VARIATION IN MALAYSIAN *Dura* × *Pisifera* PLANTING MATERIALS. I. BUNCH YIELD

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A random sample of 99 dura × pisifera *(D × P) biparental progenies from six agencies were evaluated for their yield performance. The performances of the materials from the six agencies were significantly different. On the average, the trial produced a fresh fruit bunch (FFB) yield of 123.57 kg/palm/year. Among the six agencies, the highest mean yield was 132.01 kg/palm/year from Agency 4. Fifteen outstanding progenies had FFB productions ranging from 138.39 to 158.17 kg/palm/year: these high yields were a result of balanced bunch number (BNO) and average bunch weight (ABWT). A large proportion of the variation – between 80 to 90 per cent – was confined to variation at the seedling level. The proportion of genetic variability attributed to progeny differences was 7–20 per cent. Broad sense heritabilities (h^2_B) using intra-class correlation were 0.39 for ABWT, 0.19 for BNO and 0.13 for FFB.*

INTRODUCTION

Malaysia's commercial plantations of oil palm (*Elaeis guineensis* Jacq.) owe their beginning largely to an unsuccessful planting of coffee (*Coffea sp.*) at Tenammaran Estate in 1917 (Jagoe, 1952). The coffee was replaced at Tenammaran with plants grown from Deli *dura* seeds taken from oil palms planted as ornamental avenue trees at Rantau Panjang. *Elaeis guineensis* subsequently developed – unexpectedly – into the biggest earner in Malaysia's agricultural sector.

Independently, formal selection of planting materials was initiated by the Department of Agriculture (DOA) in 1920s. Kumpulan Guthrie and Socfin began work on oil palm about a decade later. Harrisons

& Crosfield (now Golden Hope), the Highlands Research Unit (HRU), United Plantations, and the Federal Land Development Authority (FELDA) embarked on oil palm breeding in later years *(Figure 1)*. Although *pisiferas* were available at the Agricultural Station at Serdang (Jagoe, 1952a), early selections were exclusively of the Deli *dura* materials. The potential of *pisiferas* as the seed parent in hybrid crosses was not known at that time.

With the discovery of the single gene inheritance in oil palm (Beirnaert and Vanderweyen, 1941), *pisiferas* of La Me, Yangambi and AVROS origins were imported to meet the high demand for pollen from Serdang. Dura planting materials were eventually phased out in 1956. Meanwhile, *dura* x *tenera* (D x T) crosses were planted until 1958. They were largely replaced by *dura* x *pisifera* (D x P) seeds in 1960 (Hartley *et al.*, 1962). The parents for D x P crosses were independently developed and tested by various agencies in a number of trials over a considerable period. The characteristics of the D x P progenies derived from these different programmes can be distinguished (Soh, 1983).

This paper describes the yield performance and genetic variability of commercial D x P planting materials from six Malaysian commercial seed producers.

MATERIALS AND METHODS

In 1983, the Palm Oil Research Institute of Malaysia (PORIM) organized the first comparative trial involving a random sample of 99 D x P biparental progenies from six agencies (*Table 1*). The seedlings were laid in trial 0.189 at 148 palms per ha using the independent completely randomized design (CRD) at six palms per progeny per replicate in six replicates. The trial was located on an ex-jungle, inland soil (Bungor Series) in Terengganu, Malaysia.

Individual palm bunch numbers and bunch weights were recorded at each harvesting round (at intervals of 7 to 10 days) from 1987 to 1990. A model for the analysis is given by:

$$Y_{ijk} = \mu + \tau_i + \beta_j + \varepsilon_{ij} + \delta_{ijk}$$

where,

Y_{ijk} = yield (observation)
μ = overall mean
τ_i = effects of progeny *i*
β_j = effects of replication *j*
ε_{ij} = interaction effects between progeny *i* and replication *j*
δ_{ijk} = sampling error.

At the beginning of the experiment there were 3564 palms. Generally, there are *a* agencies (*a*=6), *r* replicates (6), *f* progenies (99) and *n* palms per progeny per replicate (6). However, due to unforseen circumstances, a number of palms were lost. In addition, abnormal data were eliminated in the final analysis. The harmonic mean was thus computed to allow for the *m* number of missing palms (Steel and Torrie, 1981). Accordingly, the degree of freedom (*df*) of the variance analysis was adjusted from the error item, *fr(n-1)-m*. Outstanding progenies were those which performed above the mean plus twice the standard error (mean + 2s.e.). Variance components and heritabilities (h^2_B) were estimated by combining the 'Agency' and 'Progeny within Agency' items of *Table 2* into a 'Progeny' item (*Table 3*).

Broad sense heritability (h^2_B) was estimated as twice the intra-class correlation, *t*, (Falconer, 1981):

$$t = \frac{\sigma^2_f}{\sigma^2_w + \sigma^2_{fr} + \sigma^2_f}$$

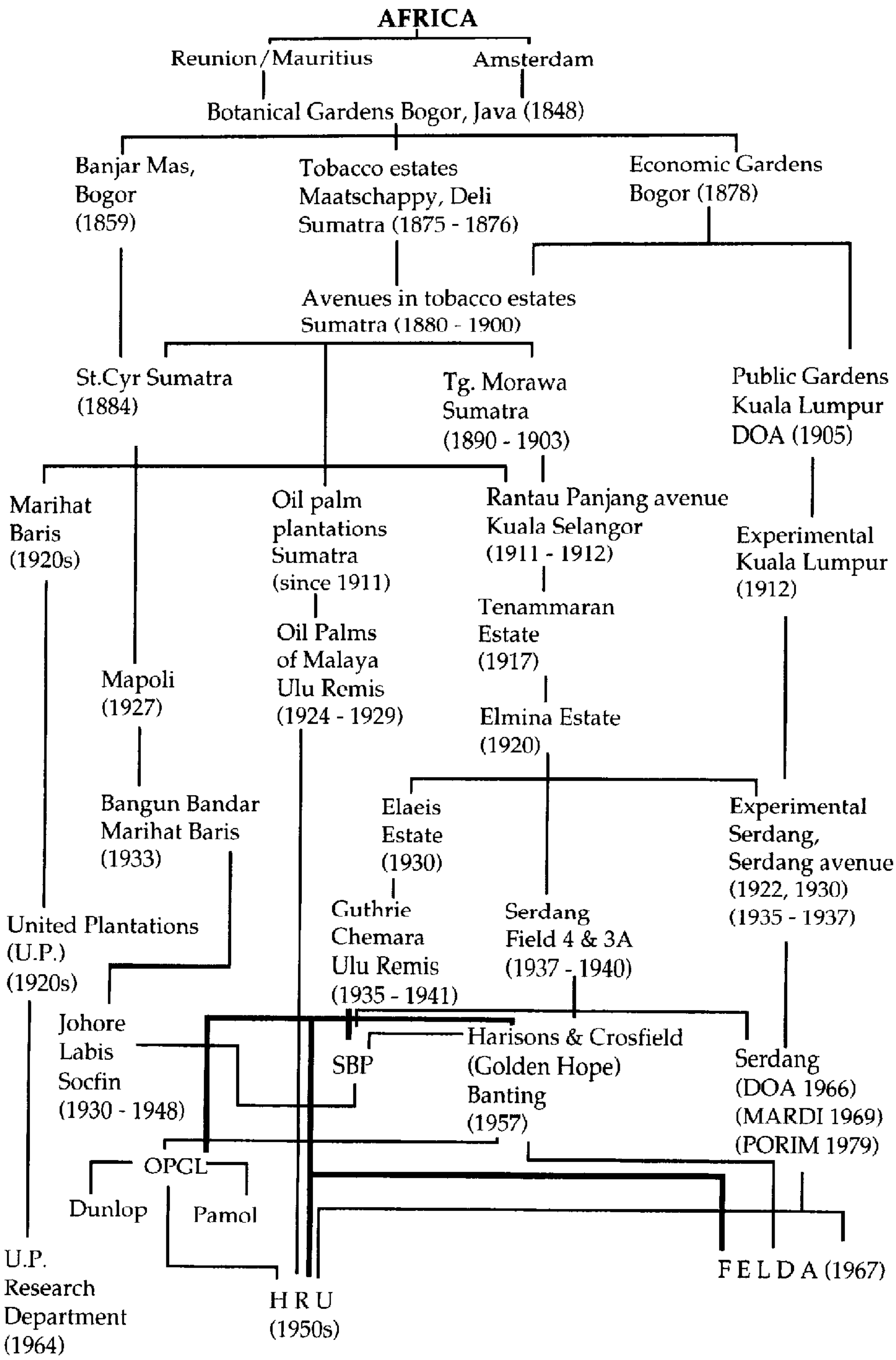
where,

σ^2_w = between palms within progeny variance
σ^2_{fr} = progeny-replication interaction variance
σ^2_f = between progeny variance

RESULTS AND DISCUSSION

The average yield performance of planting materials of the six agencies is summarized in *Table 4*. The mean fresh fruit bunch (FFB) yield of 123.57 kg/palm/year was low compared with the usual yield in the region of 200 kg/palm/year from mature palms planted in the coastal regions (Rajanaidu *et al.*, 1990). The performance of these materials may be preliminary as the evaluation was done during the pre-competition period between 4 and 7 years from planting. In addition, the low yield might be partly attributed to the poor inland soil with irregular terrain where the trial was conducted. Fresh fruit bunch yield and its components are expected to improve with age.

The FFB yields of 15 progenies were above



OPGL = Oil Palm Genetic Laboratory
SBP = Sabah Breeding Programme
MARDI = Malaysian Agricultural Research and Development Institute

Figure 1. History and developments of Deli dura *in Indonesia and Malaysia till 1979 (adapted from Hardon and Thomas, 1968; Lubis, 1984; Rajanaidu* et al., *1990; Tan, 1992).*

TABLE 1. THE D × P PROGENIES IN COMPARATIVE TRIAL 0.189

Agency	Number of progenies	*Dura* Source	*Pisifera* Source
FELDA	26	Deli	Yangambi, Kulai-AVROS, AVROS
Golden Hope	6	Deli	AVROS
Guthrie	10	Deli	Yangambi based
HRU	25	Deli	Dumpy-AVROS
Socfin*	18	Deli	Yangambi, La Me
United Plantations	14	Deli	Yangambi

*ceased seed production in 1983.

TABLE 2. ANALYSIS OF VARIANCE – AGENCY PERFORMANCE

Source	df	Mean Square	Expected Mean Square (EMS)
Replication (R)	*r-1*	MS1	$\sigma^2_w + n'\sigma^2_{fr} + n'f\sigma^2_{ar} + n'af\sigma^2_r$
Agency (A)	*a-1*	MS2	$\sigma^2_w + n'\sigma^2_{fr} + n'r\sigma^2_f + n'f\sigma^2_{ar} + n'rf\sigma^2_a$
Progeny/Agency (F)	*f-a*	MS3	$\sigma^2_w + n'\sigma^2_{fr} + n'r\sigma^2_f$
A × R	*(a-1) (r-1)*	MS4	$\sigma^2_w + n'\sigma^2_{fr} + n'f\sigma^2_{ar}$
F × R	*(f-a) (r-1)*	MS5	$\sigma^2_w + n'\sigma^2_{fr}$
Seedling	*fr(n-1)*	MS6	σ^2_w

n' = harmonic mean
σ^2_w = between palm within progeny variance
σ^2_r - between replication variance
σ^2_a = between agency variance
σ^2_f = between progeny within agency variance
σ^2_{ar} = agency-replication interaction variance
σ^2_{fr} = progeny-replication interaction variance

TABLE 3. ANALYSIS OF VARIANCE – PROGENY PERFORMANCE

Source	df	Mean Square	Expected Mean Square (EMS)
Replication (R)	*r-1*	MS1	$\sigma^2_w + n'\sigma^2_{fr} + n'f\sigma^2_r$
Progeny (F)	*f-1*	MS2	$\sigma^2_w + n'\sigma^2_{fr} + n'r\sigma^2_f$
F × R	*(f-1) (r-1)*	MS3	$\sigma^2_w + n'\sigma^2_{fr}$
Seedling	*fr(n-1)*	MS4	σ^2_w

n' = harmonic mean
σ^2_w = between palms within progeny variance
σ^2_{fr} = progeny-replication interaction variance
σ^2_f = between progeny variance
σ^2_r = between replication variance

TABLE 4. YIELD PERFORMANCES (1987–1990) OF SIX AGENCIES IN TRIAL 0.189.

Agency Code *	FFB kg/p/yr	BNO number/p/yr	ABWT kg/p/yr
1	118.31	11.14	10.65
2	130.34	12.60	10.25
3	110.09	12.66	8.79
4	132.01	11.51	11.48
5	126.35	12.09	10.54
6	124.33	11.47	10.79
Mean	123.57	11.91	10.42
s.e.	3.41	0.38	0.26

* in random order
FFB = Fresh fruit bunch
BNO = Bunch number
ABWT = Average bunch weight
s.e. = Standard error

TABLE 5. MEAN DIFFERENCE FOR FRESH FRUIT BUNCH (FFB) YIELD

Order	Progeny	Mean	Order	Progeny	Mean
1	62	158.17	52	08	119.51
2	51	149.86	53	42	119.46
3	72	148.29	54	59	119.42
4	61	147.76	55	41	119.42
5	96	146.36	56	07	118.69
6	93	145.72	57	30	118.21
7	32	144.99	58	15	117.86
8	56	144.48	59	67	117.83
9	52	143.83	60	54	117.65
10	74	143.47	61	47	117.56
11	94	143.43	62	27	117.14
12	87	140.79	63	70	117.02
13	31	138.72	64	68	116.87
14	53	138.57	65	90	116.76
15	97	138.39	66	58	116.75
		137.50(Mean+2s.e.)	67	57	116.67
16	78	136.89	68	76	115.47
17	71	135.27	69	23	114.41
18	64	134.40			*113.92*(Mean-s.e.)
19	69	134.32	70	81	113.52
20	75	134.06	71	12	113.05

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(TABLE 5. Cont.)

Order	Progeny	Mean	Order	Progeny	Mean
21	06	133.99	72	45	112.92
22	10	133.93	73	20	112.73
23	02	132.18	74	92	112.56
24	04	132.03	75	55	111.57
25	29	131.34	76	73	111.42
26	28	130.78	77	17	111.40
27	98	130.58	78	85	111.31
		129.64(Mean+s.e.)	79	38	111.06
28	09	129.10	80	88	109.82
29	13	128.91	81	49	109.33
30	25	128.78	82	34	108.84
31	43	128.02	83	39	108.57
32	89	127.96	84	46	107.92
33	77	127.46	85	48	106.42
34	91	126.91	86	36	106.19
35	60	125.86			*106.06*(Mean-2s.e.)
36	66	125.71	87	83	105.62
37	95	125.03	88	99	105.29
38	80	124.92	89	35	105.01
39	14	124.88	90	11	104.96
40	05	124.62	91	44	103.53
41	22	123.91	92	50	103.46
42	79	123.06	93	82	103.26
43	63	123.04	94	01	102.37
44	18	122.67	95	40	98.71
45	65	122.45	96	16	98.17
46	33	121.86	97	26	95.96
		121.78(Mean)	98	24	95.63
47	03	121.34	99	37	88.03
48	19	121.28			
49	86	120.15	Progeny × Replicate as error term		
50	84	120.01	Degrees of freedom		= 465
51	21	119.73	Standard error (s.e.)		= 7.86

TABLE 6. MEAN DIFFERENCE FOR BUNCH NUMBER (BNO)

Order	Progeny	Mean	Order	Progeny	Mean
1	72	15.54	52	19	11.67
2	33	14.70	53	64	11.65
3	87	14.06	54	37	11.63
4	41	13.99	55	47	11.63
5	43	13.94	56	05	11.56
6	56	13.86	57	18	11.54
7	94	13.83	58	06	11.50
8	32	13.81	59	57	11.41
9	74	13.71	60	30	11.37
10	46	13.61	61	49	11.35
11	38	13.53	62	08	11.33
12	29	13.51	63	70	11.30
13	25	13.47	64	80	11.30
14	98	13.37	65	85	11.25
15	52	13.30	66	81	11.22
16	42	13.23	67	91	11.14
17	31	13.20	68	27	11.11
		13.18(Mean+2s.e.)	69	68	11.09
18	48	13.16	70	54	11.03
19	61	13.09			*11.02*(Mean-s.e.)
20	51	13.07	71	92	10.84
21	34	13.01	72	16	10.81
22	13	12.94	73	90	10.76
23	71	12.88	74	79	10.75
24	10	12.84	75	86	10.69
25	28	12.74	76	95	10.64
26	09	12.62	77	76	10.62
27	96	12.58	78	11	10.59
28	97	12.55	79	60	10.54
29	45	12.55	80	63	10.48
30	93	12.54	81	40	10.42
		12.46(Mean+s.e.)			*10.30*(Mean-2s.e.)
31	17	12.43	82	04	10.24
32	02	12.43	83	59	10.23
33	20	12.42	84	14	10.20
34	39	12.40	85	84	10.16
35	03	12.32	86	73	10.15
36	66	12.26	87	67	10.07
37	50	12.22	88	21	9.99
38	77	12.21	89	15	9.85
39	88	12.20	90	99	9.79
40	53	12.18	91	23	9.75

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(TABLE 6. Cont.)

Order	Progeny	Mean	Order	Progeny	Mean
41	65	12.17	92	22	9.70
42	75	12.15	93	82	9.60
43	44	12.07	94	24	9.43
44	36	11.98	95	55	9.26
45	62	11.98	96	83	8.82
46	07	11.97	97	58	8.77
47	89	11.89	98	26	8.64
48	78	11.89	99	01	8.31
49	12	11.84			
50	35	11.74	Progeny × Replicate as error term		
		11.74(Mean)	Degrees of freedom		= 465
51	69	11.71	Standard error (s.e.)		= 0.72

TABLE 7. MEAN DIFFERENCE FOR AVERAGE BUNCH WEIGHT (ABWT)

Order	Progeny	Mean	Order	Progeny	Mean
1	58	13.50	53	99	10.46
2	62	13.49	54	90	10.45
3	22	13.28	55	09	10.44
4	04	12.54	56	30	10.43
5	21	12.28			*10.43*(Mean)
6	01	12.06	57	47	10.41
7	14	12.05	58	54	10.37
8	06	11.99	59	32	10.36
9	84	11.93	60	70	10.31
10	95	11.91	61	94	10.25
11	83	11.89	62	81	10.20
12	23	11.75	63	66	10.18
13	55	11.71	64	57	10.14
14	15	11.71	65	07	10.05
15	60	11.69			*10.01*(Mean-s.e.)
16	93	11.67	66	98	10.00
17	63	11.55	67	03	9.98
18	51	11.54	68	72	9.94
19	78	11.45	69	28	9.85
20	67	11.44	70	87	9.84
21	59	11.39	71	12	9.77
22	53	11.39	72	11	9.76
23	79	11.38	73	49	9.73

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(TABLE 7. Cont.)

Order	Progeny	Mean	Order	Progeny	Mean
24	96	11.35	74	24	9.68
25	64	11.33	75	13	9.64
26	61	11.31	76	25	9.60
		11.27(Mean+2s.e.)			*9.59*(Mean-2s.e.)
27	91	11.21	77	85	9.50
28	74	11.12	78	65	9.42
29	89	11.12	79	42	9.41
30	75	11.06	80	40	9.40
31	82	11.03	81	43	9.37
32	80	10.92	82	29	9.29
33	69	10.89	83	35	9.23
34	73	10.86	84	36	9.17
		10.85(Mean+s.e.)	85	44	8.94
35	05	10.80	86	20	8.91
36	86	10.79	87	17	8.84
37	52	10.79	88	39	8.83
38	56	10.79	89	41	8.80
39	31	10.78	90	88	8.71
40	71	10.75	91	45	8.70
41	76	10.69	92	33	8.66
42	02	10.66	93	16	8.49
43	27	10.65	94	50	8.36
44	92	10.61	95	34	8.21
45	77	10.61	96	46	8.08
46	08	10.60	97	48	8.03
47	26	10.59	98	38	7.77
48	97	10.58	99	37	7.17
49	19	10.56			
50	68	10.52	Progeny × Replicate as error term		
51	18	10.51	Degrees of freedom		= 465
52	10	10.50	Standard error (s.e.)		= 0.42

TABLE 8. MEAN SQUARES FOR AVERAGE BUNCH YIELDS (1987–1990) OF SIX AGENCIES

Source	df	FFB	BNO	ABWT
Replicate (R)	5	7648.34**	153.24**	117.78**
Agency (A)	5	32815.55**	213.00**	446.20**
Progeny/Agency (F)	93	4796.65**	60.09**	27.40**
A × R	25	1853.90**	14.19^{NS}	5.04^{NS}
F× R	465	2007.07**	16.85**	5.72**
Seedling	2710	1763.94	14.71	5.38

Harmonic mean = 5.41 , *P < 0.05 , ** P < 0.01, ^{NS} = Non significant
FFB = Fresh fruit bunch, BNO = Bunch number, ABWT = Average bunch weight

TABLE 9. MEAN SQUARES, VARIANCE COMPONENTS AND HERITABILITY ESTIMATES OF 99 D × P PROGENIES

Source	df	FFB	BNO	ABWT
Replication (R)	5	7648.34**	152.24**	117.78**
Progeny (F)	98	6226.19**	67.89**	48.81**
F × R	490	1999.25**	16.72**	5.68**
Seedling	2710	1763.94	14.71	5.38
σ^2_w		1763.94	14.71	5.38
		(91.03)	(88.30)	(79.47)
σ^2_{fr}		43.50	0.37	0.06
		(2.24)	(2.22)	(0.89)
σ^2_f		130.22	1.58	1.33
		(6.72)	(9.48)	(19.64)
σ^2_T		1937.66	16.66	6.77
t		0.07	0.09	0.20
$2t = h^2_B$		0.13	0.19	0.39

**P< 0.01
Harmonic mean = 5.41
FFB = Fresh fruit bunch
BNO = Bunch number
ABWT = Average bunch weight
σ^2_w = between palms within progeny variance
σ^2_{fr} = progeny-replication interaction variance
σ^2_f = between progeny variance
σ^2_r = between replication variance
Figures within parentheses are percentages of variance components to total variance.

the 'mean + 2 s.e.' region, with production ranging from 138.39 to 158.17 kg/palm/year (*Table 5*). Seventeen progenies were outstanding for bunch number (BNO) with an annual production varying between 13.20 and 15.54 bunches/palm/year (*Table 6*). Twenty-six other progenies had heavy average bunch weights (ABWT) ranging from 11.31 to 13.50 kg/palm/year (*Table 7*). However, none of these progenies had all three traits simultaneously performing above the 'mean + 2 s.e.' level. These progenies showed either high BNO or high ABWT. For a high FFB yield, a reasonable balance between the two yield components is needed. For instance, in the case of Agency 3, the BNO was high but the ABWT was too low, resulting in low overall FFB yield.

There were significant differences in yield performance between the six agencies and the 99 progenies. A substantial amount of genetic variability existed between and within the progenies. This was illustrated by the highly significant mean squares of each trait (*Table 8*). The bulk of the total variation, amounting to 80–90 per cent, was attributed to the seedling variance components (σ^2_w). A large seedling variation is not uncommon in a cross-pollinated crop like the oil palm as the genetic and environmental variances are confounded (Steel and Torrie, 1981). The genetic variation due to progeny differences (σ^2_f) was between 7 and 20 per cent of total phenotypic variance.

Broad sense heritability for FFB at 0.13 was the lowest compared to its components (*Table 9*). Surprisingly, ABWT with h^2_B 0.39 was twice h^2_B 0.19, of BNO. However, the similar magnitudes of heritability estimates in some Malaysian oil palm breeding populations had been reported (Ahiekpor and Yap, 1982).