BREEDING

KUK Nampoothiri and **PS Ravindran**
CPCRI Research Centre, Palode, 695 562, Thiruvananthapuram, Kerala

Introduction

The ultimate yield of palm oil is dependent on many attributes viz., no. of bunches, bunch weight, no. of fruits per bunch and mesocarp. To achieve the objective of evolving oil palm genotypes with high oil yield, breeders manipulate one or more of these factors by making use of the genetic resources available with them. The main oil palm breeding programmes are from INEC (Zaire), NIFOR (Nigeria), IRHO (Cote d' Ivoire), PORIM (Malaysia) and ASD (Costa Rica). These have been dealt with in detail by Hartley (1988) in the recent edition of his book 'The Oil Palm' and no attempt is made here to go into those details. The broad principles involved in oil palm breeding is discussed with special reference to the work in India.

Commercial planting material

Ever since Beirnaert and Vanderweyen (1941) described the hybrid nature of *tenera*, plant breeders have concentrated on production of thin shelled *teneras* by crossing *dura* (thick shelled) and *pisifera* (shell-less) varieties. Apart from the thinner shells, the fruits have a ring of fibres around the shell. Only *tenera* hybrids are planted on a commercial scale all over the world (Fig. 1)

Fig. 1. Tenera hybrid

Shell thickness is monogenic, *duras* being homozygous for the dominant gene (Sh+Sh+) and *pisiferas* for the recessive (Sh-Sh-) gene. The latter generally has no shell and are mostly devoid of embryo. *Pisiferas* can therefore be produced only by crossing or selfing *teneras*. However, differences in yield are observed when various individual cross combinations are considered. In general, crosses between genotypes of wider origin with contrasting characters give better yields. This can be explained on a mathematical basis. *Deli* with 5 bunches and 20 kg FFB/bunch produces 20x5 = 100 kg FFB; *Lame* with 20 bunches and 5 kg FFB/ bunch also produces 5 x 20 = 100 kg FFB. But when *Deli* is crossed with *Lame* on an average it can produce 156. 25kg FFB instead of 100 kg.

$$\frac{5+20}{2} \times \frac{20+5}{2} = 12.5 \times 12.5$$

Breeding programme

The present day oil palm breeding programmes are modified versions of reciprocal recurrent selection. This is aimed at identifying *dura* and *pisifera* parents which when combined would give high yielding *teneras*. While *duras* can be assessed based on their own yield, the potential of *pisifera* cannot be directly measured. Its worth has to be gauged based on the performance of their progenies. In hybrid production, sterile *pisiferas* are preferred since fertility is normally related to shell thickness. A negative correlation between fertile *pisiferas* and thinness of shell in their *tenera* sibs has been reported (Sparnaaij *et al.*, 1963).

Based on these information, a breeding programme is outlined in Figure 2.

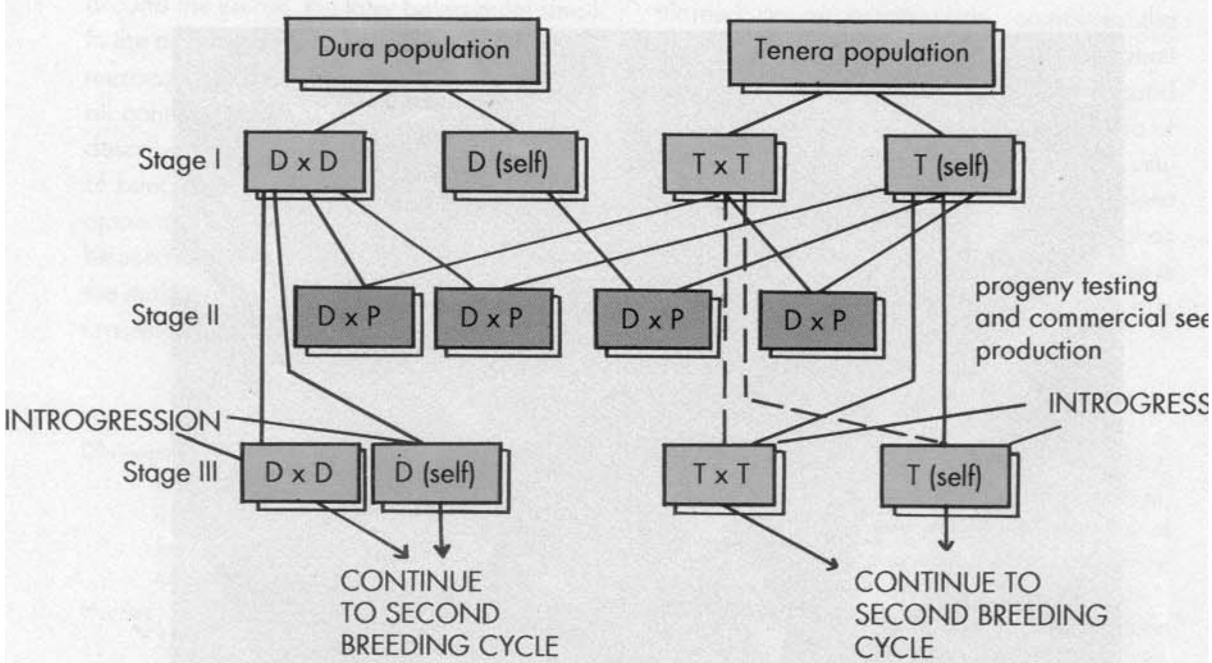

Fig 2. Oil palm breeding programme

In this scheme, *duras* are selected based on a system of family and individual mass selection. *Pisifera* selection is based on the performance in the *tenera* x *tenera* progenies in stage I and in stage II based on the performance of D x P progenies. Deductions made at each stage can be verified from the performance of the progenies obtained by using the selected parents. At each stage it is possible to introgress genes from any desirable new introduction.

Yield improvement obtained by following a systematic breeding programme at *IRHO* for two cycles is given in Table 1.

The first cycle resulted in 18 per cent yield increase over which 15per cent imporvement was obtained in the second cycle thus obtaining an overall progress of 36 per cent (Gascon *et al.*, 1988)

Performance of tenera in India

Eleven *tenera* hybrid combinations were planted at CPCRI, Palode during 1976 in a randomised block design. The *dura* parents of Malaysian origin available at Thodupuzha and four pollen samples received from NIFOR, Nigeria were used to make these crosses. The performance of these D x P combinations grown purely under rainfed conditions is given in Table 2.

The hybrids 65d x 30.103p and 120D x 30.103P were the best followed by 92D x 30.3154P. Combinations 156D x 30.4336P, 187D x 24.3087P and 269D x 30.4336P were poor performers giving only an average of 63.6, 66.6 and 81.4 kg FFB per palm per year respectively. Such combination wise differences indicate the necessity for identifying specific combinations.

The highest yields were obtained in 1986, for which introduction of the pollinating weevil (*Elaeidobius kamerunicus*) may be one of the main factors (Dhileepan and Nampoothiri, 1989). In that particular year also 65D x 30.103P was the best giving 164.1 kg FFB/palm. This is equivalent to 4.6 metric tonnes of palm oil which can be considered as a very good yield under rainfed conditions.

The boost in yield during 1986 was followed by a drastic reduction in 1987, 88 and 89. A 20 per cent additional dose of fertilizers was given as recommended by Suwandi *et al.*, (1984). By 1990, i.e. after three years, the yield level was restored. The trend in production of bunches was also more or less same as indicated in Table 3.

Table 1. Genetic progress on oil yield (6-9 years average)

Stage	Year	No. of progenies	FFB	oil yield t/ha	Progress
Control (original population)	1960	529	15.0	3.33	100
First cycle	1972	74	16.7	3.93	118
Second cycle	1984	74	19.0	4.52	136

Table 2. Yield of fresh fruit bunches per palm per year and oil yield

Treatments	yield of FFB (kg) 1986	1987	1988	1989	1990	Cumulative average	Oil yield MT/ha/ year*
65D x 30.103P	164.1	87.1	86.3	94.4	141.6	124.8	4.6
271D x 30.4336P	146.4	71.5	47.4	68.5	141.3	111.8	4.1
139D x 24.3087P	98.7	61.2	52.9	54.7	116.0	89.1	3.2
156D x 30.4336P	60.8	53.7	27.0	29.1	84.0	63.6	2.4
61D x 30.4336P	138.5	77.4	42.3	55.9	155.2	116.4	4.3
125D x 30.103P	125.7	77.0	85.6	73.8	137.0	113.7	3.8
108D x 30.4336P	123.0	72.9	67.3	64.6	139.8	110.7	3.9
92D x 30.3154P	124.7	91.0	49.8	104.7	161.2	127.2	4.5
269D x 30.4336P	107.2	69.4	28.6	39.8	101.1	81.4	3.0
187D x 24.3087P	63.3	48.8	36.8	40.5	85.4	66.6	2.4
120D x 30.103P	159.2	98.3	87.1	75.4	148.1	128.4	4.5

* Estimated on the basis of highest yield of FFB

Table 3. Number of bunches per palm per year

Treatments	1986	1987	1988	1989	1990	Cumulative average
	per palm per year					
65D x 30.103P	12.6	6.3	4.7	7.0	6.5	6.2
271D x 30.4336 P	12.9	5.7	2.8	6.2	6.5	5.5
139D x 24.3087P	8.7	4.8	3.1	4.9	5.8	4.7
156D x 30.4336P	5.9	3.9	3.3	3.7	4.1	3.7
61D x 30.4336P	9.1	6.2	2.9	5.2	7.2	5.3
125D x 30.103P	11.9	6.1	5.4	6.8	7.3	6.5
108D x 30.4336P	12.0	5.1	3.6	6.0	7.0	5.5
92D x 30.3154P	8.8	6.8	2.8	5.6	6.4	5.4
269D x 30.4336P	8.8	6.1	2.3	4.8	4.9	4.6
187D x 24.3087P	6.7	4.7	2.9	4.1	4.8	4.1
120D x 30.103P	12.2	6.5	4.4	6.7	6.5	6.2

There was a predominance of male inflorescences resulting in low sex ratio which could be due to the rainfed condition in which they were grown. The situation can be improved by supplementary irrigation (Nampoothiri *et al.* 1990). The preliminary reports from Karnataka where oil palm is grown as an irrigated crop support this view (Vasanth Kumar, 1991).

Germplasm

Oil palm (*Elaeis guineensis*) is now generally regarded as having originated in Africa (Chevalier, 1934; Zevan, 1967) and is endemic to West and Central Africa. Another related species, known as American oil palm (*Elaeis oleifera*) is found largely in the Central and South America. This species is gaining growing importance due to it specific advantages which could be exploited through inter specific hybrids. One more species (*Elaeis odora*) has been found in Brazil about which detailed information is not available.

Germplasm assemblage

Assemblage of germplasm is an important part of any breeding programme especially in crops like oil palm which are not indigenous. An organised collection of oil palm materials started in India during the 1960s by the Department of Agriculture Kerala. *Dura* and *Tenera* materials were imported from Malaysia and Nigeria and planted at the oil palm station, Thodupuzha, Kerala. Systematic collection of oil palm accessions was started by the Indian Council of Agricultural Research during 1979 at CPCRI, Research Centre, Palode, Kerala. Many countries are reluctant to spare oil palm planting materials. Therefore, the collection comprised mainly of random samples of *tenera* introduced by various agencies in the country from time to time for commercial purposes. The germplasm bank at Palode comprises of 22 accessions from nine countries (Table 4).

The germplasm materials are being evaluated for yield and yield attributes under uniform conditions.

Breeding for dwarfness

Short palms with larger girth and high leaf production, called dumpy palms, were described by Jagoe (1952) in a *deli* population. The well-known palm E 206 has been widely used in crossing programme to evolve dwarf palms. The height increment in further generations was only 16.3 cm in seventh year as against a 35.6 cm growth of non-dumpy palms in eight years. Dumpyness is considered as a homozygous character (Hartley, 1988). The dumpy *dura* x *pisifera* introduced to India from Indonesia however has not shown any height reduction compared to deli *dura* x pisifera during the initial five years growth.

Table 4. Germplasm accessions

S.No.	Source	Year of collection	No. of palms available	Remarks
1.	Nigeria (NIFOR)	1979	119	*Tenera*
2.	Cote'd Ivoire	1981	48	*Tenera*
3.	India (CPCRI)	1982	48	*Tenera*
4.	Republic of Zaire	1982	48	*Tenera*
5.	Indonesia	1986	48	*Delidura x pisifera*
6.	Indonesia	1986	48	*Dumpydura x pisifera*
7.	Malaysia	1987	20	*Tenera*
8.	Cameroon	1988	48	*Tenera*
9.	Costa Rica (ASD)	1990	55	*Tenera*

Interspecific hybridisation

Elaeis oleifera (previously referred to as *Corozo oleifera*) is found mostly in south and central America and is therefore called the American oilpalm. This species is of interest to breeders because of its dwarfness, oil fluidity and resistance to disease noticeably bud rot in Latin America as well as vascular wilt and reduced susceptability to the pest *Coelaenomenodera elaeidis* (LeGueny *et al.*, 1991). Only *dura* fruit forms have been located in this species. Therefore, the crosses are mostly made with *E. guineensis, pisifera*.

The F_1 hybrids are not directly exploited because they are low in fruit/bunch ratio, oil percentage and oil to bunch extraction (17 per cent). Certain hybrids have also been found to be susceptable to freckle (*Cercospora elaeidis*) in Africa. Therefore, a series of back crosses and selections in further generations have become necessary (Corley *et al.*, 1976). So far the interspecific hybrids have not been therefore commercially exploited. Reviewing the work by IRHO, LeGueny *et at.*, (1991) opinioned "Large scale distribution of tried and tested clones with *E. oleifera* genes would be possible in theory, in the first decade of the 21st century". This line of work on inter *specific* hybridisation has not been taken up in India.

The compact and super compact high yielding palms obtained in back cross generations of interspecific hybrids in ASD, Costa Rica give scope for increasing the yield by a clear planting of these dwarf and small crowned palms.

Clonal propagation

Through the improvements in biotechnology, it has been possible to produce large number of clonal plantlets in many crop plants which are true to type progenies. Therefore, the technique of tissue culture was tried on oil palm in many laboratories. This involves selection of suitable tissues from the ortet (clone source) and induction of callus formation and further development using artificial media under controlled laboratory conditions.

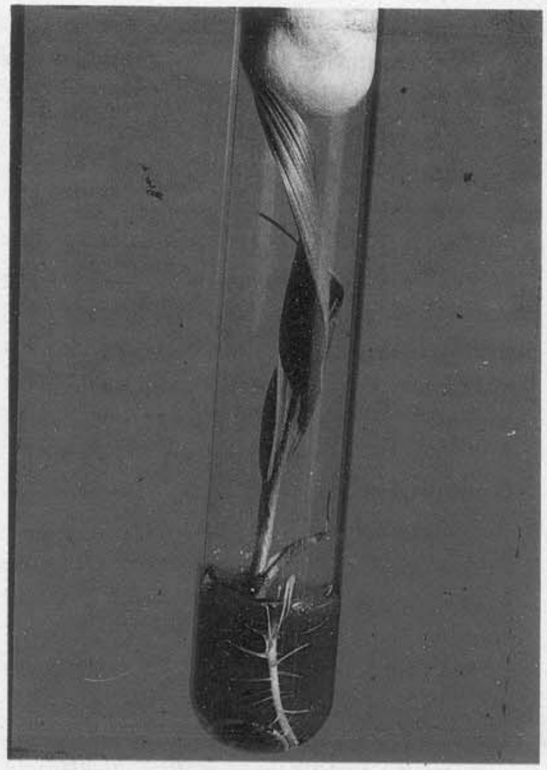

Fig. 3. Tissue cultured oil palm planlet

Since genetic change can occur during such culturing, it is necessary to field test clonal progenies before commercial exploitation. In such a trial in Malaysia planted during 1981-1983 two types of abnormalities viz. mantled poissoni fruit and androgynous inflorescence have appeared (Corley *et al*, 1986). This has caused a set back in the progress on use of clonal material. These abnormalities appear to be due to the use of fast growing cultures. Efforts are underway to overcome this by adjusting culturing methods and various compositions of media.

Clonal plantlets from adult palm tissues have been successfully produced by ORSTEM, France and the performance of these since 1983 are encouraging (Duval *et al.*, 1988). Observations in initial flowering showed that inflorescence production is better synchronised in clones than in seedling progenies. It is also reported that there is considerable improvement in yield and reduction in the within progeny variation in clonal progenies compared to seedling progenies. The tissue culture plantlets are now commercially sold from Tropiclone, Montpellier, France, at a cost of 4.5 US $/plantlet. It is advisable to restrict the extent of clonal progenies in any plantation to 10-15 per cent. (Nampoothiri, 1989)

In India success has been achieved in obtaining plantlets from leaf tissues of oilpalm seedling at CPCRI (Fig. 3) and BARC (Thomas *et al.*, 1985). It has been possible to develop a non-destructive sampling method to collect tissues from adult palms for culturing (Anonymous, 1988). However, it is necessary to produce clonal progenies from such adult palm tissues and field test them before commercial planting.

Commercial seed production

The commercial scale seed production commenced in India only after 1982, when *pisifera* palms were identified in the oil palm plantation, Thodupuzha in Kerala. Prior to that the commercial plantings were taken up using seeds imported mainly from Malaysia, Cote d' Ivoire, Nigeria and Zaire. Now it is possible to produce 0.4 million seeds annaully with present facilities available at CPCRI Research Centre, Palode.

Hybrid seed production is being done by pollinating superior *dura* mother palms with pollen collected from selected *pisifera* palms, which require controlled pollination.

Collection and storage of pollen

Male inflorescence is bagged 7 days before opening of the inflorescence. Before bagging, the spathe of the inflorescence must be sprayed with 40 per cent formaldehyde solution diluted by water in the ratio of 1:9. The solution kills all the foreign pollen grains

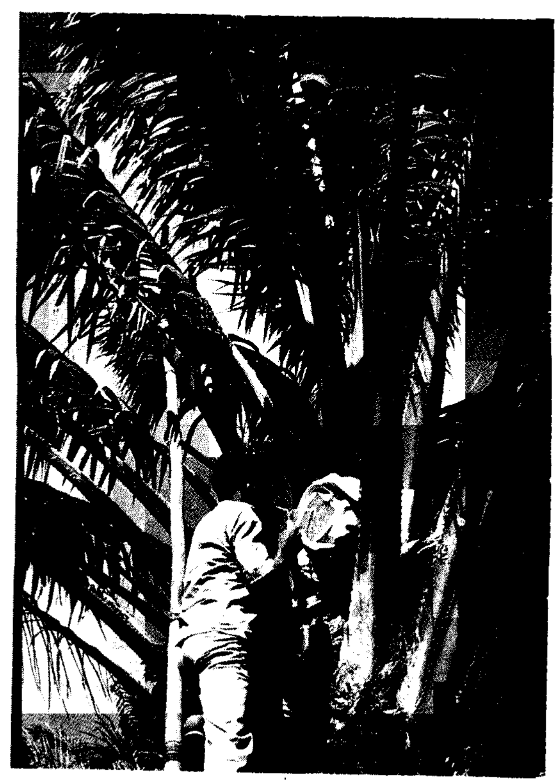

Fig. 4. Controlled pollination

Fig. 6. Oil palm sprouts

of sprouts vary from 0.4 to 0.5 US $ depending on the size of the order. Department of Biotechnology, M/s Radhika Vegetable Oils, M/s Godrej Soaps Ltd. and, Sri Ponnambalam Thiruchirappally have imported *tenera* hybrid sprouts from ASD, Costa Rica totalling to over one million (Anon. 1991).

Hartley (1988) lists the following points which the seed purchaser should bear in mind

1. The seeds should be obtained as progenies with information on parental achievements and analysis.
2. A clear definition of the terms 'proved seed' or 'proved parentage' should be obtained if these terms are used by the seller.
3. The following data relating to parents, sites or progeny should be obtained.
   a) Bunch yield at maturity over a given number of years with statement of location, soil, rainfall distribution, water deficit and sunshine.
   b) Fruits/bunch, mesocarp, shelll and kernel to fruit; oil to mesocarp.

Needless to mention that the buyer should make sure that the seeds are produced using parental palms which are free of diseases and pests. It may be pointed out here that since only *tenera* hybrids are commercially planted the seeds will have to be obtained everytime for planting from a known reliable source. Seeds collected from *teneras* grown in plantation should not be used for raising planting material.

Future strategy

The direct usefulness of *teneras* in the germplasm is very limited. It is necessary to collect *dura* parents which have been proved to produce high yielding hybrids. Serious effort has to be made for a systematic collection of oilpalm germplasm materials by prospection in the original habitat of *E. guineensis* and *E. oleifera* in view of the availability of valuable genetic resources in Nigeria, Cameroon, Honduras, Nicaragua, Costa Rica, Panama, Columbia, Surinam etc.

In India we have to use indigenous material to the maximum extent, import proven hybrids and purchase clonal progenies as a short term measure. The long term strategies would involve improvement of the indigenous hybrids mainly through introgression from imported advanced lines, establishing seed gardens to increase hybrid seed production and developing Indian technology for tissue culture.

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