PERFORMANCES OF SOME *PISIFERA*S OF BINGA, EKONA, URT AND ANGOLAN ORIGINS: PART 1 - BREEDING BACKGROUND AND FRUIT BUNCH TRAITS

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ABSTRACT

The Unilever-Harrisons & Crosfield's Combined Breeding Programme-Part 13 (CBP13) was a progeny testing of pisifera*s from Binga (Congo), Ekona (Cameroon) and URT (Malaysia). The* pisifera*s were tested in* dura *x* pisifera *(DxP) crosses with selected Deli and African x Deli* dura*s. The three* pisifera *populations had been developed independently and under different conditions. The Binga programme focussed on high yield in an environment endemic with* Fusarium wilt*, selection at Ekona emphasized high bunch oil content, especially from oil/mesocarp, and Ulu Remis were developed from Deli* dura *x African* pisifera*s. The widely used Algemeene Vereniging van Rubber Planters ter Oostkust can Sumatra (AVROS)* pisifera*s, first developed in Sumatra, were also included as Deli x AVROS* pisifera *link crosses. The Angolan origin was represented by only one* pisifera.

The DxP progenies of AVROS and Ekona gave the highest bunch oil content. In AVROS, the superiority was obtained from more fruit/bunch and mesocarp/fruit whereas in Ekona, it was better oil/mesocarp. The DxP of Binga and URT pisifera*s were poorer in bunch oil content because of lower mesocarp/fruit and less oil/mesocarp. The DxP of both the latter, especially some of the URT* pisifera*s, gave more kernel/bunch, while those of Binga PKg111* pisifera*s had more fruit/bunch. Binga* pisifera*s were more variable for DxP bunch traits than AVROS and Ekona.*

Among the dura *female parents, Deli had a higher DxP bunch oil content than those of African or African x Deli* dura*s, the better value obtained from more fruit/bunch and mesocarp/fruit. The fruits were also larger. The DxP of African* dura*s and African x Deli* dura*s, especially of the former, had more oil/mesocarp and correspondingly less moisture and fibre. The large variation in mesocarp fibre in both the* dura *and* pisifera *populations suggests breeding for an optimal value based on maximum oil expression with the current milling technology. Inter-crossing Deli and African* dura*s and among* pisifera*s of different origins should generate trait combinations for higher bunch oil content than that of the currently widely used Deli x AVROS.*

Keywords: *Elaeis guineensis, pisiferas,* origins, progeny testing.

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INTRODUCTION

Palm oil, the oil from the mesocarp of the oil palm fruit, is one of the major edible oils in global trade. Notwithstanding the fact that it is the highest yielding oil crop, the oil palm is continually being improved through breeding. An important feature in its breeding is the occurrence of three fruit forms – *dura*, *pisifera* and *tenera* - mainly distinguished by their shell thickness (Janssens, 1927; Smith, 1935; Beirnaert and Vanderweyen, 1941).

The *dura* has a thick shell of 2-8 mm and a low (35%-55%) mesocarp/fruit ratio. The *pisifera* is shell-less and has about 95% mesocarp. This would be the fruit form to plant except that it is generally female sterile. The *tenera*, with a shell of medium thickness of 0.5-4 mm and 60%-95% mesocarp, is a hybrid between *dura* and *pisifera*. Following the elucidation of shell thickness inheritance and hybrid nature of *tenera* (Beirnaert and Vanderweyen, 1941), commercial cultivation has been based on quality *dura* x *pisifera,* or DxP, as the planting material.

In the production of DxP, the *pisifera* is used as the male parent because it is female sterile. Its pollen is collected to pollinate female *dura* inflorescences. A single male inflorescence produces 50-100 g pollen but as little as 0.05 g is required to pollinate a female inflorescence. Hence, selecting a good *pisifera* parent is of far greater importance than selecting a good *dura* parent. This study examines the performances of some *pisifera*s from four distinct origins - Binga, Ekona, Ulu Remis *Tenera* (URT) and Angola. Control DxP crosses of *pisifera*s of AVROS origin were used to link the trials planted in different places and at different times. African, African x Deli and Deli *dura*s were used in the progeny testing.

BREEDING BACKGROUND

*Pisifera*s

Binga. Binga was a Yangambi substation in the Democratic Republic of Congo. The seven Binga *pisifera*s involved in CBP13 were from four selected families (*Figure 1*), of which Bg142 produced exceptionally high oil/bunch, the highest among 470 progenies in the 1970s trials there. Progeny Bg 271 had the second highest oil yield from good fruit bunch yield and good bunch oil content, while Bg414 was a cross between 187III and 69MAB, both of which had high breeding values for oil yield. Also included in CBP13 were five *pisifera*s from Pamol progeny PKg111. This family also originated from Binga but was brought earlier to Malaysia through Oil Palm Genetics Laboratory (OPGL), a research consortium of which Pamol was a member. Binga selections may, in addition, have *Fusarium* tolerance as the disease is endemic there.

Ekona. The four Ekona *pisifera*s in CBP13 were received as pollen in 1989 from Unilever's Lobe Station in the Cameroon (*Figure 2*). All four had produced good progenies in Lobe Experiments 81/1 and 82/1. In addition, two other Ekona *pisifera*s, each from progenies PSh1019 and PSh1021, were tested; they were acquired earlier in 1969 by Pamol through the Sabah Breeding Programme (SBP) (Pamol, 1969; Rajanaidu *et al*., 1985). One characteristic of the Ekona Breeding Programme was the intense selection for bunch oil through higher mesocarp oil content.

Ulu Remis* Tenera *(URT). Guthrie imported bulked pollen of good progenies from Yangambi, Congo for crossing with their best Deli *dura*s in Ulu Remis, Malaysia to generate what is known as the Ulu Remis *Tenera* (*Figure 2*). Selected *tenera*s were inter-crossed to produce *pisifera*s. The eight URT *pisifera*s tested in this trial were from three of the five Ulu Remis TxT families offered to the SBP - PSh1037, PSh0984 and PSh1042 - with two, four and two *pisifera*s, respectively.

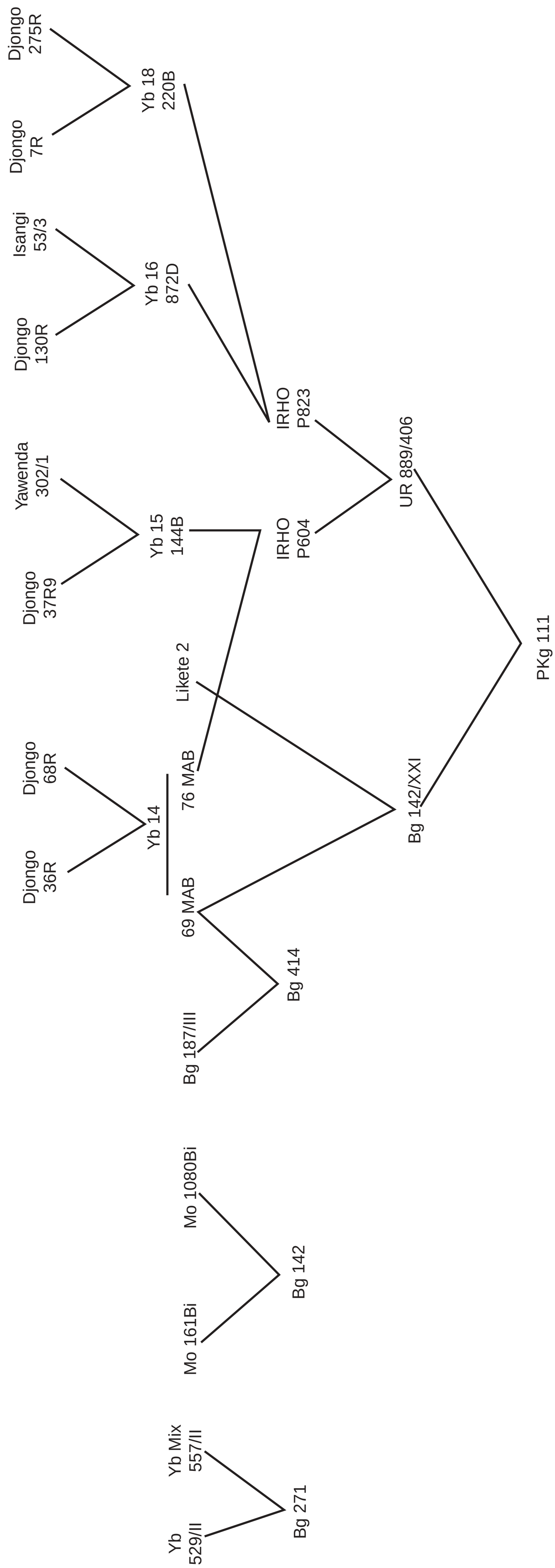
Angola. The Angolan material was obtained from the breeding programme of the Nigerian Institute for Oil Palm Research (NIFOR). Ang 263, a selfed family, was the source of *Pisifera* Lb135 (*Figure 2*). This origin had produced good progenies in the Lobe Experiments 81/1 and 82/1. Although the Angolan material comprised only one *pisifera* (which was crossed to two Deli palms), it was included because of scant information on this rare material.

Algemeene Vereniging van Rubber Planters ter Oostkust can Sumatra (AVROS). This intensely bred population is arguably the most extensively used source of *pisifera*s for DxP production (*Figure 2*). AVROS performance is good and recognized. Three crosses of proven AVROS *pisifera*s with selected Deli *dura*s were used as the standard crosses in CBP13.

*Dura*s

Broadly, two distinct groups of *dura*s were involved - Deli *dura*s and mixed *dura*s. The Deli *dura*s were descendents from the four original oil palms first introduced to Southeast Asia (Indonesia) in 1848, the second generation of which were planted in Deli, North Sumatra. Selection at Deli subsequently produced a *dura* type with larger fruits and thicker mesocarp than those commonly found in Africa. For convenience, the latter are referred to as African *dura*s. The African *dura*s and African x Deli *dura*s are collectively referred to as mixed *dura*s in this study.

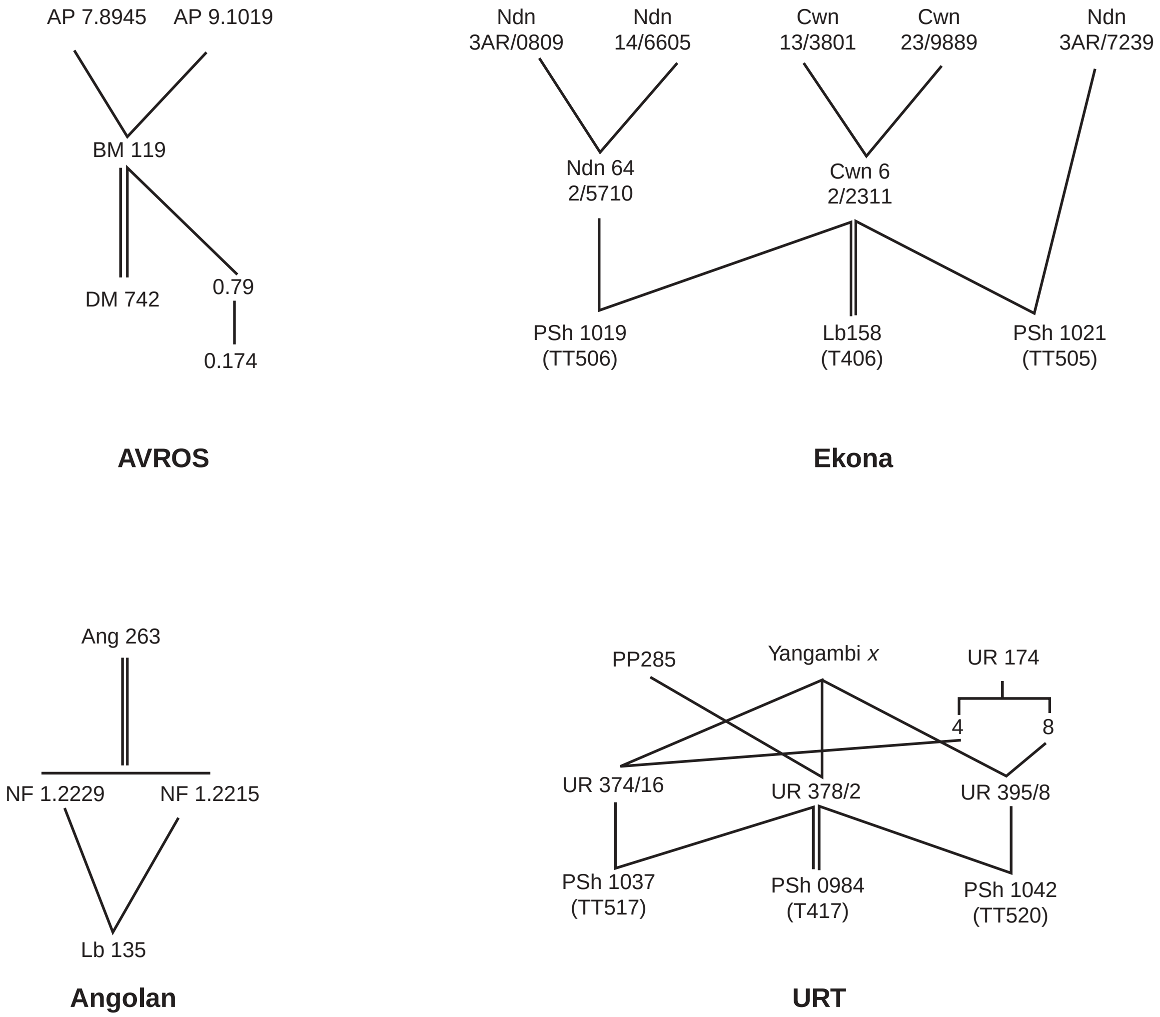
The specific Deli *dura*s used in CBP13 were from Pamol Trial PBT 74/1, planted with progenies from Deli *dura*s selected for lower height and high bunch index (*Figure 3*). The parents were from Ulu Remis and selected by OPGL. Of the parents, Palm



Notes: Bg - Binga, Yb - Yangambi, UR - Ulu Remis, Mo - Mongana, PKg - Pamol Kluang
(Bg 142 is not related to Bg 142/XXI)

Source: Rosenquist (1988).

Figure 1. Pedigree of Binga pisiferas *used in CBP13.*



Notes: Lb - Lobe, PSh - Pamol Sabah, AP - Aek Pancur, BM - Banting, DM - Dami, UR - Ulu Remis, NF - Nifor, Ndn - Ndian, Cwn - Cowan.

Source: Rosenquist (1988).

Figure 2. Pedigree of Ekona, URT, Angolan and AVROS pisiferas *in CBP13.*

UR666/166 had given particularly good progenies, and 17 of the 28 Deli *dura*s used for CBP13 were derived from it. The Ulu Remis parents were fourth generation Deli *dura*s.

The 13 mixed *dura* palms in CBP13 were from DxT progenies planted in 1981-1982 at Pamol, Kluang. The latter were obtained from Unilever (Cameroon) and included selections from Ekona, Yaligimba and NIFOR (*Figure 4*). Two of the DxT progenies, PKg 208 and PKg 217, were part Deli *dura*s. The eight URT *pisifera*s also had Deli genes. So, the trials included a range of DxP progenies with 75%, 50%, 25% and no (0%) Deli *dura* genes.

EXPERIMENTAL DETAILS

The DxP crosses were made in 1989-1991 at Pamol, Kluang as part of the CBP by Unilever and Harrisons & Crosfield to expand and evaluate their respective breeding stocks. The Deli *dura*s used were seed parent palms while the mixed *dura*s were high yielding palms from selected DxT progenies. The *pisifera*s were generally from selected TxT crosses with some, like AVROS, being male parent palms.

The 126 crosses made were planted out as three trials, 13A, 13B and 13C, in 1992-1993 at Pamol, Kluang. All the trials were close together and

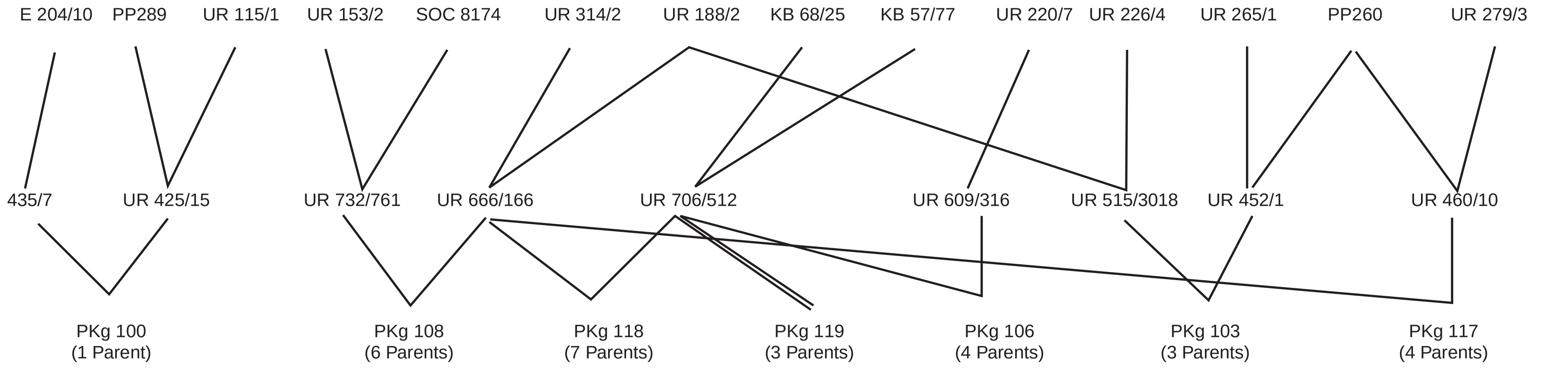
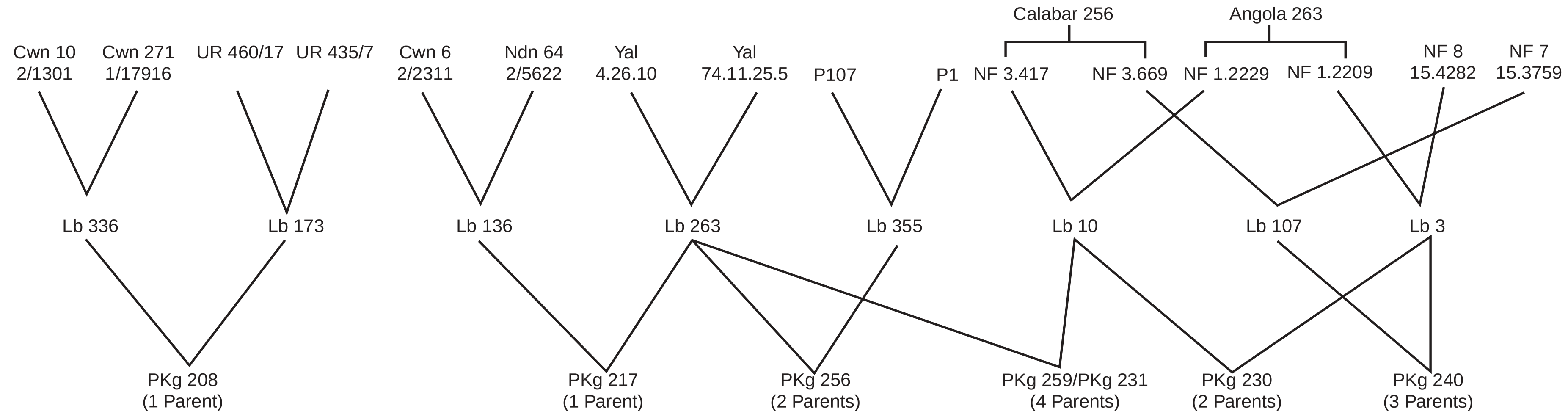


Figure 3. Pedigree of Deli duras *used in CBP13.*



Notes: PKg - Pamol Kluang, Lb - Lobe, NF - NIFOR, P - Pobe, Yal - Yaligimba, Cwn - Cowan, UR - Ulu Remis, Ndn - Ndian, Soc - SOCFIN, KB - Klanang Baru, E-Elaeis, PP - Parent Palm.

Source: Rosenquist (1988).

Figure 4. Pedigree of mixed duras *used in CBP13.*

planted within six months of each other. Trial 13A was planted on Rengam soil, 13B on Beserah soil and 13C on both Beserah and Rengam soils. All three were underplanted as the replanting practice then, with 50% of the old stand felled at 18 months and the rest at 24 months. The planting was triangular at 9.14 m spacing, giving a density of 138 palms ha^{-1}, and standard estate management was practised throughout.

Trial 13A was planted with the Deli *dura*s x test *pisifera*s progenies and Trials 13B and 13C with both the Deli and mixed *dura*s x test *pisifera*s progenies. The first trial consisted of 37 progenies, the second 40 and the third 42. Each progeny was represented by 48 palms in a randomized block design of 12 palms/progeny/plot replicated four times.

Individual palm yields from 1995-2000 were recorded and vegetative measurements taken when the palms were three and a half, five and a half, and seven and a half years old. Fruit bunches were sampled from each palm between 1996-2000 for bunch analysis and most palms had at least three bunches analysed for a total of 16 000 analyses. Bunch analysis followed the method of Blaak (1963) as modified by Rao *et al.* (1983). Fruit set was determined as the ratio of fertile fruits to the sum of fertile and parthenocarpic fruits and undeveloped flowers. The bunch analysis data are discussed in this paper while the yields and vegetative measurements will be the subject of a later communication.

RESULTS AND DISCUSSION

Pisifera Effects

A general comparison of the DxP fruit bunch traits of Binga, Ekona and URT *pisifera*s, represented by 12, 8 and 10 *pisifera*s, respectively, shows the origins to be distinctively different (*Table 1*). DxP AVROS expectedly gave the highest bunch oil content from good fruit/bunch with relatively large fruits with thick mesocarp and medium sized kernels in very thin shell nuts. It should be noted that the bunch oil content and some of the component values in *Table 1* are lower than what are commonly reported. The bunches were first sampled six months from first bearing when they had low oil due to poor fruit development and ripening, whereas most of the reported figures are from older palms. However, the lower values should not affect the progeny rankings and detract from the usefulness of comparison between them.

The Ekona progenies were, on average, the closest to AVROS in their high bunch oil content. In AVROS, the high oil/bunch (O/B) derived from good fruit set/bunch and a thick mesocarp, whereas in Ekona it was from a high mesocarp oil content and correspondingly less water in the fruit. Rao *et al*. (1999) had observed the same in other trials.

Compared to AVROS, the DxP of Ekona *pisifera*s had an average higher shell/fruit (S/F). This implies that better O/B or kernel/bunch (K/B) can be obtained in this population by selecting for thinner shell, or lower S/F, which is highly heritable (Hardon *et al*., 1985). The relatively small DxP fruit in Ekona can also be improved by selecting *pisifera*s which produce larger DxP fruits. Large fruits are more conveniently collected when shed.

Both the Binga and URT *pisifera*s transmitted lower O/B from a thinner mesocarp and less oil in the mesocarp although the Binga *pisifera*s gave progenies with good fruit set. The *pisifera*s of both populations gave DxP progenies with the highest bunch kernel content because of the large kernel/fruit. URT *pisifera*s are involved in much of the DxP planted in Malaysia and mills processing the crop consistently produce high kernel extraction rate (KER), sometimes at the expense of oil extraction rate (OER) (MPOA, 2000). Considering only the mesocarp, the AVROS and Binga progenies had more oil because of less fibre than the DxP of the other origins. The oil/fibre (O/Fi) ratio should be investigated for its optimum in terms of sufficient structural fibre to bear the maximum oil and minimal

TABLE 1. *PISIFERA* INFLUENCE ON BUNCH AND FRUIT TRAITS OF DxP PROGENIES

Population	N	F/B	M/F	D/WM	O/DM	O/Fi	O/WM	K/F	S/F	O/B	K/B	FWt
Binga	12	64.8	80.5	58.8	73.4	294.7	43.6	9.0	6.8	22.7	5.9	10.5
Ekona	8	62.0	82.8	62.5	73.1	288.5	46.1	6.9	6.9	23.7	4.4	9.0
URT	10	62.7	80.6	58.9	72.9	287.1	43.4	9.1	6.4	21.8	5.9	9.8
Angola	1	65.4	82.2	58.8	72.8	280.3	43.1	8.2	6.1	23.0	5.5	10.3
AVROS	3	64.2	83.5	60.0	73.8	297.0	44.6	7.9	5.3	23.9	5.2	10.7
LSD (5%)	-	0.89	0.55	0.89	0.54	6.75	0.83	0.26	0.23	0.55	0.20	0.20

Notes: n – number of *pisifera*s tested/population; F/B - % fruit/bunch, M/F - % mesocarp/fruit, D/WM – % dry mesocarp/wet mesocarp, O/DM – % oil/dry mesocarp, O/Fi – % oil/fibre, O/WM – % oil/wet mesocarp, S/F - % shell/fruit, K/F - % kernel/fruit, O/B - % oil/bunch, K/B - % kernel/bunch, F Wt. - mean fruit weight (g).

absorption loss during milling. The AVROS and Binga progenies can provide useful variability to breed for the trait.

Only one Angolan *pisifera* was tested in this trial and the results must therefore be viewed with caution. Its DxP progenies were poorer in O/B than those from AVROS and Ekona but better than those from Binga and URT *pisifera*s. The superiority of the Angolan *pisifera* over the other two origins stemmed from a very good fruit/bunch and good mesocarp/fruit.

Twelve Binga, eight Ekona and 10 URT *pisifera*s were tested in the CBP13 trials. Though the numbers were small, the variation between the *pisifera*s provided additional information for each origin. The Binga *pisifera*s were from four families - Bg142, Bg271, Bg414 and PKg111 (*Table 2*). Overall the DxP of PKg111 *pisifera*s had higher O/B and K/B but the *pisifera*s from Bg142 and Bg271 were not much lower for the more important O/B. The superiority of the PKg111 *pisifera*s was due entirely to a better fruit/bunch (F/B), as the mesocarp/fruit (M/F) and oil/wet mesocarp (O/WM) were lower than those for the other origins. In the breeding programme at Binga, family Bg142 had the highest O/B [due to a particularly high O/WM] of the 470 progenies tested (Rosenquist *et al*., 1991). In this study, three of the four *pisifera*s from Bg142 had the highest oil/dry mesocarp (O/DM), possibly reflecting selection progress. In contrast, the two *pisifera*s of Bg414 gave low O/B, low O/WM and were average for most of the other traits.

In some families, the sib *pisifera*s differed considerably in their DxP performance. In Bg142, *pisifera* Bg142/B079/19 was markedly inferior than its sibs in M/F and O/WM, and hence also O/B, but produced good K/B. In the poorly performing Bg414, *pisifera* Bg414/E080/28 was particularly poor with a DxP progeny average O/B of only 17.3%. *Pisifera*s of family PKg111 showed even more contrasting sib differences. *Pisifera*s PKg111/26/02 and PKg111/16/01, for example, gave good oil and kernel values from good F/B and good O/M, while PKg111/21/14 had poor O/B from poor fruit set and lower M/F and especially poor O/M. Such differences may be the reason why one breeding station in Malaysia is using this family extensively for commercial DxP seed production while another has eschewed it.

Unlike the Binga families, the three Ekona families, Lb158, PSh1019 and PSh1021, were related as half sibs as Palm 2/2311 was a common male parent. Hence, the DxP progenies of the respective *pisifera*s were comparable (*Table 3*). On average, Lb158 *pisifera*s, from the self of Palm 2/2311 gave the best O/B, the superiority stemming entirely from a better O/M. Bunch oil content and its component, O/M, were key selection traits in the Unilever Breeding Programme at Lobe, Cameroon (Rao *et al*., 1999). The progenies of PSh1019 *pisifera*s also had good bunch characteristics with the M/F, at 84.2%, being especially high. The average M/F of DxP from the Ekona *pisifera*s was more than 82% and the kernel/fruit (K/F) correspondingly lower. Clearly, planting Ekona DxP will result in high OER and lower KER, as illustrated by the DxP progenies of PSh1019 *pisifera*s.

Among the DxP progenies of Lb158 *pisifera*s, small but important significant differences were found in F/B, M/F and O/WM, the latter from more O/Fi and less mesocarp moisture. The net difference was an absolute O/B disparity of 3.4%. The two best *pisifera*s in this family, Palms 12640 and 12433, gave DxP progenies with an average O/B near to or

TABLE 2. DxP PERFORMANCE OF BINGA *PISIFERA*S AT PAMOL, KLUANG

Pisifera	N	F/B	M/F	D/WM	O/DM	O/WM	K/F	S/F	O/B	K/B	FWt
Bg142/B079/19	4	64.4	79.7	56.6	72.9	41.9	9.3	6.9	21.5	6.2	10.5
Bg142/B062/04	4	63.5	82.5	60.4	74.7	45.6	8.1	6.0	23.9	5.2	10.7
Bg142/B101/33	3	60.4	83.9	61.1	74.7	45.9	7.5	5.4	23.1	4.6	11.2
Bg142/B116/12	3	61.7	81.4	59.0	75.1	44.6	9.2	5.7	22.2	5.9	11.1
Bg271/E046/17	4	62.8	81.6	60.4	73.0	44.5	8.6	6.1	22.7	5.5	9.5
Bg414/E062/28	2	65.1	82.5	54.1	71.3	39.2	8.1	6.0	21.1	5.4	11.0
Bg414/E080/28	2	56.4	78.1	56.3	70.0	40.0	10.2	7.1	17.3	6.1	9.1
PKg111/26/02	4	68.7	80.1	59.1	73.4	43.7	9.3	6.7	24.1	6.5	11.0
PKg111/26/07	4	66.3	80.3	56.8	73.4	42.0	9.0	6.8	22.3	6.1	11.5
PKg111/16/01	4	67.9	79.6	59.9	73.7	44.4	8.9	7.9	24.0	6.1	10.6
PKg111/21/08	3	65.0	78.7	60.3	74.2	45.1	9.6	7.7	23.0	6.3	10.3
PKg111/21/14	3	65.9	77.0	55.5	70.4	39.9	10.3	8.4	20.4	6.9	9.6
LSD (5%)	-	1.54	0.97	1.66	0.98	1.53	0.48	0.40	0.98	0.37	0.37

Notes: n – number of *pisifera*s tested/population; F/B - % fruit/bunch, M/F - % mesocarp/fruit, D/WM – % dry mesocarp/wet mesocarp, O/DM – % oil/dry mesocarp, O/Fi – % oil/fibre, O/WM – % oil/wet mesocarp, S/F - % shell/fruit, K/F - % kernel/fruit, O/B - % oil/bunch, K/B - % kernel/bunch, F Wt. - mean fruit weight (g).

exceeding 26%. This was indeed high, especially as the bunches were from young palms. The four *pisifera*s tested did not differ much for K/B in their DxP progenies. The two *pisifera*s of PSh1019 gave almost identical DxP progenies except for M/F, which was a remarkable 88.5% in PSh1019/2965 at the expense of having only 3.3% S/F. This *pisifera* gave DxP progenies with large fruits but extremely small nuts. In contrast to PSh1019, the two *pisifera*s of PSh1021 differed considerably, especially in F/B and mesocarp moisture content. Both the latter *pisifera*s, however, produced small fruits in their DxP progenies.

Like the Ekona families, the three URT families, PSh0984, PSh1037 and PSh1042, were half sibs with UR378/2 as the common male parent. They may even have been more related as the maternal grand parents of the non-common parents of PSh1037 and PSh1042 were sibs from the Deli family, UR174, and the maternal grandparent of PSh0984 a closely related Deli (*Figure 3*).

Among the three PSh families, *pisifera*s of PSh1037, particularly palms 4252 and 4292, transmitted poorer O/B to their DxP progenies mainly because of lower O/WM (*Table 4*). In contrast, the *pisifera*s from PSh0984 had better O/B despite the lower F/B. This was due to a better M/F or O/WM or both. However, *pisifera* PSh0984/171deviated markedly with high F/B, low M/F and very high K/F. More *pisifera*s from this family have to be tested for a better picture of such inter-progeny variation. The URT *pisifera*s can be considered the F2 of Deli x Yangambi grandparents and it would not be surprising that segregation had engendered different performances in the DxP testing. The three *pisifera*s of PSh1042 showed less inter-progeny variation for M/F and O/DM than those from the above two URT families. Two of the *pisifera*s in this

TABLE 3. DxP PERFORMANCE OF EKONA *PISIFERA*S AT PAMOL, KLUANG

Pisifera	N	F/B	M/F	D/WM	O/DM	O/WM	K/F	S/F	O/B	K/B	FWt
Lb158/12/12428	2	60.2	81.0	62.8	74.6	47.0	6.8	8.8	23.0	4.2	11.2
Lb158/12/12640	3	62.3	83.3	65.3	74.9	49.1	6.4	7.1	25.6	4.1	9.9
Lb158/12/12440	4	61.8	81.9	61.3	73.1	45.2	7.8	6.6	22.9	4.9	9.5
Lb158/12/12433	4	62.2	83.2	67.9	74.6	50.8	6.6	7.1	26.3	4.2	8.6
PSh1019/2949	4	63.8	83.1	61.6	72.9	45.3	6.2	7.5	24.0	4.0	9.3
PSh1019/2965	1	60.2	88.5	60.9	74.5	45.5	5.7	3.3	24.2	3.5	10.0
PSh1021/3169	3	64.6	81.8	61.9	71.5	44.8	7.9	6.7	23.7	5.2	7.5
PSh1021/3207	4	59.4	82.6	58.8	70.8	42.4	7.1	6.9	20.8	4.3	8.1
LSD (5%)	-	1.63	0.92	1.57	1.01	1.47	0.40	0.46	1.03	0.30	0.32

Notes: n – number of *pisifera*s tested/population; F/B - % fruit/bunch, M/F - % mesocarp/fruit, D/WM – % dry mesocarp/wet mesocarp, O/DM – % oil/dry mesocarp, O/Fi – % oil/fibre, O/WM – % oil/wet mesocarp, S/F - % shell/fruit, K/F - % kernel/fruit, O/B - % oil/bunch, K/B - % kernel/bunch, F Wt. - mean fruit weight (g).

TABLE 4. DxP PERFORMANCE OF URT *PISIFERA*S AT PAMOL, KLUANG

Pisifera	N	F/B	M/F	D/WM	O/DM	O/WM	K/F	S/F	O/B	K/B	FWt
PSh0984/174	3	57.2	84.6	58.5	72.3	42.8	6.9	5.4	20.5	4.1	10.2
PSh0984/175	4	59.4	84.0	64.9	74.4	48.6	7.5	5.2	24.1	4.7	9.9
PSh0984/165	3	58.8	81.9	62.6	74.0	46.6	7.8	6.7	22.3	4.8	9.0
PSh0984/171	4	64.1	75.9	61.2	72.3	44.7	11.7	7.6	21.7	7.7	8.1
PSh1037/4295	4	65.9	80.1	58.0	71.9	42.6	9.6	6.2	22.5	6.4	8.4
PSh1037/4252	4	64.5	82.3	53.0	71.3	38.3	8.5	5.5	20.4	5.6	9.9
PSh1037/4292	4	65.3	79.7	53.9	71.2	39.1	9.5	6.6	20.4	6.3	9.8
PSh1042/4350	4	61.3	81.5	60.1	74.4	45.0	8.9	5.9	22.4	5.7	11.9
PSh1042/4313	4	64.2	79.1	58.5	74.1	43.6	9.3	7.7	22.0	6.1	11.5
PSh1042/4344	1	61.6	78.8	62.5	73.9	46.5	10.0	7.0	22.5	6.3	9.0
LSD (5%)	-	1.55	0.95	1.51	0.96	1.40	0.46	0.38	0.92	0.36	0.30

Notes: n – number of *pisifera*s tested/population; F/B - % fruit/bunch, M/F - % mesocarp/fruit, D/WM – % dry mesocarp/wet mesocarp, O/DM – % oil/dry mesocarp, O/Fi – % oil/fibre, O/WM – % oil/wet mesocarp, S/F - % shell/fruit, K/F - % kernel/fruit, O/B - % oil/bunch, K/B - % kernel/bunch, F Wt. - mean fruit weight (g).

family, palms 4350 and 4313, gave DxP progenies with exceptionally large fruits.

Dura Effects

A comparison of the female parents expectedly showed the Deli *dura* to be superior for, *inter alia*, F/B, although, interestingly, not fruit set. This suggests that the larger fruits of the Deli more than compensated for the fewer fruits borne (*Table 5*), and implies that there is an optimum fruit set, not necessarily the highest, for maximum O/B. The superiority of the Deli *dura* for M/F at the expense of K/F, and, to a lesser extent, S/F is well illustrated in this trial. Furthermore, the Deli *dura*s transmitted marginally higher O/DM than the mixed *dura*s although the concomittently higher mesocarp moisture resulted in the mixed *dura* having better O/WM. Nevertheless, the net effect of the differences in component ratios was higher O/B in the DxP progenies of the Deli *dura*s. The mixed *dura*s transmitted superior K/B but as the overall commodity economics favour O/B, the Deli *dura*s remain the *dura* parent of choice. It may also be noted that the Deli *dura*s transmitted larger fruit size which is preferred for easier gathering during harvesting.

Of the Deli *dura*s tested, those from PKg106 gave DxP progenies with the highest F/B from a high fruit set, while those from PKg118 conferred the opposite characteristic (*Table 6*). For M/F, the *dura*s of PKg119 transmitted the highest values but, conversely, also the lowest K/F and a very low S/F, while the opposite obtained in the progenies of *dura*s from PKg103. Indeed, the two families, PKg103 and PKg117, whose *dura*s transmitted the lowest M/F, also transmitted the highest S/F suggesting that there is scope to reduce the latter in this Deli sub-population. The *dura*s from PKg103 also transmitted lower O/M, as did the *dura*s of PKg 108, in both cases from higher mesocarp moisture. Interestingly, while the DxP progenies of PKg119 had a high mesocarp moisture content, similar to that by PKg108, the lower fibre resulted in a better O/DM and, more obviously, a much higher O/Fi. The similar observations with *pisifera*s in the previous section suggest some breeding scope for this trait in both the parents of DxP progenies.

TABLE 5. FRUIT BUNCH TRAITS OF THE PROGENIES OF DELI AND MIXED *DURA* FEMALE PARENTS

Dura type	N	F/S	F/B	M/F	D/WM	O/DM	O/WM	K/F	S/F	O/B	K/B	FWt
Deli	84	63.7	64.0	82.5	59.7	73.6	44.3	7.9	6.2	23.3	5.2	10.5
Mixed	46	63.9	63.3	80.3	60.7	73.2	44.9	9.1	6.7	22.8	5.9	9.4
LSD (5%)	-	0.52	0.34	0.21	0.34	0.20	0.31	0.10	0.09	0.21	0.08	0.08

Notes: N – number of families with such *dura* parents; F/S – fertile fruits/total fertile and parthenocarpic fruits and undeveloped flowers; F/B - % fruit/bunch, M/F - % mesocarp/fruit, D/WM – % dry mesocarp/wet mesocarp, O/DM – % oil/dry mesocarp, O/Fi – % oil/fibre, O/WM – % oil/wet mesocarp, S/F - % shell/fruit, K/F - % kernel/fruit, O/B - % oil/bunch, K/B - % kernel/bunch, F Wt. - mean fruit weight (g).

TABLE 6. FRUIT BUNCH TRAITS OF DxP PROGENIES OF DIFFERENT DELI *DURA* FEMALE PARENTS

Deli *dura*	N	F/S	F/B	M/F	D/WM	O/DM	O/WM	O/Fi	K/F	S/F	O/B	K/B	FWt
PKg100	4	65.1	63.4	82.8	61.7	74.3	46.1	301.5	7.8	6.0	24.2	5.0	9.3
PKg103	7	65.3	65.8	78.6	57.6	72.7	42.4	284.5	9.5	7.7	21.9	6.3	10.0
PKg106	11	66.6	65.9	80.8	58.6	73.9	43.7	300.3	8.7	6.8	23.2	5.9	10.8
PKg108	19	63.4	63.4	83.1	59.4	72.7	43.6	282.2	7.6	5.9	22.9	5.0	9.9
PKg117	13	65.1	65.5	79.4	60.8	73.9	45.2	298.1	9.0	7.7	23.5	6.0	10.6
PKg118	18	60.1	62.2	84.9	60.0	74.2	44.9	303.6	7.1	5.0	23.6	4.5	11.5
PKg119	8	64.6	63.4	85.4	59.6	73.5	44.2	294.7	6.4	5.2	23.9	4.2	10.1
LSD (5%)	-	1.29	0.84	0.47	0.84	0.48	0.77	6.36	0.23	0.21	0.52	0.18	0.18

Notes: N – number of families with such *dura* parents; F/S – fertile fruits/total fertile and parthenocarpic fruits and undeveloped flowers; F/B - % fruit/bunch, M/F - % mesocarp/fruit, D/WM – % dry mesocarp/wet mesocarp, O/DM – % oil/dry mesocarp, O/Fi – % oil/fibre, O/WM – % oil/wet mesocarp, S/F - % shell/fruit, K/F - % kernel/fruit, O/B - % oil/bunch, K/B - % kernel/bunch, F Wt. - mean fruit weight (g).

The K/F of the DxP progenies of the Deli *dura*s ranged from a low 6.4% to a high 9.5%, the latter being almost the maximum for the progenies of mixed *dura*s. Clearly, there is considerable scope for increasing M/F in these materials by selecting against K/F while holding S/F down. A high K/F translates to high K/B and, conversely, lower O/B. The reverse is however not always true, *i.e.* a high M/F does not necessarily engender high O/B. The highest values for the latter arise from a high O/WM and a good M/F, or the other way round, provided F/B is satisfactory. Observations from other trials suggest that reducing K/F very low can result in poorer fruit set and hence, lower F/B.

The DxP progenies of mixed *dura*s showed similar or more variability than the Deli *dura* progenies for all the bunch traits (*Table 7*). F/B, for example, ranged from 57.8%-64.3% for the mixed *dura*s as compared to only 62.2%-65.9% for the Deli *dura*s, and O/Fi was 279%-320% compared to 282%-304%.

The results of this study suggest that the main benefit that the African materials can confer on the Deli *dura*s is an increased mesocarp oil content. The superiority of the former for this trait stems from more O/DM, presumably from less fibre and less moisture in the mesocarp of the ripe fruit. The K/F of DxP from African *dura*s is generally higher than that from the Deli *dura*s with some exceptions, *e.g.* PKg259 which gave DxP progenies with small kernels and a very low S/F. The mean fruit weight of these progenies suggest a large fruit with thick mesocarp and small kernel enclosed in a very thin shell.

CONCLUSION

The CBP13 trials are the most extensive comparative progeny testing of Binga, Ekona and URT *pisifera*s. All the three origins were independently developed for different needs. AVROS *pisifera*s crossed to selected Deli *dura*s were used as the standard to compare against the DxP progenies of these other *pisifera*s.

The results support the continued use of AVROS materials in breeding for increased bunch oil content. However, the less widely available Ekona origin is also good with some DxP progenies from its *pisifera*s even better than the best AVROS DxP progeny. However, the two origins produce their superior bunch oil contents through different bunch components - AVROS from better F/B and M/F whereas Ekona from superior O/WM. Hence, introgression between them may well effect more progress in O/B than by breeding within each population alone.

The DxP of Binga and URT *pisifera*s were generally poorer in O/B, either from lower O/M (Binga) or poorer F/B (URT). Their M/F was also lower from a larger kernel or thicker shell. The net effect would be DxP progenies with lower OER. The KER may or may not be correspondingly higher depending on the shell thickness.

The CBP13 trials also compared Deli *dura* with African and African x Deli *dura*s. In the Deli *dura*, there was some variation for S/F and K/F despite its long selection history for M/F. Hence, further selection within Deli *dura*s should emphasize the

TABLE 7. FRUIT BUNCH TRAITS OF DxP PROGENIES OF MIXED *DURA* FEMALE PARENTS

Female	N	F/B	M/F	D/WM	O/DM	O/WM	O/Fi	K/F	S/F	O/B	K/B	FWt.
PKg208	3	64.0	82.2	60.0	73.3	44.4	292.4	8.1	5.9	23.3	5.3	9.3
PKg217	3	63.4	79.0	59.0	72.5	43.5	288.0	9.8	7.1	21.9	6.3	8.5
PKg230	7	64.3	79.9	62.2	72.6	45.5	279.0	9.5	6.6	23.3	6.3	8.9
PKg231	10	64.3	79.6	61.9	73.8	46.1	298.2	9.3	7.2	23.6	6.1	9.4
PKg240	8	63.3	79.8	58.8	72.2	43.1	280.8	9.4	6.7	21.8	6.1	8.6
PKg256	3	64.0	77.9	60.3	73.5	44.8	295.1	9.7	8.3	22.3	6.4	9.0
PKg259	4	57.8	84.9	61.7	75.2	46.7	320.3	7.1	4.9	22.8	4.3	12.9
LSD (5%)	-	1.16	0.71	1.16	0.74	1.09	8.58	0.36	0.28	0.70	0.28	0.25

Notes: N – number of families with such *dura* parents; F/S – fertile fruits/total fertile and parthenocarpic fruits and undeveloped flowers; F/B - % fruit/bunch, M/F - % mesocarp/fruit, D/WM – % dry mesocarp/wet mesocarp, O/DM – % oil/dry mesocarp, O/Fi – % oil/fibre, O/WM – % oil/wet mesocarp, S/F - % shell/fruit, K/F - % kernel/fruit, O/B - % oil/bunch, K/B - % kernel/bunch, F Wt. - mean fruit weight (g).

ideal ratios for mesocarp, shell and kernel in their DxP fruit, taking into account crop milling requirements and the relative prices of oil and kernel.

Despite having a higher O/M compared to the Deli *dura*, the African and African x Deli *dura*s gave DxP with lower bunch oil content. They transmitted lower M/F and lower F/B. The superior O/M of their DxP stemmed from less fibre or moisture or both.

The relative amounts of oil and fibre in the mesocarp, expressed as the O/Fi ratio, varied considerably in both the *dura* and *pisifera* populations examined. It may be worth breeding for this trait, as there is an optimum proportion of fibre, oil bearing cells and nuts in milling to express the oil physically.

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