CROP IMPROVEMENT IN OIL PALM - PRESENT STATUS AND FUTURE STRATEGIES

K.U.K. NAMPOOTHIRI* and R.S.N. PILLAI**
Central Plantation Crops Research Institute,
Kasaragod 671 124, Kerala

I. INTRODUCTION

Oil palm breeding in India made its beginning in 1960 when the Department of Agriculture, Kerala established a 40-hectare plantation at Thodupuzha (Kerala), using Deli *dura* materials from Malaysia and *Tenera* and TxT from Nigeria. However these materials were utilised only from 1982 in the breeding programme. Oil palm improvement through breeding is aimed at the generation of palms having high potentialities of producing maximum palm oil. It is also the concern of the breeder to incorporate other desirable traits like reduced height, better oil qualities and resistance to pests and diseases. The present day oil palm breeding programmes are mostly the modified versions of Reciprocal Recurrent Selection since the oil palm is not usually fitted into any known straight forward selection schemes. It has a number of characteristics which set it apart from other crops. Some of them are long generation time, monoecious nature of the palm, simultaneous improvement of two characters *viz.*, oil and

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* Director, CPCRI, Kasaragod

** Senior Scientist, CPCRI, Research Centre, Palode

kernel etc. A special situation also exists in oil palm in that male parent used for commercial hybrid seed production is female sterile, preventing the possibility of effecting the reciprocal crosses.

II. PRESENT STATUS

II. 1. Breeding Programme:

The present day oil palm breeding programmes are aimed at identifying *duras* (thick shelled type) and *pisiferas* (shellless type) parents which when combined would give high yielding *teneras* (thin shelled type). While *duras* can be assessed based on their own yield, the potential of *pisifera* cannot be directly measured since they are female sterile. Its worth has to be gauged based on the performance of *dura* x *pisifera* hybrid progenies.

With this background informations CPCRI has formulated a breeding programme as outlined in Figure 1.

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 new introduction.

Selection work as per the breeding programme has been in progress at CPCRI Research Centre, Palode since 1982 and presently it has reached the second stage.

II. 2. Genetic Resources:

Generally, oil palm breeding programmes elsewhere are handling populations of restricted origin tracing back to a few wild palms or unimproved palms and as a result several such programmes have reached such a stage where further progress will depend on the introduction of variability by way of recombination or introduction of new breeding materials. Therefore assemblage of germplasm so as to cover the maximum variability spectrum in the species *(Elaeis guineensis)* is a very important step in the breeding programme.

In India a systematic collection of oil palm germplasm materials was initiated since 1981 and a germplasm bank consisting of 73 exotic accessions was established at the Central Plantation Crops Research Institute, Research Centre, Palode. Efforts are underway to establish an alternate germplasm at the National Research Centre for Oil Palm in Andhra Pradesh. The details of these introductions are presented in Table-I.

Comparative performance of all these accessions are being assessed. Of these collections, the materials collected from Cameroon are sources for cold toleranance and those from Guinea Bissau, Tanzania and Zambia drought tolerance. These materials have been distributed to various locations for assessing their

performance in Andhra Pradesh, Karnataka, Kerala, Maharashtra and Tamil Nadu with respect to yield and tolerance to drought and cold.

Comparative performance of six of the accessions assessed at Palode during 1996-97 is presented in Table-II.

Introductions from Cote'd'Ivoire, India (Palode) and Indonesia-I performed better than others in the first, second and third sets respectively.

II. 3. Selection of Dura parents:

As a first step of the breeding programme, 43 *Dura* palms were selected based on yield and other characters during 1983-84 from a large *Dura* population available at the Thodupuzha Farm. Selfed and *inter-se* crossed progenies of these palms were planted at Palode to initiate the second cycle of selection. A total of 32 such progenies were planted during 1989, 1993 and 1994 in three experiments.

II. 4. Selection of *Pisiferas*:

In order to have a wider choice of suitable *Pisiferas*, seven high yielding *tenera* palms were inter-crossed and progenies were planted at Palode during 1991 in a RBD with 8 palms per plot and three replications. A preliminary screening done during 1996-97 revealed that the progenies segregated into 23 *Duras*, 40 *Teneras* and 6 *Pisiferas*. The progeny is being monitored for further classification and selection of *Pisifera* male parent.

II. 5. Hybrid performance trials:

Selection of suitable *dura* and *pisifera* parents for commercial hybrid seed production is to be done after progeny testing. This is achieved by assessing the performance of a large number od d x p combinations at every cycle of selection for a number of years. As part of the selection programme, 11 D x P combinations were planted at CPCRI 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-III.

The hybrids 65 D x 30.103 P and 120 D x 30.103 P were the best, followed by 92 D x 30.3154 P. Combinations 156 d x 30.4336 P, 187 D x 24.3087 P and 269 D x 30.4336 P were poor performers. Such combinationwise 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 factors. In that particular year the best hybrid gaves 164.1 kg FFB/palm (equivalent to 4.6 metric tonnes of palm oil) which can be considered as a very good yield under rainfed conditions.

Another trial was laid out at the Chithara Estate of M/s. Oil Palm India Limited, Kerala during 1985. Five D x P combinations being evaluated there are:

1. 271 D x 102 P
2. 128 D x 1 P
3. 266 d x 310 P
4. 82 D x 310 P
5. 118 D x 1 P

The experiment was laid out on a RBD with 3 replications and 8 palms per plot. During 1996-97, the combination 271 D x 102 P gave the best yield of 102.5 kg ffb/palm.

Three trials to compare 40 combinations were laid out at M/s. Nava Bharat Enterprises, Lakshmipuram, Andhra Pradesh during 1991.

II. 6.1. Hybrid Seed Production:

In India, commercial hybrid seed production was started in 1981 by CPCRI as soon as *pisifera* palms were identified at the Thodupuzha Farm. A total of 40 mother palms were selected at that Farm mainly based on the bunches and yield of fresh fruit bunches (FFB). Although a large number of *Pisifera* palms could be identified, only 11 of them having sterile characters were selected as male parents. Systematic hybrid seed production has been in progress using the above palms and an average of 0.3 million seeds/annum could be produced until 1996. Consequent on the initiation of hybrid seed production by M/s. Oil Palm India Ltd., at Thodupuzha, CPCRI continued the seed production at Palode using the *Duras* and *Pisiferas* in the second cycle of selection.

II. 6.2. CROSSING TECHNIQUE

Since *pisiferas* are female sterile, they are used only for collection of pollen, whereas *duras* are always used as the mother parent. Since male and female flowers are not generally found in

the same inflorescence, emasculation (removal of male flowers) is not necessary. The crossing involves many steps which should be meticulously followed to ensure that the seeds in a bunch are all borne out of desired pollen.

II. 6.3. Seed preparation:

The fruits ripen six months after pollination. When mature, they become reddish orange. The fruits can be detached and the mesocarp can be scraped off by using a knife. Although clean seeds with less damage can be obtained by this method, it is too laborious when large quantities are to be handled. Alternately the bunches are soaked in water for a week. The husk portion from the fruits are removed by pounding the fruit with sand or more desirably using a depericarper.

Seeds thus extracted are well cleaned and dipped in a solution of Emisan G (0.1%) or Foltaf 80w (0.2%) or Thiram 75 WDP (0.2%) for 20 minutes. They are then dried in shade for a day. Seeds are properly labelled and stored in polythene bags at room temperature. Care should be taken to maintain the moisture in seeds at 18%.

II. 6.4. Seed germination:

Seeds are processed for germination as and when required. They are kept in a heating chamber at 40°C for 80 days in air tight polybags. After heating they are again soaked in water for five days with a daily change of water so as to attain 22% moisture. The seeds are dried gently until their colour passes from shining to dull black. The seeds are again treated with

fungicides and returned to polybags with enough air inside and kept at room temperature. The seeds start germinating from one week and completes germination by sixth week. Sprouts are removed periodically from the bag and are ready for sowing.

II. 6.5. Packing and Despatch:

The sprouts are very delicate and hence have to be handled carefully. When nursery is raised away from the seed production centre, it is preferable to send the preheated seeds. If the customer has no expertise on germination, sprouts have to be despatched to him. For this the sprouts are packed (when the plumule and radicle can be distinguished) in white polythene bags. Moist sponge or vermiculate is filled in between sprouts to avoid injury to them. In a polybag 500 sprouts can be packed. The polybags are stapled and packed in hard board cartons. These cartons can accommodate 2000 to 8000 sprouts depending on the size of the cartons. Sprouts can remain in the polybags for 10-15 days. It is necessary to handle the sprout packets carefully and it is advisable that the cartons are carried as accompanied baggage to the destination.

II. 6.6. Sprout selection:

Unhealthy, ill formed, weak and disease affected sprouts are rejected and only healthy ones are selected for supply. Since there are expected rejections at the nursery stage also, the seed requirement per hectare is 200.

II. 6.7. Demand vs availability:

Against an annual demand of 2 million, CPCRI Research Centre, Palode produces 0.3 million seeds. The production cannot be increased in view of the limitation on the number of desirable *dura* mother palms available. Therefore, it has become necessary to import seed material. The recommended sources are ASD Costa Rica, New Britain Oil Palm Development Ltd., Papua New Guinea, IDEFFOR, Cote d'Ivoire, Unipalm, London and NIFOR, Nigeria. Seed gardens have been established to augment this constraint.

II. 6.8. Seed gardens:

Five million oil palm seeds will be required to plant a conservative estimated area of 25,000 hectares per annum in India. The demand will be much higher if the pace of planting becomes faster. To increase the indigenous production seed gardens have been established by Department of Horticulture, Andhra Pradesh at Rajahmundry, Department of Horticulture, Karnataka and Taraka, Nava Bharat Enterprises at Laxmipuram (Andhra Pradesh), Oil Palm India Ltd., Kottayam (Kerala) and Plantation Corporation of Kerala covering a total area of 60 hectares. They consist of *inter se* progenies of selected *dura* palms and *tenera* x *tenera* progenies involving high yielding *teneras* supplied from the Palode Centre.

III. Breeding for Dwarfness:

The advantages of incorporating dwarf genes into otherwise desirable oil palm hybrids is obvious. The dumpy palm having

unusually large girth and slow height increment in spite of high rate of leaf production has been used as a source for dwarfness elsewhere. A search for dwarf palms within the country resulted in the identification of one such palm at CPCRI (Research Centre), Palode. The details are given in Table-IV. This palm was self pollinated and a total of 54 seedlings are being monitored for identifying dwarf segregents.

IV. INTERSPECIFIC HYBRIDS:

The species *Elaeis oleifera* is endemic to Central/South America. There are perceptable differences in morphological characters between *Elaeis guineensis* and *E. oleifera*. The stem of *Elaeis oleifera* is usually procumbent and stem growth is very slow, usually less than half of the other species. In *E. guineensis* leaflets on each side of the rachies are arranged as upper and lower ranks but in *E. oleifera* all leaflets are in one plane and the individual leaflets tend to be wider. The progress of *E. oleifera* may prove to be an interesting source of resistance against some major diseases of oil palm. The oil quality is also reported to be superior to that of *Elaeis guineensis* mainly with respect to lower melting point, high iodine value and rich unsaturated fatty acids. But the yield of ffb is low /nuts are small and shell thickness is more resulting in a poor oil yield. Breeders have been attempting to incorporate the desirable traits of *Elaeis oleifera* into the cultivated species through interspecific hybridization since two decades. CPCRI Research centre, Palode is maintaining 23 *E. oleifera* palms imported from Malaysia and costa Rica since 1992. They are

regularly monitored for their morphological and yield characters. Interspecific hybridization [*E. oleifera x E. guineensis* and reciprocal] was initiated during 1995 and progenies are short listed for further evaluation.

V. Clonal propagation:

Through the advancement in biotechnology, it has been possible to produce large number of clonal plantlets in many crop plants which are true to type. Therefore, the technique of tissue culture was tried on oil palm in many laboratories.

In India success has been achieved in obtaining plantlets from leaf tissue of oil palm seedlings at CPCRI and Bhabha Atomic Research Centre (BARC), Trombay. It has been possible to develop a non-destructive sampling method to collect tissue from adult palms for culturing. However, it is necessary to produce clonal progenies from such adult palm tissues and field test them before commercial planting.

VI. MULTILOCATION TRIALS:

With a view to assessing the performance of 23 hybrids from Costa Rica multilocation trials have been laid out in Andhra Pradesh, Karnataka, Kerala and Tamil Nadu under the aegis of Technology Mission on Oilseeds and Pulses. Similarly 11 indigenous *tenera* combinations are being evaluated at Vijayarai (Andhra Pradesh), Gangavathy (Karnataka), Mulde (Maharashtra) and Aduthurai (Tamil Nadu) under the all India coordinated Research Project on Palms.

VII. FUTURE STRATEGIES:

Taking stock of the present status of oil palm research and development with respect to oil palm improvement, the National Research Centre for Oil Palm, Pedavegi, Andhra Pradesh, has formulated a perspective plan for the next 25 years, the broad aspects proposed are given below:

VII. 1. Widening Genetic Base:

The present germplasm contains seven indigenous and 71 exotic accessions from 11 countries. However, most of these are *teneras*. Widening germplasm collections through explorations has to be undertaken for the collections of *Elaeis guineensis, E. oleifera* and related species. Expedition programmes for *in situ* collection of materials from oil palm growing countries in Africa, Asia and south America are necessary. The assistance of an international organisation will be sought for. In spite of the reluctance of donor countries, efforts will be made to obtain proven *dura* and T x T parent material from leading oil palm research groups. The collections can be organised as a collaborative programme involving other oil palm research organisations in the world.

VII. 2. Construction of genetic linkage maps:

One of the impediments to genetic studies in oil palm is lack of markers. Biochemical and molecular markers will be developed using the techniques of "Restriction Fragment Length Polymorphism (RFLP)", "Random Amplied Polymorphic DNA (RAPD)"

"DNA amplification fingerprinting (DAF)" and isozymes. RFLP markers will be used to assess genetic variability between and within oil palm species and also for identifying *duras, pisiferas* and *teneras* in the seedling stage itself. Construction of a genetic linkage map for the oil palm will be tried.

VII. 3. Breeding:

Breeding programme will contemplate to evolve varieties/hybrids for high FFB yield, oil yield and high iodine value coupled with dwarf trait, multiple resistance to pests and diseases. It is also necessary to evolve hybrids which could perform well under low and high temperatures, as well as saline and drought prone situations.

VII. 4. Improvement of genetic material:

The collections available in the germplasm bank are mostly '*tenera*" received as sample from commercial imports. these cannot be directly used in breeding programmes. Available high yielding *teneras* will be selfed to obtain *duras* and *pisiferas* of various sources.

VII. 5. Identification of DxP:

The number of high yielding combinations identified are too few. A large number of cross combinations will be field tested so that sufficient number of hybrid lines are available for commercial exploitation.

VII. 6. Molecular breeding in Oil Palm:

Until recently, plant breeders depended on the conventional method of hybridization and selection to insert new genes into plants. This method has several limitations such as linkage between desirable and undesirable genes leading to their co-inheritance. Oil quality in *Elaeis oleifera* for example is very desirable but linked to low yielding traits. Moreover, the sorting and selecting genetically stable new genotype is extremely slow. Molecular recombinant technology provides a new avenue to overcome these problems. Efforts on the improvement of the palms for the production of oil containing high level of monounsaturates will be made.

VII. 7. Resistance Breeding:

All the germplasm accessions and hybrid combinations will be kept under observation for reaction to important diseases like "spear rot" and "ganoderma" and "basal stem rot" with a view to identifying the genes for resistance.

VII. 8. Interspecific hybridization:

Attempts to transfer the dwarf nature, high unsaturated fatty acid and disease resistance of *Elaeis oleifera* to *Elaeis guineensis* will be made through interspecific hybridization and further back crossing.

VII. 9. Physiological and biochemical characterization of hybrid vigour and stress tolerance

In view of the practical difficulties in field testing very large number of combinations, studies have to be undertaken to

identify combinations with comparatively better vigour in seedling stage itself. Physiological investigation primarily intended to evaluate hybrids for photosynthetic efficiency, dry matter production and desirable harvest index will be taken up. Studies on biochemistry and molecular biology of enzymes involving fatty acid biosynthesis are worth attempting. Non-availability of moisture is recognised as the single most important constraint for FFB production. Indepth physiological and biochemical studies are necessary to understand the mechanism of stress tolerance in oil palm leading to identification of hybrids with desirable traits to withstand moisture stress under field conditions.

VII. 10. Cryopreservation and storage:

Attempt on *in vitro* and *in vivo* long term storage and retrieval of valuable oil palm genetic material will be made.

VII. 11. Establishment of Seed Gardens:

The present production of 0.3 million *tenera* sprouts per annum is far inadequate considering the demand for quality planting material. Imports are resorted to for meeting the demand. Seed gardens are to be established using improved D x D and T x T parents selected out of second breeding cycle as well as proven parents available in the other countries to overcome shortage and achieve self-sufficiency.

VII. 12. Micro-propagation:

Presently the oil palm planting materials are solely from D x P seeds. Being heterozygous, they show a considerable level of variability. It is estimated that more than 30% increase in yield could be realised by cloning the elite palms in the best family. Micropropagation using adult palms ortets will be standardised to multiply high yielding *teneras* and selected *dura* and *pisifera* parents.

Table I. Germplasm collections of Palode.

Sl. No.	Source	Year of collection	Exotic No. of palms available	Remarks
1.	NIFOR (Nigeria)	1979	119	*Tenera*
2.	Cote' d'Ivoire	1981	48	*Tenera*
3.	Republic of Zaire	1982	48	*Tenera*
4.	Indonesia I	1986	48	*Deli dura x Pisifera*
5.	Indoensia II	1986	48	*Dumpy dura x Pisifera*
6.	Malaysia	1987	20	*Tenera*
7.	Cameroon	1988	48	*Tenera*
8.	Malaysia	1988	20	*Tenera*
9.	Malaysia	1988	2	*Tenera x Pisifera*
10.	Malaysia	1989	4	Surinam x Avos
11.	Costa Rica	1989	4	*E.oleifera x E.guineensis*
12.	Costa Rica	1989	6	Clone
13.	Malaysia	1990	26	*E.oleifera*
14.	Costa Rica	1990	12	46787
15.	Costa Rica	1990	12	46264
16.	Costa Rica	1990	12	46695
17.	Costa Rica	1990	12	45272
18.	Costa Rica	1992	1	*E.oleifera*
19.	Cameroon	1994	14	*Dura*
			3	*Tenera*
20.	Guinea Bissau	1994	8	*Dura*
21.	Tanzania	1995	2	*Tenera*
			9	
22.	Zambia	1995	9	*Dura*

Table-II. Performance of *Tenera* introductions (1996-97).

Accession	Year of planting	No. of bunches (palm/year)	Yield of FFB* kg per palm per year
NIFOR, Nigeria	1981	5.53	40.93
Cote' d'Ivoire	1981	6.73	50.12
Palode	1982	6.85	56.58
Rep. of Zaire	1982	4.86	50.87
Indonesia I	1986	5.04	80.70
Indonesia II	1986	4.73	61.11

* FFB - Fresh Fruit Bunches

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

Treatments	Yield of FFB (Kg)					Cumulative average	Oil yield MT/ha/year*
	1986	1987	1988	1989	1990		
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
129D x 39.193P	159.2	98.3	87.1	75.5	148.1	128.4	4.5

* Estimated on the basis of highest yield of FFB.

Table-IV. Description of Dwarf palms

Sl.No.	Characters	Dwarf	Tall
1.	Age	14 years	14 years
2.	Source	NIFOR, Nigeria	NIFOR, Nigeria
3.	Fruit type	Tenera	Tenera
4.	Total height	7.5 meters	13.77 meters
5.	Stem height	2.20 "	50.2 "
6.	Stem girth	1.70 "	1.78 "
7.	Length of leaf	4.80 "	7.71 "
8.	Length of petiole	1.10 "	2.00 "
9.	No. of leaflets	112 Nos.	180 Nos.
10.	Length of middle leaflet	74 cm	94 cm
11.	Width of middle leaflet	4 cm	5 cm
12.	No. of bunches	7	7
13.	Weight of FFB	81 kg	101 kg

Fig . 1. Oil Palm Breeding Programme