letter in the same column are not significantly different based on DMRT at α = 0.05; FFB = fresh fruit bunch yield; BN = number of bunch; OY = oil yield; K/B = kernel to bunch; K/F = Kernel to fruit; KY = kernel yield; HT = Height increment

CONCLUSION

Genetic variability was found among the studied oil palm progeny population, indicating that selection can be done in that oil palm population for the traits of interest. The phenotypic coefficient of variation was relatively higher than the corresponding genotypic coefficient of variation for all the characters. High heritability coupled with moderate expected genetic advance as percent of mean for all the traits were obtained in this study. Selection of the best oil palm crossing parents at 10% of selection intensity released LM11087T x LM2749D and LM12960T x LM7409D as superior crossing parents yielding 6.26 ton CPO ha^{-1} per year. Thus they can be used for seed production and in the further breeding program.

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