A COMPARISON OF THE DELI DUMPY AND POBÉ DWARF SHORT STEMMED OIL PALMS AND THEIR OUTCROSSED PROGENIES

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ABSTRACT

Deli Dumpy and Pobé Dwarf oil palm materials, from Malaysia and Ivory Coast respectively, were crossed with normal teneras, *and the progenies tested in the Democratic Republic of Congo, in comparison with progenies without Dumpy or Dwarf genes. The semi-Dumpy progenies gave low yields, but with heavy bunches, while the semi-Dwarf material gave better yields but with smaller bunches; neither material gave particularly good bunch composition. The short stem character of both origins was heritable, the semi-Dwarf being shorter than the semi-Dumpy. However, the strong resistance to vascular wilt noted in pure Deli Dumpy was not observed in the descendants. Of the two origins, the Pobé Dwarf, with small fronds and high bunch index, looks the more promising progenitor, as it should be suited to high density planting with consequent higher yields.*

Keywords: breeding, bunch index, Deli Dumpy, Pobé Dwarf, height, short stemmed palms.

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INTRODUCTION

The economic life of an oil palm planting is determined by the height of the palms, and the cost and difficulty of harvesting tall palms. As a result, breeders have long been interested in reducing height growth. Sparnaaij *et al.* (1963) identified several sources of material for their *short-stem programme*, including the Deli Dumpy from Malaysia and Pobé Dwarf from Benin. These two populations, discussed further below, are the subjects of this paper.

Jagoe (1952) described a palm, the Deli Dumpy palm E206, at Elmina Estate in Malaysia, which had a slow height increase. The selfed progeny of this palm was uniformly short, and was included in many breeding programmes. Despite its short stature, successful use of the Deli Dumpy palm in breeding has been limited (Rosenquist, 1999). Soh *et al*. (1981) noted that it tended to give low fresh fruit bunch (FFB) yield and poor fruit-to-bunch (F/B), but found that Deli *dura* (D) parents with 75% Dumpy ancestry gave D x Avros *pisifera* (P) offspring with yields comparable to those from normal Deli x Avros. More recently, Muluk *et al.* (1992) reported that DxP crosses from the Dumpy gave yields close to those from normal DxP, while retaining some of the slow height growth of the Dumpy. Another approach to exploiting the Dumpy has been the development of *pisifera*s which are 25% Dumpy in ancestry; these have been used by several organizations (Rosenquist, 1999).

At Binga, in the Democratic Republic of Congo (DRC), Dumpy material was found to be highly resistant to vascular wilt disease caused by *Fusarium oxysporum* f.sp. *elaeidis* (Rosenquist *et al*., 1990). A non-destructive test for wilt (Mepsted *et al.*, 1991) confirmed that there was no wilt infection in 16-year-old Dumpy palms at Binga (unpublished). The resistance of Dumpy palms to this highly damaging disease would increase interest in this material if the resistance were heritable.

The Pobé population, from Porto Novo in Benin, has largely been ignored because of its poor fruit composition (Gascon and de Berchoux, 1964), but included some exceptionally short palms. These have been referred to as *Pobé Dumpy*, but we prefer the term *Pobé Dwarf*, as they are quite different from

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the Dumpy in their characteristic small leaves, very low vegetative dry matter and high bunch index (Rosenquist *et al*., 1990). Adon *et al*. (2001) reported that crosses of a Pobé Dwarf with other palms were very short, but had low yields and poor bunch composition.

In this paper, we report the progeny performance of Dumpy and Dwarf parents crossed with parents of other origins. Yield, bunch, vegetative growth and other characteristics were compared to those of other progenies without Dumpy or Dwarf ancestry. Wilt incidence at Binga, a highly infested area, was also recorded.

MATERIALS AND METHODS

Origin of the Dumpy and Dwarf Palms in Congo

The Joint Research Scheme (JRS, a collaboration between Plantations et Huileries du Congo and Société de Cultures) at Binga, DRC, undertook exchanges of breeding material with several other oil palm breeding centres in the 1970s. In 1972, the JRS received two Dumpy progenies from Chemara (Malaysia). Both progenies showed exceptional resistance to vascular wilt. One progeny, Bg259 (*Figure 1a*), was planted in trial Bg73/38 in 1973. The Pobé Dwarf was received by the JRS from the Institut pour Recherche sur les Huiles et Oléagineux (IRHO, now CIRAD-CP, or Centre de Coopération Internationale de Recherche Agronomique pour le Développement – Cultures Pérennes); *Figure 1b* shows the pedigree of family Bg699, planted in trial Bg76/74 in 1976.

Locations

Trials Bg73/38 and Bg76/74 were planted at Binga, located in the North of the DRC (2°22′ N, 20° 31′ E, 400 m asl), in the 1970s; results of this programme were described by Dumortier *et al.*

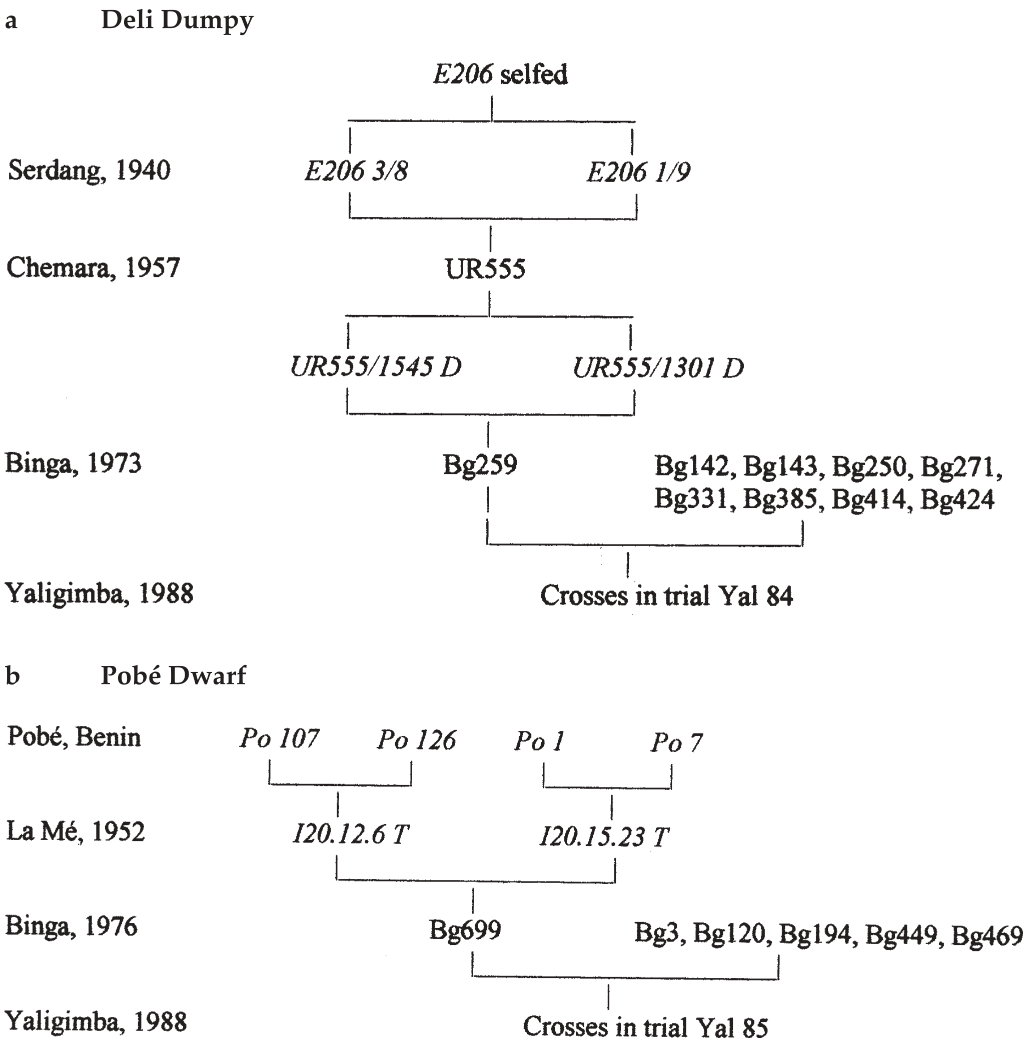

Figure 1. Pedigrees of Deli Dumpy and Pobé Dwarf material (palm numbers are shown in italics; other numbers are family codes).

(1992). The next phase of trials was planted in 1988 at Yaligimba Research Department of Plantations et Huileries du Congo, also in the North of DRC (2° 17′ N, 22° 51′ E, 435 m asl), about 450 km from Binga. The mean annual rainfall at Yaligimba was 1720 mm; there was a three-month dry season from December to February, typically with less than 50 mm per month. The mean maximum temperature was 30°C and the minimum 19°C. The soils of northern Congo have been described as hygro-kaolinitic ferralsols (FAO-UNESCO, 1990).

Experiments

Binga programme. As reported by Dumortier *et al.* (1992), all trials at Binga were in randomized complete blocks (RCB), with eight replicates of nine-palm plots, at 143 palms ha^{-1}. All the trials included three standard crosses, and most data were expressed as percentages of the mean of these standards.

The Yaligimba trials were duplicated at Binga for recording of *Fusarium* wilt incidence, as infestation was much more severe at Binga than at Yaligimba. All the trials included a standard cross, but this was a *tenera* (T) self which was relatively low yielding, so served as a poor standard.

Experiment Yal 84. This trial at Yaligimba included 27 DxT progenies, and 1 TxT standard cross. The design was RCB, with single palm plots and 40 replicates. All the female parents were from Bg259. Sixteen of these pure Dumpy *dura*s were crossed with Binga Ts and the semi-Dumpy progenies obtained were planted in trial Yal 84. Eleven Ts from eight families were included; the origins represented were Djongo, Deli x Yangambi and Mongana. This trial was part of the Combined Breeding Programme (CBP8) described by Rosenquist *et al.* (1990).

Experiment Yal 83. This trial at Yaligimba was contiguous with trial Yal 84, and so gave a reasonable *non-Dumpy* population for comparison, but apart from the TxT standard all 10 crosses were DxD, so there were no Ts for comparison of bunch composition. The trial was in RCB with nine replicates and eight palms per plot, at a planting density of 143 palms ha^{-1}. All families were crosses between Ds in the Djongo family Bg143 (Rosenquist *et al.*, 1990) and Ds from Brabanta (six crosses) or Ekona x Djongo (four crosses).

Experiment Yal 85. This was a density x progeny trial, planted in a split-plot design with density as main plots, with three replicates, and progenies as sub-plots; each sub-plot contained nine palms. The three densities included were 143, 180 and 217 palms ha^{-1}. The same standard cross as in trials Yal 83 and Yal 84 was included. Four of the parents were Dwarf Ts from Bg699; other parents, though not as compact as the Pobé Dwarf, were also selected for high bunch index; the trial was part of CBP10, described by Rosenquist *et al.* (1990). The Dwarf palms were crossed with five Binga Ts (origins Yangambi, Yangambi x Ekona, Deli.Yangambi x Mayumbe, Deli.Yangambi x Mongana, Brabanta x Deli). The trial included 27 other TxT crosses between the same Binga *tenera*s and others, predominantly of Yangambi origin.

For yield and vegetative measurements, only the lowest density in this trial is considered here, as the effects of higher densities were expected to differ between families, depending on vegetative vigour. Of the six Dwarf crosses, only four were represented at the lowest density. Bunch analysis data from all three densities were included, as density has quite small effects on bunch composition (Donough and Kwan, 1991).

Recording

At Yaligimba, FFB yields were recorded during the first five years of production; the trials at Binga were recorded for nine or 10 years. All bunches were counted and weighed separately for each palm. Yields are given relative to the standard cross, for reliable comparison between the trials. Bunch analysis was done as recommended by Rao *et al.* (1983); statistical analysis was not done, as the bunch analysis data were not collected on a plot basis. We calculated oil + 60% of kernel yield (referred to below as O+K) to give an indication of total products, adjusted for the lower value of palm kernels (Donough and Law, 1995). Vegetative growth parameters were estimated by non-destructive methods (Corley *et al*., 1971; Breure and Verdooren, 1995); measurements were made eight years after planting in Yal 83 and Yal 84, and nine years after planting in Yal 85.

Vascular wilt infection was assessed at Binga, where the same progenies as in Yal 84 were planted in trial Bg89/156. Binga Station was very heavily infested with *Fusarium* wilt, so the results from there were expected to give a good indication of the resistance of these materials. The wilt incidence percentages included palms which had died of wilt, surviving palms showing wilt symptoms, and palms which had shown symptoms in the past but subsequently recovered.

Statistical analysis

Standard errors are given for the population (Dwarf and non-Dwarf) means for trial Yal 85. Bunch analysis data were not collected plot by plot, so we have not done statistical analysis. The raw data from the Binga trials and from trials Yal 83 and Yal 84 were lost during civil unrest in the DRC, so we were unable to calculate standard errors for these trials. In the *Tables*, we have shown a t-test comparison based on the two groups of progeny means from trials Yal 83 and Yal 84. A significant t-value indicates that the trial means differ, but this is not necessarily due to the presence or absence of Dumpy genes; because the Dumpy and non-Dumpy progenies are in different trials, a site effect is also possible.

RESULTS

Dumpy and Dwarf Performance at Binga (Bg73/38, Bg76/74)

Table 1 shows that the FFB yield of the Dumpy was very poor, but family Bg259 was inbred (*Figure 1*), with an inbreeding coefficient of 0.375, and inbreeding is known to lead to low FFB yield (Hardon, 1970; Luyindula *et al*., 2005). Bunch weight is usually also depressed by inbreeding, but the Dumpy had above average bunch weight. Oil/bunch was reasonable, compared to the predominantly African *dura*s in other families. Vegetatively, the Dumpy was very short, leaf area and rachis length were below the trial mean and the mean of the standard crosses. Leaf weight was well above the average, and with a small leaf area, the leaf area ratio (LAR) was very low. Vegetative dry matter (VDM) was low, but despite this, bunch index (BI, the ratio of yield dry matter to total dry matter production) was low because of the very low yield. No wilt was recorded in the Dumpy family; this contrasts with 470 non-Dumpy crosses in the complete Binga programme, only one of which recorded zero wilt.

In Trial Bg76/74, all crosses (except the standards) were from the IRHO programme; the trial mean data in *Table 1* show that all the families were vegetatively smaller than the standards. However, the Dwarf family was exceptionally small, in height, leaf area, leaf weight and VDM. Yield was low, with a large number of very small bunches, but BI was high. Wilt incidence was slightly higher than in the other families, and oil/bunch was lower. Kernel/bunch was high in the Pobé palms (data not shown).

Yaligimba Trials (Yal83, Yal84, Yal85)

FFB yield. Yields and yield components are shown in *Table 2*. The top part of the *Table* shows that the semi-Dumpy DxT progenies in Yal 84 were distinctly lower yielding than the *dura*s planted at the same time in the adjacent trial Yal 83, but retained the Dumpy characteristics of large bunch weight and small bunch number. The semi-Dwarf progenies had better yields, not significantly below the other families in Yal 85, with an above average number of significantly smaller bunches.

Bunch composition. Bunch analysis results showed distinctly lower oil/wet mesocarp for *dura*s in the semi-Dumpy families than in African *dura*s, but although oil/bunch was slightly lower in consequence, the difference was small (*Table 3*). Trial Yal 83 contained no *tenera*s for comparison.

The semi-Dwarf *dura*s had lower mesocarp/fruit and higher kernel/fruit than the other families in trial Yal 85 (*Table 3*); the *tenera*s behaved similarly, but with higher shell/fruit (*Table 4*). Oil/bunch was significantly lower in the semi-Dwarf *tenera*s, and although kernel/bunch was higher, O+K was lower than for *tenera*s in the other families. Among the *dura*s, O+K did not differ between the groups.

Vegetative growth characteristics. *Table 5* shows that the semi-Dumpy and semi-Dwarf families were both appreciably shorter than other families; the semi-Dumpy was only 75% of the height of the non-Dumpy material, and the semi-Dwarf families only 67% of the other families in Yal 85. The semi-Dumpy families also had the Dumpy growth characteristics of heavy fronds and large trunk diameter. Despite low leaf production, VDM of the semi-Dumpy was

TABLE 1. DUMPY AND DWARF PERFORMANCE AT BINGA

	FFB yield	Bunch number	Bunch weight	Oil/ bunch	Height	Leaf area	Rachis length	Leaf weight	VDM	LAR	Bunch index	Wilt incidence
	as % standard crosses			%	as % standard crosses							%
Trial Bg73/38												
Deli Dumpy	37	28	125	16.9	48	84	83	118	82	76	49	0
Trial mean	87	95	100	16.6	103	105	98	100	105	105	95	25
Trial Bg76/74												
Pobé Dwarf	66	139	50	19.2	30	78	98	66	38	136	127	21
Trial mean	82	104	86	21.6	72	92	100	83	72	118	108	16

Notes: Oil/bunch (for *dura*s in *Bg73/38*) and wilt incidence are actual figures; other data are expressed relative to the mean for the three standard crosses (from Dumortier *et al*., 1992).
FFB = fresh fruit bunch yield; VDM = vegetative dry matter production; LAR = leaf area ratio.

TABLE 2. YIELD AND YIELD COMPONENTS IN YALIGIMBA TRIALS

	Trial	No. of crosses	FFB Yield kg palm^{-1} yr^{-1}	FFB Yield (% std)	Bunch No. palm yr^{-1}	Bunch No. (% std)	Bunch Wt (kg)	Bunch Wt (% std)
Semi-Dumpy	Yal 84	27	39.3	121	6.5	83	6.1	147
African *dura*	Yal 83	10	58.5	157	10.8	128	5.4	124
t-test (probability of equal trial means)			0.000		0.000		0.000	
Semi-Dwarf	Yal 85	4	50.6	143	12.9	161	3.9	89
standard error			2.52		0.69		0.20	
Other families	Yal 85	27	52.5	148	11.3	141	4.7	107
standard error			0.98		0.27		0.08	

Notes: Figures are means for *dura*s and *tenera*s, where applicable.
In Yal 85, only plots planted at 143 palms ha^{-1} are considered.
FFB = fresh fruit bunch yield; % std = as percentage of standard cross.

TABLE 3. *Dura* BUNCH ANALYSIS RESULTS FROM YALIGIMBA TRIALS

	Trial	No. of crosses	No. of analyses	F/B (%)	M/F (%)	S/F (%)	K/F (%)	O/WM (%)	O/DM (%)	O/B (%)	K/B (%)	O+K (%)
Semi-Dumpy	Yal 84	27	483	63.8	51.1	31.8	8.1	54.0	80.6	17.7	5.2	20.8
African *dura*	Yal 83	10	497	63.1	50.6	32.5	8.2	56.5	81.1	18.1	5.2	21.2
Semi-Dwarf	Yal 85	6	67	63.4	46.4	34.2	10.2	58.0	81.2	17.1	6.4	20.9
Other families	Yal 85	27	371	63.6	49.7	33.3	7.9	56.3	80.6	17.8	5.0	20.8

Notes: F/B = fruit/bunch; M/F = mesocarp/fruit; S/F = shell/fruit; K/F = kernel/fruit;
O/WM = oil/wet mesocarp; O/DM = oil/dry mesocarp; O/B = oil/bunch; K/B = kernel/bunch;
O+K = (oil + 60% kernel)/bunch.

TABLE 4. *Tenera* BUNCH ANALYSIS RESULTS FROM YALIGIMBA TRIALS

	Trial	No. of crosses	No. of analyses	F/B (%)	M/F (%)	S/F (%)	K/F (%)	O/WM (%)	O/DM (%)	O/B (%)	K/B (%)	O+K (%)
Semi-Dumpy	Yal 84	27	491	62.4	74.9	10.0	8.0	53.6	80.1	25.1	5.0	28.1
Semi-Dwarf	Yal 85	6	137	62.7	71.0	11.9	8.6	55.6	80.3	24.6	5.4	27.8
Other families	Yal 85	27	957	62.8	78.1	8.4	7.1	54.3	79.5	26.6	4.4	29.2

Notes: F/B = fruit/bunch; M/F = mesocarp/fruit; S/F = shell/fruit; K/F = kernel/fruit;
O/WM = oil/wet mesocarp; O/DM = oil/dry mesocarp; O/B = oil/bunch; K/B = kernel/bunch;
O+K = (oil + 60% kernel)/bunch.

TABLE 5. VEGETATIVE GROWTH IN YALIGIMBA TRIALS

	Trial	No. of crosses	Age (yr)	Height (cm)	Trunk diam. (cm)	Leaf prodn (palm yr^{-1})	Rachis length (cm)	Leaf area (m^2)	Leaf weight (kg)	VDM (kg palm yr^{-1})	LAR (m^2 kg^{-1})	BI
Semi-Dumpy	Yal 84	27	8	69.9	46.2	23.7	482	5.8	2.44	52	2.33	28.1
African *dura*	Yal 83	10	8	92.7	44.4	25.9	477	5.4	2.04	48.5	-	38.9
t-test (probability of equal trial means)				0.000	0.03	0.000	ns	0.012	0.000	0.016	-	0.000
Semi-Dwarf	Yal 85	4	9	91.4	-	23.8	472	6.38	1.98	51.2	2.97	33.5
standard error				6.1	-	0.61	7.4	0.30	0.096	2.78	0.099	1.55
Other families	Yal 85	27	9	137.0	-	23.9	497	7.13	2.38	63.0	2.72	30.1
standard error				2.4	-	0.24	2.9	0.11	0.037	1.08	0.039	0.60

Notes: In Yal 85 only plots planted at 143 palms ha^{-1} are considered.
Yal 85 measured nine years after planting, Yal 83 and Yal 84 eight years after planting.
VDM = vegetative dry matter; LAR = leaf area ratio; BI = bunch index.

higher and BI lower than those for the standard *dura*s. In contrast, the Dwarf x Binga *tenera* crosses had small fronds, low VDM and high BI.

Vascular wilt incidence. Wilt incidence was recorded at Binga, in trials which duplicated those at Yaligimba. *Table 6* shows that there was little difference in average wilt incidence or in distribution across wilt categories between the semi-Dumpy or semi-Dwarf populations and the other families, though there was a wide range in all groups. In particular, the semi-Dumpy progenies did not appear to have inherited the very strong resistance of the pure Dumpy. *Table 7* shows that performance of crosses appears to depend more on the male parent: the contrast between E27/27 (resistant) and F54/17 (susceptible), even when crossed with the same Dumpy *dura*s, was a striking example.

Sumatra, Muluk *et al.* (1992) found that *second cycle* Deli Dumpy DxP yielded about the same as normal DxP. Lee and Pang (2000) found that Deli x Dumpy Avros *pisifera* (25% Dumpy) material gave comparable yield to Deli x Avros; however, the short stem of the Dumpy had been lost. Rosenquist (1999) summarized results from PNG with similar Dumpy. Avros *pisifera*s, and showed that yields were slightly lower than for progenies derived from pure Avros *pisifera*s, while height increment was the same for both groups of *pisifera*s. At Yaligimba, the semi-Dumpy produced the biggest bunches, 15% heavier than those of normal palms. This high bunch weight could be advantageous in terms of harvesting cost, depending on the payment system adopted. It is at least partly a characteristic of Deli material in general, not only of the Dumpy. For example,

TABLE 6. WILT INCIDENCE IN BINGA TRIALS

	Trial	Age (yr)	No. of crosses	Wilt incidence (%) Dead	surviving	recovered	Total	Range of cross means (total wilted)
Semi-Dumpy	Bg89/156	8	38	5.3	14.1	4.1	23.5	4.8 - 55.0
African *dura*	Bg90/161	7	18	5.3	12.7	1.7	19.7	1.4 - 36.1
Semi-Dwarf	Bg90/160	7	4	4.9	14.8	1.7	21.4	11.0 - 32.1
Other families	Bg90/160	7	13	2.7	11.8	3.4	17.9	2.4 - 34.5

TABLE 7. WILT INCIDENCE IN SOME SEMI-DUMPY FAMILIES

Male parent (non-Dumpy):	E27/27	F54/17	G31/24	F50/12	B78/19	E09/19	G49/23
Female parent (Dumpy)				**Percentage wilt**			
C36/22	10.1	40.0	34.1	-	-	-	-
C36/37	12.2	-	12.2	22.0	-	-	-
C50/33	7.0	40.5	-	-	44.4	-	-
C14/13	17.0	-	-	55.0	-	-	-
C15/12	7.5	34.1	-	-	-	-	-
C49/32	-	-	-	36.6	-	-	19.5
C37/18	-	-	-	-	41.5	26.8	-
C15/11	-	-	-	-	-	39.0	53.7

DISCUSSION

The FFB yields in the Yaligimba experiments were very low, partly because of the long dry season, but also because the economic situation in DRC made it impossible to apply fertilizer during the mature period. Nonetheless, we believe the results show valid relative differences between the different materials.

Considering first the semi-Dumpy families, these yielded 30% less FFB than the normal materials, with even the best semi-Dumpy family still yielding below the mean for the non-Dumpy families (data not shown). Low yield is one of the deficiencies attributed to this material (Soh *et al.*, 1981). In Dumortier *et al.* (1992) found that Ulu Remis Deli had the highest GCA value for bunch weight among the 37 different origins studied at Binga. However, Soh *et al.* (1981) observed heavier bunch weight in Dumpy x Deli crosses than in non-Dumpy Deli.

Bunch composition of *dura*s in the semi-Dumpy DxT progenies was very similar to that of the African *dura*s, so O+K yields were low as a result of the low FFB yield. Although the pure Dumpy was very strongly resistant to *Fusarium* wilt, the semi-Dumpy material was not particularly resistant, with behaviour apparently being mainly dependent on the male parent used. This was disappointing, and suggested the possibility that the resistance of the Dumpy depends on recessive genes. However, Rosenquist (1999) reported that, in an inter-origin DxP comparison at Binga, progenies of Dumpy-Avros *pisifera*s gave much lower wilt incidence than other origins, and speculated that only a small proportion of Dumpy ancestry was necessary. If wilt resistance depends on only a few genes, as proposed by de Franqueville and de Greef (1988), then resistance might be lost in some crosses, but retained in others. Thus, we consider that further work on the wilt resistance of the Dumpy would be justified.

With poor yields, and if wilt resistance is no greater than in other material, the only remaining interesting feature of the semi-Dumpy progenies is their reduced height. The semi-Dwarf progenies were even shorter, with better yields: FFB yield was only 4% below that of the other families in trial Yal 85, but oil/bunch was low, and O+K yield of *tenera*s was 8% below that of the other families. Adon *et al.* (2001) also found that a Pobé Dwarf gave shorter offspring than the Dumpy, and that oil/bunch was low. In contrast to the semi-Dumpy material, the semi-Dwarf progenies produced a large number of small bunches. Corley *et al*. (1993) considered that high bunch number was advantageous in the African environment, but under more favourable conditions high bunch weight would be preferable. On that basis, the Dumpy might be expected to perform better in Malaysia and Indonesia than in Africa.

The generally small stature of the semi-Dwarf material is notable: the palms are not only 33% shorter than the other families, but the 9% smaller leaf area would allow an increased planting density, which should be sufficient to compensate for the 8% lower O+K yield per palm. This aspect will be considered in a future paper on trial Yal 85, which included three planting densities. The Pobé Dwarf families also have several other characteristics which have been highlighted as desirable by earlier authors: low leaf weight and VDM, high LAR (Breure, 1986) and high BI (Corley *et al,* 1971; Breure and Corley, 1983; Dumortier and Konimor, 1999).

CONCLUSION

Of the two types of short-stemmed oil palm genetic material compared here, the Pobé Dwarf appears more interesting than the Deli Dumpy. The semi-Dumpy outcrossed progenies were short, but retained the thick trunk and large fronds of the pure Dumpy, while yields were poor. Others have found that a further generation of crossing to non-Dumpy material improves yields, and the short stem may be retained. This approach may be worth pursuing, and further work is also needed to exploit the wilt resistance of the Dumpy. The semi-Dwarf material has better yields than the Dumpy, short stems, and generally small vegetative stature, which should allow an increase in planting density. The poor bunch composition of the Pobé material remains a drawback, to be overcome by further breeding.

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