AGRONOMIC PERFORMANCE AND GENETIC VARIABILITY OF *Dura x Pisifera* PROGENIES

Keywords: *Elaeis guineensis*, yield, bunch quality components, morphophysiological traits, North Carolina Model I, genetic analysis, variation.

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Wide variations for bunch yields, bunch quality components and morphophysiologicak traits were noted among 52 dura x pisifera (DxP) progenies derived from a North Carolina Model I mating design. Exceptional fresh fruit bunch yields were achieved by progenies producing high bunch number of moderate sized bunches. Progenies producing bunches of high fruit (FIB), mesocarp (M/B) and kernel (K/B) contents achieved outstanding production of total economic products (TEP). Tall progenies, on average, had higher TEP attributed to the higher ratio of bunch dry matter to vegetative dry matter. Correlations among the economically important component traits were generally meaningful and any significant change in yield involved an increase in the number of bunches. Analysis of variance for yield and bunch quality components showed substantial genetic variation with several traits showing male effects, indicating additive gene action. The results suggested that palm height is inherited through the male parent. However, further introgression of the pisifera parent is required to improve the economic yield of its shorter progenies. Estimates of genetical variance components of data pooled over replications were higher than those of the individual replications, with the highest estimates from data pooled over years. Pooling of data reduced the error variances, suggesting seasonal effects and, therefore, more years of data are necessary for efficient selection programmes. The Serdang pisiferas, *20A/112 and 20A/8, introgressed with AVROS* pisifera *generated DxP progenies with high kernel yields, while those arising from AVROS x S27B* pisiferas *produced high oil yields. The mean performance and genetic structure of the materials suggested that the potential parental genotypes for high overall oil yields are the* duras *of Ulu Remis, Bunting, intracrosses of the Elmina, and the* pisiferas *of Lever Cameroon, Lever Nigeria and introgressed Serdang x AVROS.*

INTRODUCTION

The African oil palm *(Elaeis guineensis* Jacq.) has three fruit forms characterized by the monofactorially inherited shell thickness trait (Beirnaert and Vanderweyen, 1941). The thin-shelled *tenera* is the commercial planting material and is a hybrid between the thick-shelled *dura* and *shell-lesspisifera.* The oil palm industry in South-east Asia developed from four *dura* palms planted in 1848 at the Bogor Botanical Gardens in Java, Indonesia (Hartley, 1988). Progenitors of these palms gave rise to the Deli *dura* population (Hardon and Thomas, 1968). Selections within the Deli *dura* generated the Elmina, Ulu Remis (URD), Banting (BD) and Johore Labis (JLD) populations, and they are commonly crossed with the Yangambi and AVROS*pisiferas* in seed production programmes in Malaysia.

Early breeding efforts in Malaysia (Rajanaidu and Rao, 1988), and elsewhere were confined to selection within the Deli *dura* and a handful of African *pisifera* populations (Rosenquist, 1986). Population improvement is tedious because most of the economically important components are governed by polygenic systems with large environmental influence. In addition, several traits are usually linked and correlation between them are common In genetical analysis of the quantitative traits, the monoecious nature of oil palm can be accommodated by several mating designs and the North Carolina Model I (NCM I) design (Comstock and Robinson, 1952) is commonly used. The design estimates additive and dominance variances and heritability from both half- and full-sib families.

A total of *52 dura xpisifera* (DxP) progenies derived from NCM I mating design were evaluated for yield, bunch quality and morphophysiological traits with the objective of selecting superior parental genotypes for seed production based on progeny test performance.

MATERIALS AND METHODS

Selected advanced oil palm genetic materials available at the Palm Oil Research Institute of Malaysia (PORIM), Research Station, Serdang were mated in an NCM I design. A total of 52 *mf* (number of males x number of females) progenies were generated by randomly crossing each of 17 *pisiferas* (male, *m*) with separate sets of two to five *duras* (female, *f*) drawn from different populations *(Table 1*). The 52 DxP progenies were laid out as Trial 0.180 in a completely randomized design (CRD) with five randomized palms per progeny per block and replicated three times. A total of 780 experimental palms were planted in October 1982 at a density of 148 palms ha^{-1} on Rengam Series (inland) soil at PORIM Research Station Kluang, Malaysia. The mean annual rainfall for the Station between 1982-1996 was 2370 mm yr^{-1}, and evenly distributed.

Harvesting of fruit bunches, at regular intervals of seven to 10 days, was initiated at 36 months after field planting. The number of bunches harvested and their weights were recorded at each harvesting round between January 1986 and December 1991. Three to five bunches per palm were concurrently analysed for the quality traits using the 'bunch analysis' technique (Blaak *et al.,* 1963; Rao et *al.,* 1983). One round of non-destructive vegetative growth measurements (Corley and Breure, 1981) was taken in October 1990. Physiological parameters were estimated (Squire, 1984; 1986) based on data of vegetative measurements, bunch yields and bunch quality.

TABLE 1. PEDIGREES OF ***Dura*** x ***Pisifera*** PROGENIES IN TRIAL 0.180 PLANTED IN OCTOBER 1982 AT **PORIM** RESEARCH STATION, KLUANG. MALAYSIA

No.	Progeny	*Pisifera* code (C♀ x D♂)	Parents (A♀ x B♂)♀	Parents (C♀ x D♂)♂	Grandparents (ABCD) A♀	B♂	C♀	D♂
1	MS 2589	180P1	3A/12.1	0.791318	E152	E206	KB AVROS 4/27	KB AVROS 4/8
2	MS 2655	180P1	3AJ5.5	0.79/318	E206	E268	KB AVROS 4/27	KB AVROS 4/8
3	MS 2637	180P1	3AJ3.5	0.791318	E206	E206	KB AVROS 4/27	KB AVRQS 4/8
4	MS 2134	180P2	0.117/1325	0.109/105	HE	HE	20A/34	UR(T)2
5	MS 2226	180P2	0.10218326	0.109/105	4151.2 [E120]	4J51.2 [E120]	20A/34	UR(T)2
6	MS 2227	180P2	0.102/8324	0.109/105	4/3.7 [E211]	4/3.7 [E211]	20A/34	UR(T)2
7	MS 2228	180P2	0.102/8284	0.109/105	4J7.9 [E211]	UR321/1 x UR293/2	20A/34	UR(T)2
8	MS 2202	180P3	0.80/591	0.109/110	0.3/12.3 [E152 xE206]	4/49 [E93]	20A/34	UR(T)2
9	MS2246	180P3	0.10218524	0.109/110	4144.1 [E97]	4J42.1 [E152]	20A/34	UR(T)2
10	MS 2328	180P3	0.10218555	0.109/110	4J3.7 [E211]	4/3.7 [E211]	20A/34	UR(T)2
11	MS 2329	180P4	0.82/2316	0.109/150	B(D)5a	B(D)5a	LN(T)2	LN(T)2
12	MS 2335	180P4	0.8212300	0.109/150	Anon	Anon	LN(T)2	LN(T)2
13	MS 2338	180P4	0.102/8242	0.109/150	4J3.7 [E211]	413.4 [E211]	LN(T)2	LN(T)2
14	MS 2374	180P4	0.8514338	0.109/150	HE 759 [0.3/14.2x0.3/1.71	HE 184 [0.3/112.3x0.3/1.1]	LN(T)2	LN(T)2
15	MS 2253	180P5	0.85/4238	0.1091314	B(D)5a	B(D)5a	W(T)9	W(T)9
16	MS 2258	180P5	0.10218282	0.1091314	ZE 33.18	ZE 50.14	W(T)9	W(T)9
17	MS 2291	180P5	0.10218085	0.1091314	4158.1 [E268]	4J58.1 [E268]	W(T)9	W(T)9
18	MS 2157	180P6	0.10418745	0.10819596	4J3.7 [E211]	413.7 [E211]	HE ZB C.96	KB AVROS 4/8
19	MS 2172	180P6	0.10318659	0.108/9696	4/3.7 [E211]	4/3.7 [E211]	HE ZB C.96	KB AVROS 4/8
20	MS 2220	180P6	0.85/4315	0.108/9696	20A/68 [0.3/1.7xN.P]	0.3/1.7 [E206]	HE ZB C.96	KB AVROS 4/8
21	MS 2230	180P6	0.102/8352	0.10819696	UR(D)6b	UR(D)6b	HE ZB C.96	KB AVROS 4/8
22	MS 2334	180P7	0.82/2376	0.110/9745	B(D)5a	B(D)5a	20A/31	KB AVROS 4/8
23	MS 2340	180P7	0.102/8365	0.11019745	ZE 19.2	ZE 23.15	20A/31	KB AVROS 4/8
24	MS 2295	180P8	0.82/2320	0.116/1099	B(D)5a	B(D)5a	HE ZEJ39.17	S29.36
25	MS 2310	180P8	0.102/8450	0.11611099	413.7 [E211]	413.7 [E211]	HE ZE139.17	S29.36
26	MS 2204	180P9	0.82/2313	0.116/1131	Anon	Anon	ZE 29.6	S27B

Continued next page.

TABLE 1. (Continued)

No.	Progeny	*Pisifera* code (C♀ x D♂)	Parents (A♀ x B♂)♀	(C♀ x D♂)♂	Grandparents (ABCD) A ♀	B♂	C♀	D♂
27	MS 2206	180P9	0.801148	0.116/1131	Elmina	Elmina	ZE 29.6	S27B
28	MS 2243	180P9	0.10218497	0.116/1131	4/7.9 [E211]	UR321/1 x UR293/2	ZE 29.6	S27B
29	MS 2278	180P9	0.102/8101	0.116/1131	UR(d)6b	UR(D)6b	ZE 29.6	S27B
30	MS 2279	180P9	0.10218182	0.116/1131	4/3.7 [E211]	4/3.7 [E211]	ZE 29.6	S27B
31	MS 2259	180P10	0.10218252	0.116/1141	4/58.1 [E268]	4/58.1 [E268]	ZE 29.6	S27B
32	MS 2298	180P10	0.10218365	0.116/1144	ZE 19.2	ZE 23.15	ZE 29.6	S27B
33	MS 2422	180P11	0.105/9044	0.116/1180	JL(d)2b	JL(D)2b	HE ZE 26/3	KB AVROS 4/18
34	MS 2424	180P11	0.104/8755	0.116/1180	4127.2 [E207]	4/58.11 [E268]	HE ZE 26/3	KB AVROS 4/18
35	MS 2373	180P12	0.10218365	0.116/1183	HE ZE 19.2	HE ZE 23.15	HE ZE 26/3	KB AVROS 4/18
36	MS 2375	180P12	0.8514223	0.116/1183	B(D)4b	B(D)4b	HE ZE 26/3	KB AVROS 4/18
37	MS 2537	180P12	0.117/1540	0.116/1183	ZG 14 2/12	ZG 12 6/14	HE ZE 26/3	KB AVROS 4/18
38	MS 2112	180P13	0.10418889	0.116/1227	4/3.7 [E211]	4/3.7 [E211]	KB AVROS 4/34	20A/112
39	MS 2116	180P13	0.10218283	0.116/1227	ZE 48.13	ZE 80.14	KB AVROS 4/34	20A/112
40	MS 2133	180P13	0.11711325	0.116/1227	HE	HE	KB AVROS 4/34	20A/112
41	MS 2425	180P14	0.105/8921	0.116/1235	JL(D) 5a	JL(D) 5a	KB AVROS 4/34	20A/112
42	MS 2431	180P14	0.82/2369	0.116/1235	B(D)5a	B(D)5a	KB AVROS 4/34	20A/112
43	MS 2438	180P14	0.10518973	0.116/1235	JL(D)7a	JL(D)7a	KB AVROS 4/34	20A/112
44	MS 2099	180P15	0.117/1631	0.116/1286	ZG 12 19/18	Ze 13/19	HE ZE/B2/14/20	KB AVROS 4/12
45	MS 2111	180P15	0.150/9011	0.116/1286	UR(D)9a	UR(D)9a	HE ZE/B2/14/20	KB AVROS 4/12
46	MS 2114	180P15	0.117/1626	0.116/1286	ZG 14 4/3	ZE 12/17	HE ZE/B2/14/20	KB AVROS 4/12
47	MS 2308	180P16	0.801683	0.116/1303	HE 667 [0.3/14.2x0.3/1.7]	HE 184 [0.3/14.2x0.3/1.1]	HE ZE/B2/26.3	KB AVROS 4/12
48	MS 2316	180P16	0.10218532	0.116/1303	4/58.1 [E268]	4/58.1 [E268]	HE ZE/B2/26.3	KB AVROS 4/12
49	MS 2332	180P16	0.801545	0.116/1303	4/41.9 [E268]	4/41.9 [E268]	HE ZE/B2/26.3	KB AVROS 4/12
50	MS 2434	180P17	0.105/9077	0.116/1438	UR(D)5a	UR(D)5a	HE ZE/B13	HE(34/12 x19/20)
51	MS 2435	180P17	0.105/9078	0.116/1438	UR(D)5a	UR(D)5a	HE ZE/B 13	HE(34/12 x19/20)
52	MS 2437	180P17	0.10518997	0.116/1438	4/47.2 [E216]	KB BLK 1/3	HE ZE/B13	HE(34/12 x19/20)

Note:
[ ] Great grandparent. Parents for 0.3/14.2 and 0.3/12.3 were E152 x E206, parents for 0.3/1.7 and 0.3/1.1 were E206 x E206. Parents for KB AVROS were AVROS 1107 x 10/119.

In common with perennial tree crop experiments, missing plants are common in oil palm trials. Thus, the number of palms per progeny (full-sib family) in each replication was often not a constant (five) and the results of variance ratio tests were only approximations. In the analysis of variance (ANOVA), the missing values were accommodated by reducing the degrees of freedom (df) of the error item, and coefficients of the variance components of the expected mean squares (EMS) were adjusted using the harmonic mean (Steel and Torrie, 1981) of the number of palms in each full-sib family. The unequal number (two-five) of durus-within-*pisifera* were adjusted in the same manner. ANOVA, least significant difference (LSD) and phenotypic correlations were generated using Statistical Analysis System (SAS) programmes. All analyses were based on individual palms, using a random model with the assumptions of no epistasis and no inbreeding (Comstock and Robinson, 1952). The squared value of the correlation coefficient (r) is a reliable estimate of the genetical relationship between a pair of traits. ANOVA was done separately for data of individual blocks, pooled blocks and pooled over years.

The structure of ANOVA for the individual blocks for each set off number of durus-within-*pisifera* and *m* number of *pisiferas,* as shown in *Table* 2, had the following expectations:

$$Y_{ijk} = \mu + m_i + f_{ij} + \epsilon_{ijk}$$

where Y_{ijk} = observation, μ = overall mean, m_i = effect ofpisifera *i,* f_{ij} = effect of *dura j* within *pisiferu i* and ϵ_{ijk} = experimental error.

The test of significance was by the simple variance ratio. However, when the duras-within-*pisifera* item (MS2) was not significantly different from that of the seedlings item (MS3), both mean squares were combined, giving the pooled mean square (MSp). The MSp was obtained by dividing the pooled sum of squares (SSp) of these items with the pooled degree of freedom (dfp). Following this, the test of significance for the *pisiferas* items became:

$$Pisiferus\ (M) = MS1/MSp$$

When *f* number of duras-within-pisifera from *m* number of *pisiferus* were grown in a completely randomized design with *r* blocks, the structure of the ANOVA, where the data were considered as a whole, is shown in *Table 3. The* analysis had the following expectations:

$$Y_{ijk} = \mu + m_i + f_{ij} + r_k + mr_{ik} + fr_{ijk} + \epsilon_{ijk}$$

where Y_{ijk} = observation, μ = overall mean, m_i = effect of *pisifera i,* f_{ij} = effect of *dura* j within *pisiferu i,* r_k = effect of replication k, mr_{ik} = effect of interaction of*pisifera i* with replication k , fr_{ijk} =effect of interaction of *dura* j withinpisifera *i* with replication k and ϵ_{ijk} = experimental error.

While most F-tests were by the simple variance ratio, the synthesis method was adopted for the *pisiferas* component when the *pisiferas* x replication (MxR) item was significant:

$$Pisiferas\ (M) = \frac{(MS2 + MS5)}{(MS3 + MS4)}$$

The degrees of freedom of the numerator (df_n) and denominator (df_d) for the synthesis method (Satterthwaite, 1946; Cochran and Cox, 1957) were derived as follows:

$$df_n = \frac{(MS2 + MS5)^2}{[(MS2^2/df2) + (MS5^2/df5)]}$$

where df2 is the df of the *pisifera* item, and df5 is df of the F x R item.

$$df_d = \frac{(MS3 + MS4)^2}{[(MS3^2/df3) + (MS4^2/df4)]}$$

where df3 is the df of the duras-within-*pisifera* item, and df4 is the df of the M x R item.

Various error terms were used for the variance ratio test. For example, MS5 and MS6 were pooled when the former item was non-significant and the resulting pooled error term, MSp1, used to test MS4. Similarly, when both the interaction items, MS4 and MS5, were non-significant, they were pooled with MS6 to arrive at the second error term, MSp2, for the test of significance of the *duras-within-pisifera* and replications items.

TABLE 2. GENERALIZED ANALYSIS OF VARIANCE OF DATA IN INDIVIDUAL REPLICATES (blocks)

Source	df	MS	EMS§
Pisiferas (M)	m-l	MSI	$\sigma^2_w + n'\sigma^2_f + n''\sigma^2_m$
Duras-within-pisifera (F)	m(f-1)	MS2	$\sigma^2_w + n'\sigma^2_f$
Seedlings (W)	mf(n-1)-v‡	MS3	σ^2_w

Notes :

§ n' and n" = harmonic mean of number of palms in full-sib families.

f = harmonic mean of number of duras-within-pisifera.

σ^2_m = progeny variance arising from genetic differences among *pisifera* parents.

σ^2_f = progeny variance arising from genetic differences among *duras-within-pisifera* parents.

σ^2_w = error variance among plots of the same progeny.

‡v = missing values.

TABLE 3. GENERALIZED ANALYSIS OF VARIANCE OF DATA POOLED OVER REPLICATIONS

Source	df	MS	EMS §
Replications (R)	r-l	MS1	$\sigma^2_w + n'\sigma^2_{fr} + n'f\sigma^2_{mr} + n'mf\sigma^2_r$
Pisiferas (M)	m-1	MS2	$\sigma^2_w + n'\sigma^2_{fr} + n'r\sigma^2_f + n'f\sigma^2_{mr} + n'rf\sigma^2_m$
Duras-within-pisifera (F)	m(f-1)	MS3	$\sigma^2_w + n'\sigma^2_{fr} + n'r\sigma^2_f$
M x R	(m-1)(r-1)	MS4	$\sigma^2_w + n'\sigma^2_{fr} + n'f\sigma^2_{mr}$
F x R	m(f-1)(r-1)	MS5	$\sigma^2_w + n'\sigma^2_{fr}$
Seedlings (W)	mfr(n-1)-v ‡	MS6	σ^2_w +

Notes:

§ n' = harmonic mean of number of palms in full-sib family.

f = harmonic mean of number of *duras-within-pisifera*.

σ^2 = variance due to replication.

σ^2_m = progeny variance arising from genetic differences among *pisifera* parents.

σ^2_f = progeny variance arising from genetic differences among *duras-within-pisifera* parents

σ^2_{mr} = progeny variance arising from interaction of genotypes of *pisifera* parents with replication.

σ^2_{fr} = progeny variance arising from interaction of genotypes of *duras-within-pisifera* parents with replication.

σ^2_w = error variance.

v = missing values.

Besides the individual and pooled replication analyses, ANOVA of data pooled over years was carried out for bunch yield. The analysis was to determine whether bunch yield was consistent over the years, as the yield of oil palm generally follows a sigmoid curve with a plateau in the tenth to twelfth years after field planting. In the early years, the yield increases as the bunches get progressively larger but fewer in number. This period is generally considered distinctly different from the next phase during which the yield first stabilizes then gradually declines.

The structure of the ANOVA for data pooled

TABLE 4. GENERALIZED ANALYSIS OF VARIANCE OF DATA POOLED OVER YEARS

Source	df	MS	EMS
Replications (R)	r-1	MS 1	$\sigma^2_w + n'\sigma^2_{fr} + n'f\sigma^2_{mr} + n'fm\sigma^2_r$
Pisiferus (M)	m-1	MS 2	$\sigma^2_w + n'\sigma^2_{fr} + n'r\sigma^2_f + n'f\sigma^2_{mr} + n'rf\sigma^2_m$
M x R	(m-1)(r-1)	MS 3	$\sigma^2_w + n'\sigma^2_{fr} + n'f\sigma^2_{mr}$
Duras/pisifera (F)	m(f-1)	MS 4	$\sigma^2_w + n'\sigma^2_{fr} + n'r\sigma^2_f$
F x R	m(f-1)(r-1)	MS 5	$\sigma^2_w + n'\sigma^2_{fr}$
Years (Y)	y-1	MS 6	$\sigma^2_w + n'\sigma^2_{yfr} + n'f\sigma^2_{ymr} + n'r\sigma^2_{yf} + n'rf\sigma^2_{ym} + n'fm\sigma^2_{yr} + n'f$…
Y x R	(y-1)(r-1)	MS 7	$\sigma^2_w + n'\sigma^2_{yfr} + n'f\sigma^2_{ymr} + n'fm\sigma^2_{yr}$
Y x M	(y-1)(m-1)	MS 8	$\sigma^2_w + n'\sigma^2_{yfr} + n'f\sigma^2_{ymr} + n'r\sigma^2_{yf} + n'rf\sigma^2_{ym}$
Y x F	(y-1)m(f-1)	MS 9	$\sigma^2_w + n'\sigma^2_{yfr} + n'\rho\sigma^2_{yf}$
Y x M x R	(y-1)(m-1)(r-1)	MS10	$\sigma^2_w + n'\sigma^2_{yfr} + n'f\sigma^2_{ymr}$
Y x F x R	(y-1)m(f-1)(r-1)	MS11	$\sigma^2_w + n'\sigma^2_{yfr}$
Seedlings (W)	rmfy(n-1)-v‡	MS12	σ^2_w

Note: ‡v = missing values.

over years, where only the genetical variance components of the EMS were considered, shown in ***Table*** 4, had the following expectations:

$$\Upsilon_{ijkl} = \mu + m_i + f_{ij} + r_k + mr_{ik} + fr_{ijk} + y_l + yr_{kl} + my_{il} + fy_{jl} + mry_{ikl} + fryj_{kl} + \in_{ijkl}$$

where Υ_{ijkl} = observation, μ = overall mean, m_i = effect of *pisifera i*, f_{ij} = effect of *dura j* within *pisifera i*, r_k = effect of replication k, y_l = effect of year *l*, mr_{ik} = effect of interaction of *pisiferu* i with replication k, fr_{ijk} = effect of interaction of *dura j* within *pisifera i* with replication k, yr_{kl} = effect of interaction of year *l* with replication k, my_{il} = effect of interaction of *pisifera i* with year 1, fy_{ijl}= effect of *dura j* within *pisifera i* with year *l*, mry_{ikl} = effect of interactions of *pisifera i* with replication k and year *l*, fry_{ijkl} = effect of interactions of ***dura*** *j* within *pisifera i* with replication k and year *l* and $\in_{ijk}$ = experimental error.

When the bunch yields were considered separately for each year, the data became voluminous and had to be partitioned into several groups before running SAS. As before, the tests of significance were largely by simple variance ratio and, occasionally, by the synthesis method. While most sources ofvariation were tested directly against their respective error terms, the tests of significance using MSp under non-significant interaction items for the following sources were as follows:

Year x *pisiferas* x replication (YxMxR)	=	MS10/MSp1	where MSp1 = pooled data of MS11 and MS12.
Year x *duras*-within *pisifera* (YxF)	=	MS9/MSp2	where MSp2 = pooled data of MS10, MS11 and MS12.
Year x *pisiferas* (YxM)	=	MS8/MSp3	where MSp3 = pooled data of MS9, MS10, MS11 and MS12.

Heritability estimates of *pisiferas* (h^2_m) and duras-within-pisifera (h^2_f) components using intra-class correlation (t) were based on the ratio of genotypic to phenotypic variances (σ^2_p) as follows:

Pisiferas, $t_m = \sigma^2_m / \sigma^2_p$ and $h^2_m / 4t_m$

Duras-within-pisifera,
$t_f = \sigma^2_f / \sigma^2_p$ and $h^2_f / 4t_f$

The estimates of σ^2_p for each intra-class correlation were as follows:

Individual replication:
$\sigma^2_p = \sigma^2_m + \sigma^2_f + \sigma^2_w,$

Pooled over replication:
$\sigma^2_p = \sigma^2_m + \sigma^2_f + \sigma^2_{mr} + \sigma^2_{fr} + \sigma^2_w$

Pooled over years:
$\sigma^2_p = \sigma^2_m + \sigma^2_f + \sigma^2_{mr} + \sigma^2_{fr} + \sigma^2_{ym} + \sigma^2_{yf} + \sigma^2_{ymr} + \sigma^2_{yfr} + \sigma^2_w$

where the value of σ^2_w depends on the appropriate variance component, either of the seedlings item or of the pooled error term.

RESULTS AND DISCUSSION

A high bunch number (BNO) of moderate average bunch weight (ABWT) resulted in a high fresh fruit bunch (FFB) yield (*Tables* 5 and *6*). FFB correlated positively (Table 7) with BNO and ABWT with the magnitude of genetical influence on FFB greater for BNO (r^2 = 39.69%) than for ABWT (r^2 = 19.36%). BNO and ABWT were negatively associated. While bunch size is an important determinant of FFB yield, fruit size had variable effects on bunch composition (*Tables 8* and 9). Although correlations between mean fruit weight (MFW) and the oil-related traits were significant, magnitudes of the relationships were, however, small (*Table* 7). Variation among the progenies for oil to wet mesocarp (O/WM) was apparent, and as expected, the trait was associated significantly with oil to dry mesocarp (O/DM). Progenies with low O/WM and O/DM were disadvantageous for oil yields, as such fruits with large kernels would then be preferable. The UR(D)5a *dura* and 20A/112 *pisifera* may be exploited for high kernel yields On the other hand, an increase in O/WM would appreciably reduce kernel yield for an improved oil yield.

Oil to bunch (O/B) is the product of, and strongly associated with, fruit to bunch (F/B), mesocarp to fruit (M/F) and O/WM. O/B of less than 20% were common among progenies arising from the Elmina and B(D)5a *duras,* while those with higher than 20% common for UR(D)6b-based progenies. Performances (O/B, OPY, TEP) of progenies derived from Highlands Estate *duras* were generally better than those from the Elmina Selection. The E206-based progenies were generally poor in performance compared with other *duras.* Kernel (K/F) and shell (S/F) contents of the fruit were additional sources of variation for O/B, but their influences arose mainly from their strong correlations with M/F. The means for kernel content in fruits and in bunches were comparable to those of commercial progenies from six major seed producers in Malaysia – 9.39% and 6.20%, respectively (Kushairi, 1992).

Improvements in oil content through breeding and selection have been largely due to the increments in M/F. Reducing the shell to very thin in fruits with high kernels is probably not possible as compared to those with high mesocarp. The total economic product (TEP), being the sum of oil per palm per year (OPY) and 60% kernel per palm per year (KPY) produced would be high from bunches of both high mesocarp (M/B) and kernel (K/B) contents, suggesting the importance for maintaining a high F/B, especially in the *dura* parent. When high M/B, K/B and F/B are combined with high O/B and FFB, yields would likely be increased substantially. Fruits of high mesocarp would probably give the highest oil yield, and, therefore, the highest monetary return as compared with those having high kernel yields

Outstanding TEP yields were attributed to the optimum combination of traits associated with increased yields. TEP correlated significantly with all the other characters, except frond index (*Table* 7). Compared with the shorter progenies, the taller ones (*Tables 10* and II), on average, were physiologically superior (*Tables* 12 and 13). However, a small difference between the means of vegetative dry matter

TABLE 5. PROGENY MEANS (1986-1991) FOR FRESH FRUIT BUNCH (FFB), BUNCH NUMBER (BNO) AND AVERAGE BUNCH WEIGHT (ABWT) IN TRIAL 0.180

No.	Pisifera	Progeny	FFB ($kg\ p^{-1}\ yr^{-1}$)	BNO ($No.\ p^{-1}\ yr^{-1}$)	ABWT ($kg\ p^{-1}\ yr^{-1}$)
1	180P1	MS2589	119.45	8.34	14.06
2	180P1	MS2637	120.90	7.22	16.55
3	180P1	MS2655	132.02	10.60	12.89
4	180P2	MS2134	117.24	9.63	12.02
5	180P2	MS2226	151.92	14.39	10.25
6	180P2	MS2227	114.19	11.29	10.04
7	180P2	MS2228	130.14	11.15	' 11.69
8	180P3	MS2202	111.91	9.47	11.92
9	180P3	MS2246	123.88	12.46	10.23
10	180P3	MS2328	105.64	10.32	10.29
11	180P4	MS2329	156.44	12.78	12.47
12	180P4	MS2335	177.08	14.73	12.10
13	180P4	MS2338	138.02	12.16	11.24
14	180P4	MS2374	143.91	12.40	11.90
15	180P5	MS2253	144.86	13.43	11.1%
16	180P5	MS2258	146.96	12.7%	11.64
17	180P5	MS2291	100.22	11.21	8.69
18	180P6	MS2157	109.6%	9.83	11.09
19	180P6	MS2172	100.40	8.44	11.80
20	180P6	MS2200	131.61	8.97	14.70
2%	180P6	MS2230	150.82	11.24	13.96
22	180P7	MS2334	144.31	10.88	13.37
23	180P7	MS2340	119.66	10.11	11.88
24	180P8	MS2295	64.44	7.54	8.63
25	180P8	MS2310	124.68	9.34	13.51
26	180P9	MS2204	138.16	11.79	11.84
27	180P9	MS2206	111.06	8.28	13.49
28	180P9	MS2243	93.40	8.23	10.78
29	180P9	MS2278	145.32	11.60	12.64
30	180P9	MS2279	147.7%	11.38	13.03
31	180P10	MS2259	170.75	12.82	13.48
32	180P10	MS2298	139.23	12.18	11.47
33	180Pll	MS2422	125.56	10.83	11.76
34	180P11	MS2424	106.7%	7.29	15.65
35	180P12	MS2373	133.34	12.02	11.45
36	180P12	MS2375	140.66	9.28	15.38
37	180P12	MS2537	127.03	9.76	12.97
38	180P13	MS2112	116.65	10.94	10.24
39	180P13	MS2116	142.65	11.75	12.43

Continued next page.

TABLE 5. (Continued)

No.	*Pisifera*	Progeny	FFB (kg p^{-1} yr^{-1})	BNO (No. p^{-1} yr^{-1})	ABWT (kg p^{-1} yr^{-1})
40	180P13	MS2133	146.21	10.32	14.66
41	180P14	MS2425	123.74	9.41	12.57
42	180P14	MS2431	146.88	11.38	13.13
43	180P14	MS2438	138.07	10.41	13.31
44	180P15	MS2099	133.12	9.19	14.55
45	180P15	MS2111	151.79	12.79	12.66
46	180P15	MS2114	134.43	8.91	**15.09**
47	180P16	MS2308	113.75	8.10	**13.97**
48	180P16	MS2316	136.19	10.69	**12.92**
49	180P16	MS2332	122.19	7.29	**15.03**
50	180P17	MS2434	122.98	9.30	**13.24**
51	180P17	MS2435	126.81	10.16	**12.39**
52	180P17	MS2437	110.53	9.46	**11.74**
Mean			130.57	10.58	12.5
LSD (α = 0.05)			29.965	2.220	2.220

Note: figures in bold in a column are the minimum and maximum values.

TABLE 6. *Pisifera* MEANS (1986-1991) FOR FRESH FRUIT BUNCH (FFB), BUNCH NUMBER (BNO) AND AVERAGE BUNCH WEIGHT (ABWT) IN TRIAL 0.180

No.	*Pisifera*	FFB (kg p^{-1} yr^{-1})	BNO (No. p^{-1} yr^{-1})	ABWT (kg p^{-1} yr^{-1})
1	180P1	123.33	8.51	**14.70**
2	180P2	128.52	11.67	**10.95**
3	180P3	114.59	10.74	**10.80**
4	180P4	154.19	13.06	11.91
5	180P5	130.69	12.45	**10.48**
6	180P6	127.80	9.63	13.41
7	180P7	134.45	10.58	12.77
8	180P8	103.73	8.71	11.81
9	180P9	130.94	10.49	12.55
10	180P10	156.74	12.54	12.59
11	18OPll	116.14	9.06	13.71
12	180P12	133.35	10.37	13.21
13	180P13	135.17	**11.00**	12.44
14	180P14	136.23	10.39	13.00
15	180P15	139.78	10.29	14.10
16	180P16	120.71	8.69	13.97
17	180P17	120.11	9.64	12.46
Mean		130.57	10.58	12.58
LSD (α = 0.05)		18.078	1.372	1.366

Note: figures in bold in a column are the minimum and maximum values.

TABLE 7. PHENOTYPIC CORRELATION BETWEEN BUNCH YIELD, BUNCH QUALITY COMPONENTS, VEGETATIVE CHARACTERS AND PHYSIOLOGICAL PARAMETERS IN TRIAL 0.180

	BNO	ABWT	MFW	MNW	M/F	K/F	S/F	O/DM	O/WM	F/B	O/B	K/B	OPY	KPY	FP	PCS	BL	LL	LW	LN	HT	FI	f	e	VDM	BDM	TDM	BI	TEP
FFB	0.63**	0.44"	-0.02	-0.01	0.01	-0.05	0.02	0.19**	0.16"	0.06	0.17**	-0.04	0.84**	0.68**	0.17**	0.49**	0.49**	0.28**	0.49**	0.39**	0.55**	0.01	0.60**	0.65"	0.58**	0.99**	0.88**	0.52**	0.85**
BNO	•	-0.38**	-0.09*	-0.09*	0.01	-0.14"	0.07	0.05	0.08*	-0.14**	-0.01	-0.16**	0.47"	0.32**	0.15**	0.02	0.13**	0.00	0.13**	0.15**	0.24**	0.14"	0.17'"	0.45"	0.11**	0.63**	0.41"	0.59**	0.48**
ABWT		•	0.11**	0.11**	0.01	0.09*	-0.07	0.21**	0.15*	0.21**	0.22"	0.13**	0.43**	0.41**	0.04	0.53**	0.44**	0.34**	0.43"	0.29**	0.36"	-0.12"	0.53"	0.49"	0.54**	0.44**	0.55**	-0.04	0.43**
MFW				0.53**	0.34**	-0.26	-0.32**	0.26**	0.20**	-0.11*	0.22**	-0.27**	0.10**	-0.18**	-0.18**	0.19**	0.09*	0.09'	0.05	0.12"	-0.04	-0.15**	0.09*	0.01	0.07	-0.02	0.03	-0.12"	0.09*
MNW				•	-0.56"	0.49**	0.53**	-0.07	-0.07	0.12**	-0.21.'	0.49**	-0.12**	0.35**	0.03	0.04	0.00	0.16**	-0.03	0.01	-0.08	0.02	0.07	0.00	0.04	-0.01	0.02	-0.06	-0.11**
MF					•	-0.83**	-0.94**	0.35**	0.27**	-0.18**	0.47**	-0.81"	0.26"	-0.56**	-0.22**	0.17**	0.11"	-0.07	0.10'	0.11**	0.04	-0.16**	0.05	0.01	0.03	0.01	0.02	-0.03	0.24**
K/F						•	0.59"	-0.33**	-0.29**	0.18**	-0.43**	0.96**	-0.26**	0.65**	0.13**	-0.11*	-0.09	0.09*	-0.05	-0.12**	-0.08**	0.11*	-0.02	-0.05	-0.03	-0.05	-0.05	-0.01	-0.24**
S/F							•	-0.31**	-0.21**	0.15**	-0.42**	0.58**	-0.21**	0.42**	0.24**	-0.18**	-0.12**	0.05	-0.12**	-0.09*	-0.01	0.16**	-0.06	0.02	-0.02	0.02	-0.00	0.05	-0.20**
O/DM								•	0.85**	0.09	0.82**	-0.28**	0.57**	-0.04**	-0.04	0.28**	0.31**	0.14**	0.23"	0.21**	0.19**	-0.59	0.28**	0.20**	0.24"	0.19**	0.25'"	-0.01	0.56**
O/WM										-0.05	0.85**	-0.28**	0.58**	-0.05	0.02	0.23**	0.31**	0.15"	0.21**	0.20**	0.24**	0.02	0.25**	0.19"	0.24"	0.16"	0.23**	-0.03	0.57"
F/B										•	0.36"	0.43**	0.23**	0.33**	0.12	0.04	0.05	0.05	0.07	0.03	-0.02	0.02	0.09'	0.03	0.04	0.06	0.06	0.04	0.24**
O/B											•	-0.30**	0.65**	-0.09*	-0.05	0.26**	0.31**	0.11**	0.23**	0.21**	0.19"	-0.03	0.26**	0.16**	0.22"	0.17"'	0.22**	-0.03	0.64**
Km													-0.19**	0.68**	0.13**	-0.09**	-0.06	0.09*	-0.03	-0.11'	-0.09	0.11'	0.01	-0.04	-0.03	-0.03	-0.03	0.00	-0.17**
OPY														0.46**	0.10*	0.51**	0.54**	0.26**	0.49"	0.39**	0.53"	-0.02	0.58**	0.73**	0.55"	0.85**	0.78**	0.37**	0.99**
KPY															0.21"	0.29"	0.31"	0.26**	0.33**	0.19**	0.35"	0.07	0.43'	0.59**	0.41"	0.68**	0.61**	0.35"	0.48**
FP															•	-0.15**	-0.17"	0.04	0.01	-0.21**	0.43**	0.16**	-0.04	0.41**	0.39**	0.17**	0.32"'	-0.21**	0.11**
PCS																	0.74**	0.33**	0.63**	0.53"	0.41"	-0.49**	0.69**	0.65'"	0.62"	0.49**	0.74**	-0.27**	0.51**
RL																		0.44**	0.57**	0.56**	0.39**	-0.11*	0.73**	0.49"	0.59**	0.49**	0.61**	-0.03	0.54**
LL																			0.12"	0.13**	0.23**	0.26**	0.56**	0.23**	0.34**	0.28**	0.35**	-0.01	0.27**
LW																				0.34**	0.45**	0.11**	0.78**	0.49**	0.61**	0.49**	0.62**	-0.04	0.49**
LN																					0.21**	0.01	0.62**	0.31**	0.38**	0.39**	0.43**	0.07	0.39**
HT																						0.01	0.43**	0.72**	0.71"	0.55**	0.72**	-0.10*	0.53**
FI																							0.19**	-0.28**	-0.31**	0.01	-0.17"'	0.35**	-0.02
f																								0.51**	0.19**	0.60"	0.70**	0.06	0.58**
e																									0.85**	0.85**	0.96**	0.09'	0.73**
VDM																										0.58**	0.89**	-0.35**	0.55**
BDM																											0.88**	0.52**	0.85**
TDM																												0.09'	0.78**
BI																													0.37**

Note: ● • Significant at P< 0.01 and P< 0.05 respectively. otherwise non-significant.

TABLE 8. PROGENY MEANS (1986-1991) FOR BUNCH QUALITY COMPONENTS IN TRIAL 0.180

No.	*Pisifera*	Progeny	MFW (g)	MNW (g)	M/F (%)	K/F (%)	S/F (%)	O/DM (%)	O/WM (%)	F/B (%)	O/B (%)	K/B (%)	OPY (kg)	KPY (kg)
1	180P1	**MS2589**	**9.84**	2.50	75.51	10.81	13.68	76.22	42.80	65.77	21.44	7.08	28.84	8.98
2	180P1	MS2637	10.57	2.56	76.17	10.39	13.44	75.95	42.71	66.33	21.75	6.91	28.17	8.80
3	180P1	MS2655	10.62	2.26	78.51	10.20	11.29	73.85	40.95	62.02	19.88	6.46	27.13	8.51
4	180P2	MS2134	10.30	2.41	77.36	9.31	13.33	75.55	40.43	67.57	21.37	6.32	26.42	7.16
5	180P2	MS2226	12.08	2.41	79.34	8.32	12.34	77.53	45.00	61.17	21.56	5.19	33.32	8.08
6	180P2	MS2227	8.58	1.43	83.29	6.80	9.91	73.51	37.51	61.53	19.06	4.23	21.92	4.85
7	180P2	MS2228	10.24	2.16	78.68	8.85	12.47	76.19	45.59	64.87	23.34	5.75	30.32	7.33
8	180P3	MS2202	11.78	2.04	82.50	7.71	9.79	77.26	44.35	64.72	23.54	5.06	26.34	5.79
9	180P3	MS2246	8.73	1.98	77.99	9.85	12.16	74.45	38.79	65.07	19.68	6.42	25.20	8.18
10	180P3	MS2328	8.05	1.77	78.89	8.84	12.27	73.18	37.23	65.98	19.39	5.82	20.33	6.16
11	180P4	MS2329	7.70	2.34	**71.17**	9.02	**19.81**	**71.93**	37.07	64.58	**17.00**	5.80	26.67	9.10
12	180P4	MS2335	6.01	1.45	77.29	8.24	14.48	76.04	44.00	65.55	22.22	5.40	39.07	9.60
13	180P4	MS2338	6.50	1.60	76.69	8.04	15.27	75.21	41.70	67.36	21.59	5.43	31.97	7.91
14	180P4	MS2374	8.83	2.13	76.83	8.19	14.98	75.85	43.09	63.50	21.18	5.20	30.86	7.56
15	180P5	MS2253	6.29	1.80	72.78	9.40	17.82	76.07	49.66	61.30	22.21	5.76	32.06	8.61
16	180P5	MS2258	6.85	1.89	73.45	9.55	17.00	76.91	51.92	63.38	24.08	6.10	35.31	9.10
17	180P5	MS2291	5.88	1.57	75.18	9.41	15.42	73.47	45.72	63.19	21.70	5.99	23.51	6.21
18	180P6	MS2157	8.14	1.50	82.21	7.54	10.25	76.43	45.85	62.66	23.68	4.73	26.77	5.01
19	180P6	MS2172	7.49	1.63	78.88	9.33	11.80	76.85	46.38	63.00	23.09	5.89	27.76	7.00
20	180P6	MS2200	8.79	1.71	80.77	8.73	10.50	78.33	48.25	66.43	26.00	5.77	33.80	7.64
21	180P6	MS2230	9.89	1.88	80.71	8.57	10.73	76.40	45.92	61.04	22.65	5.28	33.39	8.11
22	180P7	MS2334	8.66	2.28	74.55	9.69	15.76	76.45	44.69	66.90	22.29	6.46	32.41	9.27
23	180P7	MS2340	11.22	2.66	76.95	8.87	14.18	78.65	48.51	71.26	26.58	6.34	31.90	7.63
24	180P8	MS2295	11.31	2.35	78.87	9.09	12.04	73.83	39.45	55.64	17.24	5.13	13.49	3.88
25	180P8	MS2310	7.93	1.90	76.53	9.18	14.29	74.64	45.38	65.45	22.69	6.05	28.21	7.63
26	180P9	MS2204	8.33	2.00	76.33	9.83	13.85	76.83	47.72	66.90	24.45	6.57	34.36	8.89
27	180P9	MS2206	9.96	1.96	80.88	7.74	11.38	79.64	48.25	66.02	25.81	5.09	28.75	5.76
28	180P9	MS2243	8.76	1.74	80.85	7.79	11.36	75.00	41.23	59.64	19.94	4.67	21.51	4.85
29	180P9	MS2278	8.11	1.66	80.21	8.30	11.49	79.59	52.01	68.51	28.56	5.68	41.71	8.29
30	180P9	MS2279	10.16	1.83	82.44	7.47	10.09	78.15	49.33	61.62	25.01	4.70	37.52	6.96

Continued next page.

TABLE 8. (Continued)

No.	*Pisifera*	Progeny	MFW (g)	MNW (g)	M/F (%)	K/F (%)	S/F (%)	O/DM (%)	O/WM (%)	F/B (%)	O/B (%)	K/B (%)	OPY (kg)	KPY (kg)
31	180P10	MS2259	9.11	1.78	81.32	7.84	10.85	46.20	**42.93**	66.04	**22.94**	5.20	**39.82**	8.66
32	180P10	MS2298	8.84	1.86	79.55	8.04	12.41	75.61	42.55	63.58	21.40	5.14	30.14	7.11
33	180P11	MS2422	9.10	2.46	73.68	10.72	15.60	75.52	45.95	66.79	22.64	7.18	28.75	8.89
34	180P11	MS2424	9.79	1.69	83.09	8.24	8.67	77.53	46.80	65.93	26.02	5.42	27.16	5.82
35	180P12	MS2373	8.28	**1.40**	84.00	6.98	9.02	78.34	45.39	62.75	23.90	4.40	31.40	5.75
36	180P12	MS2375	7.52	1.57	79.68	10.20	10.12	74.02	41.69	64.23	21.37	6.57	30.55	9.25
37	180P12	MS2537	8.02	1.77	78.44	9.20	12.35	77.59	46.16	66.69	24.21	6.13	32.51	7.98
38	180P13	MS2112	6.18	1.45	77.91	8.54	13.55	74.58	43.84	65.74	22.58	5.67	27.80	6.30
39	180P13	MS2116	8.26	2.16	75.39	10.38	14.24	78.19	48.23	67.05	24.37	6.97	35.76	10.15
40	180P13	MS2133	8.96	1.97	78.58	8.91	12.51	78.83	49.55	69.01	26.86	6.14	39.21	9.05
41	180P14	MS2425	9.28	1.55	83.69	6.80	9.52	78.45	47.09	64.42	25.41	4.37	37.79	6.43
42	180P14	MS2431	8.74	2.52	72.06	**11.95**	15.99	76.46	47.74	65.80	22.73	7.84	33.35	11.53
43	180P14	MS2438	9.75	2.20	78.24	10.25	11.51	76.55	47.61	66.95	24.86	6.86	35.94	9.82
44	180P15	MS2099	9.56	1.99	79.96	7.90	12.15	75.69	46.00	61.93	22.70	4.93	30.30	6.53
45	180P15	MS2111	12.01	2.26	81.29	8.06	10.66	77.27	47.57	61.55	23.75	5.00	38.41	8.14
46	180P15	MS2114	10.90	1.79	83.67	7.22	9.11	78.36	47.54	65.45	6.02	4.73	37.41	7.02
47	180P16	MS2308	10.77	2.12	80.40	8.76	10.84	76.77	46.17	63.23	23.51	5.53	31.14	6.96
48	180P16	MS2316	8.45	2.03	77.05	10.58	12.37	74.16	41.03	62.68	19.77	6.69	28.23	9.13
49	180P16	MS2332	8.32	2.08	76.22	10.49	13.29	75.42	40.94	63.41	19.98	6.63	25.52	8.46
50	180P17	MS2434	10.52	2.83	73.76	10.57	15.67	74.95	41.73	65.78	20.28	6.96	24.89	8.56
51	180P17	MS2435	9.89	2.71	73.61	10.82	15.57	75.22	42.50	67.38	21.08	7.30	28.03	9.64
52	180P17	MS2437	9.28	1.78	81.37	7.74	10.89	75.54	45.15	63.10	23.20	4.89	26.28	5.29
Mean			8.98	1.99	78.26	8.97	12.77	76.21	44.83	64.81	22.76	5.84	30.74	7.79
LSD (α = 0.05)			1.62	0.38	3.51	1.56	2.31	2.51	4.97	4.15	3.15	1.09	8.24	2.14

Notes: figures in bold in a column are the minimum and maximum values.

MFW, MNW, M/F, K/F, S/F, O/DM, O/WM, F/B, O/B, K/B, OPY and KPY (see motes ***Table 9***).

TABLE 9. *Pisifera* MEANS (1986-1991) FOR BUNCH QUALITY COMPONENTS IN TRIAL 0.180

No.	*Pisiferu*	MFW (g)	MNW (g)	M/F (%)	K/F (%)	S/F (%)	O/DM (%)	O/WM (%)	F/B (%)	O/B (%)	K/B (%)	OPY (kg)	KPY (kg)
1	180P1	10.33	2.45	76.60	10.48	12.92	75.45	42.25	64.93	21.12	6.84	28.11	8.78
2	180P2	10.30	2.10	79.75	8.28	Il.97	75.68	42.11	63.67	21.26	5.34	27.94	6.83
3	180P3	9.48	1.93	79.77	8.80	11.43	74.92	40.06	65.27	20.83	5.77	23.87	6.70
4	180P4	7.21	1.85	75.64	8.36	16.06	74.86	41.64	65.27	20.63	5.45	32.51	8.57
5	180P5	6.37	1.76	73.76	9.46	16.78	75.56	49.25	62.63	22.72	5.95	30.57	8.04
6	180P6	8.76	1.70	80.83	8.52	10.65	77.31	46.99	63.98	24.39	5.46	31.55	7.14
7	180P7	9.68	2.43	75.51	9.36	15.13	77.33	46.22	68.65	24.01	6.41	32.21	8.61
8	180P8	9.01	2.04	77.27	9.15	13.58	74.39	43.49	62.33	20.96	5.76	23.53	6.44
9	180P9	9.07	1.85	79.96	8.32	11.73	78.26	48.64	65.38	25.48	5.47	34.33	7.27
10	180P10	8.99	1.83	80.53	7.93	11.54	75.94	42.76	64.95	22.26	5.17	35.52	7.97
11	180P11	9.45	2.08	78.38	9.48	12.14	76.52	46.37	66.36	24.33	6.30	27.96	7.36
12	180P12	7.94	1.58	80.65	8.81	10.55	76.67	44.46	64.61	23.19	5.71	31.51	7.67
13	180P13	7.83	1.86	77.32	9.27	13.41	77.24	47.26	67.31	24.65	6.26	34.37	8.51
14	180P14	9.24	2.13	77.58	9.86	12.57	77.07	47.50	65.79	24.24	6.49	35.53	9.45
15	180P15	10.80	2.01	81.60	7.73	10.67	77.07	47.01	62.95	24.12	4.89	35.26	7.21
16	180P16	9.00	2.07	77.61	10.08	12.32	75.30	42.32	63.09	20.81	6.37	27.97	8.32
17	180P17	9.90	2.43	76.31	9.69	14.01	75.30	43.14	65.37	21.53	6.36	26.36	7.79
Mean		8.98	1.99	78.26	8.97	12.77	76.21	44.83	64.81	22.76	5.84	30.74	7.79
LSD (a = 0.05)		1.01	0.25	2.26	0.97	1.49	1.53	2.95	2.48	1.92	0.69	4.92	1.34

Notes: figures in bold in a column are the minimum and maximum values.
MFW = mean fruit weight.
MNW = mean nut weight.
M/F = mesocarp to fruit.
K/F = kernel to fruit.
S/F = shell to fruit.
O/DM = oil to dry mesocarp.
O/WM = oil to wet mesocarp.
F/B = fruit to bunch.
O/B = oil to bunch.
K/B = kernel to bunch.
OPY = oil per palm per year.
KPY = kernel per palm per year.

(VDM) and bunch dry matter (BDM) would suggest a balanced partitioning of assimilates, without competition among progenies. Contrasting bunch indices (BI) among tall progenies of distinctive TEP yields implied the importance for maintaining a high BI with increased TDM. The significant heritable variation in BI suggests that neglecting this trait in selection may result in populations of highly competitive palms. Such palms perform well at the expense of their neighbours and a stand of them would not necessarily be high yielding (Hardon et al., 1985). In addition, it was noted that DxP progenies derived from E206 were of normal height when it was crossed with AVROS *pisiferas.*

Despite the significant negative correlation between BI and height (HT), the magnitude of the genetical relationship was, however, weak (*Table 7*). BI correlated positively with conversion effkiency (e) and fractional interception (f), with groups of progenies showing different performances, suggesting that the selection in Ulu Remis provided palms vegetatively and photosynthetically different from the Banting palms. In addition, BI correlated significantly with the components of bunch yield and, therefore, selection for BI would simultaneously be selecting for BNO and FFB.

Variance analyses of bunch yield data in individual replication (*Table 14*), pooled over replicates (*Table 15*) and over years (*Table 16*) indicated substantial variation for the *duras*-within-pisiferu component with the magnitude ofvariance (σ^2_f) roughly twice that of *thepisiferas*

(σ^2_m). This suggests that the differences in FFB yield were largely due to ABWT of the *duras*-within-*pisifera* component. The estimates for h^2_f were generally higher than h^2_m. Variable levels of significance were accounted for genotype x environment (GxE) interaction over six years, with larger environmental variation for FFB and ABWT than BNO. The error variance (σ^2_w) for bunch yield was dramatically reduced as the data were progressively pooled over replications and years. This was probably due to the partitioning of σ^2_w into the genetical, environmental and interaction components, suggesting the presence of large environmental influences. Therefore, a more reliable estimate of the variance components and, hence, heritability for bunch yield would be from data pooled over years. Though the first and second level interaction items were significant occasionally, the generally low magnitudes of the variance components would be of little interest in practical plant breeding.

The individual replicate ANOVA for bunch quality components (Table *14)* showed a significant *duras*-within-*pisifera* item for all the traits, while the *pisiferus* item was meaningful for mean fruit weight (MFW) and S/F across replicates. Similar to those for bunch yield, increased levels of significance, hence, of heritability estimates, were noted in the pooled replicate analysis for both parental item (*Table 15).* The variation in bunch quality components, especially those for oil-related traits was due, in part, to the genetical make-up of the materials and the micro-environment.

Previous workers noted large variation in F/B to be caused by different pollination efficiencies which were considered as an important source of environmental variation (Hardon et *al.*, 1985). Improved pollination by the weevil, *Elaeidobius kumerunicus* (Syed, 1979), has markedly reduced the environmental variation and probably raised the heritability estimates for F/B. The heritability estimates based on h^2_f and h^2_m for F/B pooled over replications were highly significant. Mesocarp to fruit is highly heritable, despite the reduction in magnitude with the increase in kernel to fruit content.

The vegetative performances of the progenies *andpisiferus* are shown in *Tables 10* and *11*, respectively. Genetical differences of both parental components for vegetative traits were largely significant, with frond production (FP), rachis length (RL) and HT significantly different for the *pisiferas* item across replications (*Table 14).* Analysis of the pooled replications *(Table 15*) showed significant genetical differences for most vegetative characters, with heritability estimates between 12% and 92%, very promising estimates for those in the upper range. Heritability estimates for FP and leaflet length (LL) of both parental components were highest among the vegetative traits and, more importantly, higher in h^2_m than h^2_f suggesting additive gene action.

Variation for the physiological parameters among progenies (*Table 12*) *andpisiferus (Table 13*), although showed some differences by LSD, but the values were generally low. Consequently, the genetical variance components for both parent influencing the physiological parameters were generally low within each replication *(Table 14*), despite significant differences in the pooled replicate analysis (*Table 15*), suggesting a moderate response to selection.

CONCLUSION

Wide variation in the 30 traits studied were shown by DxP progenies of advanced breeding materials. Phenotypic correlations among the economically important traits were generally significant with 5%-20% of the relationships attributable to genetical causes. Significant changes in yields would involve an increase in the number of bunches Although ANOVA for bunch yield was generally significant for GxE, the magnitudes of the variance components were, however, lower than those for the genotypes. For bunch yield, higher estimates of genetical variances and, hence, heritabilities were obtained from data pooled over years, suggesting seasonal effect, and, therefore, that more years' data necessary in selection programmes. For most traits, the genetical variance components were generally high, with several traits showing substantial variation for σ^2_m, suggesting additive gene action responsive to selection. Estimates of the genetical variance components and heritability suggested that kernel content is influenced maternally.

TABLE 10. PROGENY MEANS (1990) FOR VEGETATIVE CHARACTERS IN TRIAL 0.180

No.	Pisifera	Progeny	FB (No. p^{-1} yr^{-1})	PCS (cm^2)	RL (m)	LL (cm)	LW (cm)	LN (No.)	HT (m)
1	180P1	MS2589	24.36	19.75	4.38	84.64	5.12	146.18	1.64
2	180P1	MS2637	26.08	20.63	4.63	90.50	4.79	146.83	1.66
3	180P1	MS2655	23.78	23.39	4.62	86.45	4.86	157.11	1.69
4	180P2	MS2134	20.67	26.63	5.19	92.20	4.79	167.08	1.27
5	180P2	MS2226	23.62	22.66	4.99	80.47	5.00	166.08	1.28
6	180P2	MS2227	21.62	20.68	4.71	79.60	4.80	154.77	1.33
7	180P2	MS2228	21.50	24.13	5.11	85.96	5.01	170.67	1.20
8	180P3	MS2202	20.86	24.43	5.00	87.30	5.07	165.86	1.37
9	180P3	MS2246	21.86	22.51	5.00	90.69	4.66	160.57	1.32
10	180P3	MS2328	22.64	21.88	4.59	82.46	4.69	157.71	1.13
11	180P4	MS2329	27.33	21.83	4.81	86.06	5.04	167.42	1.63
12	180P4	MS2335	27.27	24.21	5.02	84.72	5.42	161.53	2.29
13	180P4	MS2338	25.77	23.11	4.95	81.61	5.24	161.54	1.87
14	180P4	MS2374	26.00	23.45	4.76	86.21	4.72	166.50	1.90
15	180P5	MS2253	24.64	21.15	5.09	89.68	4.57	170.50	1.65
16	180P5	MS2258	25.38	19.88	5.10	84.49	4.88	161.85	2.01
17	180P5	MS2291	24.69	14.39	4.39	83.25	4.42	146.00	1.42
18	180P6	MS2157	22.14	19.75	4.82	79.77	4.86	166.57	1.38
19	180P6	MS2172	22.48	20.71	5.00	84.48	5.13	160.40	1.44
20	180P6	MS2200	20.13	27.81	5.50	88.18	5.18	168.07	1.49
21	180P6	MS2230	22.11	28.99	5.49	87.67	5.64	167.56	1.55
22	180P7	MS2334	25.83	23.15	4.83	86.59	4.99	170.67	1.55
23	180P7	MS2340	23.75	20.99	4.89	90.57	4.82	168.25	1.52
24	180P8	MS2295	25.83	17.34	4.46	72.11	4.57	159.33	1.78
25	180P8	MS2310	23.33	24.36	5.12	81.41	5.05	167.73	1.55
26	180P9	MS2204	23.29	23.55	5.07	83.71	5.319	169.86	1.50
27	180P9	MS2206	19.21	26.22	5.37	84.62	5.13	166.83	1.12
28	180P9	MS2243	23.33	17.78	4.72	82.76	4.32	160.83	1.03
29	180P9	MS2278	22.43	27.16	5.48	81.73	5.49	167.57	1.53
30	180P9	MS2279	23.92	29.45	5.45	85.05	5.68	165.17	1.89
31	180P10	MS2259	21.93	29.40	5.37	86.31	5.38	170.67	1.66
32	180P10	MS2298	21.92	23.57	5.10	84.03	5.24	166.23	1.45
33	180Pll	MS2422	25.00	21.24	4.95	89.95	4.87	148.67	1.57
34	180Pll	MS2424	23.20	27.17	5.33	89.71	5.57	168.33	1.72
35	180P12	MS2373	22.36	26.46	5.30	88.05	5.49	169.21	1.85
36	180P12	MS2375	23.92	23.26	5.10	85.64	5.04	163.31	1.52
37	180P12	MS2537	22.07	23.24	5.03	78.20	5.30	160.80	1.39
38	180P13	MS2112	24.38	21.14	5.16	96.52	5.11	154.62	1.56

Continued next page.

TABLE 10. (Continued)

No.	*Pisifera*	Progeny	FB (No. p^{-1} yr^{-1})	PCS (cm^2)	RL (m)	LL (cm)	LW (cm)	LN (No.)	HT (m)
39	180P13	MS2116	24.13	23.50	5.42	**94.55**	5.18	**159.40**	1.54
40	180P13	MS2133	23.13	26.30	5.44	**95.75**	5.24	167.07	1.73
41	180P14	MS2425	22.15	30.53	5.65	81.73	5.98	169.69	1.87
42	180P14	MS2431	27.00	24.57	5.19	93.61	5.24	166.27	1.76
43	180P14	MS2438	25.88	23.33	5.22	95.74	5.58	160.33	1.80
44	180P15	MS2099	21.73	25.29	5.05	94.15	4.74	169.07	1.62
45	180P15	MS2111	23.71	23.42	5.19	89.06	4.93	**171.93**	1.71
46	180P15	MS2114	21.64	25.94	5.39	94.94	4.78	168.07	1.71
47	180P16	MS2308	21.00	29.55	5.38	91.55	5.06	169.08	1.44
48	180P16	MS2316	23.87	24.58	5.18	90.86	4.68	163.74	1.48
49	180P16	MS2332	23.08	24.52	5.05	90.68	4.66	165.00	1.69
50	180P17	MS2434	20.60	29.22	5.29	90.49	5.33	169.00	1.19
51	180P17	MS2435	21.93	25.21	5.08	89.60	5.01	166.29	1.19
52	180P17	MS2437	19.00	24.49	5.08	91.32	5.01	160.20	1.20
Mean			23.22	24.08	5.09	87.46	5.07	163.92-	1.56
LSD (a = 0.05)			1.99	5.11	0.43	6.48	0.54	9.23	0.37

Notes: figures in bold in a column are the minimum and maximum values.
FB, PCS, RL, LL, LW, LN and HT (see notes *Table 11*).

TABLE 11. *Pisifera* MEANS (1990) FOR VEGETATIVE CHARACTERS IN TRIAL 0.180 PLANTED IN 1982

No.	*Pisifera*	FP (No. p^{-1} yr^{-1})	PCS (cm^2)	RL (m)	LL (cm)	LW (cm)	LN (No.)	NT (m)
1	180P1	24.84	21.10	4.54	87.35;	4.92	**149.50**	1.66
2	180P2	21.88	23.45	4.99	84.39	4.90	164.48	1.27
3	180P3	21.79	22.94	4.86	86.82	4.81	161.38	1.27
4	180P4	26.59	23.22	4.89	84.66	5.11	164.13	1.94
5	180P5	24.90	18.54	4.87	85.90	4.62	159.73	1.69
6	180P6	21.33	25.55	5.30	85.90	5.22	166.58	1.48
7	180P7	25.00	22.28	4.85	88.18	4.92	**169.70**	1.53
8	180P8	24.05	22.36	4.93	78.75	4.91	165.33	1.61
9	180P9	22.27	25.62	5.27	83.63	5.26	166.80	1.45
10	180P10	21.93	26.69	5.25	85.25	5.32	168.61	1.56
11	180P11	24.10	24.20	5.14	89.83	5.22	158.50	1.65
12	180P12	22.74	24.32	5.14	83.79	5.28	164.38	1.58
13	180P13	23.86	23.76	5.35	95.57	5.18	160.63	1.61
14	180P14	25.12	25.94	5.34	90.76	5.58	165.23	1.81
15	180P15	22.35	24.89	5.21	92.75	4.81	169.67	1.68
16	180P16	22.71	26.14	5.20	91.02	4.79	165.83	1.53
17	180P17	20.48	26.33	5.15	90.49	5.12	165.14	1.19
Mean		23.22	24.08	5.09	87.46	5.07	163.92	1.56
LSD (a = 0.05)		1.24	3.08	0.26	3.89	0.32	5.63	0.22

Notes: figures in bold in a column are the minimum and maximum values.
FP = frond production. PCS = petiole cross sectional area. RL = rachis length.
LL = leaflet length. LW = leaflet width. LN = leaflet number. HT = height.

TABLE 12. PROGENY MEANS (1990) FOR PHYSIOLOGICAL PARAMETERS IN TRIAL 0.180

No.	*Pisifera*	Progeny	FI	*f*	*e* (g MJ^{-1})	VDM (kg p^{-1} yr^{-1})	BDM (kg p^{-1} yr^{-1})	TDM (t ha^{-1} yr^{-1})	BI	TEP (kg p^{-1} yr^{-1})
1	180P1	MS2589	3.34	0.83	0.77	66.96	68.94	20.11	0.50	34.23
2	180P1	MS2637	3.22	0.84	0.79	76.04	64.08	20.70	0.44	33.45
3	180P1	MS2655	2.97	0.85	0.82	76.66	69.97	21.70	0.48	32.23
4	180P2	MS2134	2.98	0.88	0.71	70.18	62.14	19.50	0.46	30.71
5	180P2	MS2226	3.11	0.85	0.83	68.22	80.52	22.17	0.52	38.17
6	180P2	MS2227	2.94	0.81	0.71	59.31	62.72	18.06	0.51	24.38
7	180P2	MS2228	3.21	0.88	0.73	66.58	68.98	20.06	0.50	34.71
8	180P3	MS2202	3.17	0.87	0.68	66.88	59.31	18.67	0.45	29.82
9	180P3	MS2246	3.14	0.86	0.73	64.33	67.25	19.47	0.51	30.11
10	180P3	MS2328	2.88	0.83	0.68	63.15	55.99	17.73	0.47	24.03
11	180P4	MS2329	3.43	0.87	0.91	83.89	82.91	24.68	0.49	32.13
12	180P4	MS2335	3.20	0.89	0.99	91.70	93.85	27.46	0.51	44.83
13	180P4	MS2338	3.14	0.86	0.89	83.87	77.31	23.86	0.48	36.72
14	180P4	MS2374	3.00	0.86	0.89	85.12	76.27	23.89	0.47	35.39
15	180P5	MS2253	3.42	0.87	0.82	73.19	76.79	22.19	0.51	37.22
16	180P5	MS2258	3.50	0.85	0.82	69.01	77.89	21.78	0.53	40.77
17	180P5	MS2291	3.71	0.77	0.64	51.55	57.05	16.41	0.49	27.23
18	180P6	MS2157	3.43	0.84	0.66	58.49	58.10	17.26	0.49	29.78
19	180P6	MS2172	3.45	0.86	0.65	65.21	53.21	17.52	0.43	31.95
20	180P6	MS2200	2.94	0.89	0.76	71.96	69.75	20.97	0.49	38.39
21	180P6	MS2230	3.06	0.90	0.86	82.88	79.93	24.09	0.49	38.25
22	180P7	MS2334	3.32	0.88	0.85	80.44	76.48	23.22	0.49	37.97
23	180P7	MS2340	3.58	0.88	0.71	67.32	63.42	19.35	0.48	36.47
24	180P8	MS2295	2.99	0.76	0.62	63.29	37.69	14.98	0.34	15.82
25	180P8	MS2310	2.99	0.87	0.77	74.06	66.08	20.74	0.48	32.79
26	180P9	MS2204	3.32	0.88	0.79	73.14	73.23	21.66	0.51	39.69
27	180P9	MS2206	2.93	0.88	0.67	64.29	58.86	18.23	0.48	32.21
28	180P9	MS2243	3.39	0.79	0.61	54.75	49.50	15.43	0.46	24.41
29	180P9	MS2278	2.91	0.89	0.83	77.93	77.02	22.93	0.50	46.68
30	180P9	MS2279	2.95	0.90	0.89	90.19	78.28	24.94	0.47	41.69
31	180P10	MS2259	2.88	0.89	0.92	82.77	90.50	25.65	0.52	45.01
32	180P10	MS2298	3.27	0.87	0.76	66.44	73.97	20.78	0.52	34.41
33	180P11	MS2422	3.21	0.85	0.78	71.92	66.55	20.49	0.48	34.09
34	180P11	MS2424	3.25	0.91	0.74	84.51	56.56	20.88	0.40	30.65
35	180P12	MS2373	3.24	0.90	0.79	80.77	70.67	22.41	0.47	34.85
36	180P12	MS2375	3.22	0.87	0.81	73.25	74.55	21.88	0.51	36.09
37	180P12	MS2537	3.00	0.85	0.77	66.90	69.82	20.38	0.51	37.29
38	180P13	MS2112	3.69	0.88	0.69	68.75	61.82	19.10	0.46	31.58
39	180P13	MS2116	3.54	0.89	0.81	74.78	77.83	22.78	0.51	41.85

Continued next page

TABLE 12. (Continued)

No.	Pisifera	Progeny	FI	*f*	e (g MJ^{-1})	VDM (kg p^{-1} yr^{-1})	BDM (kg p^{-1} yr^{-1})	TDM (t ha^{-1} yr^{-1})	BI	TEP (kg p^{-1} yr^{-1})
40	180P13	MS2133	3.33	0.91	0.83	80.10	77.49	23.32	0.49	44.64
41	180P14	MS2425	2.97	0.90	0.89	89.72	77.99	25.45	0.46	41.65
42	180P14	MS2431	3.48	0.91	0.88	89.85	77.85	24.82	0.47	40.27
43	180P14	MS2438	3.81	0.92	0.83	82.75	76.38	23.87	0.48	41.83
44	180P15	MS2099	3.21	0.88	0.77	72.66	70.55	21.19	0.49	34.22
45	180P15	MS2111	3.39	0.89	0.83	73.37	86.44	23.05	0.55	43.29
46	180P15	MS2114	3.10	0.88	0.81	75.47	76.18	22.45	0.49	41.63
47	180P16	MS2308	2.92	0.89	0.77	80.01	65.85	21.59	0.46	35.32
48	180P16	MS2316	3.01	0.86	0.82	76.19	72.18	21.96	0.48	33.71
49	180P16	MS2332	3.00	0.90	0.78	75.63	67.56	21.19	0.47	30.59
50	180P17	MS2434	2.99	0.88	0.75	76.31	65.18	20.94	0.46	30.03
51	180P17	MS2435	3.09	0.88	0.75	70.35	68.29	20.49	0.49	33.81
52	180P17	MS2437	3.18	0.88	0.65	61.12	58.58	17.72	0.49	29.46
Mean			3.19	0.87	0.78	73.98	70.55	21.39	0.48	35.42
LSD (α = 0.05)			0.41	0.05	0.12	15.67	14.77	3.93	0.06	8.93

Notes: figures in bold in a column are the minimum and maximum values.
FI, *f*, *e*, VDM, BDM, TDM, BI and TEP (see notes *Table 13*).

TABLE 13. Pisifera MEANS (1990) FOR PHYSIOLOGICAL PARAMETERS IN TRIAL 0.180

No.	*Pisifera*	FI	*f*	*e* (g MJ^{-1})	VDM (kg p^{-1} yr^{-1})	BDM (kg p^{-1} yr^{-1})	TDM (t ha^{-1} yr^{-1})	BI	TEP (kg p^{-1} yr^{-1})
1	180P1	3.19	0.84	0.79	73.09	67.31	20.78	0.47	33.38
2	180P2	3.06	0.86	0.75	65.98	68.81	19.99	0.50	32.04
3	180P3	3.06	Q.85	0.70	64.79	60.73	**18.61**	0.48	27.89
4	180P4	3.18	0.87	0.93	86.38	82.88	25.05	0.49	37.65
5	180P5	3.54	0.83	0.76	64.80	70.91	20.22	0.51	35.39
6	180P6	3.14	0.88	0.75	71.14	67.74	20.55	0.48	35.83
7	180P7	3.43	0.88	0.79	75.19	71.26	21.67	0.46	37.37
8	180P8	2.99	0.84	0.72	70.98	57.05	18.91	0.44	27.39
9	180P9	3.07	0.87	0.77	73.77	69.40	21.19	0.49	38.69
10	180P10	3.06	0.88	0.74	75.19	82.83	23.39	0.52	40.30
11	180P11	3.23	0.88	8.76	78.22	61.55	20.69	0.44	32.37
12	180P12	3.15	0.87	0.79	73.49	71.61	21.55	0.49	36.11
13	180P13	3.51	0.90	0.78	74.81	72.26	21.78	0.48	39.48
14	180P14	3.44	**0.91**	0.87	87.33	77.39	24.68	0.47	41.20
14	180P15	3.23	0.88	0.80	73.81	77.35	22.18	0.51	39.58
16	180P16	2.98	0.87	0.80	77.22	68.71	21.60	0.47	32.97
17	180P17	3.08	0.88	0.71	69.24	63.82	19.68	0.48	31.03
Mean		3.19	0.87	0.78	73.98	70.55	21.39	0.48	35.42
LSD (α = 0.05		0.24	0.03	0.07	9.24	8.91	2.35	0.03	5.37

Notes: figures in bold in a column are the minimum and maximum values.

FI = frond index. *f* = fraction interception. e = conversion efficiency. VDM = vegetative dry matter. BDM = bunch dry matter. TDM = total dry matter. BI = bunch index. TEP = total economic product.

TABLE 14. LEVELS OF SIGNIFICANCE AND HERITABILITY ESTIMATES FOR BUNCH YIELD, BUNCH QUALITY COMPONENTS, VEGETATIVE TRAITS AND PHYSIOLOGICAL PARAMETERS IN INDIVIDUAL REPLICATES IN TRIAL 0.180

Trait	Replicate	σ^2_m	σ^2_f	h^2_m (%)	h^2_f (%)
Fresh fruit bunch (FFB)	1	ns	**	5.18	66.19
	2	ns	**	0.00	70.22
	3	ns	*	18.83	33.05
Bunch number (BNO)	1	ns	**	24.98	67.54
	2	ns	**	36.92	97.81
	3	*	*	43.61	41.23
Average bunch weight (ABWT)	1	ns	**	7.54	87.09
	2	**	ns	65.70	0.00
	3	ns	**	16.31	72.99
Mean fruit weight (MFW)	1	**	**	70.39	86.63
	2	**	**	63.07	53.91
	3	*	**	57.44	73.36
Mean nut weight (MNW)	1	ns	**	44.44	100.00
	2	ns	**	12.90	100.00
	3	*	**	48.48	72.73
Fruit to bunch (F/B)	1	ns	**	4.98	64.74
	2	ns	**	0.00	57.83
	3	ns	*	13.09	41.72
Mesocarp to fruit (M/F)	1	ns	**	26.46	100.00
	2	ns	**	36.28	93.10
	3	*	**	53.62	87.88
Kernel to fruit (K/F)	1	ns	**	15.73	100.00
	2	ns	**	13.97	55.90
	3	ns	**	22.35	66.28
Shell to fruit (S/F)	1	*	**	51.47	91.18
	2	*	**	61.49	97.31
	3	**	**	100.00	84.41
Oil to dry mesocarp (O/DM)	1	ns	**	30.66	85.77
	2	ns	**	0.00	86.93
	3	ns	**	38.55	58.11
Oil to wet mesocarp (O/WM)	1	**	*	63.59	39.25
	2	ns	**	37.35	60.79
	3	**	*	71.39	39.29
Oil to bunch (O/B)	1	**	*	56.73	36.27
	2	ns	**	0.00	96.61
	3	**	**	84.57	46.51
Kernel to bunch (K/B)	1	ns	**	11.48	100.00
	2	ns	**	5.29	18.06
	3	ns	**	11.16	79.68
Oil per palm per year (OPY)	1	ns	**	29.62	49.81
	2	ns	**	6.03	74.97
	3	ns	**	33.52	46.40
Kernel per palm per year (KPY)	1	ns	**	0.00	100.00
	2	ns	**	0.00	97.76
	3	ns	**	0.00	86.94

Continued next pa

TABLE 64. (Continued)

Trait	Replicate	σ^2_m	σ^2_f	h^2_m (%)	h^2_f (%)
Frond production (F/P)	1	**	**	100.00	67.96
	2	**	ns	97.38	0.00
	3	**	**	78.80	70.26
Petiole cross section (PCS)	1	ns	**	0.00	75.23
	2	*	ns	26.25	0.00
	3	ns	**	27.26	57.87
Rachis length (RL)	1	**	*	46.15	30.77
	2	**	ns	30.00	0.00
	3	**	ns	43.24	0.00
Leaflet length (LL)	1	**	ns	46.35	0.00
	2	ns	**	23.36	65.03
	3	**	**	80.39	50.05
Leaflet width (LW)	1	ns	**	27.27	54.55
	2	**	ns	38.71	0.00
	3	ns	**	16.00	80.00
Leaflet number (LN)	1	**	ns	37.20	0.00
	2	ns	**	0.00	87.17
	3	**	*	57.73	41.03
Height (HT)	1	**	*	52.17	52.17
	2	*	**	47.06	58.82
	3	*	ns	34.78	0.08
Frond index (FI)	1	*	*	40.00	40.00
	2	ns	*	16.00	48.00
	3	ns	**	0.00	72.73
Fractional interception (*f*)	1	ns	**	19.51	58.54
	2	ns	ns	6.56	0.00
	3	ns	**	19.51	58.54
Conversion efficiency (*e*)	1	ns	**	34.48	0.00
	2	**	ns	30.09	0.00
	3	**	ns	21.52	0.00
Vegetative dry matter (VDM)	1	**	ns	46.49	0.00
	2	ns	ns	22.30	0.00
	3	*	ns	27.50	0.00
Bunch dry matter (BDM)	1	ns	**	12.51	69.04
	2	ns	**	17.69	79.62
	3	**	ns	29.55	0.00
Total dry matter (TDM)	1	ns	**	26.22	53.45
	2	**	ns	24.33	0.00
	3	**	ns	27.28	0.00
Bunch index (BI)	1	ns	ns	7.84	0.00
	2	ns	**	33.33	53.33
	3	ns	ns	9.76	0.00
Total economic product (TEP)	1	ns	**	13.41	68.95
	2	ns	**	4.64	78.06
	3	**	ns	38.30	0.00

Notes: **, *, ns - significant at P < 0.01 and P < 0.05 and non-significant, respectively.
The most reasonable range for a heritability estimate is between zero and 100%.

TABLE 15. LEVELS OF SIGNIFICANCE AND HERITABILITY ESTIMATES FOR BUNCH YIELD, BUNCH QUALITY COMPONENTS, VEGETATIVE TRAITS AND PHYSIOLOGICAL PARAMETERS POOLED OVER REPLICATIONS IN TRIAL 0.180

Trait	σ^2_r	σ^2_m	σ^2_f	σ^2_{mr}	σ^2_{fr}	h^2_m (%)	h^2_f (%)
Fresh fruit bunch (FFB)	ns	ns	**	ns	ns	14.85	45.81
Bunch number (BNO)	ns	*	**	ns	ns	37.21	56.59
Average bunch weight (ABWT)	ns	*	**	ns	ns	32.20	62.08
Mean fruit weight (MFW)	*	**	**	ns	ns	69.22	68.55
Mean nut weight (MNW)	ns	*	**	*	ns	36.36	96.97
Fruit to bunch (F/B)	ns	**	**	ns	ns	16.18	50.85
Mesocarp to fruit (M/F)	ns	**	**	ns	ns	38.66	93.58
Kernel to fruit (K/F)	ns	**	**	ns	ns	14.05	77.69
Shell to fruit (S/F)	ns	**	**	ns	ns	78.36	84.52
Oil to dry mesocarp (O/DM)	**	**	**	*	ns	14.60	55.21
Oil to wet mesocarp (O/WM)	**	**	*	*	ns	48.68	28.92
Oil to bunch (O/B)	**	ns	**	**	ns	23.68	62.51
Kernel to bunch (K/B)	ns	ns	**	ns	ns	14.88	84.30
Oil per palm per year (OPY)	**	ns	**	ns	ns	21.91	41.04
Kernel per palm per year (KPY)	ns	ns	**	ns	ns	4.03	81.03
Frond production (F/P)	ns	**	**	ns	ns	91.97	61.04
Petiole cross section (PCS)	*	ns	**	ns	ns	12.58	61.40
Rachis length (RL)	ns	*	**	ns	ns	34.71	45.71
Leaflet length (LL)	*	**	**	ns	ns	59.99	36.72
Leaflet width (LW)	ns	**	**	ns	ns	22.64	37.74
Leaflet number (LN)	ns	*	**	ns	ns	23.18	57.11
Height (HT)	*	**	*	ns	ns	46.15	15.38
Frond index (FI)	**	**	ns	ns	**	29.33	5.33
Fractional interception (*f*)	**	**	**	ns	ns	16.33	48.98
Conversion efficiency (*e*)	**	**	**	ns	ns	33.33	46.97
Vegetative dry matter (VDM)	**	**	**	ns	ns	24.53	35.33
Bunch dry matter (BDM)	**	**	**	ns	ns	25.50	46.84
Total dry matter (TDM)	**	**	**	ns	ns	27.95	46.20
Bunch index (BI)	**	ns	**	**	ns	13.79	34.48
Total economic product (TEP)	**	**	**	*	ns	19.46	43.75

Note: **, *, ns - significant at P < 0.01 and P < 0.05 and non-significant, respectively.

TABLE 16. LEVELS OF SIGNIFICANCE AND HERITABILITY ESTIMATES FOR BUNCH YIELD POOLED OVER YEARS IN TRIAL 0.180

Traits	σ^2_r	σ^2_m	σ^2_f	σ^2_{mr}	σ^2_{fr}	σ^2_y	σ^2_{yr}	σ^2_{ym}	σ^2_{yf}	σ^2_{ymr}	σ^2_{yfr}	h^2_m (%)	h^2_f (%)
Fresh fruit bunch (FFB)	ns	*	*	ns	**	**	na	ns	**	ns	ns	41.96	51.16
Bunch number (BNO)	*	*	**	ns	**	**	ns	ns	**	**	ns	60.30	87.21
Average bunch weight (ABWT)	ns	*	**	ns	**	**	ns	**	ns	ns	ns	48.31	100.00

Notes: **, *, ns - significant at $P<0.01$, $P<0.05$ and non-significant, respectively.
The most reasonable range for a heritability estimate is zero to 100%.

The results also suggested that trunk height was inherited through the male parent. However, the yields of short progenies were only moderate, thus requiring further introgressions of the *pisifera* parent for better yield. DxP progenies based on introgressedpisiferu, AVROS x S27B, produced high oil yields. The Serdang *pisiferus,* 20A/112 and 20A/8, introgressed with the AVROS were good parents for high kernel yield. The mean performance and genetical structure of the materials suggested that the potential *duras* for high overall oil yield are Ulu Remis, Banting, Johore Labis and intracrosses of the Elmina. The potential *pisiferus* for the same trait is Lever Cameroon, Lever Nigeria and introgressed Serdang x AVROS.

ACKNOWLEDGEMENTS

The authors thank the Director-General of PORIM and the Vice Chancellor of Universiti Kebangsaan Malaysia (UKM) for permission to publish this paper.

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