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Performances of The Oil Palm (Elaeis Guineensis Jacq.) Gerplasm Collection Planted at Yaligimba (DRC)

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***Abstract* – The genetic prospection materials, collected by PORIM in DRC, were planted in trial at Yaligimba Research Station (DRC). The FFB and vegetative development measurements of progenies from 8 ecotypes, 56 sites were evaluated in a field experiment by ecotype, site and progeny. It was noted that progenies from the site located in the worst conditions in mountain performed well and gave the best results when planted in good environment. Progenies with exceptional high yield, close to the best selected progenies have been identified. These materials could be used efficiently for future breeding program.**

***Keywords* – DRC, FFB Production, Prospection, Mountain Site, Vegetative Development.**

I. Introduction

It is evidence, now, that the oil palm, *Elaeis guineensis* Jacq, is originated from the wet forest of Central and West Africa. However, this tree exists in wild, semi-wild and cultivated state not only in Africa, but also in Southeast Asia and Latino America. Most of the oil palms cultivated, surprisingly, came from a few ancestral palms [1]. So the well-known Deli palm, on which the whole of the oil palm industry in Far East is based, derived from only four palms [2]. Despite this, Corley and Lee [3] have shown that the oil palm production has increased fourfold in Malaysia in the last 50 years, half of this being attributed to genetic improvement of material.In order to make more improvement of current selected materials for yield, resistance to diseases and pests, bunch qualities and other desirable characters, the oil palm research programs fully agree on the need of re-establish new germplasm coming from a genetically highly variable populations [2],[4]. In fact, the wide and semi-wide populations of oil palm are deteriorating rapidly in Africa, due to progressive conversion of oil palm groves to agriculture land and other live needs. Then, some exceptional genes from palm groves could be destroyed and lost. Systematic prospection and collections of wild and semi-wild palm groves could help to preserve a high genetic diversity for oil palm industry [2],[5], [6]. The deli palm is a successful example of an introduction material which proved to be well-adopted to its new environment in Far East [2]. Eventual inbreeding depression effects have been observed resulting from the use the RFLP markers to determine genotype variation between oil palm populations [4]. In DRC, former Zaire Republic, the earliest prospection and collection of oil palm materials was carried out before sixty in Southern and Central region by INEAC. Later, the Palm Oil Research Institute of Malaysia (PORIM) exploited the semi-wild oil palm in DRC, one of the biggest centers of wild and semi-wild oil palm The PORIM collection was carried out jointly with the Joint Research Scheme (JRS), in mid-1984. The main aim of this prospection was to sample the oil palm genetic material available in the natural palm groves and to conserve them for the future breeding and selection program. A small part of collected seeds was, therefore, attributed to JRS and planted at Yaligimba Research Department, located at Northern DRC.

The main objective of this paper is therefore to discuss on the growth and yield results of the oil palm from the seeds collected at various sites throughout all the DRC, with different climatic conditions. The yields were compared with some selected progenies planted closely in the same site.

II. Material And Methods

A. Prospection and collection of materials

The prospection and collection of materials, which was carried out in 1984, were described by Rajanaidu and Rao[7]. Briefly, the prospection has covered more than the half of the 2.34 million km^2 of the country and the selected palms came from 56 different sites. The dispersion of collected palms was expressed in three variables: “ecotype”, “site” and “family”. The ecotype referred mainly to the geographic position, as shown in Table I. Palms from the same ecotype were supposed to have grown in the similar soil and climate. The collection materials from DRC were categorized into height (8) ecotypes or locations, named by alphabet letter from A to H. Each location was divided into several sites, from 2 to 11.The site was identified by the name of the nearest region or station where the seeds were collected.

Table I. Details on Ecotypes, Sites and Families of DRC collection germplasm

Ecotype (Location)	Name of known station in ecotype	Number of sites	Number of families	Identification of family code
A	Binga	8	26	0101 – 0807
B	Yaligimba	7	57	0901 – 1507
C	Yangambi	8	52	1601 – 2301
D	Boteka	6	36	2401 – 2910
E	Bukavu	2	7	3001 – 3105
F	Lusanga	5	56	3201 – 3607
G	Mapangu	9	69	3702 – 4406
H	Boma	11	52	4601 – 5610
TOTAL		56	356	

The sites of the same ecotype were far from at least some tenskm. So, each site referred to a population and the number of palms sampled by site was at least ten, depending essentially on the number of palms with ripening bunches. The seeds from a bunch and palm were kept separately and, later, planted as a family or progeny. The descendants of one palm or bunch had the same female parent but probably different male parents, due to the open-pollination of the female inflorescence. A total of 369 bunches (progenies) were collected and their characteristics detailed by Rajanaidu and Rao [7].

B. Experimental Design

The seeds from prospection were planted at Yaligimba Research Station, now known as *Creaty*, in Northern DRC, in trial Yaligimba 55. Yaligimba plantation, which area has corresponded to the location "B" in study, has its climate conditions also briefly given in Table II. The seeds from a palm or bunch, known as a family or progeny, were represented only by 10 or 15 palms in field, planted in 2 or 3 replicates. From 365 bunches collected, a total of 356 progenies have been planted. The experiment was conducted as a completely randomized design because of the complete flexibility of this design. The experimental area was uniform, well drained and flat. The soil structure was sandy on the first 25 cm of the top and sandy-clay on the depth. The palms which were planted in mid-1986 on 25 has, received any fertilizer.

The fresh fruit bunches (FFB) were recorded during the first 4 years, from 1990 to 1993. The vegetative development measurements were done only once, at 4 years after planting, using the non-destructive method described by Breure and Verdooren [8]. At this early stage, the growth of palms was not yet influenced by their neighbors and, therefore, the real first development of palms could be efficiently appreciated.

a. Comparative Trials

The same seeds from DRC germplasm collections were planted at Yaligimba, but also at Bangi (Malaysia) by the Palm Oil Research Institute of Malaysia (PORIM). The same materials planted in the 2 different environmental conditions were compared. The Yaligimba results of prospection materials were also compared to the Binga tenera (DxP of expYal 58) and the Dami deli dura. The two comparative trials were planted at the same year, in adjacent area and received the same fertilizers. So, their results could be effectively comparable.

C. Method of Analysis of Data

The FFB yield and vegetative growth parameters were analyzed per ecotype, site and family respectively. The palms from one family included mostly the dura (D), but also a few tenera (T). In order to get reliable estimates of family, the data from both D and T were put together for FFB and palms growths, as it is proved that the D and T sibs do not differ in fruit yield or vegetative development [3]. The differences among ecotypes, sites or families were appreciated by the percentage of trial means and by ranking system. The correlation analysis and the ranking method were considered to investigate on the relationship between the two environment results from Yaligimba (DRC) and Bangi (Malaysia). Probabilities for correlation tests were presented in the text in the form '*' P<0.05,' **' P<0.01 and '***' P<0.001.

III. Results

A. Assessment of the Ecotype Results

The first 4 years FFB yields, summarized in Table III, showed some differences among the ecotype seed origins. The highest yield ecotype, ecotype E located at mountain region, was 36 % above the lowest one, ecotype H, and 19 % above the trial mean (TM).The ecotype A, B, C and D, which were a bit similar as located all in equatorial regions, yielded closely, except the ecotype C. The highest yield ecotype gave also the highest number of small bunches per palm, while the ecotype D, located in swampy equatorial forest area, corresponded to the highest bunch weight. The variation (CV) among the 8 ecotypes was a bit higher for the number of bunches than for the bunch weight.

Table II. Geographic descriptions and climates of the different ecotypes of collection germplasm materials

Ecotype	Geographic position in country	Coordinates Lat - Long E	Rainfall mm.year^{-1}	Nb months dry <10mm	Geographic description and climate
A	North-West	0203N-2021	1700-2200	0	Equatorial climate, forest region, inland soils, 500 m asl, 25°C.
B	North	0217N-2251	1700-2200	0	Equatorial climate, forest region, inland soils, 500 m asl, 25°C.
C	North	0046N-2431	1700-2200	0	Equatorial climate, forest region, inland soils, 500 m as sea level, 25C.
D	Central	0019N-1858	1700-2200	0	Equatorial climate, forest region, inland soils, 400 m as sea level, 25°C.
E	South-East	0324S-2907	1000-1500	4	Humid tropical climate, mountain area: 2000 m, volcanic soils, 20.5°C.
F	South	0451S-1842	1000-1500	4	Humid tropical climate, savanna area: 500 m, inland soils, 24.5°C.
G	South	0420S-2024	1200-1500	3	Humid tropical climate, forest region, 500 m, inland soils, 24.5°C.
H	S-West	0506S-1214	1000-1500	4	Humid tropical climate, coastland area, 500 m, coast soils, 24.5°C.

B. Assessment of Site Results

Table 4 presents the FFB yield for the first 4 years and the early vegetative growth, only for the 10 yieldest sites among the 56 prospection sites. The 2 highest yield sites were Bukavu, from ecotype E, and Kisantu, from ecotype F. These sites produced respectively 25 % and 22 % above the trial mean. The 2 sites gave the highest number of bunches. Curiously, these 2 sites came from the marginal areas for oil palm growth, characterized by highwater deficit for both and low temperature for Bukavusite as located in the mountain. The Bongimba II and Boteka II sites, which yielded respectively 15 % and 9 % above the trial mean (TM), were characterized by the highest bunch weight of 20 % above the trial mean. Among the 10 yieldest sites above or equal to the trial mean, 2 came from ecotype E (100 % of sites existing in ecotype E), 4 from ecotype B (57 % of sites in ecotype B) and only 1 from ecotype A, D, H, G respectively, which all at least 6 sites. The ecotype H and F which gave the lowest percentage of sites above the trial mean, were located in the dry area with high water deficit. At the early stage of growth of oil palm (3 years after planting), the difference between sites was no remarkable. Nevertheless, the palms of Bongimba II sites seem to grow faster than the others while highest yield site, Bukavu, showed an acceptable growth.

C. Assessment of Family Results

Only the performances of the 6 highest yield families (progenies) were concerned in Table 5. These families were from ecotypes A, C, D and E. All the 4 ecotypes were located in the equatorial forest area.Among these 6 best families, 3 came from ecotype E and 3 from the 3 other ecotypes. As far as the 4 first production years, the families 1805 (ecotype C) and 3001, 3104, 3101 (ecotypeE) seemed to be the best ones, despite their low bunch weight.

Table III. Mean FFB yield of the first four years per Ecotype (from the yieldest to the lowest)

Location	FFB palm.year^{-1}		Nb bunches.year^{-1}		Bunch weight		Ranking	
	Kg	% mean	Number	% mean	Kg	% mean	Exp. Yal	Porim*
E	49.9	119	10.6	126	4.7	94	1	1
B	44.5	106	8.5	102	5.2	104	2	7
A	43.5	103	8.4	99	5.2	104	3	8
D	42.1	100	7.9	94	5.4	108	4	2
G	41.9	100	7.9	94	5.3	106	5	3
F	39.8	95	8.0	96	5.0	100	6	6
C	38.0	90	7.4	88	5.2	104	7	5
H	36.6	87	8.5	101	4.3	86	8	4
Mean	42.0	100	8.4	100	5.0	100		
CV %	11.0		12.6		17.3			

*Porim: Palm oil research institute of Malaysia

Table IV. Performances and references of the 10 yieldest sites and their vegetative growth data.

Site name	Ecotype reference	Nb of families in site	FFB yield in % of trial mean	FFB Porim Rank	Height (cm)	Leaf area for leaf 17 (m^2)
Bukavu	E	2	125	1	24	3.43
Kisantu	H	2	122	8	27	3.10
Ndeke	B	7	121	12	29	3.30
Lisala II	B	9	118	13	23	3.32
Bongimba II	G	6	115	7	37	3.52
Uvira	E	5	113	3	23	2.77
Boteka I	D	10	113	10	31	3.40
Gwenzele	A	5	112	15	27	3.42
Lisala III	B	11	112	16	27	3.44
Ebonda I	B	5	112	12	23	3.21
Trial mean			100		27	3.27

Table V. Performances of the six (6) FFB yieldest families and their references

Family number	Location referred	FFB per palm per year		Number of bunches		Bunch weight	
		Kg	% of mean	Nb.year	% mean	Kg	% mean
1805	C	64.7	154	8.5	100	7.5	150
3001	E	62.7	149	11.5	135	5.5	110
3104	E	62.6	149	13.3	156	4.7	94
3101	E	62.3	148	15.2	179	4.1	82
2502	D	61.8	147	10.0	118	6.2	124
0609	A	61.6	147	10.7	126	5.8	116
Trial mean		42.0	100	8.5	100	5.0	100

D. Comparative Results in Two Different Environment Conditions

The first comparison of performances for DRC prospection materials concerned the first 4 years FFB yields from plantation of Yaligimba, in DRC, and the first 4 years yields from plantation of Bangi, in Malaysia. These comparisons were essentially based on the ranking of results, as given in Table III and IV, and also on the value of the correlation coefficients (r). Table VI. Despites the low FFB yield of Yaligimba compared to Bangi (Porim), the two results were a bit similar. The correlation coefficient for FFB yields was highly significant for the family, significant for the site and not significant for the ecotype. The bunch weight correlation values were higher than those of bunch number or FFB production. This means that the bunch weight was influenced in the same way in the 2 environment conditions. The sites and families gave higher relations than the ecotype due mainly to the low number of ecotypes in study. One could note that at Yaligimba trials, the comparison of the highest yield families from the prospection materials with the highest yield progenies from an adjoining trial denoted exceptional performances from some of the unselected families. Considering the FFB results, the best prospection progeny (progeny 1805) yielded 64.7 $kg.palm^{-1}.year^{-1}$while the DxP progeny (Ya199) has produced 66.3 $kg.palm^{-1}.year^{-1}$.

Table VI. Coefficients of correlations between Yaligimba (DRC) and Bangi (Malaysia) results

Parameter considered	Trial mean results		Ecotype		Site		Family	
	YAL	BANGI	R value	Level	R value	Level	R value	Level
FFB	42.0	87.5	0.45	Ns	0.30	*	0.32	***
Nb bunch	8.4	10.0	0.73	*	0.44	***	0.30	**
Bunch wgt	5.0	8.9	0.96	***	0.54	***	0.31	**
Height	25	190	0.82	*	0.68	***	0.54	***
LA/RL§	3.1	496	0.61	Ns	0.51	***	0.33	***

Degree of freedom: ecotype = 6; site = 54; family = 323§ correlation of LA with RL (LA: leaf area for Yal / RL: rachis length Bangi)

IV. Discussions

The prospection materials from D.R. Congo, planted at Yaligimba, were analyzed per ecotype, site and family respectively. The ecotype E, located at the mountain area, 1500 to 2000 m as sea level, characterized by low temperature and dry season, surprisingly showed the highest FFB yield at Yaligimba (DRC) and also at Bangi (Malaysia). The palms from this ecotype yielded respectively 19 % and 21 % above the trial mean for Yaligimba and Bangi trials respectively. As the seeds of the ecotype E came from an unsuitable area for oil palm, this may have caused the plant to struggle for adaptation. This natural selection has surely created palms more resistant to the worst environmental conditions and therefore these palms yielded better in best conditions. In contrast from the ecotype E, the ecotype F and H located also in low altitude with dry season areas and high water balance deficit, yielded lows.

In Nigeria, Rajanaidu and Rao [7] reported also lowest yield for materials of sites in dry season. The ecotypes A, B, C and D, located in equatorial forest region, gave all acceptable yields above the trial mean. Rosenquist [1] also noted from the Nigeria collection materials that all the best populations were from the sites close to the high rainfall area of 2250 mm. Choong *et al* [9] obtained high polymorphism index value from these ecotypes located in equatorial climate and concluded that the intensive human activity due to Congo river may be one of the factors increasing the degree of polymorphism. The analyses of family results confirmed the existence of some exceptional yielding families, like progeny 1805. In fact, it is known that the average quality in some of grove palms is remarkably good [2], [10]. Rajanaidu et al. [5] noted that some of the Nigeria collection palms were very high yielding, dwarf and possess some characteristics matching the best deli dura or the selected tenera.

V. Conclusion

The genetic prospection materials, collected by PORIM in DRC, were planted in trial at Yaligimba Research Station. The FFB and vegetative development measurements have shown that the 2 best yield sites were located in the worst conditions, which are respectively the mountain region with low temperature and the drastic dry season region with 5 months without rain. As the seeds of these sites came from an unsuitable area for oil palm, this may have caused the plant to struggle for adaptation. This natural selection may create palms resistant to the worst environmental conditions and therefore yielding better in best conditions. Progenies with exceptional high yield, close to the best selected progenies have been identified. These materials could be used efficiently for future breeding program.

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References

[1] E.A. Rosenquist, “ An overview of breeding technology and selection in Elaeis guineensis”. In: *Proc. 1989 Int. Palm Oil Dev. Conf.-Agriculture* (Ed BS Jalani et al.), 1990, pp. 5-26, Palm Oil Res. Inst. Malaysia, Kuala Lumpur.

[2] R.H.V. Corley and P. B. Tinker, *The oil palm*. 4e edition, Blackwell Science Ltd. Oxford, 2003, ch.3.

[3] R.H.V. Corley and C.H. Lee, "The physiological basis for genetic improvement of oil palm in Malaysia".1992, *Euphytica* 60, pp. 179-184.

[4] S. Mayes, P.L. Jack , D. Marshall and R.H.V. Corley "The use of molecular markers to investigate the genetic structure of an oil palm breeding programme", 2000, *Heredity* 85 288-293N.

[5] A. Rajanaidu, A. Kushairi, M. Rafii, A. Mohd Din, I. Maizura and B.S. Jalani, "Oil palm breeding and genetic ressources". In: *Advances in oil palm research* Vol. I (Eds Y Basiron, BS Jalani& Chan KW), 2000, pp. 171-237, Palm Oil Res. Inst., Kuala Lumpur.

[6] E. Sapey, K. Adusei-Fosu, D. Agyei-Dwarko and G. Okyere-Boateng , "Collection of oil palm (Elaeis guineensis Jacq.) germplasm in the Northern regions of Ghana". *Asia Journal of Agriculture Sciences,* 2012, 4, pp. 325-328.

[7] N. Rajanaidu and V. Rao, "Oil palm genetic collections: their performance and use to the industry". In: *Proc. Of 1987 Int. O.P./P.O. Conf.-Agriculture* (EdsHalim Hassan A, Chew P S, Wood BJ, Pushparajah E),1988, pp. 59-85, Palm Oil Res. Inst., Kuala Lumpur.

[8] C.J. Breure and L.R. Verdooren, " Guidelines for testing and selecting parent palms in oil palm. Practical aspects and statistical methods", *ASD Oil Palm Papers*, 1995, 9 pp. 1-10.

[9] C.Y. Choong, F.H. Shah, N. Rajanaidu, A.H. Zakri, "Isoenzyme variation of Zairean oil palm (*Elaeis guineensis* Jacq.) germplasm".1996, *Elaeis* 8, pp. 45-53.

[10] K. P. Prabhakaran Nair, *The agronomy and economy of important tree crops of the developping world*. Ed. Elsevier Inc., 1e ed., London, 2010.

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Three of the Published research papers:

1. Luyindula N., Corley R. H. V. and Mantantu N., 2005. A comparison of Deli Dumpy and PobéDwartf short-stemmed oil palms and their outcrossed progenies.*Journ. O. P. Res*., Malaysia, 17:152-159.
2. Luyindula N., Mantantu N., Dumortier F. and Corley R. H. V., 2005. Effect of inbreeding on growth and production of oil palm.*Euphytica*(Netherland) 143:9-17.
3. Luyindula N. and Mariaul E., 1995. Response of coconuts to fetilizers in Zaire.*Trop. Agric.* (Trinidad) 72: 188-193.