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OIL PALM BREEDING WITH PARTICULAR REFERENCE TO BREEDING FOR SHORT STEMMED PALMS IN NIGERIA

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This paper is intended to spot-light the present situation about oil palm breeding with particular reference to breeding for short stemmed oil palm in NIFOR. An elaborate programme of breeding for short stemmed oil palm was embarked upon as far back as 1954 in NIFOR. Breeding for short stemmed oil palm is difficult partly because of the absence of suitable materials and partly because short stemmed palms are usually very poor yielders. Furthermore, short stem selection is rather difficult in African palms, because in the field, where about 8.84 meters triangular spacing is used, the short stemmed palms are frequently overshadowed by the adjacent palms and one probably low in production for this reason. Height has a significant effect on the cost of harvesting and the economic life of the palm.

MAIN BREEDING PROGRAMME

Sources of breeding material

The African oil palm, *Elaeis guineensis* Jacq., which is endemic to the tropical lowlands of West Africa from Cape Verde to Angola is capable of producing more oil to the hectare than any other plant. Zeven (1967) has summarised the origin and subsequent distribution of the oil palm. Within the vast area of distribution there is very large variation in the palms, both in yield and in fruit and bunch characteristics. It is grown commercially in South East Asia, originally only as Deli palms, but now Deli material have been crossed with African material. It is also grown in South and Central America. In South America a genus, referred to in the older literature both as *Corozo oleifera* and *Elaeis melanococa*, but now referred to as *Corozo oleifera* (Bailey, 1940) has been identified. There are many similarities between *E. guineensis* and *C. oleifera*; but the main feature distinguishing *C. oleifera* from *E. guineensis* is its procumbent trunk, although erect habit may be maintained for 10—15 years (Hartley, 1967). There is clear evidence now that this erect habit is maintained for longer than 15 years (Obasola, unpublished) under Nigerian conditions.

Prospection for genetic material

It was realized at an early stage in the breeding and selection of the oil palm that prospection among the oil palm groves in West Africa was necessary in order to obtain as wide a range of genotype as possible. Even now, it is generally appreciated among oil palm breeders everywhere that the breeding material being exploited at present comes from a very narrow genetic base, and that in order to make further substantial progress in selection it is necessary to enlarge the gene pool and this can only be done by direct prospection among natural populations in Africa for *Elaeis guineensis* and in South America for *Corozo oleifera*. As the African oil palm is more important than the South American one, priority is being given to the former. Eastern Nigeria is considered the most important centre of distribution of the oil palm. It is, therefore, likely to be the richest source of variability as already good palm types are known from that area.

Breeding and selection

The main object of breeding and selection in the oil palm is to produce planting material with higher yields of palm oil and kernel, although more emphasis has been placed on yield of oil than on yield of kernel. It is now known that yield of oil and kernel can be increased by improving bunch yield and bunch quality.

Bunch yield : Environmental factors play an important role in determining bunch yield. One of the primary aims of oil palm breeder is to reduce variation in production and to eliminate those factors causing low yield. For example, yields from similar planting material are more than twice as high in Malaysia than in West Africa. As a result of this, oil palm breeders in the Far East and West Africa place different emphasis on the means by which yield of oil and kernel can be increased. The reason for this low yield is not unconnected with the fact that sex ratio, which is defined as the ratio of female to total number of inflorescences produced in a year, is lower in palms growing in West Africa than that of palms growing in Malaysia. One point worth mentioning is that sex ratio of West African palms is considerably higher than that of *Deli duras* of Malaysian origin growing in West Africa. The *Deli* material however has the advantage of good fruit composition and large bunches. One disadvantage of the high sex ratio in the Far East is that pollination is so adversely affected that they have to resort to assisted pollination to obtain good fruit set in their plantations.

Bunch quality : The main components of bunch quality are the ratios of fruit to bunch, mesocarp to fruit, shell to fruit, kernel to fruit and oil to mesocarp. Work in Nigeria and elsewhere has shown that

most fruit and bunch characters are highly heritable and that selection of parents for good bunch quality is justified (Blaak, 1965). There is, however, less evidence of heritability of oil to mesocarp than the other bunch and fruit characters, but an examination of the data being collected will shortly make the position clearer.

The basic pattern adopted at NIFOR

Early work in Nigeria consisted largely of selection of and breeding with a relatively small population of palms growing at Calabar and it was not until 1957 that an extensive and carefully planned breeding programme was initiated. The programme was described by Sparnaaij (1963). The source material consisted of selected palms judged on the collective performance of themselves and their relatives or on their individual performance in Nigeria. A very wide range of material has been included and there are selections from Nigeria, Angola, the Far East, the Ivory Coast, Jamaica, the Congo, and Dahomey, all integrated into one breeding programme. The source material is made up of *dura* and *tenera* palms. The *dura* include the Deli and other selections from overseas which cannot include *tenera* form because it is peculiar to West Africa, the centre of origin of the oil palm.

Between 1959 and 1966 more than 400 progenies involving 62 parents were planted out in statistically designed trials and many more in observation plots. More than 243 hectares of land are involved. On the assumption of additive inheritance, compensatory crosses were made. For example, palms which yielded a relatively small number of heavy bunches and palms with large fruits and kernels were crossed with palms with high mesocarp percentage.

If the selected *dura* is considered as population (A) and the selected *tenera* palms as population (B), population A, will be used to produce selected *dura* palms in future generations and population B, will be used to produce *pisifera* palms. Thus a system can be derived where either top crosses or *dura* × *tenera* crosses can be used as a method of distinguishing combining ability.

When the NIFOR programme was first laid down, it was thought that inbreeding depression might become serious and prevent full use being made of certain desirable lines. For this reason, *dura* × *dura* crosses and *tenera* × *tenera* crosses were included so that these crosses could be used in place of selfings. The crosses were paried, following a similar pattern of choice which was applied to the *dura* × *tenera* crosses in the comparative trials so that there could be affinity between a cross and respective selfing of several parents concerned. At the same time, these crosses would provide new genotypes by recombination and reassortment of genes without losses through selfings and these crosses could again be

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used as a second stage of source material. The basis, therefore, exists for continuing with both a programme of inbred or recurrent selection either reciprocal or otherwise. The most likely deviation from the methods of reciprocal recurrent selection developed for maize (Comstock, Robinson and Harvey, 1949) will involve the elimination of selfings. This is the policy followed by the I.R.H.O. in the Ivory Coast. It can be argued that the primary purpose behind the generation devoted to producing selfs is the reproduction in large numbers of the original selection. This is important in maize breeding, as only one or two cobs are produced from each selected plant and this limits the number of crosses that can be made and the seed produced. This is not so in the case of the oil palm with its indeterminate period of flowering. Many crosses can be made, up to 20 or more in a year for a palm with a very high sex ratio. Such a programme of recurrent selection would imply making crosses in each successive generation. This can of course lead to a situation equivalent to inbreeding. But selfings, also have the important role of unmasking deleterious and undesirable recessive characters and it is reasonable to argue that for at least one or two generations, selfings are a desirable part of oil palm breeding at some stage but more than a few generations are not necessary for the purpose.

At present it is certainly true to say that at least nine to ten years must elapse between successive generations in this breeding programme. In NIFOR, possible ways by which the time between generations of a breeding programme may be shortened are being investigated. However, with the present system, improved hybrid varieties can be produced almost indefinitely every ten years. The first generation is at the moment being assessed.

It is clear that some outstanding progenies have resulted from this programme, but the breeding values of individual parents and the heritabilities of the various selection criteria cannot be calculated until the yield potential of more recently planted trials has been assessed for a little longer. However, sufficient information on the performance of some of the earlier planted progenies is available for it to be possible to choose improved parent palms for the production of seed for commercial plantings.

The breeding programme adopted by NIFOR is probably not the most ideal, because the use of tester parents is a very wasteful method of testing in view of the demands on land. It may well be that in the next generation of breeding, tester parents will not be introduced. It may be that a simple diallel programme without reciprocal crosses will be more appropriate. All these problems will, however, be clarified when the breeding programme has been sorted out.

Selection of Pisifera parents : Oil palm can be divided into varieties according to the fruit form. There is the thick shelled palm which

forms a true breeding variety called *dura*. There is another true breeding variety which has no shell called the *pisifera*. *Pisiferas* show various degrees of infertility ranging from fertile to completely infertile. It appears likely that this range of sterility is associated with genes modifying shell thickness in such a way that fertile *pisifera* are potentially thicker shelled than sterile ones. Hartley (1967) described the difficulties associated with the selection and use of *pisifera* parents which when crossed with *dura* palms produce the thin shelled *tenera* with the characteristic ring of fibre around the shell in cross-section.

Pisifera palms must be male parents and can fertilise about ten times as many flowers as a single female inflorescence produces. The selection of *pisifera* palms is therefore, more difficult and important than the selection of *dura* palms. Whereas the yields of *dura* palms and their *tenera* sibs can be recorded and their fruit and bunch characters determined, this cannot be successfully done with *pisifera* palms because they show various degrees of infertility as mentioned above. There is also evidence that since the fertile *pisifera* are potentially thicker shelled than the sterile ones, the least fertile *pisifera* produce the thinnest shelled *tenera* and vice versa (Obasola, 1970). *Pisifera* parents are normally chosen indirectly on the basis of the performance of their *tenera* sibs.

As there is the possibility that the thickness of the fibre ring in the fruits of *pisifera* is correlated with the thickness of the shell in its progenies, an investigation has been started to study the progenies of four categories of *pisiferas* ranging from fertile to completely infertile which have been crossed with selected *durans*. The thickness of the fibre rings in the fruits of *pisifera* already in use will be measured and correlations with shell thickness of their progenies will be calculated.

In order to widen the range of selection criteria, the size of the inflorescence of infertile *pisifera* is being measured to see whether there is a correlation with the bunch size of their progenies. Sex ratio of infertile *pisifera* will also be calculated, because there is a tendency to select as parents, *pisifera* which produce relatively abundant male flowers. This may lead to an unacceptable low sex ratio in the progenies. It is possible to induce male flowers on *pisifera* with a very high sex ratio by severely pruning their canopies. Furthermore, systematic comparison of sib *tenera* and *pisifera* in a range of *tenera* × *tenera* progenies is being made as this may lead to further selection criteria.

The short stem programme

It has long been recognised that one of the contributory factors to the smaller economic returns in older plantations of oil palm is the height of the palms which make harvesting expensive. A subsidiary breeding programme was, therefore, started to incorporate the short stem character

into the high yield of normal material. In order to achieve this the following approaches have been employed.

- (i) Introduction of Deli and Pobe dumpies from Malaya and Dahomey respectively.
- (ii) Selection of short-stemmed local materials in Nigeria.
- (iii) Crosses between *Elaeis guineensis* and *Corozo oleifera* (South American oil palm).
- (iv) Crosses involving *Elaeis guineensis*, selection from *Corozo oleifera* × *Elaeis guineensis* hybrids, Pobe dumpies, Malayan dumpies.

(i) *Malayan and pobe "dumpies"* : In 1954, four strains of dumpy deli from Malayan were planted with one Nigerian *dura* and one normal deli × *pisifera* in a randomised block design.

Similarly, in 1959, two Pobe dumpy progenies were planted with material from the Belgian Congo, Dahomey, the Ivory Coast and WAIFOR in a randomised block design.

The yearly yield (per hectare) obtained from both Malayan and Pobe Dumpy trials for the first eight years and their heights in January 1973, are summarised in Tables 1 and 2.

TABLE 1 : Short stem programme : Malayan dumpy trial : main station 1954 (Expt. 14-2). First eight years cumulative yield in kg/hectare and height in January 1973

Progeny	No. of bunches	Bunch weight kg.	Single bunch weight kg.	Average height Jan. 1973 (metres)
1. G69 E206 2.5×2.3	4,693	50,794	10.8	4.9
2. G71 E206 1.7×1.7	3,759	35,062	9.3	3.7
3. G72 E206 1.9×2.3	3,878	43,026	11.1	3.7
4. G74 E206 2.3×2.3	3,183	32,873	10.3	3.6
5. 551.25 × 5148	12,634	77,447	6.1	8.4
6. 5.1439×1.474	8,334	64,215	7.7	6.8

1-4 : From Malaya

5 : .. Nigeria *dura*

6 : .. Deli *dura* × Nigeria *pisifera*

Although the dumpies show very slow stem elongation compared with normal oil palm, their yields are much below the average of selected oil palm.

TABLE 2 : Short stem programme : Pobe dumpy trial, main station, 1959 (Expt. 14.4)
First eight years cumulative yield in kg./hectare and height in January 1973

Origin	No. of bunches	Bunch weight kg.	Single bunch weight kg.	Height January 1973 (metres)
Tangambi <i>dura</i> × <i>pisifera</i>	11,229	83,954	7.5	3.3
Pobe Dumpy <i>tenera</i> × <i>tenera</i>	9,570	57,471	6.0	1.6
Lame <i>tenera</i> × Dabou Deli+	10,696	97,737	9.1	3.1
Dabou Deli × Sibiti <i>pisifera</i> +	6,760	72,106	10.7	3.6
NIFOR <i>dura</i> × <i>tenera</i>	14,231	96,028	6.7	4.3

All yields given are per bearing palm

◆ Dry season nursery seedlings.

(ii) Selection of short stemmed material in NIFOR : Because the yields obtained from the dumpies introduced from Malaya and Dahomey were poor, seven short stemmed palms were selected in the NIFOR Experiments in 1963.

The following crosses were later made and planted out in 1963 as Experiment 6-7.

- (1) 1.2904 selfed (T selfed)
- (2) 1.2804 × 6.21 (T × T)
- (3) 21.271 × 111.308 (*C. oleifera* × *pisifera*)
- (4) 21.271 × 31.2813 („ „ „)
- (5) 1.2804 × 1.814 (T × P)
- (6) 1.2804 × 14.2598 (T × D)
- (7) 2.3489 × 32.364 (D × T)

A summary of the yield for the first four years is given in Table 3, while their vegetative characters are given and discussed in (iii) crosses between *Elaeis guineensis* and *Corozo oleifera* (South American oil palm).

Progenies 4 and 5 in the above table are crosses between *Corozo oleifera* and *Elaeis guineensis*. Although all the palms here are selected for slow stem elongation and then crossed among themselves, the hybrids between *C. oleifera* and *E. guineensis* are the shortest. The yield of these short stemmed palms are still fairly low after four years of recording. Further observations are still to be carried out.

(iii) Crosses between *Corozo oleifera* and *Elaeis guineensis* : The American oil palm is referred to in the older literature both as *Corozo oleifera* and *Elaeis melanococa*. It is now accepted that the most acceptable

name is *Corozo oleifera* (Bailey, 1940) and therefore, the cross between the American and African oil palm is regarded as being intergeneric.

TABLE 3 : Trial of short stemmed material selected in NIFOR 1963 : (Expt. 6-7)
First four years' Cumulative yield in kg/hectare

Progeny	No. of bunches	Bunch weight kg.	Single bunch weight kg.
1. 1.2804 × 1.2804 (<i>tenera</i> × <i>tenera</i>)	5,445	24,839	4.6
2. 1.2804 × 6.21 (" ")	4,557	26,974	5.9
3. 21.271 × 111.308 (<i>C. oleifera</i> × <i>E. guineensis</i> (var. <i>pisifera</i>)	4,831	25,149	5.2
4. 21.271 × 3.2813 (<i>C. oleifera</i> × <i>E. guineensis</i> (var. <i>pisifera</i>)	4,608	20,956	4.5
5. 1.2804 × 1.814 (<i>tenera</i> × <i>pisifera</i>)	5,636	33,381	5.9
6. 1.2804 × 14.2598 (<i>tenera</i> × <i>dura</i>)	3,343	29,008	8.7
7. 2.3489 × 32.364 (<i>dura</i> × <i>tenera</i>)	7,229	34,828	4.8

There are many similarities between *E. guineensis* and *C. oleifera*. Both *Elaeis* and *Corozo* have short, female flower clusters that nestle close to the trunk. In *Corozo* they lie in the remains of the fibrous spathe surrounded by fibres while in *Elaeis* they are not surrounded by fibre. The greatest similarity is in the male florets, which are on very short fingers close to the trunk on a short pedicel. These fingers adhere for long periods and can usually be found on a fruiting tree at all seasons. Dead or alive they maintain their unique and easily recognisable appearance.

There is no evidence that varieties comparable to *tenera* and *pisifera* exist in population of *Corozo*, but it was pointed out by Ferrand (1960) that the nigrescens, albescens and virescens types probably exist and that the fruits of *C. oleifera* are generally small and exhibit a marked tendency for parthenocarpy.

The main feature distinguishing *C. oleifera* from *E. guineensis* is its procumbent trunk, although an erect habit may be maintained for 10-15 years (Hartley, 1967). *Corozo* which grows much more slowly is shorter than the African oil palm and has been found to be resistant to *Fusarium* wilt Blaak, 1967).

Pollination and compatibility : The crosses were made mainly using *E. guineensis* as the female parent. Data on fruit set after pollination, seed germination and emergence, collected for 73 progenies out of 140 crosses made between 1957 and 1969 showed that all crosses made

were successful, and an average of 382 fruits was set for each pollination out of which 50 per cent germination was recorded. This showed that the two genera hybridise well and seedlings are likely to be derived from seeds which germinate relatively well. No significant correlation was found between the age of pollen and the subsequent fate of the seed. In certain crosses the fruit set and subsequent germination and growth were poor probably because of some degree of incompatibility. In general, however, vigorous F_1 were obtained. It is intended to examine the chromosomes to study their behaviour at pachytene and to see whether differences occur in arm ratio and length and distribution of heterochromatin of the two genera. Attempts will also be made to identify the individual chromosomes.

Yield of bunches : The "one-loose-fruit" standard was employed before the bunches were harvested. The harvesting date, the palm number, the number of bunches and the weight of bunch or bunches were recorded before the removal of the bunches for analysis and processing. Summaries of yield per hectare of *C. oleifera* crossed with *E. guineensis* (varieties *pisifera*, *tenera* and *dura*), Nigerian *dura* crossed with Nigerian *pisifera*, Deli *dura* crossed with Nigerian *pisifera*, Deli *dura* crossed with Nigerian *tenera* (standard cross) and pure *C. oleifera* planted between 1960 and 1964 are given in Table 4.

TABLE 4 : Short stem programme : Crosses between *C. oleifera* and *E. guineensis* : First four years' Cumulative yield in kg./hectare

Progeny	No.	weight	Single bunch weight
1. <i>C. oleifera</i> × <i>E. guineensis</i> (var. <i>pisifera</i>)	4,646	28,393	6.1
2. <i>C. oleifera</i> × <i>E. guineensis</i> (var. <i>tenera</i>)	5,246	27,629	5.3
3. <i>C. oleifera</i> × <i>E. guineensis</i> (var. <i>dura</i>)	4,925	32,665	6.6
4. <i>C. oleifera</i> × <i>E. guineensis</i> (var. Deli <i>dura</i>)	3,977	29,702	7.5
5. Nigerian <i>dura</i> × Nigerian <i>pisifera</i>	6,501	31,247	4.8
6. Deli <i>dura</i> × Nigerian <i>pisifera</i>	5,233	33,858	6.5
7. Nigerian <i>dura</i> × Nigerian <i>tenera</i>	6,546	26,916	4.1
8. Corozo <i>oleifera</i> (pure)	639	2,813	4.4

Yields of over 11,200 kg. per hectare have been obtained from crosses between *C. oleifera* and *E. guineensis* in some cases. The yields obtained from *C. oleifera* × *E. guineensis* hybrids are generally higher than those from pure *E. guineensis*. A single plot of one Deli × *C. oleifera* progeny planted at NIFOR Substation, Abak (South Eastern State of Nigeria) in 1962, (not mentioned in Table 4) yielded 6,301 kg. of bunches per hectare in 1966. This was just below the high average of 6,842 kg.

of bunches per hectare of *E. guineensis* progenies planted at the same time in an adjacent experiment.

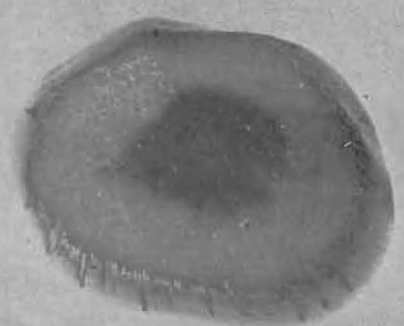
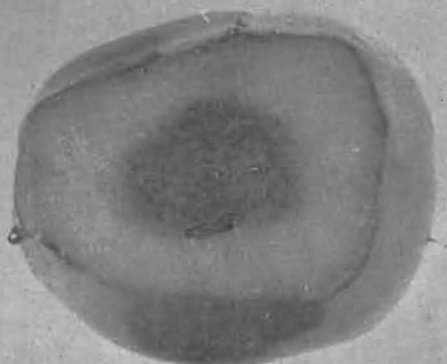
On this basis, the yields of bunches of the hybrids appear to be promising. However, the general appearance of bunches of the hybrids resemble more closely *C. oleifera*.

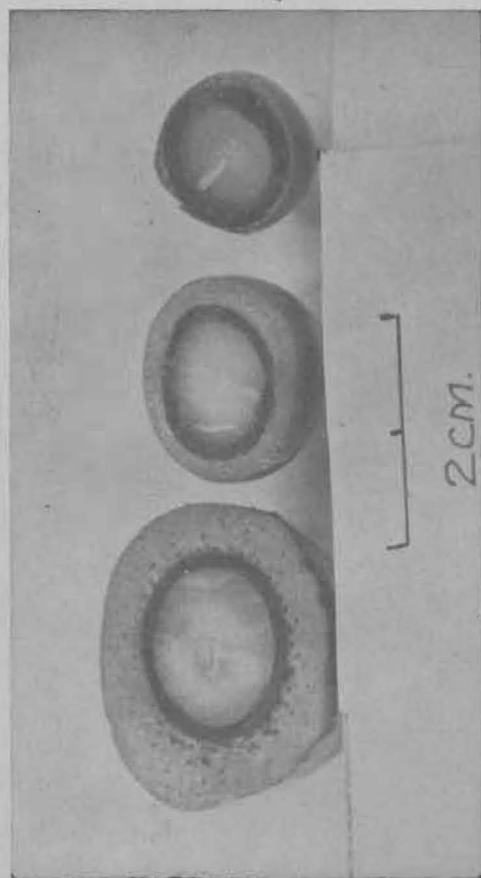
Bunch quality : In the laboratory, the different varieties were first determined (*dura*, *tenera*, *pisifera*) using only the loose fruits. The bunches were analysed the same day (if for oil analysis) or the next morning (Hartley, 1967). The percentage of oil to pulp of the samples was determined by both direct and indirect methods (Chapas, *et al.*, 1957). Bunch quality data of *C. oleifera* × *E. guineensis* *E. guineensis* (pure) and *C. oleifera* (pure) seedlings planted from 1960 to 1964 show that fruits produced by the hybrid *C. oleifera* × *E. guineensis* (var. *pisifera*) at maturity were found to be morphologically of *tenera* fruit form with thicker shells, but without the distinguishing fibre ring when a transverse section of the fruit is cut through the kernel (Fig. 1). Concentration of fibres are however, always found when a transverse section is cut between the point of attachment of the fruit to the bunch and the shell (Fig. 2). This is also true for *tenera* obtained from *dura* × *pisifera* of pure *E. guineensis*. The pure *C. oleifera* (which is regarded as *dura*) and the pure *E. guineensis* (*dura*) do not have such fibres.

Results of bunch analysis show that when *dura* and *tenera* are crossed (i.e. when *tenera* is the pollen parent and *C. oleifera* is the female parent) the bunch quality of *dura* resulting from such crosses compares well with that of *E. guineensis* but superior to *C. oleifera*. The *tenera* forms of the hybrids are however rather poor compared with *E. guineensis*. The percentage oil to mesocarp of *C. oleifera* is substantially lower than in *E. guineensis* and *C. oleifera* × *E. guineensis*. Although the single fruit weight is small in *C. oleifera* there is hardly any difference between that of *E. guineensis* and the hybrids.

Oil characteristics : Sample of mesocarp oil of the hybrid, *Elaeis guineensis* and *Corozo oleifera* were chemically analysed. Carotene was determined by finding the extinction at 448 of a 0.2 per cent W/V solution of the palm oil in petroleum ether. Iodine and saponification values were determined as per procedures contained in B.S.I. methods of analysis of oils and fats. The values obtained are given in Table 5.

The results obtained from the chemical analyses of the oil of the F_1 hybrid show that all the various values except Iodine value and Carotene content, are very similar to that of the African oil palm. The higher Iodine value and the fact that the oil is fluid at room temperature are indicative of greater unsaturation. This may turn out to be of economic importance, especially in the local market in Nigeria.





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Fig. 1. Transverse sections of fruit of (i) *Elaeis guineensis* (var. *tenera*); (ii) *Corozo oleifera* \times *Elaeis guineensis* hybrid; (iii) *Corozo oleifera*.

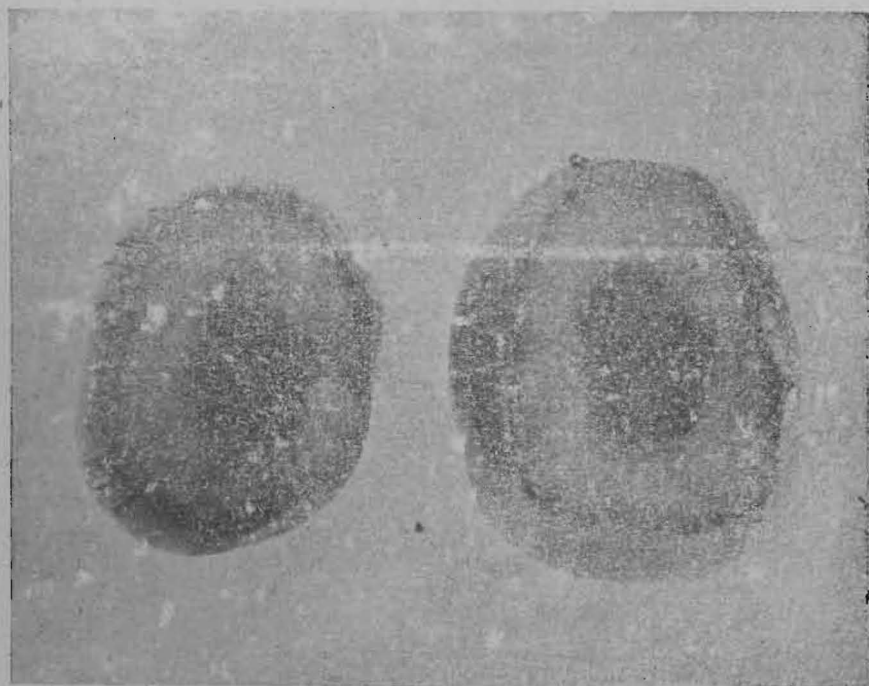


Fig. 2. Transverse sections of fruit of (i) *Corozo oleifera* \times *Elaeis guineensis* (var. *pisifera*) with the concentration of fibres; (ii) *Elaeis guineensis* (var. *tenera*) with the concentration of fibres.

TABLE 5 : Oil characteristics

Variety	Carotene ppm	Density at 140°F	Iodine value	Sap value
<i>Elaeis guineensis</i> (<i>dura</i>)	796	0.899	55.02	197.23
" " (<i>tenera</i>)	649	0.892	52.52	196.97
" " (<i>pisifera</i>)	306	0.902	57.09	196.63
<i>C. oleifera</i> × <i>E. guineensis</i>	1,048	0.893	64.14	195.92
<i>C. oleifera</i> (pure)	2,861	0.879	74.00	191.70

Hermaphroditism : Some hybrid progenies are particularly prone to the production of abnormal inflorescences during early stages of flowering, a form of andromorphic hermaphroditism being commonly found. The result obtained in some progenies is summarised in Table 6.

TABLE 6 : *Corozo oleifera* × *Elaeis guineensis* F₁ hybrids summary of female, male and hermaphrodite inflorescences

Progeny	1967			1968			Total		
	♀	♂	■	♀	♂	■	♀	♂	♀
61.271 D × 111.308 P	171	121	22	680	673	81	851	794	103
61.271 D × 3.2813 P	116	165	24	362	403	35	478	568	59
61.271 D × 1.1375 P	47	93	—	53	97	—	100	190	—
61.271 D × 1.3747 T	73	96	5	116	149	7	189	245	12
61.271 D × 1.55 P*	208	326	35	277	315	23	485	641	58
61.271 D × 5.158 D	170	178	30	248	278	29	418	457	59

*=Fertile *pisifera*

Vegetative characters of F₁ hybrids *C. oleifera* × *E. guineensis* : Certain experiments at NIFOR Main Station where the hybrid progenies of *C. oleifera* × *E. guineensis* and pure *E. guineensis* were planted between 1960 and 1963, were used for this comparison. In Experiment 21-5, planted in 1960, progenies of *C. oleifera* × *E. guineensis* were compared in an unreplicated progeny rows. In Experiment 35-3b, planted in 1960 progenies of *E. guineensis* (*dura* × *dura*) were compared in a randomised block design. In Experiment 6-7, planted in 1963, two progenies of *C. oleifera* × *E. guineensis* hybrids were planted with 5 progenies of *E. guineensis* (*tenera* × *tenera*, *tenera* × *pisifera* and *dura* × *tenera*) selected for possessing slow stem growth in a randomised block design. In Experiment 16-1 also planted in 1963, in a 6 × 5 rectangular lattice, a number of *dura* × *tenera* crosses connected with NIFOR main breeding programme were compared.

During 1971 measurements of height, stem circumference, leaf 17 thickness, leaf canopy, number of leaves, number of leaf 9 leaflets and area of leaf 9 leaflets were made. Leaves 9 and 17 were chosen because they are mature and physiologically active and because measurements from them are more reliable than those from other leaves.

Data on vegetative characters showed that height increment in the hybrid is substantially lower than in *E. guineensis*. This slow stem elongation must have come from pure *C. oleifera* which is only 0.67 metres in height after 14 years of growth. Stem circumference of *E. guineensis* is greater than that of *C. oleifera* × *E. guineensis* hybrid. After 11 years of growth this difference disappears when there is an indication of hybrid vigour. In the eighth year after planting both leaf canopy and the thickness of leaf 17 of *E. guineensis* are greater than that of *E. guineensis* selected for shortness and *C. oleifera* × *E. guineensis* hybrids. After 11 years, however, the leaf canopy and the thickness of leaf 17 of these hybrids are significantly greater than that of *E. guineensis*. There is so much overlapping at this stage that the normal 8.84 metres triangular spacing seems inadequate for these hybrids. Oil palm selected for shortness produced more leaves than *C. oleifera* × *E. guineensis* hybrid during the first eight years of growth. After 11 years, the position is again reversed as in the case of leaf 17, with the hybrids producing more leaves. Although the number of leaflets in leaf 9 was consistently higher in *E. guineensis* at 8 and 11 years after planting, leaf area was always significantly higher in *C. oleifera* × *E. guineensis* hybrids. This probably indicates hybrid vigour for area of leaflets in leaf 9. The large leaf area of the hybrid is due mainly to larger size of individual leaflets since the number of leaflets per frond is so much less in *C. oleifera* × *E. guineensis* hybrids than in pure *E. guineensis*.

One other point worth mentioning is the arrangement of the leaflets on the rachis. In *E. guineensis* the angle of insertion of the leaflets on the rachis is irregular but roughly in two planes. In *C. oleifera* the leaflets are characteristically arranged in a single plane. This single plane arrangement of the leaflets is also observed in the hybrid.

(iv) *Crosses involving Elaeis guineensis selections from C. oleifera* × *E. guineensis* hybrids, Pobe dumpies and Malayan dumpies : Now that the slow stem elongation of certain *E. guineensis* in NIFOR, hybrids between *C. oleifera* × *E. guineensis*, Pobe and Malayan dumpies has been established, a programme in which *C. oleifera*, *E. guineensis*, Pobe dumpies, Malayan dumpies, selected short stemmed oil palm and selected *C. oleifera* × *E. guineensis* hybrids crossed in all possible combinations has been started. The first field planting will be carried out soon.

It is intended that selection from the hybrids from the above crosses will be back-crossed to the oil palm. Already selections of *C. oleifera* × *E.*

guineensis hybrids have been back-crossed to the oil palm and the results obtained are promising.

CONCLUSION

The NIFOR main breeding programme is now being examined in order to find out the relative values of progenies, so that the breeding values of the parents involved, can be assessed. This will allow the choice of parents in the next generation of the breeding programme to be done in a more systematic manner than was possible in the first stage. It will also be possible to widen the range of parents in the next generation as selections will be available from palms resulting from the current prospection in Eastern Nigeria and from introduction from other countries.

It is too early to speculate on the usefulness of the short stem character, as sufficient information is not yet available. However, the results obtained from crosses between *C. oleifera* and *E. guineensis* are very encouraging from the point of view of yield, and also because the short stem character of *C. oleifera* is transmitted to the hybrids. However, bunch quality of the hybrids is found to be inferior to that of selected African oil palm, but superior to that of the American oil palm. This is of considerable economic interest as only bunch quality need be improved further, once high yielding short stemmed palms have been obtained.

The fact that there is an indication of overall dominance of *C. oleifera* over *E. guineensis* with respect to vegetative characters may prove very useful in the study of dominance. The mode of the inheritance is now being studied in the F_2 back-crosses and crosses of the selected palms in the F_1 *C. oleifera* \times *E. guineensis* with selected palms in the short stem programme.

There is no information yet on the performance of the palms obtained from the programme in which Pobe and Malayan dumpies, selected *E. guineensis*, hybrids between *C. oleifera* and *E. guineensis*, short stemmed oil palm selected in NIFOR, and *C. oleifera* are crossed in all possible combinations. The result obtained from crosses among short stemmed palms selected in NIFOR and between the short stemmed palms and the American oil palm is promising (Table 3). Bunch quality and vegetative data are at the moment being assessed.

It is hoped that the short stem character will feature prominently in the future breeding programme of NIFOR.

SUMMARY

The origin of the oil palm, *Elaeis guineensis*, Jacq., is generally accepted as West Africa. Within this region a wide range of variation exists in commercially important characters such as yield, number and weight of

bunches, size of fruit and kernel, extent of shell and mesocarp and oil content. Early work in Nigeria consisted largely of selection of and breeding with relatively small population of palms growing at Calabar and it was not until 1957 that an extensive and carefully planned breeding programme was initiated. Apart from selected palms in Nigeria, this programme included a wide range of material from Angola, the Far East, the Ivory Coast, Jamaica, the Congo and Dahomey. Between 1959 and 1966, more than 400 progenies involving 62 parents were planted out in statistically designed trials and many more in observation plots. More than 243 hectares of land are involved.

A study is also currently being made on the relationship between the morphology of the *pisifera* fruit and the *pisifera's* value as parent with particular emphasis on the inheritance of their shell and large mesocarp.

It has long been recognised that one of the contributory factors to the smaller economic returns in older plantations of oil palm in Nigeria is the height of the palms which makes harvesting expensive. A subsidiary breeding programme was, therefore, started to incorporate the short stem character into the high yield of normal material. In this programme, sources of variation such as dumpies from Malaya, Dahomey, Nigeria and the American oil palm, *Corozo oleifera* (HBK) Bailey, have been introduced.

The Malayan and Dahomian dumpies were planted with other materials in 1954 and 1959 respectively. The dumpies have shown very slow stem elongation, but unfortunately their yields are much below the average of selected normal oil palm.

Crosses between the American oil palm (*Corozo oleifera*) and African palm (*Elaeis guineensis*) have been successfully made in order to produce short-stemmed palms. The two genera were found to hybridise well and vigorous F_1 hybrids were obtained. Height increment of the hybrids is significantly lower than that of *E. guineensis*. In fact, most of the vegetative characters of *C. oleifera* exhibit complete dominance over *E. guineensis*. There is evidence that the short-stem character is transmitted to the hybrids. Bunch quality of the hybrids was found to be inferior to that of the selected African, but superior to that of American oil palm. The average bunch yield obtained from the hybrids was comparable to that from African, but superior to that of American oil palm. A form of andromorphic hermaphroditism was commonly found in the F_1 hybrids. The hybrid's oil resembles that of oil palm, except in the Iodine value and Carotene content. The higher Iodine value and the fact that the oil is fluid at room temperature are indicative of greater unsaturation.

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