DOPR | RESEARCH HIGHLIGHTS 2005-10

ICAR

DIRECTORATE OF OIL PALM RESEARCH

(Formerly National Research Centre for Oil Palm)

(Indian Council of Agricultural Research)

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Research Highlights

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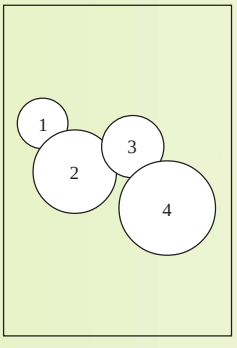
Cover Page



1. Heliconia as intercrop
2. Promising germplasm from Zambia 'ZS-3'
3. Bracket of *Ganoderma* sp. on oil pam
4. Awareness campaign

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Foreword

This publication has a gist of research activities taken up at this Directorate during the last five years. Previously two such publications were brought out during 2003 and 2005. The information is given under five broad heads namely crop improvement, crop production, crop protection, post harvest technology and social sciences.

Since 1995, systematic efforts have been made at this Centre to cater to the needs of Oil Palm community and increase production and productivity of crop by formulating production technologies under rainfed and irrigated conditions. During 2009, NRC for Oil palm was upgraded as Directorate of Oil Palm Research with the merger of AICRP (Oil palm) centers which further enables our Directorate to cater location specific research requirements of the crop.

Fifteen years have passed since the establishment of this centre and formative years were dedicated for infrastructure development and taking up field experiments. Now the centre can feel proud of research facilities of high standards. Oil palm being a perennial crop takes a minimum of 8 years for plantation establishment and yield stabilization. Hence the research highlights brought out at this stage has more significance in terms of production technology practices recommended for oil palm cultivation.

During last year, oil palm FFB prices have fallen and farmers are unhappy. Since price of oil palm is governed by international palm oil prices, price fluctuations do happen often. In this regard, the Government of India took initiative and introduced Market Intervention Scheme (MIS) of Rs. 5000/- per tonne of Fresh Fruit bunches. My sincere advice to the farming community is to aim at improving productivity per unit area and reduce cost of cultivation by adopting recommended package of practices so as to compensate for the price fall.

Hope the research achievements highlighted in this booklet will help oil palm community in making oil palm cultivation more profitable and sustainable.

I thank all my colleagues for their devoted and untiring efforts in taking oil palm research in India to new heights and providing valuable inputs required for bringing out such a nice publication.

Pedavegi
18-06-2010

(M. Kochu Babu)
Director

Crop Improvement

- Oil palm gene bank has been enriched with collections from commercial plantations in India, i.e., 4 from Nellore (ASD Costa Rica), 22 from Little Andamans (Ivory Coast, Nigeria, PNG and Zaire), 5 from Theni (Malaysia), 2 from Krishna (PNG) and one from Mysore (IRHO). Two *oleifera* palms are identified in commercial plantations of OPIL which are being utilized in breeding programmes.

- One palm (Palm No.151), suspected to be dwarf, has been identified in *tenera* x *tenera* population at Palode.

- The pooled analysis revealed significant differences among hybrids from different sources for fresh fruit bunches (FFB) weight and number of bunches. The highest FFB weight was recorded in Palode hybrids (118 kg. palm^{-1}. y^{-1}) followed by PNG hybrid (109.3 kg). Maximum bunch index was recorded in Ivory Coast hybrid (IC9 C x 1001) followed by ASD Costa Rica hybrid (ASD Deli x Lame) and Palode hybrid (65D x 111P).

- The evaluation of Costa Rican hybrids did not reveal significant differences in terms of growth and yield characters like trunk height, girth, number of leaves, inflorescence production and FFB yield.

- Pooled analysis of variance in three progeny testing trials (source-Palode) at Lakshmipuram, A.P., revealed significant variations in terms of number of bunches, FFB weight and average bunch weight. Year to year variations were also significant, however, genotype x year interactions were non significant. The *tenera* hybrid 26D x 98P recorded highest FFB yield (24 T.ha^{-1}.y^{-1}) followed by 108D x 266P and 139Dx 283P (22.7 T.ha^{-1}.y^{-1}).

- Fifty eight mother palms in Palode population and 20 mother palms in Costa Rican population were found to be promising and are being utilized in commercial hybrid seed production at Pedavegi.

- A segregation ratio of *dura* (27): *tenera* (97): *pisifera* (28) has been recorded in *tenera* x *tenera* population at Pedavegi and six *pisifera* palms have been selected based on bunch analysis.

- Evaluation of inter-specific progenies revealed that height increment of IS 2 was less than that of IS 1. Mean FFB weight & ABW of 361D x 11Eo was more than 360D x 13Eo which also recorded high palm to palm variation. The oil/ bunch ratio in these palms varied between 6.5 and 16.5 %.

- Among the African germplasm, Zambian accessions, in general, performed better under both irrigated & stress conditions and were of medium height. Guinea Bissau accessions produced more bunches but were small, high sex ratio, tall and poor yielders. Cameroon accessions were of medium height with less height

Genetic variability in African *duras*

increment and moderate yielders. Tanzanian accessions were tall growing like of Guinea Bissau, but recorded higher yields 118 kg.palm^{-1}.y^{-1} (TS-7) to 161.6 kg.palm^{-1}.y^{-1}(TS-4).

- Four 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)] have been selected as drought tolerant. Most of the promising selections are from Zambian accessions with average bunch weight ranging between 9.6 and 15.5 kg. Two palms in Tanzanian accession (TS-9) were also found promising under irrigated conditions with medium bunch weight (8.5 to 9.1 kg). One palm in Zambian accession (ZS-3) was comparatively dwarf (0.85 m) with more number of bunches and high yield.

ZS-3

- Fruit form testing in Thodupuzha mother palm population revealed that seven out of 341 palms were suspected to be *teneras*. High coefficient of variation was observed for seed weight and kernel weight. Eight *dura* palms (US356, US225, US147, US239, US380, US297, S285 and US375) were also found to be potential based on mesocarp content and oil per fruit (>84%).

Thodupuzha *dura*

- In African germplasm (Cameroon, Guinea Bissau, Tanzania and Zambia and) planted at PCKL, Athirapilli, one palm (No. 70) from Tanzania was confirmed as *Pisifera* (fruit weight of 6.6 g with shell less kernel). Palm no. 254 of Guinea Bissau had big size fruit (22 g) followed by palm no. 239 (20.5 g) of Tanzania and 269 (20.3 g) of Guinea Bissau. High variability

Pisifera fruits

for nut and kernel content was observed (0.61 to 11.28 g and 0.14 to 2.7 g). High amount of mesocarp oil to fruit was recorded in palm no.70 (54.8 %) from Tanzania followed by palm no. 97 (51.5 %) from Guinea Bissau. Kernel oil was high in palm no. 239 (16.32 %) followed by palm no. 251 (15.61 %) from Tanzania.

- Frond, root pruning and stress treatments showed positive response in initiating male inflorescences and pollen production in *pisifera*. However, duration required for different treatments varied with age and genotype.


- A *dwarf tenera* palm from Nigerian (NIFOR) collection (27 years old) and dwarf *Elaeis oleifera* from Surinam (16 years old) were characterized based on Biodiveristy International descriptor and the former recorded bunch yield of 118 kg.palm^{-1}.y^{-1}, 24 cm height increment and 20.4 % and 1.08 % mesocarp oil to bunch and kernel oil to bunch respectively while the latter recorded 75 kg.palm^{-1}.y^{-1}, 15 cm height increment and 9.25 % and 3.1 % mesocarp oil to bunch and kernel oil to bunch respectively.



- Maximum germination (97.6 %) and superior quality was observed when fruit reached stage S4 i.e., 165 days after anthesis (DAA), coincided with lowest moisture content, followed by stage S5 (180 DAA).

- No significant differences were observed for girth and height increment under rainfed conditions among T x T progenies derived from Thodupuzha and Nigerian germplasm. However they showed significant differences for bunch number and weight. 137 T × 137 T showed best performance followed by 614 T x 614 T. Among 168 palms tested, two *tenera* (palm Nos.146 and 149) one *dura* (palm No. 69) and two fertile *pisifera* (palm Nos. 42 and 45) from 614 T X 614 T, 65 T X 323 T and 663 T X 699 T respectively recorded more than 150 kg FFB.palm^{-1}.y^{-1} based on five years consecutive yield data. Highest yielding palm (No. 45) with an yield of 185.2 kg FFB.palm^{-1}.y^{-1} and 18.4 bunches was confirmed as fertile *pisifera*.

- T x T palms yielding more than 125 kg FFB/palm/year were subjected to bunch component analysis and among them 69 D recorded high oil to bunch ratio (24.8%) followed by 99 D (19.4%) and 132 D (19.4%). The 42 P from 663 T × 699 T recorded maximum oil to bunch (24.3%) and both 42 P and 45 P had shell-less

kernel with fruit to bunch ratio of 42.9% (42 P) and 23.1% (45 P). 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.

- Effect of different substrates namely peat mass, sand, red soil, and germination paper on growth of germinated oil palm seeds were tested and results revealed that germination paper can be used as substrate for evaluating germinated seed performance with a testing duration of three months and red sandy soil showed comparable performance.

- Bunches possessing long stalk facilitates access for effortless harvest and insect pollination. Among various sources (Cameroon and *Dura* × *Pisifera* (Palode-indigenous), Guinea Bissau, Tanzania, Zambia) bunch stalk length varied from 11 cm (palm no. 261 of Zambia) to 24 cm. (palm no. 220 of Guinea Bissau).

Bunch stalks of Zambia and Guinea Bissau

- *Oleifera* (Source: Costa Rica Malaysia and Surinam) fruit has developed steadily in size and weight from anthesis (0.27 g) to 135 DAA (8.62 g) Embryo matured at 78 DAA and shell became hard and lignified from 113 to 126 DAA. Mesocarp oil synthesis was initiated at 65 DAA, increased from 113 DAA onwards and peaked at 135 DAA (50.9 %). The seeds extracted from ripe fruits (135 DAA) showed 44.4 % germination whereas seeds extracted from other stages showed no germination. Surinam *oleifera* fruit bunch takes about 4.5 months (135 DAA) for fruit ripening and harvestable maturity. Highest seed germination (90 %) was recorded both at 180 DAA and 192 DAA, whereas complete fruit shedding was observed after 192 DAA.

- Evaluation of interspecific hybrids at Palode resulted in identification of three promising dwarf palms (viz., 47, 48 and 6) that can be used for further improvement. Among them palm no 48 recorded height of 1m (12 yrs), high % fruit set and oil/bunch (21.13).

Interspecific dwarf palm

- Zygotic embryo sterilization and germination under *in vitro* conditions were standardized and can be adopted when natural germination is a problem.

- Destructive sampling causes permanent loss of an elite palm. To avoid it, non destructive sampling of spear leaves from cabbage portion of the palm has been developed.

Non destructive method of sampling and subsequent survival of the palm

- After initial experiments with 400 media combinations, embryogenic callus induction from spear leaf explants was achieved and plantlet regeneration was possible from these calli.

Embryogenic calli from leaf explants

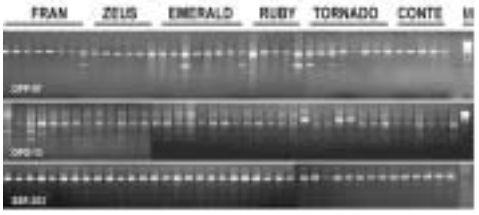
Plantlet regeneration

- Immature inflorescences collected from less than 10th axil responded well for callus and somatic embryo induction. Y3 media was found to induce better callus within 3 months. Mature inflorescence showed only sporadic response.

Somatic embryos

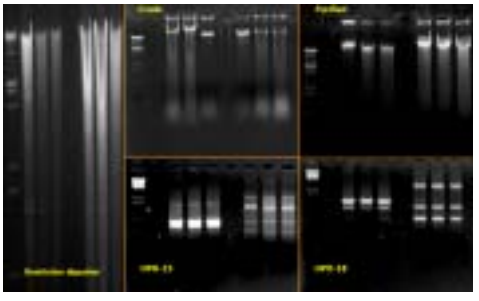
- The first report of direct somatic embryogenesis without callus phase was obtained from cotyledonary nodes of germinated immature zygotic embryos of oil palm hybrids. The globular embryos with clear suspensor region appeared directly on explants and multiplied. Other stages such as torpedo and heart shaped embryos were seen on sub culturing. On transfer to light in Y3 media (BA and ABA) they matured into complete plantlets.

- Molecular markers were used for evaluation of genetic uniformity in field planted tissue cultured plants imported from ASD Costa Rica. Preliminary results showed wide genetic variation among different clones.



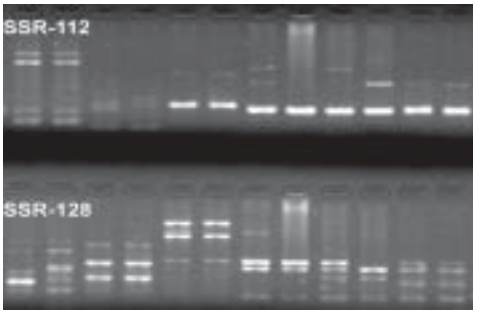
Variation among Costa Rican clones

- A novel protocol for DNA extraction from spear leaf of oil palm without any detergent was developed. The protocol is further simplified and avoided the use of a few chemicals. The same protocol is also validated for coconut and arecanut palms. Quality of DNA was tested using restriction digestion and PCR amplification.



Lane 1 : EcoRI+HindIII, Lane 2-4: Coconut
Lane 5-7 : Arecanut

- Using the available database in public domain, Simple Sequence Repeats (SSR) or microsatellites primers were designed using 'Oligos' software. The best possible pair of primers was selected in each case and custom synthesized. The primers were tested for their functionality with oil palm as well as DNA from other palms such as coconut, arecanut, date palm and palmyra. Out of 116 pairs of primers synthesized and tested, 108 were found functional in oil palm and 94 each for

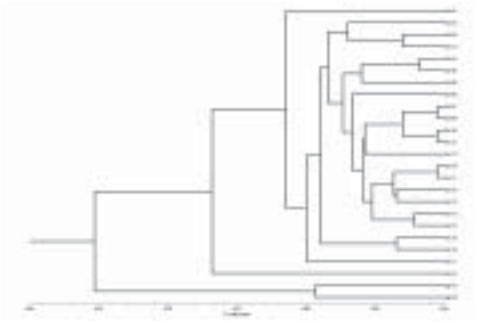


SSR primers functional for oil palm and other palms

coconut, arecanut, palmyra, and 95 for date palm. All the primers functional for oil palm were found functional for other palms also.

- Optimization of reagents was done before using SSR markers for routine use. The quantity of Primers (from 0.2µM to 50nM), *Taq* Polymerase (from 1U to 0.25U) and dNTPs (from 0.5µM to 0.25µM) were reduced gradually from a standard reaction protocol and quantity required for PCR amplification was optimized. The reaction volume was also reduced from 25µl to 10µl. Hence the cost of reactions was considerably reduced from Rs 8200/- to Rs.920/- per 1000 reactions.

- RAPD analysis of 23 *E. oleifera* palms along with two *E. guineensis* palms for their genetic diversity revealed 5 major clusters. However, fours palms were standing apart without forming any group. There were a few primers which could distinguish *E. guinensis* from *E. oleifera*. This result along with fatty acids composition would be useful for *oleifera* improvement programme.

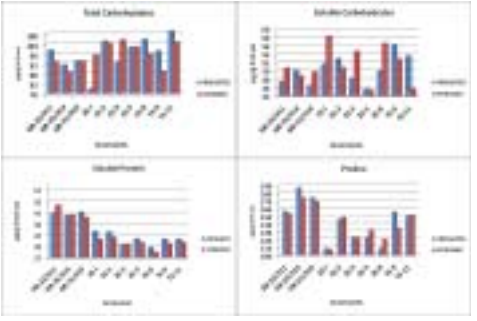


diversity among the *E. oleifera* palms

- Bunch analysis of *Elaeis oleifera* palms at Palode releaved that oil/ bunch ratio ranged from 24.69 to 3.05 %, and Oil yield per palm per year ranged from 36.42 kg to 2.50 kg . Combining this result with oil quality (fatty acid composition), superior palms can be selected for interspecific hybrids as well as *oleifera* improvement programme. It is observed that many fruits in *oleifera* are parthenocarpic, which contain less amount of oil in mesocarp, and oil is comparatively more saturated than that of shelled fruits.

Shelled and parthenocarpic fruits of *E. oleifera*

- Biochemical studies of ten selected African germplasm accessions under water stress vis- à -vis full irrigation indicated that water stress did not have significant effect on photosynthetic pigments except for GB-25/314 and ZS-2 accessions. Few accessions like ZS-2 (increase in peroxidase activity, reduced chlorophyll content), ZS-1 and ZS-8 (increase in soluble carbohydrate) responded to water stress. But they got adjusted to stress by increased soluble sugar and peroxidase activity. However, most of the accessions were having no difference under stress which indicted that those accessions got already adapted to grow under less water than that is recommended for irrigated oil palm.



Effect of water stress on total & soluble carbohydrates, soluble protein and proline

- Based on stomatal and physiological observations, rankings were given to different African duras grown under stress and irrigated conditions. "Duras having lower stomatal frequency, stomatal index, guard cell length, stomatal pore area, transpiration rate, leaf temperature and higher plastid number, photosynthetic rate, photosynthetic water use efficiency, leaf water potential were ranked lower i.e., superior drought tolerant duras". Under stress, ZS-1 recorded the lowest rank compared to that of other duras and highest rank was recorded by TS-9. Among the Guinea Bissau duras, GB-25 recorded the lowest rank and GB-21 recorded the

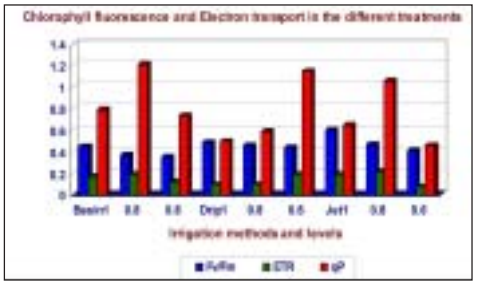
highest rank. Among Zambian duras, ZS-1 and ZS-2 recorded lowest and highest ranks respectively.

- Interspecific hybrid (*Eg* X *Eo* and vice versa) palms were evaluated for their bunch component and oil quality in terms of fatty acid composition (FAC) along with control *E. guineensis tenera* (D X P) hybrids and *E. oleifera* parental palms. Bunch component analysis and FAC showed intermediate values in case of bunch related parameters. However, the oil/mesocarp and oil/bunch were lower than those of parents. Out of seven interspecific crosses, three were found to be on par with better performing *E. oleifera* parental palms with respect to fatty acids. Since performance of each palm is different, individual interspecific hybrid palms were assessed based on total unsaturated fatty acids and oleic acid content and 20 superior palms were selected, which could be employed for further back crossing programmes.

Crop Production

- Studies on photosynthetic efficiency, dry matter production and partitioning in oil palm hybrids revealed significantly lower stomatal frequencies and maximum photosynthetic water use efficiency in Palode hybrids and higher photosynthetic rate in Palode (12 X 313) and Ivory Coast hybrids (IC 9C X 1001 hybrids). Highest bunch index was recorded in Palode (65D X 111), ASD Costa Rica (Deli X Lame) and Ivory Coast hybrids (IC 9C X 1001). This study would help in selecting hybrids associated with high photosynthetic efficiency and high bunch index.

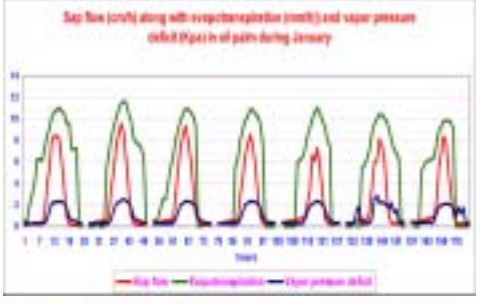
- The gas exchange rate and chlorophyll fluorescence in oil palm under different methods (basin, drip and jet) and levels of irrigation (1.0, 0.8 and 0.6 based on IW/CPE) indicated that palms irrigated with drip and jet irrigation methods recorded higher photosynthetic rates, chlorophyll contents, water use efficiency, leaf water potential, Fv/Fm ratio, Fv/Fo ratio and electron transport rate. There was a decreasing trend in these parameters as IW/CPE ratio decreased. Photosynthetic rate exhibited significant positive correlations with total chlorophyll content, water use efficiency, leaf water potential and Fv/Fm ratio.

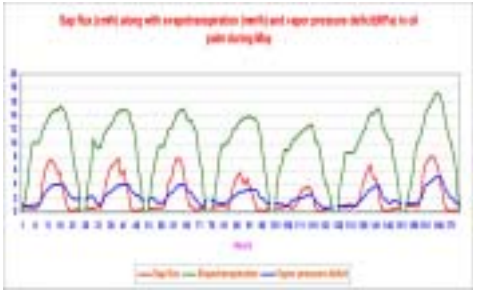


- Photosynthetic rates studied in different leaves of an adult oil palm canopy indicated higher activities in 9th leaf and progressively declined with leaf age. Transpiration rate and stomatal conductance also followed a similar trend. Higher leaf area and leaf dry mass were recorded in 9th and 17th leaves and decreased

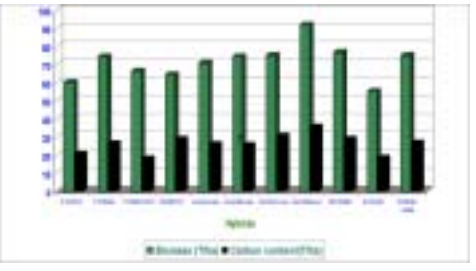
progressively as leaf age increased. Photosynthetic rate exhibited positive relationship with stomatal conductance and specific leaf area. The study reveals that oil palm leaf remains photosynthetically active for a longer time in canopy and contribute significantly to more dry matter production in general and greater fresh fruit bunch yields in particular.

- Diurnal variations in sap flux indicated that sap flux increased gradually from 9.00 A.M reaching a peak during 1.00 to 2.00 P.M and decreased as day progressed. Evapotranspiration and vapor pressure deficit also showed similar trend as that of sap flux. Seasonal variations in sap flux indicated higher sap flux during February and March and lower flux during May and June. The lower flux during dry months could be due to closure of stomata after mid day as atmospheric vapor pressure deficit increased.





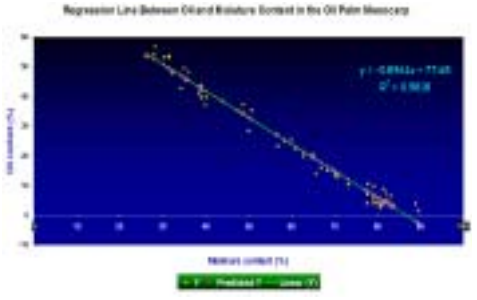
- Carbon sequestration studies in eleven mature oil palm hybrids belonging to ASD Costa Rica, Ivory Coast, Papua New Guinea and Palode revealed that standing above ground biomass in different hybrids ranged from 55.08 to 91.58 T.ha^{-1}. The highest biomass was recorded in ASD Costa Rica hybrid (Deli X Lame), while lowest was in ASD Costa Rica hybrid (Deli X Avros). The amount of carbon sequestered by hybrids ranged between 17.98 and 35.44 T C.ha^{-1} with Papua New Guinea and Ivory Coast hybrids sequestering highest and lowest carbon contents respectively.



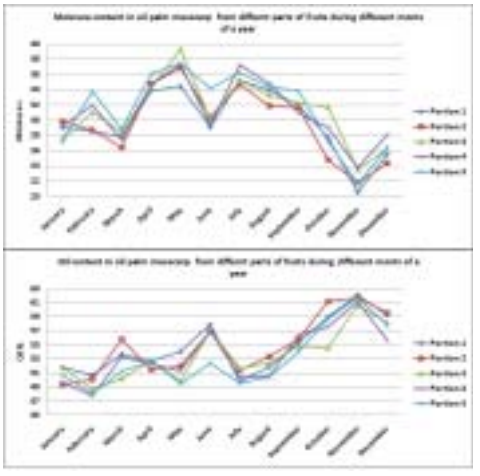
- Studies conducted in six year old oil palm plantation in relation to biomass, carbon and nitrogen distribution with leaf age revealed that total leaf biomass ranged from 1.65 to 2.74 kg, specific leaf weight ranged between 0.24 and 0.45, carbon contents ranged from 0.413 to 1.314 kg and nitrogen contents ranged between 11.5 and 26.3 g. Correlation studies indicated a

positive relationship between leaf carbon and leaf nitrogen contents. Leaf carbon content was also positively related with specific leaf weight.

- Qualitative and quantitative changes in mesocarp oil during fruit maturation of *dura* oil palm were studied and it was found that oil content increased and moisture content decreased gradually during entire period of oil palm fruit/ bunch development from 14 weeks after anthesis. The oil quantity and quality improved in terms of total unsaturated fatty acids composition during oil palm fruit/ bunch development.



- Qualitative and quantitative differences of oil in five different portions of FFB (source ASD Costa Rica) were studied. Each bunch was divided into five portions and data analysis is in progress. However, analyzed data revealed that oil content in mesocarp was more in the Portion 1 and Portion 2 of bunch (toward peduncle), which were significantly higher than that of other three portions of bunch. Oil content was found significantly higher in mesocarp during November followed by December and October. The moisture and oil contents in different portions of the bunch during different months of year showed similar trend.



Moisture and oil content in different portions of bunch

- Fertility status of soils of thirteen mandals of West Godavari district, A.P revealed that soils were very acidic to slightly alkaline in nature (pH: 4.17 - 8.30) low in electrical conductivity (0.015 - 0.352 dS m^{-1}) very low in organic carbon content (2.2 - 12.1 g kg^{-1}). The available phosphorus status of soils was medium to high (10.8 - 145.6 kg ha^{-1}), available potassium content varied between 31 kg ha^{-1} and 694 kg ha^{-1} and available sulphur content ranged from 2 to 167 mg kg^{-1}.The nutrient index values of phosphorus and potassium varied from 1.00 to 1.90 and 1.17 to 2.44 respectively. Sulphur was deficient in 44.3 per cent of the studied area and nutrient index value was 1.93.

- Constraint assessment and evaluation of performance of oil palm in Kari land soils of Kerala was taken up. In general, soils were highly acidic in nature (pH 2.61 to 3.62) and acidity tended to increase in lower layers. The soils had very high amount of soluble salts (4.14 to 9.72 dS m^{-1}), organic carbon content (70.2 to 94.0 g kg^{-1}), available sulphur (1050 to 2288 ppm) and relatively high available potassium (154 to 291 kg ha^{-1}). However, they were low in available phosphorus (2.03 to 4.75 kg ha^{-1}1).

Palms in kari lands

- Growth and yield performance of palms grown in karilands of Kerala under assured drainage was found to be highly encouraging. FFB yield of 20 $T.ha^{-1}$ could be harvested from seven year old palms under optimum soil and water management conditions suggesting its potential.

- A fertilizer dose of 1200-600-1200 g N, P_2O_5 and K_2O per palm was found to produce better growth, maximum flowering and early yields from third year of replanting oil palm under rainfed conditions. One fourth and half of this dose were found to be optimum during first and second year of planting.

- Two thirds of the nutrient requirement of palms could be met through compost made from wastes available from oil palm plantation without affecting its yield. Organic substitution upto this level was also found to be economical.

- Agroforestry systems in oil palm involving multispecies crop combinations with cocoa, black pepper, cinnamon and anthurium have been established to intensify productivity and improve soil and water conservation in undulating terrain of high rainfall areas.

- Red ginger and *Heliconia* have been found as most suitable inter crops in adult oil palm gardens.

Red ginger

Heliconia

- Soil: farm yard manure and soil: pig manure in 1:1 ratio was found to be a good media for growing oil palm seedlings.

Crop Protection

- Psychids, slug caterpillar, leaf web worms and rhinoceros beetles were observed as major pests during roving survey conducted in Andhra Pradesh, Assam, Karnataka, Kerala, Mizoram and Tamil Nadu. Rat incidence was less in Kuttanad area of Kerala. Psychids were abundant due to high humidity.

Damage caused by slug caterpillar

- Incidence of psychids and grass hoppers in nursery and rats in adult plantations was observed in Mizoram. Stagnation of water and presence of weeds were found to be congenial for pest incidence in nursery. A new rodent pest called as *Boi* was found infesting roots of young oil palm plantations causing mortality.

Rat damage

Psychid damage

- Control of slug caterpillar using *Beauveria bassiana* @ 40 g per 10 l water was found on par with Lambda cyhalothrin (0.005%).

- Application of zinc phosphide using gloves and keeping bait in banana leaves were found effective in bringing down rat incidence compared to that of using used news paper bags and handling with bare hands.

- Application of neem cake to growing media of *Metarhizium anisopliae* has enhanced spore production while *Trichoderma viride* reduced both spore production and viable count numbers. Hence application of neem cake in growth medium needs to be done cautiously.

- A new pest namely *Sylvanus* sp on young plants of oil palm was observed.

Sylvanus sp (Inset : Grub)

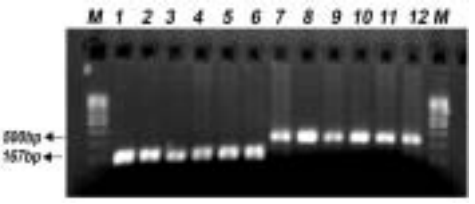
- Oil palm + Cocoa ecosystem enhanced spore number of *Trichoderma viride* compared to that of Coconut + Cocoa ecosystems due to the presence of more functional roots at lower depths.

- Mechanical stirring enhanced spore count in *Metarhizium anisopliae* when initiated at 3 days after inoculation compared to that of immediate stirring after inoculation.

- Identification of fungi associated with leaf spot disease of oil palm seedlings raised with imported sprouts from Thailand and Costa Rica at Mizoram revealed presence of *Curvularia* sp., *Colletotrichum gloeosporioides*, *Colletotrichum sp.*, and non sporulating isolate. No exotic pathogens were noticed.

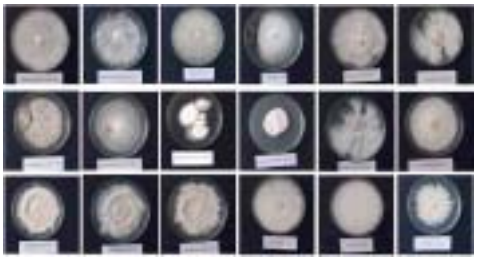
- A total of 168 samples from 12 SRD, 10 YLD and 12 RWD palms of various locations in Kerala and Tamil Nadu were collected for characterization of Phytoplasma and results indicated three diseases namely SRD of oil palm, YLD of arecanut, and RWD of coconut were caused by Phytoplasma. However, subsequent analysis of same DNA did not show clear band, but a smear during PCR amplification with A&Sf-A&Sr primers, which might be due to instability of Phytoplasma DNA.

- Detection of the presence of *Ganoderma* causing basal stem rot in oil palm is difficult at early stage. When the symptoms appear, palms are not in a stage to recover. A diagnostic methodology has been developed for detection of *Ganoderma* isolates by PCR.

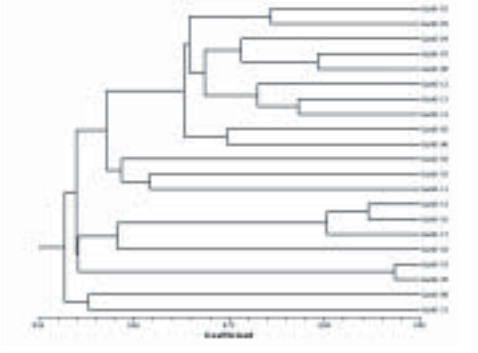


PCR detection *of Ganoderma* sp. using *Gan*1 & *Gan*2 and *Gan*ET & *Gan*ITS primers

- *Ganoderma* isolates causing BSR in oil palm were collected from oil palm plantations of different oil palm growing states. Based on colony morphology, isolates were grouped into five, where as RAPD analysis revealed six major clusters. Variability was also studied based on *in vitro* biomass degradation and laccase activity of the isolates. Sequencing of ITS region revealed that isolates are either *G.lucidum* or *G.applanatum*.



Colonies of *Ganoderma* isolates



Diversity among 21 *Ganoderma* isolates

Post Harvest Technology

- A mini palm oil mill of 1 MT / hr capacity was established and process parameters were standardized. The total cost of the mill was 30 lakhs.

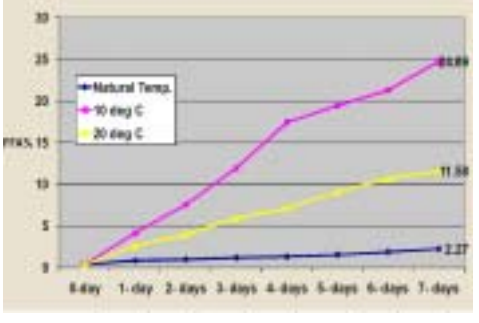
- Study taken up for estimating variation in OER in relation to season, age of palm as well as extent of mill oil loss indicated that maximum OER of 17.41% was obtained during July to December and the total mill oil loss varied from 1.59 to 5.88 % in young palms. In adult palms, maximum OER was 19.46 % and lowest OER was recorded during August. Total mill oil loss varied from 1.53 to 8.62 %. Highest oil loss during processing was through clarifier sludge (41 to 48 %) followed by EFB (33 to 35 %) and press cake fibre (12 to 21%).

- Studies conducted for developing grading system for oil palm FFB indicated that total chlorophyll and oil content were inversely related where as carotene content was directly correlated to oil content up to optimum ripeness stage. Image analysis revealed that there is strong correlation between stage of ripeness and color values. Correlation of red color with ripeness was maximum (R^2 = 0.97) indicating its suitability for distinguishing fruits of different ripeness.

- Studies on effect of low temperature on free fatty Acid (FFA) content of oil after harvesting of FFB indicated that increase was steady upto seven days and further increase was expected.

- Post harvest studies on crude palm oil indicated that oil extracted without sterilization had high amount of FFA in comparison to conventional methods.

- Though FFA content does not increase much when bunches are stored at higher temperature, low temperature storage of FFB drastically increases FFA in oil. This is possibly due to internal lipase; however, the study is continuing to know involvement of internal and/ or external lipase in increasing FFA after harvest.



Increase in FFA content due to low storage temperature

- A mechanized process was developed for making stripes used for preparing window shades from oil palm fronds.

Window shade

- Dehydrated Palm Oil Mill Effluent (POME) could be incorporated in diets of buffalo calves, lambs, kids (goats) and piglets up to 40 %, 60% , 50 % and 20 % respectively without any decrease in growth rate and milk production and a marked economic advantage over traditional systems. Dried Palm Oil Sludge (POS) can be included in diets of fresh water fish (Rohu) as well as ornamental fish (Koi- Carp) up to 60% and fresh water fish (Catla catla) upto 40% with increased body mass.

Utilization of POME

- Biogas production from POME slurry was comparable and even better than cow dung, a conventional medium used for biogas production.

- Composite formulation of essential microorganisms comprising *Saccharomyces*, *Lactobacilli* and *Rhodopseudomonas* improved quality of POME by reducing BOD and COD to eco-friendly level.

Social Sciences

- A total of 23 interventions were identified and implemented in the form of on farm trials and verification trials under Institute Village Linkage Programme for Technology Assessment and Refinement in coastal Agro-Ecosystem:

  Introduction of high yielding varieties of paddy in place of traditional varieties recorded high yields and reduced cost of cultivation. Use of balanced dose of fertilizers along with blue green algae and zinc sulfate reduced the excess use of Nitrogenous fertilizers and enhanced paddy yields. Adoption of recommended dose of fertilizers in Oil Palm increased FFB yields by 17-24 percent and reduced nutrient deficiencies.

  Application of Carbofuran @ 25 $kg.ha^{-1}$ in Paddy during early transplanting controlled gall midge, application of Propiconazole and Validomycin controlled sheath blight and formation of alleys of 20 cms at 2 m interval and spraying of chloropyriphos @ 2 $ml.l^{-1}$ at tillering stage controlled brown plant hopper. Use of Endosulfon @ 1.6 $ml.l^{-1}$ and Nuclear Polyhedrosis virus controlled tobacco caterpillar and increased yields by 20 per cent. Application of Ridomil and Calixin reduced incidence of Black shank and Fusarium wilt respectively in Tobacco. Application of Phorate granules @ 20 $g.palm^{-1}$ in the spindles and castor cake baiting and treating breeding sites with green muscardine fungus reduced incidence of Rhinoceros beetle in Oil Palm. Use of 0.2 % Carbendzim in crown region effectively controlled bud rot in Oil Palm. Maize shoot borer was effectively controlled by using Endosulfon and enhanced yields by 7-14 per cent. Spraying of Dithane M 45 @ 3 $g.l^{-1}$ at 30-35 days and 50-55 days after sowing and field sanitation reduced powdery mildew incidence in maize. Application of Chloropyriphos @ 2.5 $ml.l^{-1}$ twice and adopting sanitary measures controlled leaf eating caterpillar in green gram.

  Introduction of de-worming in cattle effectively reduced incidence of ecto and endo-parasites and improved animal health. Effective use of nutrient supplements in cattle improved animal health in the village. De-worming in sheep also resulted in improving the health and productivity of animals. Implementation of fresh water technology of Catla, Rohu and Mrigal (2:7:1) in community pond has increased net returns and in turn improved their livelihood.

- Feed back from trained officers revealed that training was beneficial and subject matter dealt was relevant. Officers are disseminating the technology through farm and home visits and

distributing literature during field visits/group discussions/training programmes. They indicated to have refresher courses on specific subject matter and these topics may be considered and included in future training programmes. Training need assessment may be done in advance to assess the requirement of various trainees / officials.

- Feed back from trained farmers indicated that marginal farmers having juvenile and adult plantations attended the training programmes to learn crop production practices for adopting recommended practices and get the higher yields. Technology has to be disseminated to small and big farmers. Majority of the farmers had attended training either at NRC for oil palm or at their own place, hence facilities may be created to have congenial environment.

Demonstration on FFB harvesting

Demonstration of planting oil palm

Demonstration on nursery management techniques

Farmers were categorized into low, medium and high skill gap category. Organisation of skill oriented training programmes to identified farmers is required. The frequency of visits by extension staff to farmers' plantations may be increased to disseminate the technology or to attend field problems. Though majority of farmers are in high knowledge category, they are of medium adoption category and this may be due to various constraints expressed by them. Hence these constraints need to be addressed for adoption of all recommended package of practices and get better yields. Refresher training courses need to be conducted on topics indicated by the farmers.

❖ Officers training programme

Name of the training	2005		2006		2007		2008		2009		2010	
	A	B	A	B	A	B	A	B	A	B	A	B
Oil Palm Production technology	3	35	2+1	26+28 =54	2	63	3+1	48+ 100	1	23	1	3
Oil Palm Hybrid Seed Production	-	-	1	7	1	9	1	10	1	7	-	-
Plant Protection in Oil Palm	-	-	2	20	1	16	1	9	1	8	-	-
Nursery Management in Oil Palm	1	5	1	4	1	6	-	-	2	14	-	-
Soil and Leaf Nutrient Analysis in Oil Palm	1	4	-	-	1	5	-	-	-	-	1	8
Oil Palm Cultivation	3	38	-	-	-	-	-	-	1	22	2	30
Orientation on Oil Palm Production Technology	-	-	-	-		-	-	-	2	3	2	4
Total	**8**	**82**	**6**	**57**	**6**	**99**	**5**	**67**	**8**	**78**	**6**	**42**

A. No. of training programmes conducted
B. No. of officers attended

❖ Farmers training programme

Name of the training	2005		2006		2007		2008		2009		2010	
	A	B	A	B	A	B	A	B	A	B	A	B
Oil Palm Cultivation at DOPR, Pedavegi	19	640	16	593	12	352	14	467	7	196	6	199
Oil palm cultivation at DOPR, RS,Palode	-	-	-	-	-	-	2	34	3	83	4	64
Oil palm Integrated Nutrient Management	6	234	-	-	-	-	-	-	-	-	-	-
Oil Palm Fresh Fruit Bunches harvesting	-	-	-	—	-	-	-	-	-	-	-	-
Oil palm Cultivation (On farm)	14	819	11	646	19	1325	8	627	9	471	-	-
Fresh Fruit Bunches harvesting (On farm)	9	496	-	-	-	-	-	-	-	-	-	-
Integrated Nutrient Management (On farm)	1	45	6	267	6	385	1	30	2	90	-	-
Plant Protection in Oil Palm (On farm)	-	-	-	-	7	445	3	260	2	139	-	-
Total	**49**	**2234**	**33**	**1506**	**44**	**2507**	**28**	**1418**	**23**	**979**	**10**	**263**

A. No. of training programmes conducted
B. No. of farmers attended

Farmers training

- Three different statistical models of Analysis of variance (ANOVA) based on individual palm wise observation, plot wise observation and plot wise observation averaged over years have been applied on existing experimental data to identify promising oil palm hybrids

- Stepwise multiple linear regression analysis was performed to understand the relationship of different morphological, physiological and stomatal characters with bunch index in eleven oil palm tenera hybrids belonging to four different sources namely ASD Costa Rica, Ivory Coast, Papua New Guinea and Palode and results revealed existence of genetic variations in bunch index among different sources. The bunch dry weight and leaf area led to higher bunch indices in all the sources.

Transfer of Technology activities

- 'Crop seminar on Oil palm' was organized by Doordarshan (in association with NRCOP) at NRCOP on June 21, 2008 which was telecasted 'live' on Doordarshan 'SAPTAGIRI' channel.
- Participated in 11 exhibitions organised at different locations in Andhra Pradesh, Bihar, Karnataka, Orissa and U. P. Provided exhibition material to 6 exhibitions at different location in Andhra Pradesh, Karnataka and New Delhi.
- A committee was constituted for identification of additional potential area in Orissa with Dr. P. Rethinam as Chairman. Dr. H.H.Khan, Sri. Chandrasekar Patro, Dr. Dilip Kumar Dash as Members and Dr. P.K. Mandal as Member Secretary. The Committee reassessed additional potential area and recommended 38,500 ha. in 13 districts of Orissa.
- Participated in phone in programmes on oil palm cultivation, recorded and live broadcasted through AIR-Vijayawada.
- Participated in Television programme recordings telecasted by Doordarshan and private T V channels.
- Queries from oil palm growers regarding cultivation practices received through letters and phone calls were attended and replied. Queries from Entrepreneurs/ development department on oil palm cultivation were also answered.
- Based on the request received from farmers / entrepreneurs / state department of agriculture / horticulture, regular visits to oil palm plantations are undertaken for diagnosing the problems faced by growers and suggesting suitable remedial measures.
- A total of 31 students exposure visits were conducted to 1193 students on Oil Palm at DOPR, Pedavegi. A total of 17 students exposure visits were conducted to 1195 students on Oil Palm at DOPR, Regional Station, Palode.

Brain storming on harvesting of oil palm

Awareness campaign on basal stem rot of oil palm

Diagnostic field visit to oil palm plantations

Participation in an exhibition organised at Lucknow

Publications/Technical Bulletins/Folders

- Compendium of lectures on Oil Palm production technology
- Compendium of lectures on Oil palm hybrid seed production
- Compendium of lectures on Plant protection in oil palm
- Compendium of lectures on Nursery management in oil palm
- "Oil palm Sagu" - Telugu language (Oil Palm cultivation – English)
- "Tala bila krishi" - Kannada language (Oil Palm cultivation – English)
- Pamphlet on "Management of basal stem rot in oil palm"
- Folder on "Oil palm cultivation" (English, Hindi and Telugu)
- Technical folder on "Importance of leaf nutrient analysis in oil palm and method of leaf sampling" (English & Telugu).
- Frequently Asked questions in oil palm
- Technology Assesmnet and refinement through Institution Village Linkage Programme.
- "The Golden Palm" a Digital Video Film on Oil Palm cultivation was brought out in English, Hindi, Gujarati, Malayalam, Mizo, Oriya, Tamil, Telugu and Kannda.

OIL PALM AT A GLANCE

Oil palm	:	Highest vegetable oil yielder per Unit area (3-6 t/ha)
Family	:	Palmae
Species	:	*Elaeis guineensis* (African Oil Palm) *Elaeis oleifera* (American Oil Palm)
Source of oil	:	Mesocarp : Palm oil ; Kernel : Kernel oil
Fruit forms (Variety)	:	*Dura* (Thick shell) *Pisifera* (Shell less) *Tenera* (Thin Shell)
Economic cropping period	:	25 - 30 years
Climatic requirements	:	Above 2000 mm distributed rain/irrigation Max. temp. 29 - 36°C Min. temp. 18 - 24°C Sunshine hours - 5 & above
No. of palms/ha	:	143 (9 x 9 x 9 m triangular)
Nursery period	:	12 - 18 months
Pollination	:	Insect (*Elaeidobius kamerunicus*)
Tree height	:	20 - 30 m
Leaf production/year	:	24 - 30
Leaf length	:	6 - 8 m
First harvest	:	36 months after planting
Yield of FFB/ha/y	:	15 - 30 t
No. of bunches/palm/year	:	5 - 12
No. of fruits/bunch	:	Above 2000
Av. bunch weight	:	25 kg.
Weight of fruit	:	30 g.
Fruit to bunch	:	42 - 65%
Mesocarp to fruit	:	60 - 83%
Oil to mesocarp	:	77 - 81%
Kernel to fruit	:	7 - 12%
Oil to kernel	:	49 - 52%
Shell to fruit	:	3 - 11 %
Palm oil yield/palm	:	Bunch weight/palm x fruit/bunch x mesocarp/fruit x oil/mesocarp

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