HYBRID SEED PRODUCTION IN OIL PALM: ACHIEVEMENT, PROGRESS AND FUTURE

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The oil palm is an exceptional example where selection progress is obtained through a single gene. The gene (Sh) controls shell thickness of the fruit are; 1. Dominant homozygote (Sh+ Sh+) formed the thick-shelled *dura* (D) 2. Recessive homozygote (Sh- Sh-) formed the shell-less *pisifera* (P) and 3. Heterozygote (Sh+ Sh-) formed the thin-shelled *tenera* (T). The *pisifera* is generally female sterile (no fertile bunch production), although there are some fertile *pisifera* in the population. The *tenera* is generated by crossing the *dura* (female) with the *pisifera* (male), i.e. *dura x pisifera* commonly referred as D x P (Fig. 1). The D x P progenies produce 30% more oil compared to the *dura*. As the oil palm has an economic life of 20-25 years the use of high quality planting materials from legitimate sources is very crucial to sustain high yield. Oil yield is the prime interest in oil palm cultivation. Kernel yield is a secondary product. The selection of these traits involves evaluation of the FFB yield and oil determination. The *dura* parents for use in hybrid seed production are selected on its own merits based family and individual palm selection. On the other hand, due to the sterile nature of the *pisifera*, its yield potential is determined indirectly through progeny test with elite *duras*. *Pisiferas* with a good general combining ability (GCA) are selected based on the *tenera* performance of the D x P or *dura x tenera* (D x T) progeny test experiment. In progeny testing, the *pisiferas* that give the best average performance of its half-sib progeny are selected.

Progeny testing and Hybrid seed production

The research work of the Oil Palm improvement in India was started with selections from *dura* palms planted at Oil Research Station at Thodupuzha, Kerala during 1961 for the development of

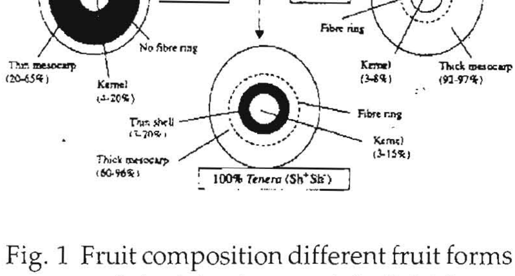

Fig. 1 Fruit composition different fruit forms and the inheritance of shell thickness in *Dura* × *Pisifera* cross

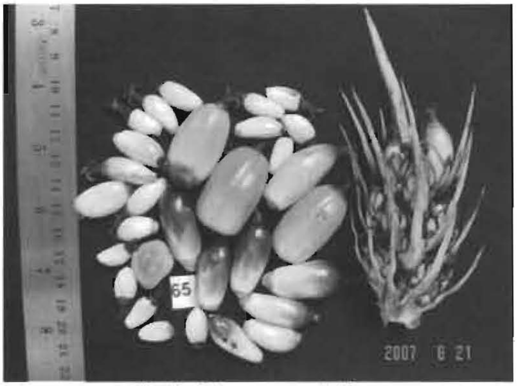

Fig.2. Viresence pisifera

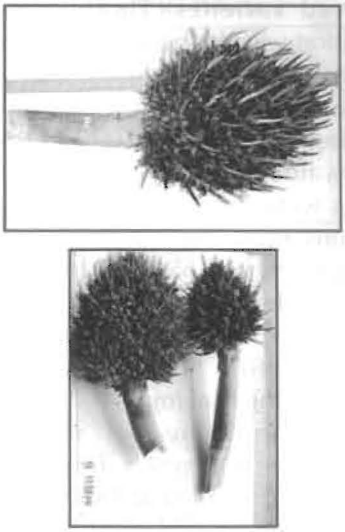

Fig. 3 Preponderance in female bunch

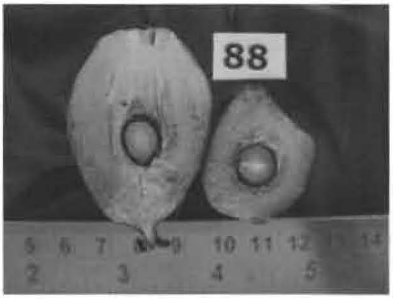

Fig.4 Tenera x Tenera progenies

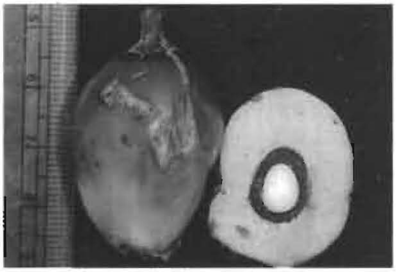

Fig 5. Thodupuzha dura

Fig 6. Dwarf interspecific hybrids

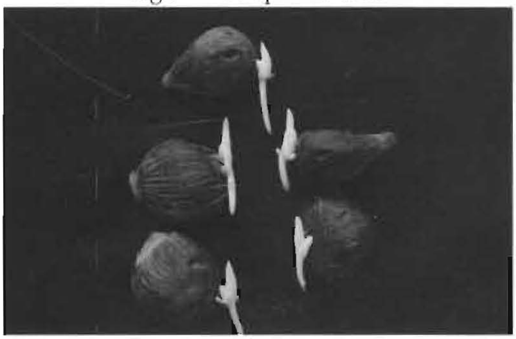

Fig.7. Germinated seeds

Fig 8. Seed size variation

improved varieties. Thodupuzha *dura* population was the base breeding material for Indian Oil palm industry. A systematic trial was taken up in 1976 at Palode consisting 11 *duras* of exotic origin and four *pisiferas* along with one selfed *dura*. The hybrids were maintained under rain fed conditions. From this experiment, two high yielding *tenera viz.*, 65d x 30.103p and 120d x 30.103p has been recommended as promising hybrids. Based on evaluation in *dura* population of Thodupuzha and progeny testing trial improved sets of *Dura* x *Dura's* and one set of different combinations of *Tenera* x *Tenera* has been produced and planted at DOPR RS Palode during different period of time. *Dura* I population consisting selfed progenies of 120 and 65 *duras* and *Tenera* x *Tenera* progenies consisting sterile *pisiferas* has been sourced for producing hybrids of Palode 1 and 2. Apart from this several field experiments were started to hybridization programme and commercial seed production. The field experiments which formed back bone of seed production programme in DOPR are given in Table 1.

The brief report on achievement and recent progress of hybrid seed production programme of DOPR with special emphasis to improvement work at Regional station, Palode is presented in this paper.

Germplasm collection and evaluation

It has been reported that despite the vast wild and semi wild populations existing in the palm belt in Africa, most of the world breeding programme has narrow genetic base and traced back to only few palms. Therefore, need for collection of new material of sufficient genetic variability was felt and systematic collection of germplasm material was undertaken from primary sources in Africa namely, Guinea Bissau, Tanzania, Zambia and Cameroon. The representative accessions of different sources were planted at DOPR RS Palode during 1988. Apart from above prospection, collections were also made from commercial material and farmer's field and they were planted during 1981-1992 in old germplasm block at Palode. Two accessions of *oleifera* palms of unknown origin were planted during 1994. Similarly, two accessions of advanced *dura* palms sourced from ASD Costa Rica through UNDP breeding for seed production programme were planted as non replicated trial during the year 2000. Though, some individual palms were introgresed into hybridization programme, majority of the genetic resources were not fully exploited. At present, new germplasm register has been prepared based on approved format and descriptor study has been completed based on IBPGR format for the representative and selected individual palms.

Identification of new *pisifera* sources

The germplasm evaluation revealed that three *pisiferas*, one *tenera* and 83 *dura* palms were observed out of 87 palms at Palode Regional Station. All the *pisiferas* and lone *tenera* palm were located from Tanzanian source. The characterization of palms revealed that one *pisifera* (Palm No.66) showed fertile character which recorded normal bunch and fruit development with 25% Fruit to Bunch where as other *pisiferas* (Palm Nos 65 and 75) showed aborted bunches throughout the evaluation period. However, palm number 65 found to set few fruits once with virescence fruit pigmentation and shell-less kernel (Fig. 2). Efforts are on to introgress these materials to ongoing improvement programme

Table 1: Oil Palm improvement field experiments at DOPR RS Palode.

Sl. No.	Particulars of experiment	Year of planting	Area	No. of Palms
1	Progeny testing	1976	10.28	1440
2	Old germplasm	1981-92	4.65	651
3	*Dura* I	1989	2.65	371
4	*Dura* II	1993	0.97	136
5	*Dura* III	1990	1.33	186
6	*Tenera* X *Tenera*	1991	1.41	198
8	*Elaeis oleifera*	1992	0.18	24
9	Inter specific hybrid	1998	0.38	53
10	African germplasm	1998	0.62	86
11	Exotic and indigenous hybrids (G× E)	1993	1.26	180
12	Advanced exotic *Duras*	2000	0.25	35

Preponderance of female bunches

Bunch stalk is housed inside the leaf axils of Oil palm. Bunches possessing long stalk facilitates access for effortless harvest and insect pollination. The samples analysed in different palm of various sources of African sources planted during 1998 reveled promising values for bunch stalk length. Mean value of stalk length variations in different sources ranges from 16.05 cm (Zambia) to 18.13 cm (Guinea Bissau) and maximum length was observed in Guinea Bissau (18.13 cm). This study revealed that irrespective of different sources of African germplasm, many of the palms planted at Athirapally location under rain fed condition showed long stalk (Fig 3). Hence, it is proposed to continue detailed evaluation in order to infer conclusion and further utilization of genetic resources for improvement work.

Evaluation and characterization of dwarf *tenera* and *oleifera*

Tall palms are difficult to harvest and excessive height increment of the palms reduces the economic life of a commercial plantation. As a part of improvement work, evaluation was undertaken in the field gene bank consisting several exotic germplasm collections planted during 1981-1994. A *tenera* palm from Nigerian Palm Oil Research Institute (NIFOR) collection planted during 1981 and *Elaeis oleifera* of Surinam origin planted during 1988 showed low stem elongation when compared to their counterparts. Dwarf *tenera* had bunch yield of 118 kg/palm/year with 9.1 bunch numbers and 24 cm height increment, whereas Surinam had 75kg/year/palm with 6 bunches and 15 cm height increment. It was proved by characterization study that both of them had dumpiness *viz.*, short trunk, short leaves and other vegetative characteristics. In order to improve the yield and bunch quality components of these compact materials, selfing and *inter se* crossing and back crossing (with *E. guineensis*) have been attempted for *tenera* and *oleifera*, respectively.

Performance of *Tenera* × *Tenera* progenies

Evaluation was conducted on the segregating populations of seven *Tenera* x

Tenera (*inter se*/self) on the basis of girth, height increment, bunch numbers and bunch weight during 1992 to 2005. Fruit typing was done during 2005 to 2007 which showed expected Mendelian monofactorial ratios of fruit forms like *dura*, *tenera* and *pisifera* with slight variation. No significant differences were observed for girth and height increment among different combinations; however different fruit forms of *Tenera* x *Tenera* progenies showed significant differences for bunch numbers and weight. 137T × 137T showed best performance followed by 614T x 614T, whereas 763T × 323T showed poor performance in terms of bunch weight and numbers. Among 168 palms tested, two *tenera* (Palm 146 and 149) one *dura* (Palm 69) and two fertile *pisifera* (Palm 42 and 45) from 614T X 614T, 65T X 323T and 663 T X 699 T, respectively surpassed 150kg/palm/year based on five year consecutive bunch yield data. Top yielding (185 kg/palm/year FFB and 18.4 bunches) palm (Palm 45) from this experiment was confirmed as fertile *pisifera*. Two *Tenera* palms (149*T* from 614*T* x 614*T* and 114*T* from 648*T* × 648*T*) showed promising bunch quality components which could be used as parental palms for producing progenies for new seed garden by *inter se* matting or selfing (Fig. 4)

Performance of Indigenous and exotic planting materials

Yield and bunch analysis study were undertaken in the farmers fields revealed that Indigenous plantings materials have recorded more bunch weight and other bunch components and they are on par with respect to oil yields of Costa Rica materials. The experimental trial laid out at DOPR, Pedavegi also confirmed above results especially on Fresh Fruit Bunch yields. However, detailed studies are required to be done to assess the performances of different sources of planting materials under Indian conditions.

Yield potential and phenotypic variation of Thodupuzha *duras*

Although, Thodupuzha *dura* population is widely utilized for seed production and genetic improvement, there was no information about its phenotypic variations especially for fruit quality components. A total of 341 *dura* palms of Thodupuzha materials were assessed for different fruit and seed characteristics. Fruit form analysis revealed that seven palms (2%) are *teneras* out of 341 palms and rest of the palms are *duras*. The percentage of co-efficient (CV %) of variation was high for shell weight followed by kernel weight and lowest CV % was recorded for percentage of mesocarp and kernel oil per fruit. This study also unearths potentiality of unexploited *dura* palms (US356 US225, US147, US239, US380, US297, S285 and US375) mainly on the basis of mesocarp content and oil per fruit (>84%) (Fig. 5). Promising palms could be effectively utilsed for introgression into the current breeding programme

Variation in phenotypic Characteristics of exotic hybrids

Eighteen Costa Rican (C65711, C11067, C11239, C11225, C11143, C11146, C65635, C11044, C11076, C11053, C65893, C11142, C65758, C11169, C11189, C11092 and C11075) and two palode (65D x 111P and 120D x 111P) hybrids of representative palms were evaluated for phenotypic characteristics by Nut component analysis. The variation was high for shell weight (57.7%) followed by kernel weight (40.3%) and nut weight (39.8%). Mean highest kernel weight was recorded in C65711 of ASD Costa Rica and single dry kernel weight showed a range from 0.48 (C11075) to 1.35g (C65711) while single nut ranged from 1.57g (C65635) to 3.97g (Palode). The individual palm analysis indicated that the hybrids of ASD Costa Rica namely, C11146, C65635, C11044, C65758, C11092 and C11075 had very thin shell and palm number 112 (C65711) and 78 (C11189) had high kernel weight. This investigation revealed a good potential for improving palm kernel utilizing promising hybrids of ASD Costa Rica by hybridization or introgression to generate desirable segregates that posses large kernels.

Inter specific Hybridization

Elaeis oleifera (previously referred to as *Crozo oleifera*) is found mostly in South and Central America and hence is known as 'American Oil Palm'. 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 susceptibility to the pest. Only *dura* fruit form with thick shell has been reported in this species. Therefore, the crosses are mostly made with thin shell *teneras* of *E. guineensis* or *pisiferas*. The F1 hybrids are not directly exploited because they are low in bunch characters. Therefore, a series of back crosses and selection in further generations have been necessary. Evaluation results on interspecific hybrids at Palode resulted in identification of three promising dwarf palms (*viz.*, 47, 48 and 6) to be used for further improvement. Among them palm no 48 showed high % fruit set and Oil/Bunch (Fig. 6).

Basic studies on Seed maturity and germination

a. Seed maturity in African oil palm

Maximum germination (97.6%) of African oil palm seed was obtained at 165 Days After Anthesis (DAA) and 180 DAA showed slight decline in germination (94%). High dry matter accumulation and low moisture content was recorded in both 165 and 180 DAA. Seedlings obtained from 165 DAA showed superior quality. Mesocarp oil formation initiated (6.62%) at 75 DAA and highest content (74.93%) was recorded at 180 DAA.

b. Seed and fruit maturity in American oil palm

Substantiate weight increase was observed in case of fertile fruits whereas parthenocarpy fruits recorded no appreciable weight during the course of bunch development of American oil palm. However, changes in fruit components were more erratic during 46 -110 Days After Anthesis (DAA) than matured phase (124 to 180DAA) due to inherent characteristics of *oleifera*. Mass maturity (seed filling) occurred at about 148-186 DAA at which time seed moisture content declined gradually from 87.65% to 19.69%. Oil formation in the mesocarp initiated (13.69%) approximately at 92 DAA and peaked (67.7%) at 186 DAA. The entire seed development period from immature to the ripe fruit took about 186 days (6.2 months) under tropical climate of Kerala. On set of germination was obtained only during matured phase of seed development

Commercial Hybrid Seed Production

Hybrid seed production is done by controlled pollination between selected *Dura* and *Pisifera* palms. Seeds are extracted from *dura* palms, which are graded and stored in on air conditioned room at 18-20? C or taken to heat treatment at 39-40? C for 40-60 days which is necessary to break the dormancy. This is followed with soaking for three to four days to raise the moisture content. They are then packed in polythene bags and placed on racks at ambient temperature (25-35?C). Frequent mist spraying or distilled water is necessary to avoid the seeds from desiccation. The first flush of germination can be expected in 7-10 days and continues for another two weeks or so. The first sorting of germinated seeds is carried out after 10-14 days with further sorting every 5-6 days. Germination rates vary between 70-90%. Germinated seeds for delivery are packed at 200-500 seeds per polythene bag and neatly placed within PU foam cushion in hardy cartons. (Fig. 7)

Seed quality studies

Medium size seeds showed significantly high germination and superior seedling quality in African germplasm of *dura* fruit types. Per cenatge of multi kernel seeds are high in big size seeds when compared to medium size seeds. Effect of seed size and its variation (Fig. 8) has been studied in Palode mother palms and their seed quality has been assessed and documented.

Future Thrust

DOPR has narrow genetic base of germplasm material. It is necessary to select *dura* parents which have proven to produce high yielding hybrids. Efforts have to be made for a systematic collection of oil palm germplasm materials by prospection in the original habitat of *E. guineensis* and *E. oleifera.* It would be worthwhile to obtain seed materials of proven performance for augmenting the breeding programme. Identification of dwarf oil palm and incorporation of the dwarfness into the seed production programme should be intensified. Identification and utilization of proven palms should be hastened especially for high yield and other special characteristics of economic importance. ■