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Review Article

OIL PALM BREEDING

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Till 1950s oil palm breeding was confined to the thick shelled *dura* variety. Efforts to improve wild genes in Africa as well as the work in Malaysia and Indonesia on the progenies of the four famous Bogor pálms resulted in various breeding populations of restricted origin. Since the discovery of Beirnaert and Vanderveyan (1941) that the *tenera* is a hybrid between *dura* and *pisifera*, full attention was diverted to production and improvement of d x p crosses. Salient features of some of the most important breeding programmes with special emphasis to Indian work are reviewed in this paper.

BOTANY

Oil palm is monoecious, with male and female inflorescences produced separately on the same palm. Rarely hermaphrodite inflorescences are also seen.

It is a cross-pollinated crop with the female and male inflorescences being produced in alternate cycles (Hartley, 1988). Artificial pollination is resorted to when specific hybrids are to be produced. Fruits ripen within six months after pollination.

The fruit of oil palm is a drupe. It consists of a pericarp, made up of exocarp (skin), mesocarp (husk) and endocarp (shell) surrounding the Kernel. Kernel has a testa (skin), a solid endosperm and an embryo. Shell thickness is of direct relevance to breeding. This is controlled by a single gene (Beirnaert and Vanderveyan, 1941). The homozygote *Pisifera* (Sh^-Sh^-) is shell-less. Generally, they are sterile, though some palms set fruit and varying degrees of sterility are observed. The other homozygote *dura* (Sh^+Sh^+) has a thick shell. The hetrozygote Tenera (Sh^+Sh^-) has a thin shell surrounded by a ring of fibres in the mesocarp. *Tenera* is the only form used for commerical planting because of higher mesocarp content.

MAJOR BREEDING PROGRAMMES

Although the endosperm of ripe fruit contains oil (kernel oil), palm oil of commerce is extracted from the mesocarp. Therefore the main emphasis of breeders is to evolve varieties with high FFB yield and better mesocarp content thereby increasing the palm oil yield potential. Better oil quality, reduced height increment, drought, pest and disease tolerance as well as precocity are also becoming important considerations. The salient features of the major breeding programmes in Côte d'Ivoire, Republic of Zaire, Nigeria, Costa Rica, Malaysia and Indonesia are outlined and the Indian programme is described in detail.

The IRHO (IRAFED) Programme - Côte d'Ivoire

The first step for oil palm improvement was taken in 1924 when over 60 open pollinated progenies from comparatively thick shelled *teneras* (20% shell) were planted. The best palms from these were selfed and planted at La Me. As the performance of these were disappointing this line of work was not continued. A deli *dura* plantation (Sumatra origin) was established at Dabou by IRHO. Crosses were made between selected deli palms and some of the original *tenera* palms at La Me and at Sabiti. IRHO also organised an exchange programme with INEAC at Yangambi and SOCFIN in Malaysia. The same comparative trials were planted at five different stations. The results showed clearly that inter population crosses were superior to intra population crosses. Another finding was that bunch number and mean bunch weight are controlled by quantitative factors whose effects are generally additive (Noiret *et al.* 1966). Gascon and de Berchoux (1964) outlined a comprehensive breeding progremme based on reciprocal recurrent selection. This involved one population with 80 Dabou deli *duras* and Sumatran and Malaysian *duras* and another one made up of 172 *tenera X pisifera* selections from La Me and Sabiti. Four hundred and forty six *tenera X dura* and *dura X pisifera* test crosses as well as 85 *dura X dura* and 79 *dura X tenera* crosses and selfings of best progenitors were planted between 1958 and 1965 at La Me.

The results after two cycles of breeding published by Gascon *et al.* (1988) showed that an yield improvement upto 36 per cent could be obtained through this programme (Table 1).

The INRA (Formerly INEC) Programme - Republic of Zaire

Improvement by selection started in 1922 when Yangambi (the main station of the INEAC) laid out the first experiment with illegitimate seeds of nine *tenera* palms selected from nearby palm groves and one *tenera* palm from the Ela botanical Garden. This palm, generally referred to as Djongo palm had a good mesocarp content (80-85%).

During 1933-39, a legitimate F_1 generation involving crosses between the best *tenera* characterised by well filled bunches of large ovoid fruits with a thin shell and comparatively large kernel was found. The demerit of this type is its relatively rapid rate of stem increment. Another selection programme for specific combining ability carried out during 1950-56 consisted of 36 progenies produced by diallel crossing and selfing of best selected six *tenera* palms from the F_1 generations. Due to political unrest in the nineteen sixtees, this programme was not fully implemented.

Though selection for yield of bunches would bave been affected by the inbreeding involved, it helped in clarifying the single gene inheritance of shell thickness and in studying the variation in fruit and bunch characteristics. INEAC material has proved to be a major source for improvement in these characters in beeding programmes in Côte d'Ivoire, Indonesia and Malaysia (Gascon and de Berchoux, 1964).

Costa Rica

Contributions to oil palm breeding in Central America is solely that of United Fruit Company (Now ASD). The germplasm collection was initiated by them in 1920. The finding that Deli *dura* types had better oil and Kernel yields than the African types resulted in ignoring African introductions (Richardson, 1995). Deli *dura* seed of Lancetilla origin was the main source of planting material till 1966.

Table 1. ***Progress in yield in Côte d'Ivoire***

Stage	Year	No. of Progenies	FFB (t/ha)	Oil/ bunch	Oil/ ha	Progress
Inter-origin crosses	1960	529	15.0	22.2	3.33	100
First cycle	1972	74	16.7	23.2	3.93	118
Second cycle	1984	14	19.0	24.0	4.52	136

Starting from 1967, a series of oil palm germplasm exchanges were carried out with African and Asian oil palm breeding units and a collection of *E. guineensis* germplasm was assembled at Coto. Experiments were set up in 1989 with materials from Deli X Ekona type and Deli x Calabar in addition to the traditional Deli x AVROS. Results have shown that Ekona and Calabar materials are as productive as AVROS. Calabar materials have a shorter leaf length and a higher leaf area/leaf dry weight ratio than traditional materials. Ekona materials have a greater oil to bunch ratio (Sterling and Alvarado, 1995).

The yield of present day hybrids supplied for commerical planting is claimed to be 30 MT of FFB/ha/year with an extraction ratio of 22.5%. ASD de Costa Rica is one of the largest oil palm seed suppliers in international market having supplied 60 million seeds to 34 countries (Anon. 1996).

NIFOR (Nigeria) Programme

The breeding materials used in Nigerian breeding programme included introductions of Deli *duras* from Sumatra (1926), Serdang (1939), Deli *duras* and pollen from IRHO Programme (Nineteen fiftees and sixtees), from INEAC Programme in Zaire (1950-1960), Unilever programmes in Nigeria and Cameroon as well as Angolan material from sierra Leone (1942 and 1961). This along with indigenous collections gave a wide genetic base to start with.

The programme is somewhat similar to IRHO programme. In Nigeria six groups were formed based on yield and fruit characters. 53 *duras* and 65 *teneras* were thus classified. *Dura X tenera* and *tenera x tenera* crosses were made between palms of various categories. At the same time, the best *duras* and *tenera* crosses were made. This type of assortative mating is especially opportune for characters showing negative genetic correlations. This system also enables to increase genetic differences between populations (Corley, 1976).

Results of the breeding programme based on a modified reciprocal recurrent selection scheme started in 1962 is given in Table 2 (Okwuagwu, 1986).

Indonesia and Malaysia

Planting of four oil palms in the Botanic Garden at Bogor, Java in 1948 marked the introduction of the crop to south East asia. Progenies of these four palms were planted as avenue in Sumatra (Indonesia) around 1890. The first commercial plantings were established between 1911 and 1920 on Sumatra's east coast and in Malaysia using illegitimate seeds collected from the avenue

Table 2. ***Improvement in NIFOR planting material.***

Period	Type of material	Yield FFB	Oil
		t/ha/year	
1930-1950	Open and control pollinated DxD, DxT and DxP crosses of selected grove palms.	2.5-5.0	0.5-1.0
1960-1970	DxP control pollinated materials from first stage of oil palm breeding programme.	5.0-10.0	1.0-2.0
1970-present	DxP controlled reproduction of elite *tenera* progenies from the first cycle of reciprocal recurrent selection programme.	15.0-20.0	3.0-4.0

palms. Through selection of these *dura* palms, deli *duras* characterised by a high production potential and a uniform good bunch and fruit characters were identified. This was followed by selection for high number of bunches in some cases and for high single bunch weight in some other cases. The population of deli *dura* is most commonly used around the world as a female line for the production of seeds. The AVROS line is at the same time the source of *Pisiferas* used in Malaysia and Indonesia owing to its good production capacity when it is combined with Deli *duras*. The hybrids have vigorous vegetative growth and precocity in addition to their potential for high yield and good rate of oil extraction (Rosenquist *et al.* 1990).

PORIM (Palm Oil Research Institute of Malaysia) gathered a large oil palm germplasm collection. The collections made from Nigeria in 1973 provided valuable genes for high yield, dwarfism and unsaturation (Rajanaidu *et al* 1993). The work was then concentrated on *inter se* crossing of materials from various origins to form a new breeding population (Hardon, 1970).

In addition to Deli *dura x* AVROS *pisifera,* a limited propagation of progenies produced using Yangambi, La me, Nigeria (NIFOR), Serdang and Sibiti sources were also tested. As a result of these conscious programmes *tenera* hybrids are available which has tremendous yield potentials of up to almost 9 MT oil/ha as detailed in Table 3 (Lee Chong Hee, 1997).

Table 3. ***Yield potential of Malaysian hybrids.***

Material	Year of planting	No. of progenies	FFB yield (t/ha)	Oil/bunch ratio	Projected oil yield (t/ha)
DDxAVROS	1964	22	31.0	23.5	7.3
DDxAVROS	1968	16	31.1	22.1	6.9
DDxAVROS	1970	29	31.6	24.1	7.6
DDxAVROS	1979	5	34.5	25.8	8.9
DDxdumpy AVROS	--	10	33.3	25.8	8.6

India

The possibility of commerical exploitation of oil palm was not realised till the eighties. The first conscious import of breeding material, purely for observational trials, was made during 1963-67. These materials consisting of DxD, DxT, DxP and TxT seed material imported from Malaysia and Nigeria were planted at the Oil Palm station, Thodupuzha (Kerala) during 1963-67. The performance of this plantation which was in general encouraging, prompted Government of Kerala and Andaman Forest Development Corporation to raise large scale plantations.

A boost in oil palm breeding in the country was given with the systematic trials taken up in 1976 at the Palode (Kerala) centre of Central Plantation Crops Research Institute. This trial consisted of 11 d x p combinations involving 11 *duras* of Malaysian origin and four *pisiferas* of Nigerian origin. The design adopted was RBD with three replications and 16 palms/plot. The hybrids were raised under rainfed conditions (Nampoothiri, 1994). The results of this trial are given in Table 4.

From this experiment two high yielding *teneras viz.,* 65 d x 30.103p and 120d x 30.103p have been recommended for release (Anon. 1998).

A breeding programme based on Reciprocal Recurrent Selection was initiated in 1984. This programme is directed towards selection of elite *duras* and *pisiferas*

Table 4. ***Performance of tenera hybrids***

Combination	No. of bunches/ year		FFb (Kg) per palm/year		Oil t/ha/yr	
	Average		Average		Best	Esti-
	1980-93	1986-93	1980-93	1986-93	yield	mated
65d x 30,103p	4.89	6.24	73.44	114.38	164.10	4.59
271d x 30.4336p	4.09	5.30	60.03	93.71	146.43	4.10
139d x 24.3087p	3.13	4.68	47.57	78.35	115.95	3.25
156d x 30.4336p	2.37	3.48	35.54	58.39	96.29	2.70
61d x 30.4336p	3.81	5.28	59.10	94.28	155.15	4.34
125d x 30.103p	4.57	6.29	66.27	105.80	157.28	4.40
108d x 30.4336p	4.23	5.66	58.68	92.21	139.83	3.92
92d x 30.3154p	3.56	4.85	62.85	100.19	161.18	4.51
269d x 30.4336p	2.84	4.02	42.69	69.24	107.22	3.00
187d x 24.3087p	2.58	3.87	35.40	58.49	85.43	2.39
120d x 30.103p	4.59	5.88	76.90	117.16	159.27	4.46
Average	3.72	5.07	56.84	90.23	-	-

separately and crossing them to produce d x p seeds. Palms with good combining ability are selected as parents in seed production. An improved set of DxDs and TxTs has been planted as a part of the programme. The most serious handicap in this country's breeding work is the narrow genetic base available. Although the germplasm collection has 80 accessions from eleven countries most of them are *teneras*. However, recent collections made from Cameroon, Tanzania and Zambia will provide valuable genes for cold tolerance and drought resistance (Pillai, 1994).

A large number of hybrids are being field tested in plantations of Oil Palm India (Kerala), Nava Bharat Enterprises (Andhra Pradesh) as well as in State Agricultural Universities under the All India Co-ordinated Research Project of Palms Network. More intensified work has been launched at the National Research Centre (Oil Palm) established at Pedavegi (Andhra Pradesh) by Indian Council of Agricultural Research (Rethinam and Murugesan, 1998).

SEED PRODUCTION

Since only hybrids are used for commercial planting, growers will have to depend on recognised seed producers for the planting material. The world wide requirement of quality *dura X pisifera (tenera)* seeds is estimated as 80 million per year with Indonesia (61 million), Malaysia (50 m), Costa Rica (12 m) and Papua New Guinea (10 m) as the main producers.

It was originally estimated that 80 million seeds will be required by the turn of the Century for undertaking oil palm area expansion in India. This is based on the assumption that 50% of the 0.8 million hectares of area, identified as suitable for oil palm cultivation will be covered by 2000 AD. However the rate of expansion has been only around 0.01 million ha/year thereby reducing the demand to two million seeds/year. India has been importing seeds from Malaysia, Côte d'Ivoire, Nigeria, Papua, New Guinea, Republic of Zaire and Costa Rica since 1962.

Though indigenous production of *tenera* hybrids was initiated in the country by 1974 for experimental purposes, commerical production was started only in 1982 (Nampoothiri *et al.* 1993). The Research Centre of Central Plantation Crops Research Institute at Palode and Oil Palm India, Kottayam are the only centres from where seeds are sold now. These are produced using 40 *dura* mother palms identified at Thodupuzha and 20 *duras* at Palode. The present capacity is restricted to 0.5 million seeds annually. Sprouts are sold at the rate of Rs. 10/-.

To meet the additional requirement, import has to be resorted to. The cost is generally 0.4 to 0.45 US $ per sprout. To obviate this constraint five seed gardens have been established in Andhra Pradesh, Karnataka and Kerala States. A 20 ha seed garden will enable production of about three million seeds annually.

DISEASE RESISTANCE

Since diseases are the major single factor limiting yield, breeders have been very eager to evolve tolerant hybrid combinations.

The most systematic and effective work pertains to vascular wilt disease caused by *Fusarium oxysporum* F. sp. *elaeidis* which is a major problem in Africa. The genetic control of wilt resistance is not well-known, but a polygenic control is suggested (Hardon, 1976). An elaborate programme is underway at IRAFED involving identification of parental material with improved resistance and breeding with such material (Renard *et al.* 1972). Clonal material with potential resistance is also now under field screening. Unilever claims to have progenies with "expectional resistance to vascular wilt and foliar diseases".

In the case of blast (caused by *Rhizoctonia lamellifera* and *Pythium* sp.) it is reported that material originating in arid regions of Nigeria is more sensitive than that from forest zones. So also those from deli origin are more susceptible than African materials. In Deli x African crosses, the resistance is dominant. However selection for resistance is of limited use since the disease affects the palm only for a short period of its life for which there is a feasible control method.

Elaeis oleifera is largely resistant to a form of spear rot (Sudden wither - Marchitez sorpresiva) recorded in Columbia and Peru. This resistance is inherited to *E. guineensis x E. oleifera* hybrids. Certain *E. guineensis* progenies have remained healthy in plantations devastated by this disease suggesting the scope for selecting for resistant progenies within the species.

Cercospora leaf spot caused by *Cercospora elaeidis* is prevalent in Africa. Though *Elaeis oleifera* progenies are highly susceptible, interspecific hybrids are less susceptible (Hartley, 1988). Since satisfactory control is obtainable by using some of the newer fungicides, it is doubtful if such work will receive priority in breeding programmes.

Lethal bud rot (fatal yellowing) of unknown etiology occurs in Central and South America. It was reported from La Arenora (Coldesa) plantations in Columbia that *E. oleifera* and its interspecific hyrids were immune or resistant to the disease. Field trials and experimental plantings clearly showed that in areas subject to lethal bud rot, planting of *E. oleifera x E. guineensis* crosses is the best known method of combating the disease.

Breeding for resistance to Ganoderma trunk rot has been attempted and differences of incidence between West African and Deli materials and between *dura* and *tenera* have been reported (Akbar and Kusnadi, 1976). But Turner (1981) considers that any natural resistance is likely to be overcome by the volume of inoculum.

Work on dry basal rot in Nigeria (Robertson, 1962) indicated that the incidence was confined to progenies having the same parent and that there are differences in incidence between progeny lines. Selection for resistance was considered as a promising line of work in controlling the disease. However, no concerted further work was taken up since natural recovery was usual and serious outbreaks have not been reported.

Detailed work has been done on genetic nature of crown disease by Gascon and de Berchoux (1964) in Côte d'Ivoire and by Blaak (1970) in West Cameroon. Crown disease susceptibility is postulated to be due to monofactorial recessive genes (aa) whose expression is prevented if an inhibitor gene is present in homozygous condition.

White stripe is another disease attributed to genetic disorder. A certain *tenera x dura* cross showed similar percentrage of white stripes when planted in Côte d'Ivoire and East Cameroon. So also certain Deli selfs in Côte d'Ivoire showed the symptoms while others did not (Gascon and Meunier, 1979). Some forms of chlorosis are genetic. One condition is characterised by leaves which may be wholly or partly pale or bright yellow.

The only serious disease encountered in India is the spear rot disease caused by phytoplasma. This malady is confined to the Kerala state. Search for resistant lines have not so far yielded any encouraging result (Kochu Babu, 1994).

It can therefore be seen that while some efforts have been made and the importance of resistance breeding in oil palm is recognised, the results obtained so far do not commensurate with the importance of this line of work.

BREEDING FOR SHORT COMPACT PALMS

The objective of this programme is to evolve lines which are short and compact in stature so that more number of palms can be accommodated per hectare and harvesting operations are much easier. The main sources of dwarfness in oil palm are given below:

(1) **Dumpy**: This is a deli *dura* selection (E 206) identified by Jagoe (1952) in Malaysia. Dumpy *dura* selfed progenies have been introduced to germplasm collections of many countries. Although these were comparatively short and produced large bunches with a good fruit-bunch percentage, the palm was not quite upto the selection standards set.

(2) **Pobe dumpies**: These are dwarf palms identified at Pobe Station of IDEFOR.

(3) **Indian dwarf**: One dwarf *tenera* palm was identified from a Nigerian introduction at CPCRI Research Centre, Palode. This had a height of only 7.54 m in the 14th year compared to 13.77 m height of palms of similar age in the same plot. This dwarf is incorporated into the breeding programme.

(4) ***Elaeis oleifera:*** This species (Previously referred to as *Corozo oleifera* and *Elaeis melanococca)* is currently the most useful parent in breeding for dwarfness. Efforts have been made to prospect and establish *E. oleifera* collections in Malaysia, Côte d'Ivoire, Dahomey, Cameroon, Columbia and Indonesia. In addition to low height increment the species is a good donor parent for oil quality and disease resistance. As no *pisiferas* have been identified in *E. oleifera,* the interspecific crosses are always between *E. oleifera dura* and *E. guineensis pisifera.*

These species are easily crossable and there are no strong interspecific isolation barriers. The F_1 hybrids have offered some immediate and remarkable improvements in oil quality, resistance against some diseases and reducing trunk height (Table 5).

Until the *E. oleifera* collections are fully utilized and studied in detail it will not be possible to evaluate the actual potential of the interspecific hybrids.

(5) **Compact palms**: In Costa Rica a natural *E. oleifera x E. guineensis* hybrid was pollinated with *E. guineensis* and planted in Coto. This progeny had an abnormal palm

Table 5. Features of interspecific hybrids

	Character	*E. guineensis*	E.O. x E.G.	*E. oleifera*
1.	Height increment (m)	0.34	0.18	0.09
2.	No. of leaflets	321	256	188
3.	FFB weight (kg)*	148	190	120
4.	Bunch weight (kg)	18	12	12
5.	Oil percentage	50	34	30
6.	Unsaturated fatty acids	52	66	79

with a short trunk and short bunch which was called the original compact palm. This was back crossed to materials of proven agronomic characteristics and further selection was practised for short stem and leaves. Some exceptional compact palms (super compact) were identified in the second back cross of compact palms x Ekona. These have short compact crown permitting a higher planting density. However, planting materials of this line are not yet available (Nampoothiri, 1988).

OIL QUALITY

Improving the oil quality through production of higher level of unsaturated fatty acids will increase the market share for palm oil. Breeding programmes are in progress using various *E. guineensis* and E. *oleifera* sources to achieve the above objective.

VEGETATIVE PROPAGATION

Clonal propagation through tissue culture would be highly valuable for multiplying the elite ortets with exceptional characters like high FFB (fresh fruit bunch) yield and oil percentage, disease and pest resistance/tolerance as well as superior oil quality. Since some evidence is available in the Malaysian clonal plantations, regarding variation among the clones for fatty acid ratios in terms of the degree of saturation, possibilities for multiplying clones possessing high ratios of saturated or unsaturated fatty acids are open. Use of modern tools of gene mapping would further facilitate the unravelling of the genetic architecture enabling us to precisely analyse the genetic basis of desirable traits.

MICRO-PROPAGATION

As oil palm is an outbreeder, natural clonal propagation is not possible because the axillary buds give rise to the inflorescences. The advantages of producing good clonal population of selected high yielding trees in oil palm have been described by Corley, *et al.* (1981). Besides obtaining uniformly high yielding clones of individual trees, clonal propagation will also facilitate the propagation of proven *dura* and *pisifera* parents to produce desirable *tenera* combinations. This is particularly important to a country like India which is poised for expansion of oil palm cultivation and availability of quality planting meterial is a constraint.

The major work on *in vitro* culture of oil palm was carried out in France (Institute Recherch de Huiles et oleagineux or IRHO), the UK (Wye College), University of London and Unifield TC Unilever/Harrison and crossfield), Malaysia (Palm oil Research Institute of Malaysia or PORIM); and Indonesia (Marihat Research Station).

It has been claimed that through clonal propagation yields of palm oil would be increased by as much as 30% over the seedling progeny. Progress in commercialization of clonal propagation suffered a set back when abnormal flower development (mantled) was reported in palms transferred to field (Corley *et al.* 1986). The French group's (IRHO-

ORSTÓM) experiments at La Me, Côte d' Ivoire have now resulted in reducing floral abnormalities to only 3.1% (Durand - Gasselin *et al.* 1990).

Using the same technique (Lubis *et al.* 1993) observed normal vegetative growth and flowering of clones in Indonesia. The Fresh Fruit Bunch (FFB) yields were about 20% higher in clones over those of seedling origin.

Successful vegetative propagation of oil palm through tissue culture has been reported by Jones (1984), Rabachault and Martin (1976), Paranjothy (1984; 1986), and many others from the united Kingdom, Côte d'Ivoire, France and Malaysia. The first attempt in India to develop a protocol for clonal multiplication of oil palm from tender leaf explants through somatic embryogenesis was by Thomas and Rao (1985) at Bhabha Atomic Research Centre, Bombay. They used young leaves from 6 months old *tenera* seedlings. Somatic embryoids were produced within one week. About 50-60 embryos per culture were obtained which gradually developed into shoots. Thomas and Rao (1985) could obtain embryogenesis in both liquid and solid media. Shoots of 10-12 cm size with 2-4 leaves were isolated individually and maintained in tubes with filter paper bridges containing MS liquid medium supplemented with 1mg/l NAA and 1mg/l GA_3 to initiate root growth. Plantlets containing 3-4 leaves with roots were transferred to paper cups with pre-sterilised soil compost.

Raju *et al.* (1989) reported the successful culturing of explants from tender leaf of three year old *tenera* seedlings. The tender leaf column of seedlings was dissected out along with growing apices and after sterilizing with 70% ethanol, the tender leaf was cut into explants of 5mm length. Somatic embryoids were obtained from one explant of 5mm length with a few cell layers of primary callus when cultured in media in which 2,4-D was gradually replaced with NAA. Development of somatic embryoids were obtained in 8-20 weeks. Small white club shaped structures attained the size of 3-5mm length within 6 to 8 weeks of their appearance. They also claimed that, on a germination medium, about 50% of embryoids developed shoots, 30% showed simultaneous shoot and root development, and 15% with root development followed by shoot. The plants after development of lateral roots, were transferred to a mixture of sand and vermiculite moistened with Hoagland's solution with 0.01mg/l IBA in pots kept under high humidity condition. Subsequently, these were transferred to the garden soil mixture and kept under shade. These plantlets were field planted at Palode, Kerala and their performance indicates no difference from that of seedling progenies.

Plantlet development was achieved from leaf explants of 18 month old *dura* and 6 month old *tenera* oil palm seedlings (Anitha Karun and Sajini, 1996). Recently Rajanaidu *et al.* (1997) reviewed the current status of oil palm clonal production on commercial scale. According to them, not all embryoids formed will proliferate and germinate successfully in polyembryogenic tissues (PE). Besides, the performance of clones derived from selected high oil yielding ortets is not consistent for fresh fruit bunches (FFB). Hence the immediate prospect of tissue culture techiques is to develop biclonal seeds. This involves the multiplication of elite *dura* and *pisifera* parents through tissue culture and then crossing these to produce D X P seeds. Simultaneously the various stages in tissue culture process must be improved to produce normal plantlets for final selection. In any event, it would be safer to plant polyclonal orchards of elite DxP combinations, in view of the risks involved in planting monoclonal plantation, losing the advantages of heterozygosity in the event of new strains of pathogens and pests appearing.

MOLECULAR MARKERS

Jack and Mayes (1993) reported for the first time the use of molecular markers in oil palm. Further the same group studied the application of RFLP probes derived from organelles and nuclear DNA in a number of oil palm genotypes (Jack, Dimitrijevic and Mayer, 1995). Recently Mayes *et al.* (1996) reported the study of comparatively limited number of highly variable RFLP probes which were used to obtain fingerprint information for 111 elite breeding palms and considered their value for palm identification. It was the first attempt towards an assessment of genotypic identity in oil palm.

Rival *et al.* (1997) used the flow cytometric analysis on two different crosses of *dura x pisifera* oil palm to get an accurate estimation of nuclear DNA content. The genome size of *Elaeis guineensis* was found to be 2C=3.76+(-) 0.09 pg and therefore ca. 3.4×10^9. Embryogenic calli and plants showed the same ploidy level but the measured 2C DNA values differred significantly. Since fast growing callus (FGC) already identified as a source of 'mantled' phenotype variants did not show any difference in their ploidy level, this proved the hypothesis that this is an epigenetic origin of a somoclonal variant.

GENETIC TRANSFORMATION

Studies on genetic transformation in oil palm was reported only recently (Chowdhury *et al* 1997). These workers have studied the efficiency of GUS (β-Glucuronidase) gene expression in embryogenic callus and young leaflets of mature and seedling palms. They studied the expression of the GUS gene driven by the Emu, Ubil, Actl, 35S or Adhl both histochemically and fluorometrically. The results indicated that either the *Ubil* or *Emu* promoter should facilitate the expression of desired genes in oil palm and aid in development of an efficient stable transformation system.

CRYO PRESERVATION

The need to conserve oil palm *in vitro* arises because of the large area which otherwise would be needed for *ex vitro* field conservation. Very little work has been done on this aspect inspite of its importance. Engelmann *et al.* (1988) were the first to standardize the technique of cryo-preservation. They were able to store the embryoids for 15 months in liquid nitrogen and then could regenerate plantlets from the frozen materials.

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