भाकृअनुप
ICAR

Vision 2030

Directorate of Oil Palm Research

(Indian Council of Agricultural Research)

Pedavegi-534 450, West Godavari District, Andhra Pradesh, India

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ISBN : 81-87561-26-2

Published by

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Correct Citation
DOPR Vision 2030
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Pedavegi - 534 450, Andhra Pradesh, India

Printed at
Swapna Art Home
Vijayawada 520 002, Ph : 0866 6520675

Message

Oil palm is recognized as one of the highest edible oil yielding crops giving 4-6 tonnes of palm oil per unit area. Oil palm would be able to help India in marching towards attaining vegetable oil security in the years ahead. At present, oil palm is grown in India to an extent of 1.64 lakh ha and yields about 20 tonnes of fresh fruit bunches of oil palm per hectare per annum.

Directorate of Oil Palm Research could identify germplasm types with high production potential, hybrids that can give better yields and crop management technologies along with plant health management measures. However, the most challenging areas like water and nutrient management, germplasm improvement and harvesting tools etc., demand concerted efforts to achieve break-through innovations. I hope that the Institute would be able to develop appropriate technologies for these challenge areas so as to make oil palm cultivation more profitable and sustainable.

I am glad that the Directorate of Oil Palm Research, Pedavegi has prepared DOPR Vision 2030, which provides a path for progressive growth of oil palm research in the country.

I look forward that the present document provides a road map for pursuing oil palm research in India so that area and production will substantially increase in general and productivity in particular, which will help in bridging significantly the demand and supply gap in vegetable oil requirements in the country.

S. Ayyappan
Secretary, DARE &
Director General, ICAR

Preface

Oil palm has emerged as the largest oil yielding crop (4-6 tonnes oil/ ha/ year) and has become the most economic crop in global vegetable oil market being utilized for food, industrial applications and bio-diesel. India too can emerge as one of the major producers of palm oil, if the potential area of 1.00 million ha is planted with oil palm. After two and half decades of oil palm introduction to India on commercial scale as small holders' crop under irrigated conditions, there is no doubt about its performance in India, as yields are comparable to that of the crop grown under traditional environments in other countries. At present, oil palm is grown in an area of about 1.64 lakh ha with average productivity levels reaching 20 tonnes FFB/ ha/year. Significant progress has been made in oil palm research under irrigated conditions.

Strengthening of research activities to address the production and processing constraints like production of quality planting materials, setting up of new seed gardens with advanced generation of parental palms, strengthening the linkage among farmers, entrepreneurs, development staff and scientists will ensure the successful cultivation of oil palm in the country. New avenues/opportunities have come up before us along with development of latest technologies. In this context, there is an urgent need to utilize these technologies for further improvement in the oil palm sector. Considering these developments along with specific issues suggested by Director General, ICAR and recommendations emerged during National Consultation Meet held at New Delhi on June 7, 2010 as well as the specific action points suggested by Deputy Director General (Hort.), ICAR, DOPR VISION 2030 document has been prepared covering oil palm scenario along with strategies and research framework to be taken up in the future.

I would like to express my sincere thanks to Dr. S. Ayyappan, Secretary, DARE and Director General, ICAR and Dr. H.P. Singh, Deputy Director General (Horticulture), ICAR for their continued guidance and valuable suggestions in making this document.

I appreciate the efforts of Dr. K. Suresh and Ms. A. Bhanusri in compiling the document and contributions from the scientists of DOPR for bringing out this document in time.

S. Arulraj
Director

VISION 2030

Preamble

The African oil palm *Elaeis guineensis* Jacq., with West Africa as the centre of origin, is known to be the highest edible oil yielding perennial crop. It produces two distinct oils, i.e., palm oil and palm kernel oil, which have culinary and industrial uses. Palm oil is derived from fleshy mesocarp of the fruit, which contains about 45-55% of oil. The palm kernel oil, obtained from the kernel of stony seed, is a potential source of lauric oil. Oil palm produces 4 to 6 tonnes of crude palm oil/ha and 0.4 to 0.6 t of palm kernel oil from 4^{th} to 25^{th} year of its productive life span. It is the crop that has a greater advantage in terms of productivity and much higher than that of other major oil seed crops.

Oil palm is the crop of the present and future vegetable oil economy of world as well as India. Palm oil has good consumer acceptance as cooking medium because of its price advantage. It is a good raw material for manufacturing oleo chemicals used in making soaps, candles, plasticizers etc. Broadly, it can be mentioned that palm oil is a source of health and nutrition, value addition, waste utilization, eco-friendly, diversification, import substitution, co-generation and sustainability.

The nine edible oilseeds, viz., groundnut, soybean, rapeseed and mustard, sunflower, sesamum, safflower, niger, castor and linseed, presently grown in about 36 million ha are unable to meet the demand for edible oil in India. Consumption of palm oil in India is highest compared to that of other edible oils. India has been mainly depending on import of oil from other countries to meet its oil requirements. During the last two decades, efforts have also been made to introduce and exploit a number of new oil bearing tree crops like jojoba. However, only oil palm has shown promise for commercial cultivation under Indian conditions.

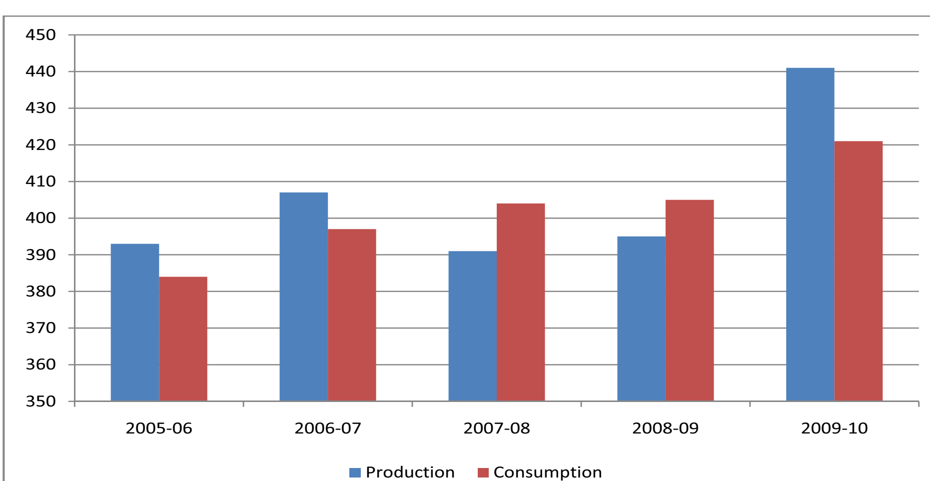
Various expert committees constituted by Ministry of Agriculture, Government of India have identified a total of 10.71 lakh hectares in 14 states of the country as suitable for oil palm cultivation. Till date, an area of 1.64 lakh ha has been covered under oil palm. Higher yield of 30-35 tonnes FFB/ha/annum from the seventh year onwards was also recorded in some plantations. If concerted efforts are taken to bring 1.00 million hectare under oil palm in the potential areas, it will be possible to get 3-4 million tonnes of palm oil and 0.3-0.4 million tonnes of palm kernel oil within the next two decades.

Oil palm, as a small holders' crop under irrigated conditions grown under varied agro-climatic conditions, is totally new to India. Location specific technologies for better production need to be developed urgently. Though four centers on oil palm under All India Coordinated Research Project on Palms were started, these centers have limited scope of taking up only a few experiments. With the establishment of National Research Centre for Oil Palm at Pedavegi, Andhra Pradesh in 1995, oil palm research got a new impetus. The Institute is conducting and coordinating research on all aspects of oil palm germplasm collection, conservation and utilization, production system and produce management, plant health management and transfer of technology.

Vegetable Oil Scenario

The global production of vegetable oils has made tremendous impact, of which progress made by palm oil, soybean, rapeseed and sunflower oil is worth mentioning. Among these oils, palm oil production has increased by thirty-three folds and is closely competing with soybean oil. Malaysia and Indonesia have played a dominant role in the production of palm oil. The world area and production of oil seeds which were 141.98 million ha and 223.20 million tonnes in 1995-96 reached about 250 million ha and 448 million tonnes by 2009-10 respectively. The current world production of oil seeds and vegetable oils is reported to be sufficient to meet the global demand. However, increasing demand for use of vegetable oils in manufacturing bio-diesel have put the oil seeds stocks under pressure.

Oilseeds: World Production and Consumption (million tonnes)



Source : Oil World Annual 2011

During 2009, production of vegetable oil in India was about 7.94 million tonnes where as the consumption was about double the amount of production (16.76 million tonnes). Consumption of palm oil in India is the highest compared to that of other edible oils, followed by soybean, rapeseed-mustard and groundnut oil. India has been mainly depending on import of oil from other countries to meet its vegetable oil requirements. During 2009-10, India imported 8.82 million tonnes of vegetable oil of which palm oil accounted for about 6.44 million tonnes, which implies that the country is dependent on palm oil imports for about 40 per cent of its annual edible oil requirement. In addition, the total demand for edible oils is expected to increase further.

The increasing demand of oil in India can be met by further increasing the area, production and productivity of existing oil seed crops, introducing and exploiting new high yielding oilseed crops and importing of oil from other countries, which is already being done. While elasticity of area available for oilseed cultivation in India is limited, there is scope for improving productivity through release of high yielding varieties and adoption of technology for which National Agricultural Research System and Govt. of India are already giving adequate emphasis.

Palm oil together with soybean, rapeseed and sunflower oils are often recognized as the big four in oils and fats trade. Palm oil contributes significantly in supplying the world's requirement for oils and fats, which is approximately 46.11 million tonnes during 2009-10 and this accounted for 27 per cent of the world's total oils and fats. At present, Malaysia is the leading producer and exporter of palm oil followed by Indonesia, Ivory Coast and Papua New Guinea. The rapid increase in palm oil production coupled with its large-scale availability for export in major palm oil exporting countries and competitive pricing have allowed palm oil to gain a larger market share in the world market at the expense of other oils and fats.

Palm oil has been available at competitive prices in the world market because of its abundant availability for export from major exporting countries. Out of 65.19 million tonnes of import of major oils and fats during 2009-10, palm oil import was 36.63 million tonnes followed by soybean oil (9.22 million tonnes). The huge savings in import bills is benefiting many countries, as they are able to import cheaper palm oil as compared to other competing oils. Among the highest importing countries during 2009-10, India (6.44 million tonnes) leads followed by EU-27 imported 5.94 million tonnes, China (5.85 million tonnes) and Pakistan (1.97 million tonnes). This trend will continue due to higher palm oil availability for global trade at a competitive price.

The demand for edible oil is expected to increase to 21.3 million tonnes by 2015. This assumes a per capita consumption increase of 4 per cent and a population growth of 1.7 per cent which translates to an overall growth in demand @ 6 per cent per annum. The world production of palm oil is set to increase to 35 million tonnes @2.8 percent growth rate per annum. Based on the growth rate of 2.3% per annum, palm oil production is projected at 49 million tonnes (as per FAO perspective). India will continue to depend on imports to the extent of about 40% of its consumption requirement. The improvement in productivity and increase in area under cultivation will ensure that domestic oilseed production is sufficient to meet 60 per cent of consumption requirement. During 2008-09, the per capita consumption of edible oils by an average Indian is only 14 kg, which is lower than the recommendations of World Health Organization and much lower than the world per capita consumption (23.89 kg). However GDP growth and rising income are the demand drivers for edible oil consumption. In India, these factors coupled with growing population lead to increasing per capita consumption and will push the vegetable oils and fats requirement to higher levels in the years to come.

Global demand and supply of major oils & fats vs palm oil during 2009-10

(million tonnes)

	Major oils & fats	Palm oil
Production	170.66	46.11
Import	65.19	36.63
Export	65.38	36.68
Consumption	170.08	46.29

Source: Oil World Annual 2011

Demand and supply of edible oils vs palm oil in India during 2009-10

(million tonnes)

	Edible oils	Palm oil
Production	7.94	0.08*
Import	8.82	6.44
Export	-	-
Consumption	16.77	6.76*

Source : Department of Food & Public Distribution, Annual Report 2010-11

*Oil World Annual 2011

Oil Palm Scenario

Oil Palm is a native of West Africa and is grown extensively in South-East Asian countries, (Malaysia, Indonesia and Papua New Guinea), African countries, (Nigeria, Ivory Coast, Ghana, Liberia, Sierra Leone, Cameroon, Republic of Congo and Zaire) and South American countries (Costa Rica, Panama, Columbia, British Guyana, Peru, Ecuador, Venezuela and Brazil). Malaysia, Indonesia and Nigeria are the leading producers of oil palm. The Malaysian oil palm industry is moving forward with its area increased in a linear fashion till the end of twentieth century. Presently, Malaysia and Indonesia have 3.90 and 5.00 lakh ha respectively of mature oil palm area and their average productivity is 21.28 and 17.00 tonnes of fresh fruit bunch (FFB) per ha per annum. Malaysia Palm Oil Board (MPOB) plays a predominant role in oil palm research and development in Malaysia. They are self sufficient in planting material, production technology, processing, value addition and product diversification. The success level of oil palm expansion programme in Malaysia was consolidated with promotion of downstream industries. As for Indonesia, it was relatively slow till late 1980s, but thereafter, its growth was exponential. This was possible only because of the commitment of these two countries to oil palm. However, oil palm is indigenous to coastal plains of Nigeria and oil palm cultivation is part of their way of life. Other countries like Thailand, Ghana, Colombia, Equador etc also have more area and production of oil palm, self sufficient in oil palm planting material and their economies revolve around oil palm.

Production and productivity of palm oil in the world - 2010

Region	Production (million tonnes)	Productivity (tonnes/ha)
Indonesia	22.20	3.87
Malaysia	16.99	4.11
Central & South America	2.31	2.66
Other countries	4.35	2.09
World	45.85	3.58
India	0.08	1.12

Source: Oil World Annual 2011

Oil palm was introduced in India at National Botanical Gardens, Kolkata during the year 1886. The Maharashtra Association for Cultivation of Sciences (MACS) later introduced African dura palms along canal bunds, home gardens and, to some extent, in forest lands in Pune during 1947 to 1959. Large scale planting of oil palm was launched from 1971 to 1984 in Kerala by Plantation

Corporation of Kerala Ltd., (subsequently taken over by Oil Palm India Ltd.,) and by Andaman Forest and Plantation Development Corporation in Andaman and Nicobar Islands during 1976 to 1985. Oil palm has established as a successful crop in a number of states in the country and productivity levels upto 6-8 tonnes oil /ha could be achieved. The Technology Mission on Oilseeds and Pulses (TMO&P) implemented by Government of India looks after development of oil palm in the country through Oil Palm Development Programme (OPDP) along with other nine annual oil seed crops.

Though Oil Palm Development Programme in the country is progressing well, area coverage is not taking place as per targets envisaged. As on 2006, various Expert Committees constituted by Ministry of Agriculture, Government of India have identified a total of 10.71 lakh hectares in 14 states of the country as suitable for oil palm cultivation. So far an area of 1.94 lakh ha was covered under oil palm but only 1.64 lakh ha exists at present as about 30,000 ha were uprooted due to various reasons. The production of palm oil in India continues to be at meager level with respect to its requirement. The FFB yields obtained by progressive farmers of Andhra Pradesh under optimum cultural and irrigated conditions are between 20 and 25 tonnes of FFB/ha/annum i.e. 4-5 tonnes of oil/ ha/annum from fourth and fifth year onwards. The highest yield of 30-35 tonnes FFB/ha/yr during the seventh year was also recorded in some plantations. If concerted efforts are taken to bring one million hectare under oil palm in the potential areas, it will be possible to get 3-4 million tonnes of palm oil and 0.3-0.4 million tonnes of palm kernel oil by the year 2030.

DOPR 2030

Oil palm research in India started with the establishment of a Research Station at Thodupuzha by Department of Agriculture, Kerala during 1960. India Council of Agricultural Research (ICAR) started oil palm research at Central Plantation Crops Research Institute Research Centre at Palode during 1975. Oil palm was included as one of the crops in the All India Coordinated Research Project on Palms during VII Five Year Plan period with the establishment of four Coordinating Research Centres at Vijayarai (Andhra Pradesh), Mulde (Maharashtra), Aduthurai (Tamil Nadu) and Gangavathi (Karnataka). ICAR established National Research Centre for Oil Palm in Andhra Pradesh during 1995 was later upgraded as Directorate of Oil Palm Research (DOPR) during 2009. Two more coordinating centres for oil palm research were established during 2009 at Pasighat (Arunachal Pradesh) and Madhopur (Bihar). Thus, a well established research system with the required infrastructural facilities is available in the country for oil palm research.

Mandate

- To conduct mission oriented research on all aspects of oil palm with an objective to improve the productivity and quality
- To serve as national repository for oil palm germplasm and clearing house for all research information on oil palm and coordinate national research project
- To act as center for training in research methodology and technology of oil palm
- To generate nucleus planting material
- To collaborate with national and international agencies in achieving the above mandate

Vision

Accelerated development of innovations and technologies in oil palm to address the challenges of producing more vegetable oils for growing population with declining land and water in the scenario of climate change.

Mission

- To ensure technology led development of oil palm for food and industrial purposes and making it available to the citizens at affordable price.
- To ensure the availability of new hybrids and technology, which can withstand against biotic and abiotic pressure and provide better profitability to the farmers
- To develop technologies which are socially compatible, politically feasible and ecologically sustainable and provide environmental services.

Research achievements

The salient achievements obtained so far from the research work on oil palm carried out in India are given below:

Genetic Resource Management

In oil palm, the characters that are being looked for hybridization are broad and proven genetic base, better adaptability over a range of environments, high precocity, high yield with better oil extraction. Exotic genes are being utilized to improve genetic variability of current breeding populations and provide wider perspective in breeding and selection. Directorate of Oil Palm Research has germplasm collected from different oil palm growing countries with wide variability for different characteristics. The germplasm assemblage of 128 exotic and indigenous accessions is being evaluated. The gene bank has been enriched with few more collections from commercial plantations raised with exotic planting materials in India. It is to be mentioned that two *oleifera* palms could also be identified in commercial plantations of Oil Palm India Ltd., which are being utilized in breeding programmes.

Amongst tenera introductions planted in 1981 at Palode, twenty best performing teneras have been identified which are being selfed for further crop improvement. Twenty four tenera accessions received from ASD Costa Rica were evaluated at multiple locations for subsequent location specific introduction of suitable ones for commercial cultivation. Efforts to develop hybrids which perform well under moisture stress conditions are under way. High yielding palms under irrigated [(ZS-2 (257), TS-9 (258 & 260), ZS-5 (37)] and water stress [ZS-3 (230), ZS-1 (275), ZS-2 (60 & 61)] conditions have been selected with an aim to develop oil palm types for water stress (drought) tolerance. Based on stomatal and physiological observations, dura palms grown under irrigated and stress conditions were ranked and the results revealed that ZS-1 from Zambia was most drought tolerant and TS-9 from Tanzania was the most susceptible. GB-22 and GB-25 from Guinea Bissau and ZS-5 from Zambia recorded significant increase in soluble protein and proline contents under stress conditions.

Trials on the comparative performance of different hybrids of oil palm were conducted at the oil palm centres of All India Coordinated Research Project on Palms. Evaluation on the performance of *tenera* hybrids of oil palm in different agro-climatic regions, since 1991, resulted in the identification of a high yielding hybrid 124D x 266P yielding 24.06 tonnes FFB/ha at Mulde centre in Maharashtra. Similarly, the hybrid 115D x 291P is performing well both at Vijayarai and Mulde. The hybrid was yielding 13.80 tonnes FFB/ha at Vijayarai and 20.32 tonnes FFB/ha at Mulde.

Evaluation of *dura* types of oil palm germplasm for drought tolerance was undertaken under rainfed conditions at Gangavathi (Karnataka) and Mulde (Maharashtra) centres from 1998 onwards. At Gangavathi centre, significant differences were observed in lipid peroxidation levels indicating its drought tolerance.

With a view to develop dwarf and compact palms and facilitate more palms per unit area and easy harvesting, inter-specific hybrids are being evaluated. A few more sources of dwarfness have been identified and efforts are being made to introgress these genes through hybridization for developing a base population of TxP and TxT for new generation seed gardens. Evaluation of interspecific hybrids at Palode resulted in the identification of three promising dwarf palms that could be used for further improvement. Among them, palm no 48 recorded a height of 1.00 metre at 12 years and showed high % fruit set and oil/bunch ratio (21.13).

DNA fingerprinting of different germplasm revealed that no two palms were genetically similar even within the same accession. Wide genetic diversity was found among different accessions by Randomly Amplified Polymorphic DNA (RAPD) analysis. Subsequently, five exotic and one indigenous accession when subjected to biochemical and molecular characterization revealed that palms from Guinea Bissau accession were more homogenous compared to that of other groups and the accession was genetically more distant from others. *E. oleifera* has more desirable characters like better oil quality, disease resistance, slow growth etc but with low yield. Among the *E oleifera* palms, a high degree of genetic diversity was observed and can be employed for developing inter-specific hybrids. Work on developing an *in vitro* regeneration protocol of oil palm using explants from mature palms has yielded promising results. Commercial hybrid seed production was started at Thodupuzha, Kerala utilizing indigenous duras and pisiferas from 1982 onwards. Advanced generation parent materials were evolved through reciprocal recurrent selection and planted at Palode, which had now come to seed production. Selection of duras was done based on yield and bunch analysis data. Parental duras and pisiferas were supplied to establish seed gardens at Rajahmundry, Lakshmipuram, Pedavegi (Andhra Pradesh) and Taraka (Karnataka). Seed processing and germination facilities were developed and techniques have been perfected to achieve 95% germination. At present, six seed gardens exist in the country with an annual production capacity for 2.00 million sprouts.

Production System Management

Nursery management techniques were perfected for raising healthy oil palm seedlings. Soil, sand and farm yard manure or oil palm waste compost in 1:1:1 proportion was found to be an ideal potting mixture for growing seedlings. A fertilizer dose of 10-5-5 g N, P_20_5 and K_20 per seedling was found optimum. Application of fertilizers in equal splits at three monthly intervals was suitable for optimum performance. Studies on the age of seedling at planting revealed that plant height and girth were significantly higher when seedlings were planted at 9 and 12 months. The levels of physiological parameters were higher in 12 month old seedlings followed by 9 month old seedlings.

Based on the long term experiments conducted in AICRP on Palms Centres, the following fertilizer schedules were recommended for oil palm cultivation in different regions:

- Coastal Tamil Nadu region : 1200: 600: 2700 gram NPK /palm/ year
- Thungabadhra Command area of Karnataka : 1200: 600: 1200 gram NPK/ palm/ year
- Konkan coastal region in Maharashtra : 1200: 600: 2700 gram NPK /palm/ year
- Coastal Andhra Pradesh region : 1200: 600: 2700 gram NPK /palm/ year

A fertilizer dose of 1200-600-1200g N, P_20_5 and K_20/palm/year applied in two equal splits was found optimum for adult palms under rainfed conditions. Diagnosis and Recommendation of Integrated Systems (DRIS) was developed for oil palm. Potassium nutrition was found critical under tropical conditions.

Under irrigated conditions, when initial yields of 15 tonnes of FFB/ha/yr or more were observed, it is advisable to apply 20% more fertilizer than the recommended dose in 3-4 splits. Boron deficiency symptoms were manifested in the form of hook leaves, rounded frond tips, blind leaf, leaflet shatter, bristle tip, crinkled leaf and fish bone leaf structure. The boron deficiency could be corrected by application of borax in three splits @ 50, 50 and 100 g/palm. Based on the influence of weather parameters, yield prediction models were worked out.

Results from irrigation experiments have indicated that when irrigation was restricted to replace evaporation losses by 100 per cent either with drip or micro jet, crop growth and yields were superior to that of basin irrigation. Oil palm may require at least 300-350 litres of water per palm per day during peak summer seasons. Irrigating palms at the rate of 90 litres/palm/day during summer months has increased annual oil yield of palms from 3.3 to 4.7 tonnes/ha under rainfed conditions.

Sap flux in oil palm with response to environmental variables viz., evapo-transpiration and vapour pressure deficit increased gradually from 9.00 hours onwards and reached peak during 13.00-14.00 hours and then decreased gradually. Sap flux measurements could give vital leads in developing an approach for monitoring the environmental responses in oil palm.

Carbon Sequestration studies in eleven mature oil palm hybrids belonging to ASD Costa Rica, Ivory Coast, Papua New Guinea and Palode revealed that standing above ground biomass in different hybrids ranged from 55.08 to 91.58 tonnes/ha. The highest biomass was recorded in ASD Costa Rica hybrid Deli X Lame, while lowest was also in ASD Costa Rica hybrid (Deli X Avros). The amount of carbon sequestered by the hybrids ranged between 17.98 and 35.44 tonnes/ha with Papua New Guinea and Ivory Coast hybrids sequestering the highest and lowest carbon contents respectively.

Crops like maize, tobacco and banana were found to be most profitable and compatible intercrops in oil palm based cropping systems during the juvenile phase, while, cocoa was found to be an ideal companion crop in adult oil palm plantations. Agro-forestry systems in oil palm involving multi-species crop combinations with cocoa, black pepper, cinnamon and anthurium have been established to maximise productivity and improve soil and water conservation in undulating terrain of high rainfall areas. Growing sunnhemp in basins of young oil palm provides a better micro environment to the crop during summer besides fixing atmospheric nitrogen and addition of organic matter.

Technique of vermi-composting has been perfected for oil palm plantation wastes, which are available in plenty in oil palm plantations. It was found that almost 90 % of N, 50 % of P and 75 % of K requirement of palms could be met through compost obtained from bio-waste recycling process. A combination of one-third of nutrient requirement as inorganic fertilizers and two-third of requirement as palm waste compost was ideal and economical.

Disaster management studies indicated that, within the course of three years of cyclone, uprooted palms, that were replanted, started yielding through application of recommended doses of fertilizers and irrigation. With proper care and management of oil palm plantations (regular application of water through drip and quarterly application of fertilizers @ 1200:600:1800:500g N, P, K, Mg per palm/year and need based boron application @ 50 g/ palm/year, 50 kg FYM/palm /year, it is possible to get 8 to 11 tonnes FFB/ha/annum in the first year of harvest i.e. three years after planting.

Plant Health Management

Roving survey on the pests of oil palm in various states of India revealed that rhinoceros beetle was most frequently observed pest in both rainfed and irrigated oil palm plantations, which was found to migrate from coconut and palmyrah palms. Leaf eating caterpillar damage was observed very severe in some plantations with yield loss up to 37 % extending to the following two to three years. Management measures for rhinoceros beetle and red palm weevil have been developed. Nylon nets in plantations were effective in reducing the bird damage. Green and violet coloured nets could attract and trap many birds followed by snuff colour. A wild boar scaring devise was developed for oil palm nurseries and young plantations. Use of bamboo noose traps was found to reduce the burrowing rat population. Single application of Warfarin could reduce only 50% of rat incidence within one week period compared to Zinc phosphide which recorded more than 75% reduction. Two applications of Zinc phosphide with no gap between the applications was found effective. Infestation of rhinoceros beetle was brought down from 8.25% to 1.8% by release of baculovirus infected beetles. Molecular studies of different strains of bio control agents used for management of oil palm pests revealed that both *Trichoderma viride* and *Beauveria bassiana* obtained from NBAII were effective in causing infection within a shorter period compared to strains of NRCOP and DOR.

Oil palm is an entomophilous crop and pollinating weevil *Elaeidobius kamerunicus*, introduced from Malaysia has established well in all agro-climatic zones of oil palm in India. Relative humidity was observed as a critical factor for the incidence of pollinating weevil. No weevil population was observed when RH was reduced to less than 40%. It was also observed that *Beauveria bassiana* was more harmful to weevil population compared to that of *Metarhizium anisopliae*.

Among the diseases recorded in oil palm plantations, bud rot, stem wet rot, upper stem rot, basal stem rot and spear rot diseases are serious though the percent incidence is low, causing mortality of the palms where as bunch rot and bunch failure are observed seasonally causing yield losses.

Standardized seed dressing techniques to prevent microbial spoilage of seeds and sprouts during storage and germination process. Spear rot disease, endemic to Kerala was found to be caused by Phytoplasma and spread by plant hopper *Proutista moesta* and lace bug *Stephanitis typica*. Stem surgery technique for management of stem wet rot and basal stem rot have been found successful. Cross infectivity of organisms from coconut to oil palm has been observed in both basal stem rot and spear rot diseases of oil palm i.e., phytoplasma associated with root (wilt) disease causing spear rot and *Ganoderma* causing basal stem rot. Molecular characterization of *Ganoderma sp* causing basal stem rot (BSR) disease in oil palm revealed polymorphism. All the isolates were confirmed by PCR amplification with two pairs of primers – Gan1 & Gan2 and Gan ET & Gan ITS.

Post Harvest Technology and Farm Mechanization

Trials conducted on the evaluation of various methods of harvesting tools showed that the sickle attached to an aluminium pole was more efficient compared to other traditional methods followed in different parts of the country. A semi mechanized hydraulically operated harvesting device was being evaluated for harvesting oil palm fresh fruit bunches.

A demonstration plant of one tonne/ hr capacity for processing FFB was designed jointly with Regional Research Laboratory (CSIR), Thiruvananthapuram and commissioned at Palode during 1991. A Mini Palm oil processing unit to cater to the needs of small farmers (up to 4.00 ha) was designed and installed in 1996 at Palode. A laboratory scale mini hand operated oil extraction device was developed for extraction of oil for laboratory analysis. Mini palm oil mill of 1 tonne/hr capacity was designed, developed and evaluated to act as a demonstration farm level processing plant and also to act as a pilot plant for quantifying oil content in fresh fruit bunches.

Production of edible grade partially refined palm oil, rich in vitamin A has been standardised. Higher levels of carotenoids from crude palm oil could be separated using specific adsorbent, retaining the edibility of oil. Palm olein was found to be the balanced oil with respect to saturated and unsaturated fatty acid content. Oil from *oleifera* was found to be better in terms of oleic and linoleic acid contents. Post harvest studies on crude palm oil indicated that oil extracted without sterilization had very high amount of FFA in comparison to conventional methods. Studies on the effect of low temperature on FFA content in the oil after harvesting indicated that the increase was steady up to seven days and hence there is no possibility of storing FFB at lower temperature before processing.

Technology and machinery for extraction of fibres from oil palm empty fruit bunches (EFB) has been standardized. Value added products like paper boards, fibre ropes, rubberized mattress, medium density fibre boards etc. were developed from palm fibre. Semi-mechanized process was standardized for making stripes from oil palm fronds and window shades from stripes. Technology of mushroom cultivation on oil palm factory wastes has been standardized. Mobile oil palm waste shredder was developed to enable chopping of fronds cut during harvesting. Various micro organisms were Isolated and identified from palm oil mill effluent (POME). In addition, POME based animal and fish feed formulations were developed.

Transfer of Technology

Technological gaps, adoption and constraints faced by the farmers in oil palm production were studied. Training needs of officers and farmers in oil palm were assessed and need based training programmes are being conducted at regular intervals. Modern Audio Visual and training facilities were created to provide training to officers and farmers. Officers training programmes are conducted on production technology, hybrid seed production, plant protection, soil and leaf nutrient analysis, nursery management, harvesting and farming systems in oil palm. Officers belonging to State Departments of Agriculture/Horticulture; scientists of State Agricultural Universities and ICAR as well as entrepreneurs participate in the training programmes. Farmers were trained on oil palm cultivation, nutrient and water management, harvesting of oil palm fresh fruit bunches and plant protection in oil palm. 36,000 farmers belonging to twelve oil palm growing states were trained.

A digital video film on oil palm cultivation "The Golden Palm" was brought out in nine languages. Literature on oil palm production technology and publicity material on oil palm cultivation practices were brought out and made available to State Departments of Agriculture/Horticulture of different oil palm growing states and entrepreneurs. Interface meetings and demonstrations on innovative practices were conducted regularly on need based issues. The Institute participated in exhibitions in different parts of the country. Scientists presented radio talks, provided video clips on different aspects of oil palm cultivation, responded to letters, phone calls and E mail queries on oil palm cultivation. Multidisciplinary scientist team visits were conducted for identifying the problems and providing technical suggestions.

Software for computerization of oil palm germplasm, seed garden, experimental plots, pests, processing units with different modules have been developed and installed. Need based up-gradation is being made in these softwares. Development of the Institute website and regular updating of its contents is a continuing process.

Major Constraints in Oil Palm Research

- Indian oil palm gene bank has very narrow genetic base and most of these collections are secondary in nature and are *tenera*, having limited use in oil palm improvement programme.
- As large land area is required for conducting progeny evaluation trials, most

of the oil palm hybrids developed using available *duras* and *pisiferas* could not be evaluated.

- Requirement of longer duration for progeny evaluation
- Being a perennial crop, developing production technologies take considerable amount of time.
- Facilities for product development, product diversification, value addition and by product utilization etc. needs to be developed.
- Trained manpower is not adequate.

Strategies and Framework

A ten point strategy would be adopted for accomplishing vision and goals of Directorate of Oil Palm Research and to enhance efficiency and effectiveness of oil palm research in the country.

I. Effective management, enhancement, evaluation and valuation of genetic resources.

- ❖ Enrichment of oil palm genetic resources through germplasm exchange, procurement and collection from centres of diversity.
- ❖ Documentation on performance indicators in the available genetic resources.

II. Development of improved hybrids with high quality characteristics, productivity and resistance to biotic and abiotic stresses.

- Evaluation of germplasm for higher yield, better performance under biotic and abiotic stress, slow vertical growth, compact canopy and superior oil quality.
- Development of high yielding hybrids with dwarf stature, high iodine value and resistant to biotic and abiotic stresses.
- Taking up new crossing programmes based on FFB yield, molecular characterization and combining ability.
- Multi-locational trials involving new promising hybrids would be laid out utilizing the facilities under All India Coordinated Research Project.

III. Strengthening of oil palm hybrid seed production with advanced generation materials to achieve self sufficiency in domestic planting material requirement.

- Strengthening of existing oil palm seed gardens by selection of more parental palms.
- Establishment of new seed gardens with advanced selection cycle material from indigenous sources.
- Conducting DxP progeny evaluation trials on a large scale to base future seed production programmes.

IV. Development of regeneration protocol from mature explants for mass multiplication of elite hybrids.

- Development of tissue culture protocol for mass multiplication of elite oil palms
- Public-private partnership programmes to be initiated for the commercial exploitation of tissue culture technology.

V. Develop agro techniques and productive use of water to get 'more crop per drop' by increasing the water and nutrient use efficiency.

- Development of suitable production technologies for maximization of yield under irrigated conditions
- Water and nutrient management studies under irrigated conditions.
- Integrated Plant Nutrient Management (IPNM) for oil palm based cropping system with major emphasis in bio-waste recycling process.
- Basic studies to know biochemical and physiological basis for growth and yield of oil palm under irrigated conditions.

VI. Impact of climate change on the metabolism of the crop and its productivity.

- Effect of climate change on growth, metabolism and yield of oil palm
- Climate resilient technologies to be developed for ensuring better oil palm productivity.

VII. Develop suitable harvesting tools for oil palm production and post-harvest technologies to improve product quality and minimize environmental impact.

- Development of efficient harvesting tools and machineries for mechanization in oil palm plantations.
- Developing maturity standards for harvesting FFB at right stage.
- Development of techniques for product diversification and by-product utilization.

- Development of advanced treatment systems for palm oil mill effluent.

VIII. Develop integrated pest management and improve pollination efficiency for better productivity.

- Development of IPM practices for major pests.
- Development of viable control measures for avian and vertebrate pests.
- Studies on conservation of the pollinating weevils and their activity during different seasons.
- Studies on impact of pheromones in attracting the weevils to the female inflorescence.
- Scope for using honey bee as a pollinating agent.

IX. Development of new innovative diagnostic techniques for rapid, accurate and cost effective detection of high impact diseases.

- Development of early diagnostics for major diseases.
- Management of important diseases like basal stem rot, stem wet rot and bud rot.
- Development of techniques to forecast pest and diseases outbreak and suggesting suitable prophylactic measures.

X. Understand social needs of communities and build their capabilities for practice the change for effective utilization of resources and adoption of technologies and respond to emerging needs.

- Development of decision-support system as a tool for precision farming.
- Human resources development programmes for farmers, officers, youth, self help groups, women and unemployed youth in oil palm production and allied industries associated with oil palm
- Promoting information technology enabled services like video conference and other cyber extension tools.
- Participatory extension mechanism to generate, evaluate and refine technologies.
- Application of statistical and computerized tools for research and development.
- Impact evaluation studies on oil palm technologies.

Strategic framework

S.No	Goal	Approach	Performance measure
1	To effectively manage, enrich and evaluate oil palm genetic resources	Enrichment of oil palm genetic resources through germplasm exchange, procurement and collection from centres of diversity. Documentation of performance indicators in the available genetic resources.	Broadening of oil palm genetic base.
2	To develop improved hybrids with high yield, quality, resistance to pest and diseases and tolerant to abiotic stresses.	Evaluation of germplasm for higher yield and better performance under biotic and abiotic stress, slow vertical growth, compact canopy and superior oil quality. Development of high yielding hybrids with dwarf stature along with high iodine value and resistant to biotic and abiotic stresses. Crossing programmes to be taken up based on FFB yield, molecular characterization and combining ability. Laying out multi-location trials with new promising cross combinations utilizing the facilities under All India Coordinated Research Project.	Oil palm hybrids with high yield and better oil quality and improved tolerance to biotic and abiotic stresses.
3	Strengthening of oil palm hybrid seed production with advanced generation	Strengthening of existing oil palm seed gardens by way of selection of more parental palms.	Production of adequate planting materials to achieve self sufficiency

S.No	Goal	Approach	Performance measure
	materials to achieve self sufficiency in domestic planting material requirement.	Establishment of new seed gardens with advanced selection cycle material from indigenous source. Conducting DxP progeny evaluation trials on a large scale to base future seed production programmes.	
4	Development of regeneration protocol for multiplication of elite palms.	Development of tissue culture protocol for mass multiplication of elite oil palms. Public-private partnership programmes to be initiated for the commercial exploitation of tissue culture technology.	Rapid mass multiplication of elite palms.
5	Develop agro techniques and system for productive use of water to get 'more crop per drop' by increasing the water and nutrient use efficiency.	Development of suitable production technologies for maximization of yield under irrigated conditions. Water and nutrient management studies to improve Water and Nutrient Use Efficiency. Integrated Plant Nutrient Management (IPNM) for oil palm based cropping system with major emphasis in bio-waste recycling process. Basic studies to know biochemical and physiological basis for growth and yield of oil palm under irrigated conditions.	Improved water and input use efficiencies. Developing suitable agro techniques for improved cultivation.

S.No	Goal	Approach	Performance measure
6	Impact of climate change on the metabolism of the crop and its productivity.	Effect of climate change on growth, metabolism and yield of oil palm would be studied. Climate resilient technologies to be developed for ensuring better oil palm productivity. Carbon sequestration studies in relation to different age groups.	Development of climate resilient technologies and management practices.
7	Develop suitable harvesting tools for oil palm production and post-harvest technologies to improve product quality and minimize environmental impacts.	Development of efficient harvesting tools and machineries for mechanization in oil palm plantations. Developing maturity standards for harvesting FFB at right stage. Development of techniques for product diversification and by-product utilization. Development of advanced treatment systems for palm oil mill effluent	Developed tools/ techniques and processed products.
8	Develop integrated pest management and improve pollination efficiency for better productivity.	Develop IPM practices for major pests which are eco-friendly. Development of viable control measures for avian and vertebrate pests. Studies on conservation of the pollinating weevils and their activity during different seasons. Studies on impact of pheromones in attracting the weevils to the female	IPM technology for oil palm pests. Improved pollination efficacy in oil palm.

S.No	Goal	Approach	Performance measure
		inflorescence. Scope for using honey bee as a pollinating agent.	
9	Development of new innovative diagnostic techniques for rapid, accurate and cost effective detection of high impact disease.	Development of early diagnostics for major diseases. Management of important diseases like basal stem rot, stem wet rot and bud rot. Development of techniques to forecast pest and diseases outbreak and suggesting suitable prophylactic measures.	Integrated disease management for major diseases.
10	Understand social needs of communities and build their capabilities for practice the change for effective utilization of resources and adoption of technologies and respond to emerging needs.	Development of decision -support system as a tool for precision farming. Human resource development programmes for farmers, officers, youth, self help groups, women and unemployed youth in oil palm production and allied industries associated with oil palm. Promoting information technology enabled services like video conference and other cyber extension tools. Participatory extension mechanism to generate, evaluate and refine technologies. Application of statistical and computerized tools for research and development. Impact evaluation studies on oil palm technologies	Better knowledge and skill levels among clients for improved efficiency.

Human Resource Development

Since oil palm is a newly introduced crop to this country, it is very much essential to train scientists on important areas at different oil palm growing countries of the world. Training will be imparted in following priority areas at the institutions mentioned against each:

- Oil Palm Breeding - PORIM, Malaysia, IOPRI, Indonesia, ASD, Costa Rica.
- Molecular studies - Uni. of California, Dept. of Horticulture, Karetsort Uni, Bangkok.
- Seed Production - PORIM, Malaysia, FELDA, Malaysia, ASD, Costa Rica.
- Biotechnology - IDEFOR, Ivory Coast, United Plantations, Berhard, Malaysia, PORIM, Malaysia.
- Water Management - Centre for International Agril. Development and Cooperation (CINADCO), Israel, CIRAD-CP, Montpelier.
- Nutrient Management - IRHO, Montpelier, France.
- Climate change - Kansas State Uni., USA, Utrecht Uni., Netherlands, Uni. of Basel, Switzerland, Colorado State Uni., USA.
- Nutrient Management - IRHO, Montpelier, France, FELDA, Malaysia.
- Drought tolerance - CSIRO, Australia; EMBRAPA, Brazil.
- Integrated Pest Management. - International Agril. Centre, Wageningen, Netherlands.
- Pollinating Weevils - IDEFOR, Ivory Coast.
- Disease management - PORIM, Malaysia, CIRAD-OP, France, IDEFOR, Ivory Coast.
- Post Harvest Technology - PORIM, Malaysia.

Expected Outcome

- Initiation of need based long term research programmes for meeting the future targets and challenges.
- Development of hybrids with higher yield potential and resistance to biotic and abiotic stresses.
- Self sufficiency in quality planting material production.
- Efficient nutrient and water management technologies.
- Effective use of bio-control agents for pest and disease management.
- New harvesting tools and machineries for oil palm cultivation.
- Processing technologies for effective utilization of oil palm products.
- New technologies expected to play a critical role in improving oil palm production and increasing the oil palm sector efficiency in the country.

DOPR Vision 2030

ISBN : 81-87561-26-2