भाकृअनुप
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वार्षिक प्रतिवेदन
ANNUAL REPORT
2010-11

तेल ताड अनुसंधान निदेशालय
(भारतीय कृषि अनुसंधान परिषद)
पेदवेगी–534 450, प. गोदावरी जिला, आ.प्र.

Directorate of Oil Palm Research
(Indian Council of Agricultural Research)
Pedavegi-534 450, West Godavari Dt., A.P.

DIRECTORATE OF OIL PALM RESEARCH

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Preface

Oil palm, the crop introduced to India to meet the edible oil requirement in the country, has been widely accepted as the highest edible oil yielding crop. In India, oil palm is being grown as small holders' crop under irrigated conditions and farmers are realizing an yield of 20-25 tonnes fresh fruit bunches per ha per annum.

During the year, significant achievements were made at Directorate of Oil Palm Research in the implementation of research programmes in different disciplines. Concerted efforts were made for the development of high yielding oil palm hybrids with compact canopy, high oil quality and tolerant to biotic and abiotic stress. This Directorate has been identified as the National Active Germplasm Sites (NAGS) for collection, management and conservation of oil palm germplasm. At present, a total of 128 indigenous and exotic oil palm genetic stocks are available in its gene bank. Recently four palms have been selected based on their slow vertical growth in palm height. Crossing programme is being effected to develop a gene pool for slow growing character which is the need of the hour and will be a milestone in developing dwarf/ slow growing oil palm hybrids. At Palode Centre, a 12 year old Olifera palm recorded very low height of 2.30 metres. To enable molecular characterization of oil palm germplasm, a time and cost saving method has been developed for DNA extraction from oil palm leaves.

Studies on nutrient dynamics in oil palm under different fertilizer levels has been initiated during the year to evolve technologies for achieving better nutrient use efficiency levels. Palm Oil Mill Effluent (POME), a bio-waste obtained from palm oil mill, is found to be a potential source of bio-fuel and the digested slurry, which is safe for soil application could reduce the nutrient and water requirement of oil palm plantations. Efforts are being made to mechanise the process of harvesting oil palm bunches from tall palms in the form of an inter-institutional collaboration with CIAE, Bhopal. During the recent past, intensive efforts were taken to strengthen the infrastructural facilities available at the Institute for conducting experiments in a better manner with the generous additional funding from ICAR.

The "National Consultative Meeting on Oil Palm" conducted at ICAR, New Delhi under the Chairmanship of Dr. S. Ayyappan, Director General, ICAR and the guidance of Dr. H. P. Singh, Deputy Director General (Hort.), ICAR paved way for launching a special programme of "Oil Palm Area Expansion" (OPAE) under "Rashtriya Krishi Vikas Yojana" (RKVY) by Government of India with a budget of Rs.300 crores during 2011-12 for which technical backdropping is provided by DOPR. Identification of additional potential areas for oil palm cultivation in the country, finalizing a price fixation formula for oil palm fresh fruit bunches, estimation of cost of cultivation of oil palm are some of the important developmental tasks assigned to this Directorate during 2010-11.

I have immense pleasure to present the 14th Annual Report of the Institute for the year 2010-11. The report covers research activities taken up at this Directorate under 35 Institute funded projects and five externally funded projects.

I sincerely thank Dr.H.P.Singh, Deputy Director General (Horticulture), ICAR for his keen interest, guidance and encouragement in the oil palm research programmes taken up at this Institute. I also would like to acknowledge the dedicated efforts of Scientists and staff of DOPR in developing a holistic approach towards oil palm research and development in the country. Efforts taken by Dr. K. Suresh and Ms. A. Bhanu Sri in bringing out this Annual report appreciably in time are gratefully acknowledged.

(Dr. S. Arulraj)
Director

कार्यकारी सारांश

फसल सुधार

तेल ताड़ जनन द्रव्यों का संग्रहण और लक्ष्य वर्णन

- येनी, तमिलनाडु (मलेशिया श्रोत) एवं ओ.पी.आई.एल, केरल (नाईफर, जाईर एवं आई.आर.एच.ओ. श्रोत) के बागानों में छांटे गये ड्यूरा और बौना पिसिफेरा ताड़ों पर प्रेक्षण दर्ज किये गये।
- आफ्रिकन तथा अन्य विदेशी संग्रहणों का लक्षण वर्णन का कार्य जारी है। जैसे कि मध्यफल भित्ति की मात्रा, फलों का रंग, फल का आकार, गुच्छों का आकार इत्यादी। तेल ताड़ की उत्पादकता जानने के लिए गुच्छा विश्लेषण का कार्य जारी है।
- चयनित ड्यूरा, पिसिफेरा इत्यादि ताड़ों का संकरण कार्यक्रम, पालोड ड्यूरा का विकास, जनसंख्या विकास इत्यादि में उपयोग किया जा रहा है।
- जननद्रव्यों के संग्रहण का नया एक्सेसन रजिस्टर तैयार किया गया है। तेल ताड़ जनन द्रव्यों के मूल्यांकन के लिए न्यूनतम विवरण (Descriptor) तैयार किया गया है।
- पालोड़ स्थित 651 ताड़ों का 1995-2005 तक अवधि के गुच्छों की उपज का डाटा इकरण किया गया एवं उनमें अन्तर प्रकार्य विश्लेशण किया गया।

तेल ताड़ के संकरों का उत्पादन, मूल्यांकन और सुधार

- पासीघाट (अरुणाचल प्रदेश) और माधोपुर (बिहार) स्थित ए.आई.सी.आर.पी. केन्द्रों को क्षेत्र विशिष्ट मूल्यांकन के लिए दस उच्च कोटि के ड्यूरा x पिसिफेरा संकरों के प्राथमिक नर्सरी के पौधों को भेजा गया।

  भारत स्थित ए.आई.सी.आर.पी. के छट केन्द्रों में मूल्यांकन के लिए दस ड्यूरा x पिसिफेरा संकरों के अंकुरों को भेजा गया।
- पेदवेगी में कुल 82 मातृ ताड़ों (46 पालोड़ एवं 36 कोस्टारिका क्षेत्रों से) का चयन किया गया है, उन्हें तेल ताड़ सुधार एवं विकास के प्रजनन कार्यों और वाणिज्यक स्तर पर संकर बीजों के उत्पादन में उपयोग किया जा रहा है।
- पालोड़ जीन बैंक में स्थित ऑलिफेरा जननद्रव्यों पर बाहरी बनावट एवं उपज के लक्षणों का आकलन किया गया। कोस्टारिका श्रोतों की ऊँचाई मलेशिया श्रोत से कम पायी गयी।
- पालोड़ में इन्टर स्पोशिफिक संकरों के मूल्यांकन में तीन बौने तथा प्रोमिसिंग ताड़ - ताड़ संख्या 47(361 Eg x 11Eo), 48(16 Eo x 18 Eg) एवं ताड़ संख्या 6(12 Eo x 82 Eg) पाये गये जिन्हें बैक क्रासिंग कार्यक्रम में उपयोग किये जा सकते हैं।

देशीय बीज उत्पादन बढाने के लिए बीज बागानों को मज़बूत करना

- वर्ष 2009-10 में 27.9 लाख अंकुरों के वितरण का लक्ष्य था जबकि कुल 9.28 लाख अंकुरों का विरतण ही किया जा सका। इस कम वितरण का मुख्य कारण ताड़ तेल उद्यमियों द्वारा माँग में कमी रहा। पालोड़ बीज बागान से 1.99 लाख एवं पेदवेगी से 0.48 लाख अंकुरों को बेचा गया।
- पेदवेगी स्थित पाँच ड्यूरा जीनोटाइप्स में गुच्छा सूचिका पालोड़ के जीनोटाइप्स में सर्वाधिक दर्ज की गयी।
- पालोड़ में कुल ओलिफेरी के 33 ताड़ एवं करी लेण्ड, कोर्रायम में 300 ताड़ो का आगे के मूल्यांकन के लिए लगाया गया।

- डी x पी. संकरों में बीज के आकार के आधार पर अंकुरण के अध्ययन के लिए आफ्रिकन जननद्रव्यों में 22 एवं ड्यूरा-II ब्लांक में 50, डी x पी. संकरों का चयन किया गया।
- पालोड़ में बीज भण्डारण पर कार्य प्रगति पर है।

तेल ताड़ में जन-तनाव सहिष्णुता पर अध्ययन

- आफ्रिका के चार देशों (जाम्बिया, तनजानिया, केमरुन एवं गुवाना बिसु) के संग्रहित जननद्रव्यों का भारत में सात स्थानों पर जल-तनाव सहिष्णुता और जल-उपयोग-क्षमता पर मूल्यांकन किया जा रहा है।
- सिंचित एवं तनाव वातावरणों में जाम्बिया और श्रवाना बिसु श्रोतों में गुच्छा सूचिका अधिकतम दर्ज की गयी, यह तनजानिया श्रोत में न्यूनतम पाया गयी।
- पाँच आफ्रिकन एवं एक पालोड़ अभिवृद्धियों के कुल 18 ताडों में वसीय आम्लों पर अध्ययन किया गया।

फल एवं बीज विकास पर अध्ययन

- फल के वृद्धि के विभिन्न स्तरों पर लिये गये नमूनों से यह ज्ञात हुआ कि मध्यफल भित्ति में तेल का संश्लेषण फूलों के खिलने के दिन से 65 दिन बाद शुरु होता है कि जो कि 113 दिनों तक बढता हुआ और 135 दिन बाद उच्चतम स्तर पर दर्ज किया गया।

तेल ताड़ जनन द्रव्यों का आणविक निरूपण

- आफ्रिकन जननद्रव्यों (23 गुवाना बिसु, 23 जाम्बिया, 23 केमरून एवं 21 तनजानियाँ) में एस.एस.आर. मार्कर के द्वारा जननिक विभिन्नता पर अध्ययन शुरु किया गया है। कुल रचित ११९ जोड़े प्राइमरों में से 119 जोड़े तेल ताड़ के लिए कार्यात्मक पायो गये।
- आर्धिक उपज वाले ड्यूरा ताडों में आर.ए.पी.डी. विश्लेषण 14 यादृच्छिक एवं 2 एस.एस.आर. मार्करों के उपयोग सम्पूर्ण कर लिया गया है।
- तेल ताड़ में डी.एन.ए. निष्कर्षण के लिए तैयार संशोधित प्रोटोकाल को नारियल एवं सुपारी के लिए भी काम में लिया गया।
- ड्यूरा, पिसिफेरा एवं टेनेरा के विस्तृत नमूनों को 20 जोड़े एस.एस.आर. प्राइमरों के द्वारा व्याख्या की गयी जिसमें से 7 जोड़ो ने विभिन्नताएँ दर्शायी।
- उत्तम संवर्धन के अध्ययन में तेल ताड़ में पहली बार प्लम्यूल के ऊतकों से भूणोत्पत्ति प्राप्त की गयी।
- किसान के खेत पर लगाये 2 टोरनाडो क्लोनल ताड़ों में से यादृच्छिक रूप से लिये गये 20 ताड़ो पर रूपात्मक अवलोकन में ताड़ की ऊँचाई, गरदनी घेरा एवं पत्तियों की संख्या में काफी अन्तर पाया गया।

फसल उत्पादन

तेल ताड़ में जल एवं पोषक तत्वों का प्रबन्धन

- जिन ताड़ों को जेट एवं बून्द-बून्द पद्धति से सिंचित किया गया या उनमें गैसीष आदान-प्रदान का रेट एवं Fr/Fm अनुपात थला पद्धति से सिंचिंत ताड़ों की अपेक्षा आर्धिक दर्ज किया गया। बून्द-बून्द पद्धति द्वारा सिंचित ताड़ों में जल-उपयोग क्षमता एवं गुच्छ उत्पादकता सर्वाधिक दर्ज की गयी। वर्तमान उत्पादन स्तर-15 रन/हे. के लिए कृत्रिम खाद उपचार 900-450-900 ग्राम एन.पी.के. प्रति ताड़ प्रति वर्ष सर्वोत्तम पाया गया।
- पुनः रोपण तकनीकों पर ओ.पी.आई.एल. के भारतीपुरम बागानों पर अनुसंधान कार्य शुरु किया गया है।

तेल ताड़ प्रबन्धन में पी.ओ.एम.इ. के द्वारा तैयार बायोगैस गारा का उपयोग

- पी.ओ.एम.ई का उपयोग करते हुए उससे निकले सह-उत्पाद - बायोगैस उत्पादन एवं गारा की उपयोगिता पर क्षेत्रीय केन्द्र पालोड़ में 6 m^3 क्षमता का जैव गैस प्लान्ट लगाया गया है।

केरल में करी लेण्ड पर तेल ताड़ का उत्पादन

- कीर लेण्ड पर लगाये गये तेल ताड़ की उत्पादकता उसके प्रबन्धन एवं रख रखाव पर काफी हद तक निर्भर पायी गयी। बहुत अच्छों रख-रखाव रखने पर तेल ताड़ की उत्पादकता 20 टन/हे. तक दर्जकी गयी। इससे यह निष्कर्ष निकला कि तेल ताड़ को करी लेण्ड पर अच्छे जल एवं मृदा प्रबन्धन की क्रियाए से सफलतापूर्वक लगाया जा सकता है।

विरेशेन्स एवं निग्रेशेन्स गुच्छों में तेल में स्वतंत्र वसीय अम्लों पर अध्ययन

- उपरोक्त विषय पर अनुसंधान कार्य शुरु किया गया है। इसमें कुछ गुच्छों का विश्लेषण किया गया जिसमें यह ज्ञात हुआ कि स्वतंत्र वसीय अम्लों कोई गुणात्मक अन्तर नहीं पाया गया।

तेल ताड़ में पत्ती छंटाई पर कार्य

- उन ताडों जिनमें किसी भी तरह की कटाई नहीं की गयी, में सर्वाधिक उत्पादन दर्ज किया गया। इससे कम उपज गिरते हुए स्तर पर 25 एवं 33 पत्तियों के उपचार में दर्ज की गयी। इन ताडों में विकिरण उपयोग क्षमता भी सर्वाधिक पायी गयी।

तेल ताड़ में सिंक परिचालन (कली हटाना) पर अध्ययन

- जिन ताड़ों में कलियों को नहीं हटाया गया था उनमें गुच्छों का उत्पादन एवं विकिरण - उपयोग क्षमता सर्वाधिक दर्ज की गयी जो कि कलियों को हटाने की आधिक्यता के साथ हटते हुए दर्ज किये गये।

तेल ताड़ बागानों में पत्तियों की टूटन पर अध्ययन

- सूरवा संवेदी सूचिका पालोड़ संकरों के सबसे कम दर्ज की गयी जिससे यह विदित हुआ कि पोलोड़ संकरों में सुखा सहन करने की क्षमता अधिक है। G x E प्रयोग में चौथे चक्कर में पत्तियों की टूटन सर्वाधिक देखी गयी।

तेल ताड़ में पौधों के रस की जाँच पडताल के द्वारा पर्यावरण की निगरानी

- ताड़ों की नौंवी एवं सत्तरहवीं पत्तियों में सुबह में रस का प्रवाह लगभग शून्य था। यह दोपहर तक सर्वोच्च 45 सेमी/घण्टा तक दर्ज किया गया। सर्वोच्च रस प्रवाह 25 वीं पत्ती में 17 वी. पत्ती की अपेक्षा कम था। तने में अधिकतम रस प्रवाह 8 स्मी/घण्टा दर्ज किया गया। इससे यह निष्कर्ष निकला कि तरुण पत्तियों में रस प्रवाह अधिक रहता है।

तेल ताड़ में कार्बन पृथक्करण क्षमता पर अध्ययन

- तेल ताड़ सकरों में 21.0 से 38.1 टन कार्बन/हे. तक पृथक्करण क्षमता पायी गयी। अधिकतम एवं न्यूनतम क्षमताएँ क्रमशः पफुआ न्यु गुवाना एवं आइवरी कोस्ट के संकरों में दर्ज की गयी।

उपज वाले तेल ताड़ बागानों में अन्तःशष्य अध्ययन

- लाल अदरक और हेलिकोनिया फसलों का व्यवसायिक स्तर के नोक उत्पादन 14,400 और 30,000 प्रति हे. प्रति वर्ष तक दर्ज किया गया। बुश पेपर की सालाना उपज (ताजा भार) 350 किलो/हे. रिकार्ड की गयी। बागान में औसत प्रकाश की तीव्रता 23% पायी गयी। कोको को त्रिभुजाकार में लगाने से उसे प्रकाश भी अच्छा मिलता है और उत्पादन भी काफी मिलता है। तेल ताड़ में कोको की उपज 250 ग्रा. से 1,500 ग्रा/ पौधा/वर्ष पायी गयी जबकि नारियल में कोको की उपज 0.5-2.7 किलो दर्ज की गयी।

मिक्षित खेती पर अध्ययन

- संकर नेपियर और गुवाना घास को अन्तःशष्य पद्धति में भैसों के चारे के लिए लगाया गया है। इस तंत्र में दो मछली की जातियाँ (कोई कार्य और पन्गास) और दो मुर्रा भैसों भी शामिल की गयी। मिश्रित खेती में लियो गये विभिन्न अंगों पर अध्ययन जारी है।

तेल ताड़ के पौधों पर जैव खादों का प्रभाव

- जैविक खाद एवं रसायनिक खादों के संयोगों में एकल खाद उपचारों की अपेक्षा आर्धिक वृद्धि एवं शक्ति दर्ज की गयी। सबसे ज्यादा पौधे की ऊँचाई, पत्तियों की संरक्षा और तना का घेरा उपचार 25 प्रतिशत आर.डी.एफ. + जैव खाद में दर्ज किये गये।

फसल संरक्षण

- आंध्र प्रदेश, कर्नाटक एवं गुजरात में किये गये रोविंग सर्वेक्षण में साइकिड्स, स्लाग केटरपिलर, पत्ती में जाला बनाने वाला कीड़ा, एक्रिया एस.पी., कौओं, मेना और चूहों के हानिकारक प्रभाव अधिक पाये गये।
- एक नया नाशी कीड़ा - *सिलवेनस* एस.पी. (सिलवेनिडी फेमिली) पाया गया है जो कि 4-5 साल के तेल ताड़ो की पत्तियों को खाता है।
- साइकिड्स पर ली गयी जैविक क्षमता आध्ययन में तने में मोनोक्रोटोफास को सेलाईन पाउच के जरिये डालने के तरीके का कीड़े के नियन्त्रण पर अच्छा असर पाया गया। जिन उपचारों में छिडकाव का तरीका अपनाया गया, उनमें एक नया कीटनाशक फ्लूबेन्डायमाइट में कीड़े का असर कम पाया। थिमेर के दोनों को मिट्टी में डालने से भी कीट नियन्त्रण में काफी सफलता मिली।
- चूहे के नियन्त्रण में केले की पत्तियों एवं ग्लोवस में जिंक फासफाईड को देना फायदेमन्द पाया गया।
- आन्ध्र प्रदेश के पश्चिमी गोदावरी जिले में किये गये सर्वेक्षण में कली सड़न, नारंगी चित्तका, गुच्छा सड़न, गुच्छा अंत सड़न एवं तने की गीली सड़न नामक बीमारियाँ पायी गयी।
- क्लोनली उत्पादित ताडों में वृद्धि में रुकावट देखी गयी। जिसका फाइटोप्लाज्मा हो सकता है।

कटाई-उपरान्त प्रौद्योगिकी

- कोस्टारिका संकरों में तेल निष्कर्षण दर 15.28 से 17.7 प्रतिशत के बीच दर्ज की गयी। औसतन कारखाने में तेल का नुकसान प्रौढ ताड़ों में 5.44 प्रतिशत एवं तरुण ताड़ों में 8.46 प्रतिशत पाया गया।
- तेल ताड़ में गुच्छों की वर्गीकरण (जैसे अपरिपक्व, परिपक्व, कम परिपक्व, ज्यादा परिपक्व इत्यादी) प्रणाली को विकसित करने के उद्देश्य से विभिन्न प्रकार के गुच्छों का मानकों जैसे - नमी की प्रतिशतता, करोटीन की मात्रा, रंग की मात्रा इत्यादि का अध्ययन किया गया। इस प्रकार का अध्ययन निग्रेशेन्स एवं विरेशेन्स गुच्छों पर भी किया गया।
- कमरे के सामान्य तापमान पर ताजा फलों के गुच्छों के भण्डारण पर अध्ययन किया गया। इसमें यह पाया गया कि सात दिन के भण्डारण के बाद ज्यादा पके हुए गुच्छों में जल का नुकसान सामान्य रुप से पके हुए फलों की अपेक्षा में अधिक पाया गया।
- फलों के बिना बन्ध्याकरण के तेल निकालने पर विमुक्त वसीय अम्लों की मात्रा अधिक दर्ज की गयी जबकि भण्डारण की अवधि के साथ इसके स्तर पर कोई ज्यादा प्रभाव देखने को नहीं मिला। इस पर आगे कार्य जारी है।

प्रौद्योगिकी हस्तान्तरण

- तेल ताड़ डेटाबेस प्रबन्धन में 15 अधिक उपज वाले तेल ताड़ उत्पादकों पर डाटा इकट्ठे किये गये। तेल ताड़ की खेती में किसानों की जरूरत के मुताबिक अनुसंधान करने लायक जरूरतों को जानने के लिए 18 तेल ताड़ उत्पादकों से डाटा एकत्रित किये गये।
- प्रतिवेदन अवधि में तेल ताड़ उत्पादन प्रौद्योगिकी पर 23 अधिकारी, तेल ताड़ संकर बीजों का उत्पादन पर 7 अधिकारी, तेल ताड़ की पौधशाला प्रबन्धन पर 7 अधिकारी, तेल ताड़ पादप संरक्षण पर 8 अधिकारी, मृदा एवं

2. EXECUTIVE SUMMARY

National Research Centre for Oil Palm was established at Pedavegi in West Godavari district of Andhra Pradesh on February 19, 1995 to conduct research on oil palm under irrigated conditions. The institute has a Research Centre at Palode in Kerala state. During XI plan, NRCOP was upgraded as Directorate of Oil Palm Research (DOPR) with the transfer of six AICRP (Oil Palm) centres to evolve location specific technologies for oil palm. DOPR conducts and coordinates research on all aspects of oil palm germplasm conservation, improvement, production, protection, post harvest technology and transfer of technology.

Mandate of the institute is 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 and to collaborate with national and international agencies for achieving the mandate.

The institute has a sanctioned staff strength of 82, including one Director, 22 scientists, 18 technical, 15 administration and 26 skilled support staff, of which 69 are in position. Total budget allocation for the institute for 2010-11 was ₹ 751.00 lakhs and the expenditure was ₹ 674.56 lakhs with a revenue generation of ₹ 25.33 lakhs.

The institute has 36 ongoing institute funded research projects and 5 externally funded project. DOPR was identified as one of the National Active Germpalsm Sites (NAGS) and involved in Plant Genetic Resources (PGR) activities including oil palm germplasm collection, management, conservation and use. DOPR has a total of 128 indigenous and exotic oil palm genetic stocks, 62 at Palode and 66 at Pedavegi.

The research activities at the Directorate during 2010-11 are summarized below:

GENETIC RESOURCE MANAGEMENT

Survey and selection of oil palm germplasm programme resulted in identification of 14 *dura*, 6 *pisifera* and 9 *tenera* palms in Yeroor and Kulathupuzha estates of OPIL, Kerala. In Karnataka, two palms (one *tenera* and one *dura*) were identified in oil palm plantation (mutants of BARC) of ARS, Bhadra Reserve forest (BRP) with comparatively less canopy spread. In Andhra Pradesh, 36 palms (13 PNG, 20 Costa Rica and 3 Ivory Coast) have been identified.

Accessions collected from Little Andaman had high specific leaf weight (SLW), a trait for drought tolerance. Promising selections for high yield could be made in accessions numbered LA-2, LA-4 and CD-471 (open) populations.

Four slow growing palms have been identified in Zambian accessions. Elite palms identified in African germplasm have been utilized in developing pre-breeding populations and diversification of Palode source. In the selfed progeny of dwarf *tenera*, segregation ratio of 13 *dura*: 30 *tenera*: 3 *pisifera* has been recorded. *Dura* palm with high yield of 205 kg has been identified which could be utilized in breeding programme.

Fatty acid composition was different in *E.oleifera* kernel oil than that of *E.guineensis*. In *E.oleifera*, lauric acid content was found highest among the fatty acids followed by oleic acid.

Tanzanian accessions were the highest yielder under both irrigated and stress conditions followed by Zambian accessions. Highest oil percentage was observed in Zambian accessions ZS-2 and ZS-5 followed by Cameroon accession CA-12.

Screening of DxP crosses for drought tolerance in nursery through measurement of membrane stability indices (MSI) indicated that highest MSI was recorded in 34CD X 110P closely followed by 124CD X 17P and 66CD X 129P, indicating their better tolerance to drought.

Studies conducted on gas-exchange characteristics, leaf water potential and chlorophyll *a* fluorescence in oil palm seedlings under water stress and recovery indicated that oil palm seedlings tolerated water stress by regulating stomatal conductance, which in turn helped in maintaining positive values of photosynthetic rates with reduced stomatal opening along with lower leafw ater potential.

Spraying of 150 ppm GA on bunches of oil palm was found to improve bunch weight and oil content in oil palm. GA did not have any effect on mesocarp oil/fruit, kernel oil/fruit, oil/wet mesocarp and mesocarp/fruit.

Evaluation of interspecific hybrids at Palode resulted in identification of three promising dwarf palms *viz*., 47(361*Eg* × 11*Eo*), 48(16*Eo* ×18*Eg*), 6(12*Eo*× 82*Eg*) and 45(Surinam origin) which can be used for back crossing programme.

During 2010-11 59,980 oil palm sprouts were distributed to different entrepreneurs from DOPR, Pedavegi and 1.35 lakhs from DOPR, RC Palode.

Studies on germination behaviour of African germplasm revealed that **s**eed weight was positively correlated with shell thickness and kernel weight and definite relationship was not observed between seed weight and percent germination.

Seeds stored in aluminum foil showed higher germination compared to those stored in plastic box, polythene cover and open storage.

Studies on seed germination behavior with reference to seed size indicated that proportion of large and medium size categories was high in all oil palm cross combinations. Highest average germination was recorded in D62x66 followed by D76x66. Shell thickness was highest in D39x435 combination and highest kernel weight was recorded in D36x435.

Highest FFB yield was recorded in Ivory Coast hybrids followed by Palode and lowest yield was recorded in ASD Costa Rica hybrids. Bunch index was highest in Ivory Coast material followed by ASD Costa Rica and lowest in PNG.

Genetic diversity analysis of 40 high yielding *dura* palms based on 19 selected random primers differentiated Eg 136 from rest of the palms. Based on Metroglyph and index score analysis, all palms were grouped into 9 clusters based on low, medium and high value of palm height and rachis length.

Genetic diversity analysis of African germplasm using SSR markers revealed that two random primers OPM-06 and OPP-08 could amplify a unique fragment specific to *E.oleifera*. Similarly, three SSR primers could distinguish *E.oleifera* from *E.guineensis*. *Eg* and *Eo* specific bands were amplified by SSR-44 primers, *Eg* specific band was amplified by SSR-132 and *Eo* specific band could be amplified by SSR-204.

Direct embryogenesis was obtained with cotyledonary node tissues of several hybrids.

PRODUCTION AND PROCESSING SYSTEM MANAGEMENT

For every 100 litres of POME fed to the gasification plant at DOPR, RC, Palode 1.4 m^3 of biogas was produced.

Studies conducted by manipulating source and sink revealed that highest FFB yield was obtained when fronds were pruned from 25th onwards followed by 33rd frond and 17th frond.

A faster indirect method of measuring LAI in oil palm has been developed for oil palm.

Destructive analysis of adult oil palms to analyze biomass and carbon distribution among different plant parts indicated that carbon content in oil palm trunks, fronds and roots ranged from 192-327 kg, 402-627 kg and 20.6-28 kg respectively.

Drought susceptibility index studies indicated that palms from Palode population recorded lower index indicating their better tolerance to drought. Chlorophyll stability index was high in palms with lowest drought susceptibility index and this index could be used as marker for palms affected with leaf breaking symptoms.

The two fruit types of oil palm, *virescens* and *nigrescens,* were not significantly different in terms of bunch components as well as FFA and fatty acid composition. However, average fruit weight was significantly higher in case of *virescens*.

Intercropping experiment revealed that more FFB yield/palm/year was recorded in inter cropped area compared to that of control. Interaction between inter crops and oil palm has been found synergistic compared to mono cropping.

In an experiment conducted to study the effect of POME sludge on growth and vigour of oil palm seedlings, better results were noticed with soil+POME (4:1) for characters like seedling height, stem girth and number of leaves/seedling.

Biochemical and colour parameters in *virescens* and *nigrescens* type bunches of oil palm varied significantly with ripeness stage.

Prediction models for loose fruit samples for oil to dry mesocarp and oil to wet mesocarp were worked out.

When harvested bunches are stored for one week under room temperature, moisture loss was high during April to June due to high temperature and during November, which could be due to low RH than temperature.

Rhizopus stolonifer, Aspergillus niger, Penicillium sp, *Aspergillius flavus, Curvularia* sp, *Glomerella* sp, *Fusarium* sp *and Cladosporium* sp were observed during 2nd week after sterilization of bunches. After 1st and 2nd week of sterilization, fruits were having *Neurospora* sp growth.

PLANT HEALTH MANAGEMENT

Leaf web worm, *Acria* sp.was found to be parasitized by both larval and pupal parasitoids and the pest was also found to be infected by entomopathogens. However, their identity is yet to be ascertained.

Rhinoceros beetle was found to cause more damage to coconut rather than oil palm because of its preferential high lignin content present in coconut leaf silhouette compared to oil palm leaf petiole.

Stem injection of insecticides using saline pouches was found effective and easy for controlling lepidopterous pests of oil palm like psychids and leaf web worms and proved safe for pollinating weevils. Soil application of phorate granules @ 100 g/palm was effective in bringing down the population of leaf web worm to 87.1 % over control.

In an experiment conducted to scare or repel avian pests, CDs having yellow and red images hung on ripening fruit bunches scarred the birds effectively while egg emulsion (1 egg/5 l water) sprayed on fruit bunches did not have any appreciable effect in controlling the pests.

Mixing of growing media with powdered form of bioagents was effective in enhancing the growth and yield of Azolla compared to broth material. Of different bioagents, *Metarhizium anisopliae* was found to record more growth compared to *Trichoderma viride*.

Pollinating weevil activity was maximum during 9-12 AM. Weevils either abandoned the gardens or activity was minimal when insecticides like monocrotophos were sprayed. Flubendiamide was found safe against pollinating weevils.

Five bacterial isolates each from bud rot and stem wet rot affected palms were isolated and pathogenic studies in *in vitro* and *in vivo* are under progress.

Fifteen native *Trichoderma* isolates were collected and subjected to RAPD analysis for their genetic variability and results showed that all 15 isolates were genetically different.

SOCIAL SCIENCES

Survey conducted by DOPR for "Estimation of cost of cultivation of oil palm" revealed that cost of cultivation of oil palm was ₹ 125186/- ha and cost of production of one tonne of FFB was ₹ 6319/-, when annual cost of cultivation of oil palm alone was considered. During yield stabilizing period (4 to 8 years), cost of production of one tonne of FFB was ₹ 9280, with a cost of cultivation of ₹ 114892/ha without considering annuity value and expenditure towards infrastructural facilities.

District-wise information was collected from state departments on planting area and production of FFB in Andhra Pradesh, Andaman and Nicobar Islands, Goa and Kerala. Increase in FFB production under irrigated conditions was rapid from year 1998-99 onwards, as seen in various entrepreneur zones of oil palm in Andhra Pradesh, Karnataka and Goa.

Significant correlation between manure application, fertilizer applied in number of splits, application of magnesium and yield was observed. It was observed that most of the farmers are following basin method of irrigation with a frequency of 7-10 days.

Data relating to fresh fruit bunch (FFB) of 1482 farmers having 1704 oil palm plantations under Foods Fats and Fertilizers (FFF) Ltd., Andhra Pradesh was validated. Oil palm area expansion in FFF zone showed an increasing trend from the year 1990-91 and production of FFB showed a steady increase from 1998-99. It was observed that most of the plantations were in the age group of 3 to 5 years (57 percent) followed by age group of 6 to 10 years (28 percent). Fifteen percent of plantations were in the age group of 11 to 18 years.

Tables were developed in MS Access database for storing data on oil palm cultivation. Queries were classified into various categories like crop production, nutrient management, pest management, disease management, harvesting etc.

Modules developed for seed garden block, parent palm selection and hybridization process were integrated. Prototype of the screens to be developed for pest and disease symptoms/ control, sprout production and indenting information was prepared.

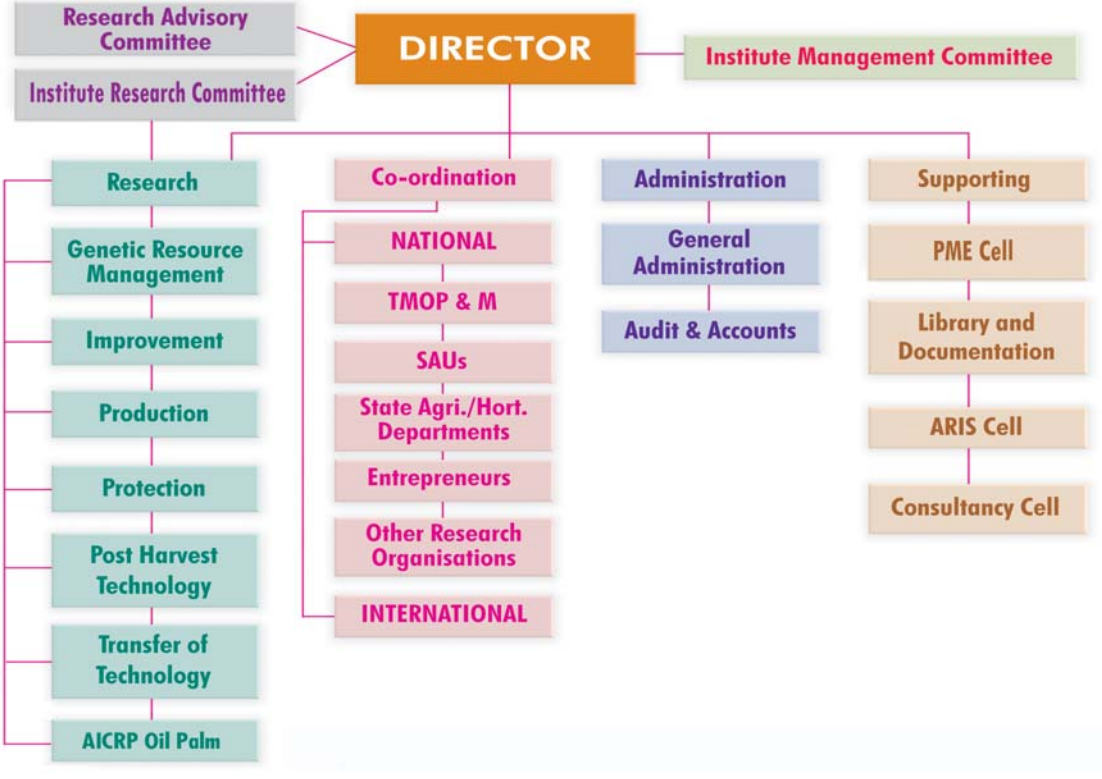
3. INTRODUCTION

To strengthen the research on all aspects of oil palm under irrigated conditions, Indian Council of Agricultural Research established the National Research Centre for Oil Palm at Pedavegi, Andhra Pradesh on February 19, 1995. The Centre, over an area of 100 ha is 13 km away from Eluru, which is the district headquarters of West Godavari. Later during April 1999, the CPCRI, Research Centre at Palode was merged with NRC for Oil Palm. Research Centre at Palode is 35 km away from Thiruvananthapuram in Kerala state. During XI plan, NRCOP was upgraded as Directorate of Oil Palm Research (DOPR) with the transfer of six AICRP (Oil Palm) centres to evolve location specific technologies for oil palm. Since 1995, systematic efforts are being made at this Institute to cater to the needs of oil palm community and to increase the production and productivity of the crop by evolving production technology under rainfed and irrigated conditions. The Institute is conducting and coordinating research on all aspects of oil palm germplasm conservation, improvement, production, protection, post harvest technology and transfer of technology.

3.1 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 for achieving the mandate

3.2 Organisational setup



3.3 Financial outlay

(₹ in lakh)

S.No.	Head	Allocation (as per RE)	Expenditure
1	Non-Plan	482.00	416.87
2	Plan	225.00	225.00
3	Pension and retirement benefits	40.00	32.45
4	P Loans and advances	4.00	0.24

3.4 Externally funded projects

(₹)

Sl. No.	Name of the scheme/ project	Opening balance as on 01.4.2010	Receipts during 2010-11	Total	Expenditure during 2010-11	Closing balance as on 31.3.2011
1	Multilocation Evaluation of oil palm germplasm	-100772	1474000	1373228	981311	391917
2	Strengthening of Training on oil palm production	-133122	653500	520378	597849	-77471
3	Establishment of Leaf analysis lab	345464	653500	998964	245805	753159
4	Strengthening of Seed gardens	1536371	570000	2106371	1407478	698893
5	Establishment of Tissue culture lab	1125313	0	1125313	1038783	86530

3.5 Resource Generation

During the year, an amount of ₹ 25.33 lakhs has been generated as revenue under the following heads:

(₹ in lakh)

Head	Amount generated
Sale of farm produce	23.59
Sale of publications	0.13
License fee	1.61
Total	25.33

3.6 Staff position

Sl. No.	Grade	Sanctioned	Filled	Vacant
1	RMP	01	01	—
2	Scientific	22	16	06
3	Technical	18	18	—
4	Administration	15	11	04
5	Supporting	26	23	03
	T o t a l	82	69	13

Library: During the year, 174 reference books worth of ₹ 3,52,000/- have been purchased. Subscribed 21 national journals worth of ₹ 31,500/- and 16 International journals worth of ₹ 5,12,600/- for scientific reference.

Website: The institute website was upgraded as per ICAR guidelines. Information regarding location map, organizational setup, cadre strength, AICRP, collaboration, awards, patents, databases / software, advisory training services, information pertaining to farmers and entrepreneurs, downloads of annual reports and newsletters were incorporated in the process of upgradation. Information pertaining to other related sub heads was also updated. The Website ID is : http://dopr.gov.in.

Crop Improvement

Slow growing *dura* at Pedavegi

CROP IMPROVEMENT

I. COLLECTION, CONSERVATION, CATALOGING AND EVALUATION OF OIL PALM GERMPLASM

a. Collection of germplasm

In Kerala, survey and selection of oil palm germplasm programme continued in OPIL estates. Biometric observations on identified palms with respect to plant height, girth and number of bunches were recorded at Yeroor. Screening of elite palms identified till date, based on biometric parameters, was taken up. As a result, 14 *dura*, 6 *pisifera* and 9 *tenera* palms were shortlisted in Yeroor and Kulathupuzha estates. Information was collected and passport data sheet was completed for 12 palms. Harvesting of ripe FFB and collection of fruit samples were done for adding to the institute collection and further evaluation.

In Karnataka, the team visited oil palm plantation of ARS, Bhadra Reserve Forest (BRP) with mutants of BARC planted by BARC in 1984. The mutant palms were having normal fruits and bunches, canopy spread was comparatively less and were reported to have irregular bearing of bunches. The plantation was in neglected condition; occasional bunches were observed in some palms. The fruit typing was done and about 100 fruits from two palms one with *tenera* fruit characters and other with *dura* fruit characters were collected. In commercial plantation of M/s Bhadravathi Balaji Ltd., a sample from PNG source was collected.

In Andhra Pradesh, explorations for collection of germplasm were carried out in commercial exotic plantations with Papua New Guinea, Costa Rica and Ivory Coast sources in Khammam, Krishna and West Godavari districts. Elite palms were selected based on traits like plant height, bunch size, number of bunches and compactness of palms. A total of 36 palms (13 PNG, 20 Costa Rica and 3 Ivory Coast sources) have been identified. A total of eight germplasm accessions were planted in field and 88 palms were planted as an observational trial.

b. Germplasm conservation

At national level, DOPR (Erstwhile NRCOP) has been identified as National Active Germplasm Site(NAGS) to act as national repository for maintaining collections, conservation and evaluation of active/ working oil palm germplasm. At present there are a total of 128 germplasm accessions (62 at Palode, Kerala and 66 at Pedavegi, Andhra Pradesh) are being maintained as field

Table 1. Variations in morphological and yield parameters in germplasm block-I (2004)

Germplasm accessions	Height increment (cm)	SLW (kg m^{-2})	No. of bunches	Total bunch wt. (kg $palm^{-1}$)
PUNE 1	54.3	1.78	4.51	46.83
PUNE 2	70.2	1.53	8.22	72.61
LA 1	40.7	2.19	6.33	63.33
LA 2	63.1	1.66	7.78	92.56
LA 3	49.0	2.10	2.17	29.50
LA 4	47.3	1.72	3.14	35.86
LA 5	115.5	2.21	9.80	94.80
Selection CS-471	58.2	1.57	8.57	74.26

gene bank. These germplasm are at various stages of evaluation for morphological, yield and other important characters and are being utilized in oil palm breeding programmes.

c. Evaluation and management of germplasm

(i) Germplasm block-I: Accessions collected from Little Andaman were planted at main campus during 2004. The accessions recorded variations for height increment, number of bunches and bunch weight (Table 1). These accessions had high specific leaf weight (SLW), an indicator for drought tolerance. Promising selections for high yield could be made in accessions numbered LA-2, LA-4 and CD-471 (open) populations.

(ii) Germplasm block-III: Twenty two accessions were field planted at main campus in the year 2009 and were evaluated. Girth of palms varied from 55.8 to 124.13 cm, maximum plant girth was recorded in AND-21 followed by AND-20 and AND-16 (Table 2). Values for plant height varied from 157.55 to 294.70 cm, Nellore and Eturu accessions were taller compared to others. Many of the accessions produced inflorescences which varied from 0.0 to 3.25, maximum being in MANG-7 followed by AND-19 and AND-17. Number of leaves produced ranged from 20.4 to 26.27, highest was recorded in Nellore-2 followed by AND-27 and AND-16. Specific leaf weight varied from 0.48 to 0.78 kg/sq. m, maximum being in AND-21.

Table 2. Variations in morphological parameters in germplasm block – III (2009)

Germplasm accessions	Girth (cm)	Height (cm)	No. of female inflorescences	SLW (kg m^{-2})
AND-15	85.3	280.6	1.74	0.74
AND-16	100.6	255.4	0.47	0.69
AND-17	94.1	276.5	2.67	0.65
AND-18	63.2	270.0	0.56	0.64
AND-19	93.1	243.2	2.96	0.51
AND-20	100.8	230.1	1.40	0.64
AND-21	124.1	164.9	0.93	0.78
AND-24	83.8	256.3	0.93	0.65
AND-27	71.0	290.0	0.00	0.74
AND-*dura*	61.3	285.3	0.17	0.68
AND-10	48.5	157.6	2.50	0.48
AND-9	56.5	233.6	0.11	0.59
CO-1	94.9	252.6	0.20	0.76
MANG-1	75.6	247.5	1.27	0.42
MANG-2	76.9	253.7	1.15	0.79
MANG-6	75.4	239.6	1.80	0.74
MANG-7	68.9	223.5	3.25	0.54
Nellore-1	94.2	290.7	1.20	0.72
Nellore-2	93.5	239.5	1.60	0.46
PNG-2	55.8	294.7	0.00	0.60
PNG-1	72.9	277.7	0.18	0.37
TTD-1	95.6	284.6	0.47	0.68

(iii) Germplasm block IV: Ten accessions are under field evaluation from the year 2010 at main campus. Girth of palms varied from 50.0 to 83.4 cm, the highest being in Nellore-4. Plant height varied from 191.5 to 323.0 cm, the maximum being in Nellore-3 followed by Nellore-4 and AND-22. Maximum leaf number was recorded in MANG-4 followed by Nellore-4 and Eturu-3. Specific leaf weight ranged from 0.67 to 0.98 kg/sq. m; highest in TTHI followed by MANG-5 (Table 3).

(iv) Utilization of germplasm: During the current year, four slow growing palms have been identified in Zambian accessions. I*nter se* crossing programme is being followed to develop slow growing gene pool for recombinations and selection for promising types at a later stage. Elite palms identified in African germplasm have been utilized in developing pre-breeding populations and diversification of Palode source.

(v) Germplasm register: Accession register of germplasm was updated as per new format. Available accession data of all germplasm were collected, conserved as field gene bank and entered in the register. A total of 62 accessions are available at DOPR, RC, Palode.

(vi) Germplasm descriptor: As a part of evaluation, characterization and yield evaluation was undertaken as per Bioversity descriptor (1989) with necessary additional characteristics for selected individual germplasm accessions. A total of 19 palms from different accessions were characterized.

(vii) Characterization of new sources of *pisifera* palms: Three *pisifera*, one *tenera* and 87 *dura* palms have been categorized based on fruit typing. All three *pisifera* and one *tenera* palms are from Tanzanian source. Detailed characterization of the three *pisifera* palms was made for 40 parameters.

(viii) Characterization of dwarf progeny palm: One selfed progeny palm from Nigerian *tenera* source was planted at DOPR, RC, Palode during 2006. It has started producing inflorescences. Initially clusters of female inflorescences were observed and subsequently entered into male cycle.

(ix) Evaluation of dwarf *tenera* progeny: The selfed progeny of dwarf *tenera* is being evaluated in field. Fruit typing was done. So far a segregation ratio of 13 *dura*: 30 *tenera*: 3 *pisifera* has been recorded. Still, 34 palms have to be fruit typed for arriving at perfect segregation ratio. *Dura* palm with high yield of 205 kg has been recorded which could be utilized in breeding programme.

d. Evaluation of *oleifera* palms

Morphological and yield characteristics along with bunch quality parameters were

Table 3. Variations in morphological and yield parameters in germplasm block – IV (2010)

Germplasm accessions	Girth (cm)	Height (cm)	No. of female inflorescences	SLW (kg m^{-2})
AND-22	66.3	291.7	0.67	0.70
AND-14	68.0	268.5	0.00	0.86
MANG-3	59.8	243.4	0.00	0.89
MANG -4	50.0	208.5	0.00	0.68
MANG -5	72.7	253.7	0.00	0.96
TTHI	55.0	191.5	0.00	0.98
Nellore-3	70.5	323.0	0.00	0.88
Nellore-4	83.4	300.5	2.00	0.78
Eturu-3	68.1	259.1	0.00	0.69
Eturu-4	68.0	272.3	0.00	0.67

recorded in *oleifera* palms planted at Palode during 1994. Mean palm height, girth and number of leaves recorded in o*leifera* palms were 4.32 m, 3.95 m, 26.6, respectively. Palm number 18 recorded lowest height (2.3 m) whereas palm no 14 was tallest (5.82 m). Minimum height increment of 0.45 m was recorded in palm numbers 2, 5, 15 and 18 (Table 4). High variation was recorded for kernel oil/bunch followed by oil/bunch. Maximum oil/bunch value (18.31%) was recorded in palm no 13. Yield of *oleifera* palms during 2000-2010 showed erratic results and no definite pattern over years could be noticed among the palms.

Inter specific hybrids were developed utilizing o*leifera* of Chithara and progenies were planted in 2009 at DOPR, RC, Palode and Kariland, Kuttanad, Kerala as an observation trial. Palms planted at Kariland showed no satisfactory growth due to continuous water logging and flooding. Palms planted at Palode showed satisfactory growth and on an average put forth 11.5 leaves with 70.12 cm girth and 2.62 m height. They also showed wide variations in height and other vegetative parameters.

Kernel oil samples from seven *E. oleifera* palms planted in 1994, were analyzed for oil content and fatty acids composition. Oil content ranged from 37.53%, 44.92%. Eo-02 showed the highest oil content and Eo-03 showed lowest among the 10 palms studied. Fatty acid composition was different in *E.oleifera* kernel oil than that of *E.guineensis*. Lauric acid was found

Table 4. Morphological and yield characteristics of *oleifera* palms (1994)

Palm no.	Height increment (m)	Bunch wt. (kg)	Leaf area (m^2)	Fruit/ bunch (%)	Mesocarp/ fruit (%)	Oil/ bunch (%)	Kernel oil/ bunch (%)
1	0.55	10.26	6.16	65.38	65.12	8.54	2.15
2	0.45	20.48	9.32	58.35	38.99	9.12	2.48
3	0.48	15.80	7.00	52.31	53.18	6.52	9.90
4	0.54	20.49	8.09	53.19	60.46	3.62	1.94
5	0.45	23.14	8.77	65.05	64.99	13.80	5.58
6	0.55	25.60	6.30	45.35	67.90	9.03	5.23
7	0.48	17.36	9.52	30.11	60.80	7.89	2.96
8	0.55	19.42	8.26	55.65	60.09	9.61	6.88
9	0.49	19.04	9.29	56.37	77.17	13.36	4.43
10	0.55	20.32	8.30	37.47	42.77	13.94	9.72
11	0.54	16.54	7.88	74.28	56.47	15.28	6.61
12	0.55	10.72	7.18	60.00	57.75	5.99	6.20
13	0.54	7.95	7.08	62.96	59.08	18.31	8.63
14	0.48	15.96	8.86	52.56	61.88	6.46	5.15
15	0.45	21.54	8.95	57.27	40.58	10.06	7.21
16	0.53	18.43	7.61	62.08	51.38	5.17	5.21
17	0.52	18.11	9.47	72.09	69.62	7.99	2.66
18	0.45	16.42	7.72	60.70	41.55	6.38	5.83
19	0.55	15.68	10.86	36.38	59.03	9.59	6.63
20	0.51	21.03	7.29	38.97	57.64	9.50	3.64
21	0.48	23.01	8.89	68.12	48.77	12.18	4.55
22	0.48	27.42	8.72	75.47	60.94	14.47	5.02

highest among the fatty acids, followed by oleic acid. Among the 10 palms, oleic acid was found highest in Eo-20 (28.90%) and lowest in Eo-09 (14.97%).

II. SCREENING OIL PALM GERMPLASM FOR WATER STRESS

Oil palm germplasm materials collected from four African countries (Cameroon, Guinea Bissau, Tanzania and Zambia) are being screened for drought tolerance and/ or high water use efficiency at different locations in India, *viz.,* Pedavegi and Nellore (Andhra Pradesh), Palode and PCKL (Kerala). The crop is being grown as rainfed at Palode and PCKL locations whereas at other two locations it is being grown under water stress conditions (IW/CPE ratio = 0.5).

A. Performance of germplasm at DOPR, RC, Palode, Kerala

(i) Bunch quality characteristics: High variation in yield, bunch size etc., were observed in germplasm planted during 1998 at Palode. Results on bunch quality parameters are presented in Table 5. Individual palms recorded mean values of 9.11, 0.79, 20.43, 4.03, 49.11, 47.19, 11.89, 6.73, 3.92 and 3.2 for bunch wt. (kg), stalk wt. (kg), peduncle length (cm), fruit wt. (kg), % fruit/bunch, % mesocarp/fruit, % oil/bunch, single fruit wt. (g), single nut wt. (g) and % kernel oil/bunch respectively. Maximum oil/bunch was recorded in TS-2-66 (Tanzania) and minimum was recorded in TS-8-78. Highest co-efficient of variation was recorded for bunch weight followed by single nut weight.

(ii) Germination behaviour of African germplasm: The experiment was carried out during 2008-2010 on bunches of 20 hybrids developed by crossing individual *dura* palms of African germplasm and Palode *pisifera* palms and planted during 1998. Two open pollinated bunches from same African germplasm were also included as treatments. Results revealed that proportion of big, medium and small fruits and their counterparts of seeds were varying among different combinations of seeds. Seed weight is positively

Table 5. Bunch quality characteristics of pooled African germplasm (1998)

	Bunch wt. (kg)	Peduncle length (cm)	Fruit wt. (kg)	Fruit/ bunch (%)	Mesocarp/ fruit (%)	Oil/ bunch (%)	Single nut wt. (g)	Kernel oil/ bunch (%)
Mean	9.11	20.43	4.03	49.11	47.19	11.89	3.92	3.20
Max.	83.92	70.45	11.55	67.43	90.51	24.09	18.62	7.70
Min.	2.73	9.30	1.09	31.62	29.65	5.61	1.08	0.00
SD	11.31	8.91	2.90	8.36	10.72	3.77	3.19	1.51
CV (%)	124.15	43.61	71.96	17.02	22.72	31.71	81.38	47.19

Table 6. Seed characteristics in pooled hybrids developed from African germplasm (1998)

	Seed wt. (g)			Shell wt. (g)			Germination (%)			Shell thickness (mm)			Kernel wt. (g)		
	Big	Medium	Small	Big	Medium	Small	Big	Medium	Small	Big	Medium	Small	Big	Medium	Small
Mean	8.80	4.89	2.65	6.10	3.34	1.77	61.61	59.43	44.67	3.02	2.54	2.03	2.30	1.28	0.70
Max	12.67	8.98	5.71	9.66	6.77	3.86	94.60	92.00	77.65	4.06	3.44	2.94	3.35	1.75	1.53
Min	4.74	2.68	0.00	3.30	1.74	0.00	24.60	18.00	0.00	1.84	1.78	0.00	1.25	0.47	0.00
SD	2.13	1.49	1.70	1.68	1.17	1.12	18.63	18.76	21.73	0.71	0.50	0.66	0.59	0.37	0.51
CV (%)	24.25	30.44	63.98	27.54	35.04	63.29	30.24	31.56	48.66	23.67	19.59	32.28	25.60	29.25	72.76

correlated with shell thickness and kernel weight in majority of crosses whereas definite correlation was not observed between seed weight and % germination (Table 6).

B. Performance of germplasm at PCKL, Athirapalli, Kerala

Morphological parameters of individual palms of germplasm planted during 1998 at PCKL Athirapilli were recorded and mean values are presented in Table 7. Mean values recorded for peduncle length, rachis length, rachis depth, number of leaflets and leaf area were 24.4 cm, 5.8 cm, 4.1 cm, 136.8 cm and 2.9 m^2 respectively.
Since very high variation was observed among palms within the population for vegetative characters, bunch analysis of individual palms was carried out. Fully ripe open pollinated bunches from a total of 139 individual palms of Guinea Bissau, Cameroon, Tanzania, Zambia and Palode accessions were subjected to analysis and data were recorded on individual palm basis. Mean values of 10.53, 1.04, 55.47, 51.46, 32.86, 13.64, 14.67, 6.89, 3.19, and 3.71 were recorded for bunch wt. (kg), stalk wt. (kg), % fruits /bunch, % mesocarp/ fruits, % shell/ fruits, % kernel/ fruits, % oil/ bunch, single fruit wt. (g), single nut wt. (g) and % kernel oil/ bunch respectively (Table 8). The palm DxP Palode 235 has yielded maximum oil/bunch and Tanzanian materials TS-2TS70 (O/B=22.29 %) and TS-2TS246 (O/B=22.09 %) also showed better bunch quality characteristics.

C. Performance of germplasm at DOPR, Pedavegi, Andhra Pradesh

(i) Replicated trial : Under irrigated conditions, Tanzanian accessions were the highest yielders followed by Zambian accessions. Guinea Bissau accessions were the lowest yielders. Mean bunch size of Tanzanian accessions was more. The Guinea Bissau accessions were having small, but highest number of bunches. Under stress, Tanzanian accessions were the highest yielders followed by Zambian accessions. Guinea Bissau accessions were the lowest yielders.

Mean yield of previous years (2007-10) under both irrigated and stress environments (Table 9)

Table 7. Morphological parameters of pooled African germplasm (1998)

	Peduncle length (cm)	Rachis length (cm)	Rachis depth (cm)	Number of leaf lets	Leaf area (m^2)
Mean	24.4	5.8	4.1	136.8	2.9
Max	71.0	8.7	6.5	188.0	7.4
Min	13.0	0.6	2.4	12.0	1.2
CV (%)	28.6	18.4	21.8	19.5	39.1

Table 8. Bunch characteristics of African germplasm (1998)

	Bunch wt. (kg)	Fruit/ bunch (%)	Mesocarp/ fruit (%)	Shell/ fruit (%)	Kernel/ fruit (%)	Oil/ bunch (%)	Single nut wt. (g)	Kernel oil/ bunch (%)
Mean	10.5	55.4	51.4	32.86	13.6	14.6	3.1	3.7
Max.	34.0	75.0	100.0	65.6	29.2	22.8	16.1	6.9
Min.	2.2	27.5	15.4	0.0	0.0	5.1	0.0	0.0
CV(%)	54.9	18.1	18.2	27.5	33.4	25.6	75.6	40.5

showed that Zambian accessions were highest yielders, followed by Tanzanian accessions. GB accessions recorded the lowest yield but number of bunches recorded were more. Mean yield loss of Guinea Bissau accessions under water stress was 11.4 %, Zambian accessions and Tanzanian accessions have shown an yield loss of 7.8 % & 11.2 % respectively. Within the accessions, Zambian accession ZS-2 recorded highest yield followed by Tanzanian accession TS-9, both under stress and irrigated conditions. In GB accessions, highest yield was observed under irrigated and stress conditions in GB 21/310 and it also recorded highest bunch number under stress. But under irrigated

Table 9. Yield performance of African germplasm under irrigated and water stress environments(1998)

Germplasm accessions	Irrigated						Stress					
	2010-11			Mean (2007-10)			2010-11			Mean (2007-10)		
	BN	FFBY	MBW	BN	FFBY	MBW	BN	FFBY	MBW	BN	FFBY	MBW
GB21/310	10.6	102.9	9.7	11.4	95.8	8.5	10.7	106.0	10.1	11.6	89.2	7.9
GB22/311	9.6	91.8	9.7	10.8	84.9	8.4	6.3	61.8	9.2	10.5	79.0	7.9
GB25/314	12.5	74.5	8.6	13.3	80.8	6.7	7.8	53.3	8.0	10.3	63.6	6.6
TS11	5.8	99.0	19.3	7.3	107.8	16.0	7.7	131.3	17.4	7.0	99.6	14.2
TS9	8.3	151.0	18.5	8.2	129.4	16.7	6.4	107.8	17.3	7.4	110.9	15.7
ZS1	7.9	114.8	16.4	8.5	119.1	15.5	8.1	111.4	16.1	9.8	114.9	13.2
ZS2	8.2	138.6	16.7	9.6	140.5	15.0	7.3	109.4	15.2	9.1	121.0	13.8
ZS3	4.9	70.7	15.3	7.5	102.2	14.4	4.7	67.8	15.2	8.0	104.8	13.5
ZS5	5.0	88.0	17.6	7.5	115.2	15.6	4.9	87.6	16.1	7.4	109.0	15.6
ZS8	5.5	89.9	17.0	8.1	118.4	15.3	6.4	113.5	17.6	6.9	99.3	14.9

BN: Bunch number; FFBY: Fresh fruit bunch yield (kg palm^{-1}); MBW: Mean bunch weight (kg)

Table 10. Bunch quality characters in African germplasm (1998)

Germplasm accessions		Total number of fruits	Sterile fruit (%)	Fruit/ bunch (%)	Moisture in mesocarp (%)	Mesocarp/ fruit (%)	Kernel/ fruit (%)	Shell/ fruit (%)	Oil/ bunch (%)
CA-12(2)	Mean	1353.0	21.9	60	37.9	50.1	10.6	31.7	14.3
	SD	623.7	0.9	10	7.1	4.9	0.6	4.1	1.0
TS-9(8)	Mean	2503.8	33.7	50	38.0	52.2	10.8	29.0	11.0
	SD	1073.3	29.8	10	4.2	4.8	1.7	3.1	6.7
ZS-1(5)	Mean	1743.4	20.2	60	46.1	56.3	12.2	29.3	13.5
	SD	404.6	6.9	10	10.9	7.5	1.9	8.2	6.1
ZS-2(9)	Mean	2109.0	19.0	60	35.7	49.1	12.5	29.8	15.3
	SD	516.6	4.5	10	5.7	5.2	2.7	3.3	3.0
ZS-5(5)	Mean	1972.2	17.5	70	38.7	46.5	13.8	30.3	14.0
	SD	609.6	7.4	10	2.0	3.1	3.6	6.2	1.0
ZS-6(2)	Mean	3119.5	43.9	60	41.6	51.8	11.0	28.6	13.8
	SD	1020.4	44.8	20	8.0	0.0	2.3	2.5	6.3
ZS-8(9)	Mean	2158.2	26.4	60	45.3	48.8	11.6	29.8	11.6
	SD	602.7	20.1	10	9.6	6.8	2.3	4.7	4.0

conditions, GB 25/314 recorded highest bunch number. These accessions have significant variations for characters like robustness, compact canopy, long stalked male inflorescence, dwarfness, position of leaflets to have maximum exposure to sun light for better photosynthetic efficiency. Some palms have been identified which produce only female inflorescence, have leaves with narrow petiole, short rachis, *virescens* fruits etc.

Bunch analysis was done in African germplasm to study different components directly or indirectly related with oil yield per unit area. Wide variation has been observed for bunch analysis characters (Table 10). Highest oil percentage was observed in Zambian accessions ZS-2 and ZS-5 with 15.3% & 14% followed by Cameroon accession CA-12. Lowest oil percentage was observed in Tanzanian accession TS-9. Variation for other bunch quality parameters has also been recorded. Highest fruit/bunch was recorded in ZS-5. Highest mesocarp/bunch was recorded in ZS-1 followed by TS-9 and sterile fruits percentage is more in ZS-6.

Annual biometric observations were recorded on parameters like girth, height, no of inflorescences, leaves and 17th leaf observations like rachis length, petiole width, petiole depth, number of leaflets, leaflet length and width, *etc*., under irrigated conditions (Table 11). Bunch index was highest in Tanzanian material followed by Zambian and least was in Guinea Bissau. Highest SLW was recorded in Zambian accessions, followed by Tanzanian and Guinea Bissau. Rachis length was more in Zambian accessions, followed by Tanzanian and least in Guinea Bissau. Under stress, bunch index was highest in Tanzanian material followed by Zambian and Guinea Bissau. SLW was similar in Zambian, Tanzanian and Guinea Bissau accessions.

In continuation of physiological studies on screening of *duras* for drought tolerance, membrane stability indices in oil palm were estimated for ten African *duras* planted during 1998. Among the 240 palms under irrigated and stress conditions, palm No. 83 belonging to ZS-2 recorded highest membrane stability index closely followed by palm No. 94 (TS-9) indicating their better tolerance to drought. Among the different *duras*, lowest membrane stability index was recorded in GB25/314 and highest in ZS-5. Among different Guinea Bissau *duras*, GB25/314 and GB22/311 recorded lowest and highest stability indices. ZS-5 and ZS-1 recorded the highest and lowest indices among the Zambian *duras*. No significant

Table 11. Biometric observations on African germplasm under irrigated and stress environments(1998)

Germplasm accessions	Irrigated					Stress				
	Girth (cm)	Height (cm)	Rachis length (cm)	SLW (kg m^{-2})	Bunch Index	Girth (cm)	Height (cm)	Rachis length (cm)	SLW (kg m^{-2})	Bunch Index
GB21/310	250.3	435.4	384.4	0.7	0.47	247.0	418.4	381.3	0.6	0.49
GB22/311	266.3	497.4	397.6	0.9	0.37	265.8	412.8	393.5	0.7	0.32
GB25/314	258.3	544.7	360.2	0.5	0.37	251.9	530.9	378.8	0.6	0.30
TS-11	269.9	348.9	478.0	0.7	0.39	259.3	302.9	461.9	0.7	0.50
TS-9	255.7	427.7	409.7	0.8	0.53	262.5	340.2	421.8	0.8	0.41
ZS-1	262.8	246.0	433.3	0.7	0.44	247.2	222.3	437.4	0.7	0.43
ZS-2	221.3	272.3	463.8	0.9	0.51	244.7	249.5	471.0	0.8	0.46
ZS-3	263.0	272.3	452.4	0.8	0.32	270.8	289.3	479.8	0.9	0.32
ZS-5	258.1	270.2	440.1	0.7	0.39	264.7	236.5	468.1	0.7	0.33
ZS-8	247.9	305.9	465.2	0.9	0.41	225.8	259.3	490.9	0.7	0.49

differences were observed between the two Tanzanian *duras*.

(ii) Observational trail : A number of accessions from four African countries are being evaluated under water stress (IW/CPE ratio = 0.5). Highest yield was recorded in CA-9. Mean FFB yield recorded by Cameroon accessions was 75.7 kg (Table 12). Highest number of bunches were recorded in CA-9 followed by CA-8. Mean bunch weight was highest in CA-8 followed by CA-7. Bunch index was more in CA-9 and least was recorded in CA-13. Highest SLW was recorded in CA-17 followed by CA-13 and least was recorded in CA-11.

Among Zambian accessions, FFB yield of ZS-2 was the highest, whereas mean yield was 110.7

Table 12. Biometric and yield observations of Cameroon accessions under water stress (1998)

Germplasm accessions	Girth (cm)	Height (cm)	Rachis length (cm)	SLW (kg m^{-2})	No. of bunches	FFB yield (kg $palm^{-1}$)	Mean bunch wt. (kg)	Bunch Index
CA-10	284.0	126.0	482.0	0.72	8.0	114.0	14.3	0.45
CA-11	285.5	166.5	347.0	0.29	7.0	38.0	5.5	0.22
CA-12	261.2	282.7	446.6	0.49	7.0	96.2	13.3	0.38
CA-13	292.3	329.7	472.7	0.74	3.0	42.7	13.7	0.21
CA-15	276.3	277.8	370.0	0.67	5.0	68.8	13.8	0.33
CA-16	270.7	243.7	440.7	0.54	3.3	40.7	12.8	0.24
CA-17	255.0	269.3	408.5	0.81	8.0	108.7	14.1	0.38
CA-18	270.8	230.4	417.8	0.68	7.2	77.2	10.3	0.35
CA-3	276.2	270.4	492.6	0.56	6.4	89.2	13.8	0.37
CA-4	265.4	297.2	490.3	0.58	6.2	77.4	13.9	0.35
CA-6	271.8	197.0	415.3	0.59	3.3	44.0	12.6	0.22
CA-7	281.0	264.2	427.0	0.66	5.3	73.5	14.9	0.33
CA-8	320.4	260.0	492.8	0.68	8.5	128.0	15.7	0.35
CA-9	277.0	249.0	390.5	0.73	11.0	137.5	13.0	0.51
Mean	277.7	247.4	435.3	0.63	6.0	75.7	12.1	0.33

Table 13. Biometric and yield observations of Zambian accessions under water stress (1998)

Germplasm accessions	Girth (cm)	Height (cm)	Rachis length (cm)	SLW (kg m^{-2})	No. of bunches	FFB yield (kg $palm^{-1}$)	Mean bunch wt. (kg)	Bunch Index
ZS-1	268.6	245.7	450.8	0.68	4.5	58.7	10.5	0.26
ZS-2	231.0	250.3	449.8	0.79	9.0	157.3	17.7	0.56
ZS-4	258.3	306.3	488.5	0.61	10.8	155.1	14.5	0.56
ZS-5	251.4	276.4	437.4	0.65	6.6	99.7	14.5	0.42
ZS-6	230.8	315.3	487.5	0.62	4.3	65.5	18.3	0.39
ZS-9	256.0	302.0	362.0	0.67	8.0	128.0	16.0	0.53
Mean	249.3	282.6	446.0	0.67	7.2	110.7	15.2	0.45

kg (Table 13). Mean bunch weight was highest in ZS-6. Rachis length was highest in ZS-6. Bunch index was more in ZS-2 and ZS-4 and least was in ZS-1. Highest SLW was in ZS-2 and least was in ZS-4.

Among the Guinea Bissau accessions, highest FFB yield was recorded by GB-22/311 which was significantly higher than general mean (Table 14). Mean bunch weight was highest in GB-1/309 and GB-29/318 followed by GB-21/308. Number of bunches were highest in GB-22/311 and GB-10/306. Production of bunches was more in GB accessions compared to that of others. Bunch index was more in GB-21/308 followed by GB-29/318 and least was in GB-5/301. Highest SLW was in GB-25/314, followed by GB-1/309, GB-23/312 and GB-29/318 and least was in GB-2/298.

Table 14. Biometric and yield observations of Guinea Bissau accessions under water stress (1998)

Germplasm accessions	Girth (cm)	Height (cm)	Rachis length (cm)	SLW (kg m^{-2})	No. of bunches	FFB yield (kg $palm^{-1}$)	Mean bunch wt. (kg)	Bunch Index
GB-1/309	304.0	545.0	426.0	0.65	3.0	37.0	12.3	0.18
GB-10/306	269.4	489.0	373.2	0.62	12.8	62.6	5.1	0.33
GB-12/308	277.3	702.3	365.7	0.60	7.3	35.3	5.4	0.21
GB-2/298	315.0	548.5	400.0	0.44	7.0	48.5	7.0	0.22
GB-21/308	255.2	447.6	377.8	0.56	9.4	81.6	8.5	0.41
GB-22/311	269.0	407.6	400.2	0.60	16.0	117.0	7.8	0.18
GB-23/312	263.0	460.1	375.4	0.65	11.0	84.5	7.5	0.40
GB-25/314	258.0	477.0	326.0	0.79	11.0	47.0	4.3	0.29
GB-28/317	271.5	603.5	366.5	0.52	7.5	52.5	7.9	0.29
GB-29/318	279.3	492.8	409.2	0.65	9.7	93.3	12.3	0.39
GB-5/301	238.0	385.0	364.0	0.62	1.0	6.0	6.0	0.06
GB-5/310	278.6	500.4	426.2	0.63	5.7	20.0	3.4	0.08
Mean	273.2	504.9	384.2	0.61	8.4	57.1	7.3	0.25

Table 15. Biometric and yield observations of Tanzanian accessions under water stress (1998)

Germplasm accessions	Girth (cm)	Height (cm)	Rachis length (cm)	SLW (kg m^{-2})	No. of bunches	FFB yield (kg $palm^{-1}$)	Mean bunch wt. (kg)	Bunch Index
TS-10	220.5	290.5	434.5	0.72	7.0	78.0	11.1	0.43
TS-11	272.0	416.3	434.0	0.75	2.7	36.1	14.8	0.20
TS-4	282.8	394.6	430.6	0.87	8.8	156.9	17.3	0.50
TS-5	270.3	425.0	424.3	0.72	8.0	156.5	20.2	0.54
TS-5	267.0	383.7	394.7	0.79	15.0	156.5	10.4	0.36
TS-7	260.0	341.0	396.0	0.82	2.0	27.0	13.5	0.18
TS-8	238.5	360.0	456.5	0.75	5.0	100.2	18.8	0.45
TS-9	243.0	369.0	382.0	0.77	4.5	78.0	17.0	0.42
Mean	256.8	372.5	419.1	0.77	6.6	98.6	15.4	0.38

Mean FFB production of Tanzanian accessions was 98.6 kg with highest yield of 156.9 kg recorded in TS-4 (Table 15). Mean bunch number was 6.6 and highest was in TS-5. Mean bunch weight was highest in TS-5 followed by TS-8. Mean bunch weight recorded by Tanzanian accessions was highest compared to other sources. Bunch index was more in TS-5 and least in TS-7. Highest specific leaf weight was recorded in TS-4 and least in TS-10 and TS-5.

Fatty acid composition of 15 palms from 6 African accessions (GB25/311, ZS-03, TS-05, TS-09, CA-04, CA-12) and 1 indigenous accession (80D x 281D) was analysed. Variation in moisture and mesocarp oil content with an inverse relation between the two parameters was observed (Fig. 1). Mesocarp oil content was highest in palm no. 419 (from accession no. TS-05). Fatty acid composition also showed variation. Major fatty acids (palmitic and oleic) and total unsaturated fatty acid percentage is shown in Fig. 2. Highest unsaturation was observed in palm no. 205 from accession no. ZS-03.

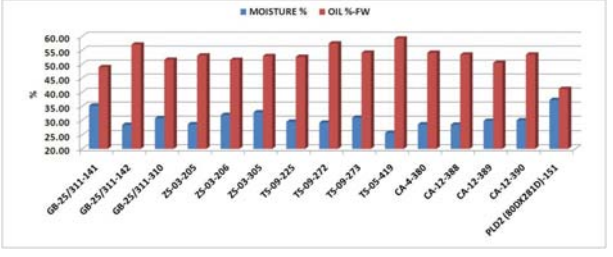


Fig. 1: Moisture and mesocarp oil content of African germplasm accessions

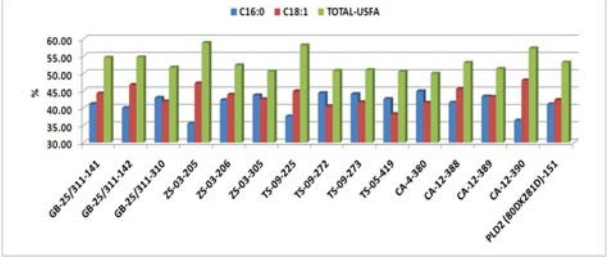


Fig.2: Palmitic acid, oleic acid and total unsaturation % in the mesocarp oil of African germplasm accessions

Evaluation of DxP hybrids for drought tolerance in nursery: Twenty one drought tolerant DxP crosses were screened for drought tolerance in nursery by undertaking studies on membrane stability index (MSI) and other parameters. The crosses were developed by utilizing identified *dura* palms from African germplasm with selected *pisifera* palms. The MSI ranged from 78.9 to 91.4. Highest MSI was recorded in 34CD X 110P closely followed by 124CD X 17P and 66CD X 129P, indicating their better tolerance to drought. 254CD X 14P and 435CD X 14P recorded lower MSI indicating their poor tolerance to drought. Other crosses recorded intermediary indices. Variation in height was recorded; the cross 92CD x 129P recorded lowest height and 198CD x 129P recorded maximum height. The latter cross also recorded highest number of leaves.

Gas-exchange characteristics, leaf water potential and chlorophyll *a* fluorescence in oil palm seedlings under water stress and recovery

The gas-exchange characteristics, leaf water potential and chlorophyll (Chl) *a* fluorescence of oil palm seedlings subjected to water stress and recovery were investigated in a greenhouse experiment. Leaf water potential (Ψ_w) in oil palm seedlings showed significant differences between two treatments on 12th day after imposition of water stress. The Ψ_w was –3.6 MPa at 24th day after imposition of stress, which was associated with photosynthetic rate (P_N) of 0.05 µmol m^{-2} s^{-1} due to stomatal closure. The P_N at the start of experiment was 6.10 µmol m^{-2} s^{-1} and progressively decreased to 0.05 µmol m^{-2} s^{-1} at 24 days after imposition of water stress. Stomatal conductance (g_s) was significantly reduced from 8th day onwards after imposition of stress. The stomatal closure occurred at 24th day after imposition of water stress in water stress treatment and consequently reached values close to zero. Transpiration rate (*E*) at start of the study was 0.13 mmol m^{-2} s^{-1} which progressively declined to 0.01 mmol m^{-2} s^{-1} at 24th day after imposition of water stress. *E* decreased to more

than 50% in water-stressed seedlings at 12th day after imposition of stress. Water use efficiency (WUE) in water-stressed oil palm seedlings was greater than that of control till 16th day and declined sharply thereafter. WUE increased due to reduced g_s, which led to greater decline in *E* than P_N.

The ratio of variable fluorescence to maximum luorescence (F_v/F_m)dropped to 0.7 in the oil palm seedlings at 24th day after imposition of water stress. Similarly photosystem II activity (Φ_{PSII}), photochemical quenching (q_L) and electron transport rate (ETR) were 0.5, 0.68, and 44 µmol m^{-2} s^{-1} respectively at 24th day in water-stressed seedlings. The non-photochemical quenching of excitation energy (NPQ) was not significantly different among seedlings in control and water stress during 24 days period.

The Ψ_w in water-stressed oil palm seedlings recovered from –3.6 MPa at 24th day after water stress to –2.8 MPa at 4th day after rehydration and reached similar value to that of control at 12th day after rehydration. P_N, g_s, and *E* also followed similar trend as that of Ψ_w in stressed oil palm seedlings after rehydration. The gas-exchange parameters were not significantly different among oil palm seedlings (control and rehydration) at 12th day after rehydration, which indicates that oil palm seedlings took 12 days to recover from water stress given for 24 days. These findings probably reveal that mesophyll cells are not irreversibly affected by water stress due to the fact that a gradual recovery of these parameters is happening after resumption of irrigation. F_v/F_m in water-stressed oil palm seedlings was on par with control at 12th day after rehydration. The differences in Φ_{PSII} and ETR values were not significant at 8th day after rehydration between control and water stressed seedlings.

The above findings indicate that oil palm seedlings tolerated water stress by regulating g_s (though mesophyll conductance also play a vital role) which in turn helped in maintaining positive values of photosynthetic rates with reduced stomatal opening along with lower $Ø_w$. The decline in F_v/F_m during water stress may be related to the activation of protection mechanisms in oil palm seedlings as rehydrated seedlings recovered their photosynthetic activity. The results also show that oil palm seedlings posses physiological plasticity during water stress and its subsequent recovery after rehydration.

D. Germpalsm evaluation at Nellore, Andhra Pradesh

Biometric observations were recorded twice in Zambian, Tanzanian and Guinea Bissau accessions planted in 1998. Observations were recorded on parameters like number of male inflorescences, female inflorescences, hermaphrodites, number of leaves, number of spindles and sex ratio. Sex ratio in different accessions ranged from 0 to 1 and number of leaves produced were 15-17. Five to six spindles were observed.

III. PRODUCTION, EVALUATION AND IMPROVEMENT OF OIL PALM HYBRIDS

(i) Development of slow growing gene pool: Four palms numbered 42 & 43 (both from ZS-1) and 465 & 497 (both from ZS-5) have been selected based on their slow vertical growth. Crossing programme is being effected to develop a gene pool for slow growing character which will aid in developing dwarf/ slow growing oil palm hybrids.

(ii) Evaluation of basic planting materials for new seed gardens: The basic planting material developed for new seed gardens has been transplanted in secondary nursery. A total of 58 *dura* x *dura* and 56 *tenera* hybrids are being evaluated for their growth in nursery with respect to height, leaf production, girth and dry matter accumulation capacity.

(iii) Improvement of Indian oil palm: With a view of improving the genetic base of Indian oil palm (commonly called Palode material), crossing programme has been initiated between selected promising *dura* palms of Palode origin and selected

palms from diverse sources (Zambia, Tanzania, Guinea Bissau, Cameroon and ASD Costa Rica). This divergent crossing programme will help in selection of transgressive seggregants for high yield, increased oil yielding capacity, height increment and other desirable characters.

(iv) Effect of gibberellic acid on bunch characters: An experiment was conducted to determine the effect of gibberellic acid (GA) on fruit set and bunch parameters in oil palm. Four concentrations of GA (50, 100, 150 and 200 ppm) were sprayed on female inflorescences at the time of anthesis. Pollination was done with fresh pollen grains, 15 minutes after the GA spray. Number of days required for bunch maturity (anthesis to harvesting) decreased (165 to 148 days) as concentration of GA increased. Fruits per bunch, fruit weight, weight of shell increased as the GA concentration increased to 200 ppm. Bunch weight increased from 10.92 kg (control) to 20.71 kg (200 ppm GA). Oil to bunch ratio ranged from 0.22 to 0.30% in different treatments. Highest oil content was recorded in palms sprayed with GA @ 150 ppm. Further increase in GA concentration resulted in decreased oil content in bunches. There was a reducing trend for single fruit weight (fresh and dry), wet and dry mesocarp contents and shell thickness with increase in GA concentration. However, GA did not have any effect on mesocarp oil/fruit, kernel oil/fruit, oil/wet mesocarp and mesocarp/fruit. Spraying of 150 ppm GA on bunches of oil palm was found to improve bunch weight and oil content in oil palm.

(v) Evaluation of *Dura* and T x T progeny at Pedavegi: It is observed that mean bunch weight in selected *dura* mother palms was highest in Palode *dura* 80 D x 281 D (Palm no. 172) as 18.1Kg; the highest number of bunches was recorded by Palode genotype 240 D x 281 D (Palm No. 34). Mean yield was highest in 240D x 281D population; palm to palm variation was also least in this population. Highest mean bunch weight was recorded in *dura* population 80D x 281D (58.8 kg). The ASD Costa Rican *dura* population was yielding less than Palode *dura* populations and also had comparatively small bunches. The pooled analysis over years (2007-11) indicated significant variation among *dura* populations for number of bunches, FFB yield and ABW. Year to year variation was significant for all the three major yield characters. Bunch analysis was carried out to know oil yielding capacity of the palm apart from bunch quality parameters. In TxT population, a segregation ratio of *dura* (27): *tenera* (97): *pisifera* (28) has so far been recorded in TxT population.

(vi) Trial on Nursery performance v/s Field performance: The trial was planted during 2003. Highest bunch number (9.9) and bunch weight (135.8 kg) were recorded in 155 x 57 (Table 16). Highest mean bunch weight was recorded in 139 x 155. Bunch index was recorded highest in 155x57 followed by 53x57. Highest SLW was recorded in 146x155, followed by 119x57. Rachis length was recorded more in 113x90, followed by 139x155 and least was recorded in 97x155. Highest sex ratio was recorded in 47x90, and lowest in 44 x 155. Lowest height was in 124 x 57 and maximum height in 113 x 90. Highest girth was observed in 135 x 155 and lowest girth in 47 x 90.

(vii) Evaluation of DxP oil palm hybrids: Twelve selected *pisifera* parents were used in crossing 30 *duras*. Significant differences were observed among *pisifera* parents with respect to morphological characters studied (Table 17). Leaf dry weight varied from 0.37 to 0.52 kg/seedling. The pollen parent P71 recorded maximum leaf dry weight followed by P82, P331 and L379 which were statistically on par with each other. The leaf area was maximum in L47 followed by P435 and L132 whereas, lowest was in P71. The number of leaves produced varied from 11.8 to 14.1. Maximum number of leaves were recorded in P71 and P331, which were statistically on par with each other and better than the rest.

Mean plant girth varied from 22.3 (P82) to 41.5 cm (P214). Plant height ranged between 115.4 and 161.2cm. Mean height increment varied from

Table 16. Performance of DxP hybrids in progeny testing trial (2003)

D x P Cross	Height (cm)	Girth (cm)	Rachis length (cm)	SLW (kg m^{-2})	No. of bunches	FFB yield (kg $palm^{-1}$)	Mean bunch wt. (kg)	Bunch Index
47 X 90	148.9	277	449.7	38.2	6.8	85.1	12.2	0.41
56 X 90	146.7	289	474.2	43.4	7.1	95.4	13.8	0.42
30 X 90	143.2	294	456.6	32.2	6.7	80.5	11.7	0.37
113 X 90	186.3	293	490.0	45.7	7.6	99.9	13.3	0.44
53 X 57	177.7	296	488.8	39.3	9.4	123.0	12.8	0.49
119 x 57	181.1	308	465.8	49.1	9.0	120.6	13.4	0.44
165 X 57	150.9	289	475.5	39.4	8.1	111.0	13.7	0.46
124 X 57	119.4	288	484.4	32.1	7.9	88.9	11.4	0.41
155 X 57	135.4	292	484.8	46.2	9.9	135.8	13.9	0.51
139 X 155	163.0	295	489.8	48.4	6.1	91.1	15.7	0.41
146 X 155	154.4	302	485.5	65.3	6.1	80.7	13.5	0.37
97 X 155	140.3	291	443.3	28.7	7.0	76.5	10.6	0.37
135 X 155	131.5	316	472.9	45.9	5.8	71.9	11.9	0.29
44 X 155	138.3	310	470.4	38.7	7.6	91.7	12.2	0.38
135 X 57	166.3	291	482.0	37.2	7.7	101.5	13.3	0.45
222 X 57	137.6	281	446.7	28.9	9.0	100.0	10.8	0.45

Table 17. Variation in morphological parameters in different *pisifera* parents at nursery

Pisifera ID	Height increment (cm)	Girth (cm)	No. of leaves	Rachis length (cm)	Leaf area (m^{-2})	Leaf dry wt. (kg)
P71	40.85	35.31	14.05	110.54	0.20	0.52
L90	37.43	29.58	11.88	96.14	0.43	0.41
L47	43.86	28.48	11.74	101.77	0.48	0.42
L379	47.34	33.31	10.69	118.94	0.24	0.45
P66	42.37	24.13	10.70	93.75	0.33	0.36
P82	56.01	41.50	13.70	119.73	0.21	0.50
P435	43.64	24.51	11.74	99.82	0.47	0.42
P214	41.13	22.24	11.31	89.91	0.36	0.37
P331	57.38	40.34	13.32	118.52	0.20	0.46
P370	55.13	38.50	11.45	120.35	0.24	0.44
L132	39.76	26.22	11.79	97.07	0.42	0.40
P167	37.92	27.26	11.83	90.32	0.38	0.41
CD	5.49	3.52	0.74	7.94	0.06	0.06

37.4 to 57.4 cm. The height increment was maximum in P331 which was on par with P82 and P370. The height increment of seedlings was lowest in L90 followed by P167 and L132.

Leaf area had high association with number of leaflets (0.91). Specific leaf weight had high and positive association with girth (0.51) followed by height (0.48), length of rachis (0.45) and height increment (0.43).

(viii) Evaluation of Inter-specific hybrids: Observations on FFB yield, number of leaves and inflorescences produced and annual biometric characteristics were recorded on two Inter specific hybrids. Number of leaf lets was more in 361D X 11 *E. oleifera* (352.54) and it also showed high width, depth (12.8.6/9.38 cm) and rachis length (565.5 cm). Highest specific leaf weight was recorded in 361D x 11 *E. oleifera* (0.99 kg/sq. m) followed by 360D x 13 *E. oleifera* and bulk materials (0.70 & 0.68 kg/sq. m).

IV. EVALUATION OF INTER SPECIFIC HYBRIDS

A. Evaluation at Pedavegi: One set of interspecific hybrids planted in 2002 as GD3 in *dura* block has been removed as no promising interspecific palms were observed for use in future back crossing programmes. Other two sets are being evaluated for morphological and yield parameters. These palms will be monitored for one or two more years for desirable characters. For estimation of fatty acid composition in the kernel oil, 16 *oleifera* kernel samples were received from Palode. Oil content and fatty acid composition was estimated for three samples (palm no. Eo-02, Eo-14 and Eo-20). Oil content was 54.22%, 53.27% and 52.88% on the basis of dry weight and 51.29%, 45.48% and 47.42% on the basis of fresh weight for palm nos. Eo-02, Eo-14 and Eo-20 respectively.

B. Evaluation at Palode: Vegetative parameters of interspecific hybrids planted in 1998 at Palode were recorded for height, girth and number of leaves. As bunch production is meager in all the individual palms, vegetative parameters are important for selection of palms for backcrossing programme. It is inferred that 16Eo x 18Eg combination showed low vertical growth. However, individual palm characteristics are important for deciding the crossing programme (Table 18).

Evaluation results on interspecific hybrids at Palode resulted in identification of four promising dwarf palms *viz*., 47(361*Eg* × 11*Eo*), 48(16*Eo* ×18*Eg*), 6(12*Eo*× 82*Eg*) and 45(Surinam origin) which can

Table 18. Vegetative characteristics of interspecific hybrids at Palode (1998)

Interspecific hybrids	Height (m)	Girth (m)	No. of leaves	No. of inflorescences		
				Male	Female	Bisexual
360Egx13Eo	3.38	3.57	24.33	1.50	5.67	0.00
12Eox82Eg	2.73	3.43	25.60	1.20	1.80	0.20
19Eox81Eg	2.68	3.06	25.67	1.33	2.17	1.00
16Eox18Eg	2.52	3.22	25.60	2.20	0.80	0.00
361Egx11Eo	3.65	3.45	27.14	2.00	2.57	0.00
DxP Palode	3.66	3.12	24.20	0.80	1.40	0.00
15Eox18Eg	2.62	3.43	24.33	2.50	0.67	0.33
10Eo open	2.34	3.41	24.50	0.33	1.83	0.83
16Eox81Eg	2.55	3.12	23.67	2.33	0.50	0.00

be used for back crossing programme as per the genetic design. Based on height increment and fruit set, four interspecific palms were selected and back crossing programme was initiated.

V. STRENGTHENING OF SEED GARDENS FOR INDIGENOUS SEED PRODUCTION

DOPR is the nodal agency for monitoring oil palm hybrid seed production activity at the National level. Seed production activities are being regularly monitored. Quality aspects of oil palm hybrid seeds have extensively been taken care. These seed gardens are producing about two million sprouts annually (Table 19 & 20) and have an annual production capacity of 4 million sprouts.

During the reported period, two national oil palm seed meets were conducted; one for 2010-11 and another for 2011-12, where allotment of sprouts from different seed gardens was decided.

A. Pedavegi seed garden: Hybrid seed production programme was started at commercial level during 2009. During 2010-11, a total of 59,980 quality oil palm sprouts were distributed to different entrepreneurs in Andhra Pradesh as per the allotment schedule. The seed garden has four mother palm population; two from Palode source and two from ASD Costa Rica, planted during 2000 and 2002, respectively. A total of 56 mother palms have so far been selected in Palode populations

Table 19. Estimated sprout production during 2011-12

S.No.	Name of Seed Garden	Estimated seed production (in lakhs)				
		Apr -Jun 2011	Jul-Sep 2011	Oct-Dec 2011	Jan-Mar 2012	Total
1	DOPR (RC), Palode (Kerala)	0.50	0.60	0.50	0.40	2.00
2	OPIL, Thodupuzha (Kerala)	0.90	2.15	1.40	1.55	6.00
3	DOH, Taraka, Mysore (Karnataka)	0.75	1.50	0.75	0.50	3.50
4	DOH, Rajahmundry (A.P.)	0.60	1.10	0.90	0.40	3.00
5	Navabharat Agro Products Ltd., Lakshmipuram (A.P.)	0.00	0.29	0.79	0.42	1.50
6	DOPR, Pedavegi (A.P.)	0.00	0.50	0.50	0.50	1.50
	GRAND TOTAL	2.75	6.14	4.84	3.77	17.50

Table 20. Allotment of sprouts for 2011-12 with additional target for meeting the anticipated demand

(in lakh)

S.No	Name of Seed Garden	Confirmed allotment	Additional allotment	Total allotment
1	DOPR, RC, Palode (Kerala)	2.00	1.85	3.85
2	OPIL, Thodupuzha (Kerala)	6.00	2.40	8.40
3	DOH, Taraka, Mysore (Karnataka)	3.50	1.00	4.50
4	DOH, Rajahmundry (A.P.)	3.00	2.00	5.00
5	Navabharat Agro Products Ltd., Lakshmipuram (A.P.)	1.50	2.00	3.50
6	DOPR, Pedavegi (A.P.)	1.50	2.50	4.00
	TOTAL	17.50	11.75	29.25
	Expected area coverage (ha)	9725	6525	16250

whereas 32 mother palms have been selected in Costa Rican source.

Mean yield was recorded highest in 240D x 281D population; variation for bunch weight was also found least in this population. Highest mean bunch weight was recorded in *dura* population 80D x 281D. The ASD Costa Rican *dura* populations were yielding less than the Palode *dura* populations and also had comparatively small bunches. Pooled analysis was done over five years (2007-11) to study the variations due to years and hybrids. Results indicated significant variation among *dura* populations for number of bunches, FFB yield and mean bunch weight. Year to year variation was significant for all the three major yield characters (Table 21). Bunch, fruit and seed characterization was also carried out through bunch analysis.

Annual biometric observations on parameters like height, girth, number of leaves and 17th leaf observations on number of leaflets, petiole width, petiole depth *etc* were recorded. Among the four accessions, bunch index was recorded highest in 240 D x 281 D followed by 80 D x 281 D and lowest was in 98C x 254D (Table 22). The lowest height increment was in 80 D x 281 D. Rachis length was longest in 98C X 208D and shortest in 80 D X 281D. The highest rachis length was in 98C x 254D and in 80D x 281D. Mean bunch weight was highest in 80D x 281D and lowest in 98C x 208D.

Establishment of new seed gardens has been envisaged in Chadha Committee Report-2006. For this purpose, efforts were made to regenerate the planting material for mother palm block and *tenera* x *tenera* block. At DOPR, Pedavegi, diverse crosses have been made involving Palode *dura* with exotic promising *dura* identified in African germplasm (Zambia, Guinea Bissau, Cameroon and Tanzania) and Costa Rican *dura* populations. Three crosses (56

Table 21. Performance of *dura* populations at DOPR, Pedavegi

Cross ID		2010			Mean for 2007-10		
		No. of bunches	FFB yield (kg palm^{-1})	Mean bunch wt. (kg)	No. of bunches	FFB yield (kg palm^{-1})	Mean bunch wt. (kg)
240D x 281D	Mean	6.2	93.0	15.1	7.3	101.0	14.4
	SD	3.3	52.6	3.8	3.6	51.8	3.7
80D x 281D	Mean	4.6	77.8	16.7	6.3	92.8	14.9
	SD	2.3	69.5	14.9	3.0	59.0	6.7
98C x 254D	Mean	3.3	45.6	14.0	5.5	61.3	12.0
	SD	2.2	29.2	4.2	3.2	36.8	3.5
98Cx208D	Mean	4.0	64.0	16.0	5.9	68.3	12.8
	SD	0.3	2.4	0.7	5.3	31.5	2.6

Table 22. Biometric observations on *dura* populations at DOPR, Pedavegi

Cross ID	Height Incr. (cm)	Rachis length (cm)	SLW (kg m^{-2})	Mean bunch wt. (kg)	Bunch Index
240D x 281D	88.99	442	0.92	15.06	0.50
80D X 281D	61.67	404	1.02	17.09	0.42
98Cx 254D	80.52	465	0.93	13.95	0.28
98Cx208D	78.52	490	0.83	16.06	0.41

in numbers) are in secondary nursery and ready for supply during next rainy season. D x D crosses are being evaluated for nursery performance.

B. Palode seed garden: During 2010-11, 1.35 lakhs germinated seeds were supplied from DOPR, RC Palode to different nurseries spread over many states.

The newly planted diverse *dura* populations (D x D) namely 44CD x 435CD and 60CD x 62CD are under observation for their initial growth. Annual biometric observations were recorded on height, girth, number of leaves and inflorescence production and on 9th leaf on number of leaflets, leaflet length and width, petiole width and depth and rachis length. Dwarf *tenera* x *pisifera* cross was planted in field. Fruit typing activity has been taken up in this material to ascertain plant type.

(i) Effect of pollen parent on bunch size: Table 23 reflects promiscuity of pollen parents (*pisifera* parents) numbered 110, 129, 195 and 15 in developing fairly good size of crossed bunches. The pollen obtained from TXT Pedavegi block was tested and the performance of pollen parent no: 74 was found to be good, as the mean bunch weight was 18.4 kg followed by pollen parent no: 195. The lowest mean bunch weight was in pollen parent no: 75.

(ii) Performance of *dura* mother palms: The trial was planted in 2000.The highest mean bunch weight was 28.0 kg (palm no 174) and the highest number of bunches (17) were recorded in palm no. 34 from 240D x 281D and palm no. 233 from 80D x 281D of Palode origin. In Costa Rican *dura,* highest mean bunch weight was 29.5 kg (palm no. 850) and the highest number of bunches were recorded in palm no 617 (genotype c9550 x 414d).

(iii) Seed germination behaviour with reference to seed size: Seed size variation in Palode hybrids and their germination potentiality along with % distribution of different size categories of fruits were studied using 25 cross combinations (Table 24). The proportion of large and medium size categories was high in all combinations when compared to small seeds and fruits. In this study, ten fruits from each category were selected for determination of physical characteristics viz., fruit and seed weight, length, breadth and circumference, shell and kernel weight, shell thickness, oil percentage of mesocarp and kernel and percentage of germination. Highest mean germination was recorded in D62x66, followed by D76x66, D109x66 and D49x66 and lowest germination was recorded in D36x435, followed by D21x214, D25x435 and D129x214. Shell thickness was highest in D39x435 combination and highest kernel weight was recorded in D36x435.

Table 23. Effect of *pisifera* parent on weight of crossed bunches

Pisifera ID	No of palms used at Pedavegi	Bunch weight (kg)	Mean bunch weight (kg)
14	21	291.11	13.86
17	60	767.18	12.78
74	60	1105.41	18.42
75	1	7.79	7.79
76	58	782.74	13.49
77	151	2529.45	16.75
110	89	1525.74	17.14
129	253	4179.98	16.52
195	127	2187.65	17.22
TOTAL	819	13377.05	133.99

(iv) Seed storage studies: Seed storage studies were conducted with DxP hybrids (Table 25) with four treatments (air tight plastic container, polythene bags, aluminium cover and open storage). Observations on germination percent, moisture content of seed and kernel were recorded at monthly intervals. Results revealed that initial moisture content of seed (18.0 %) decreased to 15.83%, 14.59% (Treatment 1)13.36%, 12.66% (Treatment 2) 14.15%, 12.61% (Treatment 3) and 12.8%, 8.40% (Treatment 4) during 2nd and 3rd months of storage. Germination percent showed improvement during dry storage. Seeds stored in aluminum foil showed high germination.

(v) Acceleration of germination in oil palm hybrid seeds : The period during which seeds develop on the parent plant has been found to affect many seed characteristics including dormancy, through interactions with the environment. Oil palm seeds harvested in seed gardens (different environments) were differing in seed dormancy status. Seeds that developed at warm temperatures were less dormant (i.e. germination percentages were higher) than seeds from the cool environment. Accordingly, dormancy treatments required to be modified depending upon the intensity of dormancy. Data on seed germination of different cross combinations of Palode and Thodupuzha were analysed on total number of seeds/bunch, seed mass, first germination, total germination etc., in different cross combinations. Mean data for all the characteristics were compared for inference. The results indicated that Thodupuzha mother palms found to show tall growth and had less number of seeds (<1000 seeds) per bunch than Palode mother palms (1200 seeds). They also differ in seed mass and germination results. Palode centre and Thodupuzha showed comparable results in case of germination. Palode mother palms had mean of 84% whereas Thodupuzha recorded 85%.

VI. PERFORMANCE OF SOURCES OF OIL PALM PLANTING MATERIALS

Pooled analysis of the data from the trial planted in 1996 at Pedavegi over 4 years (2007-11) indicated significant variation among the hybrids for number of bunches, FFB yield and mean bunch weight(MBW). Year to year variation was significant for all the three major yield characters. Genotype x

Table 24. Seed physical characteristics and germination % of different combinations of Palode hybrids

Fruit size (g)	Seed				Shell		Oil (%)		Germination (%)
	Weight (g)	Length (mm)	Breadth (mm)	Circum. (mm)	Weight (g)	Thickness (mm)	Mesocarp	Kernel	
Big	6.92	27.74	21.66	68	5.12	3.05	62.63	25.17	51
Medium	4.14	23.87	17.38	56	2.94	2.77	56.71	21.07	50
Small	2.94	19.28	15.94	51	1.98	2.33	44.42	19.22	45

Table 25. Mean germination % of stored D x P hybrid seeds in different containers

Storage containers	Storage duration (months)					
	0	1	2	3	4	5
Plastic Box	0	0	0	8	56	78
Polythene cover	0	0	4	38	74	44
Aluminium foil	0	0	0	42	88	86
Open storage	0	0	0	0	22	0

year interactions were significant for number of bunches and FFB yield, while non significant for mean bunch weight. FFB yield was recorded highest in hybrids of Ivory Coast followed by Palode (Table 26). Lowest yield was recorded in hybrids from ASD Costa Rica. Ivory Coast hybrid 18C x 2501 produced highest FFB yield among all. Highest number of bunches were recorded in Ivory Coast hybrids and lowest in PNG. The Ivory Coast hybrid 9C X 1001 recorded highest bunch number and lowest in ASD Costa Rica hybrid Deli X Avros. PNG hybrids recorded highest MBW followed by Palode hybrid and lowest in Ivory Coast. Bunch quality parameters revealed that mean bunch weight was highest in Costa Rican hybrids followed by Palode hybrids. Ivory Coast and PNG hybrids recorded highest fruit to bunch ratio. PNG hybrids had lowest shell to fruit ratio. Kernel to bunch ratio was highest in Palode hybrids. Among the four accessions, bunch index was highest in Ivory Coast material followed by ASD Costa Rica and lowest was in PNG. It was interesting to note that Palode hybrids recorded highest SLW indicating their drought tolerance. Highest vegetative dry matter was recorded in PNG and least was observed in Palode.

VII. CRYOPRESERVATION OF OIL PALM GERMPLASM

Oil palm seed has intermediate type of storage behaviour. Seed development and maturation of *oleifera* and *guineensis* showed that both species took around 180-190 days for full maturity and one type of *oleifera* (Surinam *oleifera*) took less time for fruit ripening and maturity. Initial observation indicated that *oleifera* has more sensitivity to moisture desiccation. Critical moisture content required for achieving proper germination is 22 % and reduction of moisture content below about 15 % affects germination and viability.

Matured fruits of *oelifera* were harvested and de-pulped and immediately transferred to polythene bags. Initial moisture content as well as the moisture content at 12 h interval of 20 lots of seeds was determined. Seed drying was performed in heating room maintained at 40^0 C. Samples were removed from the chamber at every 12 h and seed moisture content, germination test and vigour test were conducted. Results indicated that decrease

Table 26. Biometric and yield observations on hybrids from different sources (1996)

D x P cross	Girth (cm)	Height (cm)	Leaf area (cm^2)	LDW (kg)	BI	Mean (2007-11)		
						BN	FFBW (kg)	MBW (kg)
Deli x Avros	256	610	11.46	8.35	0.22	5.1	103.4	20.4
Deli x Ekona	260	551	14.60	9.12	0.19	5.4	119.0	22.4
Deli x Ghana	309	553	12.27	8.26	0.13	5.8	118.3	21.0
Deli x Lame	298	484	10.95	5.87	0.42	5.8	114.4	19.2
65D x 111	270	574	10.59	8.81	0.21	6.1	123.4	20.1
12 x 313	241	527	9.63	8.25	0.18	5.8	123.6	21.5
12 x 266	278	539	9.63	16.03	0.15	5.9	127.6	22.5
128 x 31323	261	511	9.22	7.85	0.32	6.1	122.2	20.6
18C x 2501	298	391	10.50	6.79	0.45	7.4	153.2	20.7
9C x 1001	297	417	9.81	7.01	0.43	8.3	148.9	18.2
1M - 0069DxP	276	560	10.98	8.38	0.10	5.4	119.4	21.4

(LDW: Leaf dry weight; BI: Bunch index; BN: Bunch number; FFBW: Fresh fruit bunch weight; MBW: Mean bunch weight)

in seed moisture was faster at the beginning of drying process and subsequently showed steady decrease during the middle stage. Seed germination progressively reduced as moisture content decreased. Abnormal seedling percent is positively correlated with reduction in germination percent. Seeds with lowest moisture content recorded total mortality of embryo which reflected in nil seed germination.

VIII. GENETIC DIVERSITY ANALYSIS

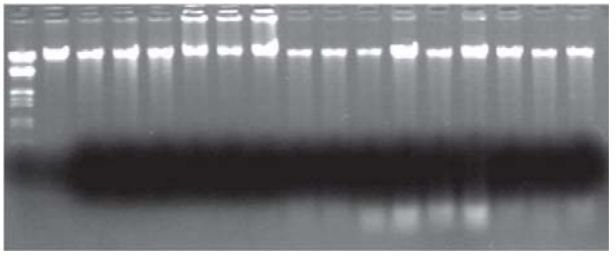
Genetic diversity of 40 high yielding *dura* palms was assessed based on amplification data of 19 selected random primers. A total of 81 reproducible bands was scored, of which 88.88 % was found polymorphic. Cluster analysis was performed based on the similarity matrix using 81 RAPD markers and dendrogram was developed. Dendrogram differentiated the palm Eg 136 from rest of the palms at 0.61 coefficient value. All other genotypes differentiated into two groups (I and II) at 0.67 coefficient value. Group I had 9 palms, where as Group II has two subgroups having 20 and 10 palms. These palms were also characterized morphologically for palm height, girth at 25 cm, sex ratio, number of developing fruit bunches, number of leaves, petiole width, petiole depth, number of leaflets, rachis length, leaflet length. Metroglyph and index score analyses were carried out for all these characters. All the palms were grouped into 9 clusters based on low, medium and high value of palm height and rachis length. Cluster V consists of nine palms, out of which six palms were in close proximity to each other. Palms in other eight clusters showed scatterings, which indicated existence of morphological variation within clusters. In other analysis, character wise index score was assigned and total index score for each genotype was calculated. All genotypes were grouped into three groups based on Mean ± SD values of index scores.

Work has been initiated for genetic diversity of African germplasm using SSR markers. Initially 50 pairs of primers were screened/selected from 119 pairs of designed primers. Phase wise DNA fingerprinting is being carried out using these primers. During the reporting period, 11 SSR primers (SSR-44, SSR-48, SSR-119, SSR-130, SSR-132, SSR-152, SSR-171, SSR-193, SSR -204, SSR -226, SSR-246,) were used, which produced a total of 31 bands. Most of the primer pairs produced amplification on a single locus, however a few amplified and produced band in multiple loci, especially, SSR- 119 and SSR-132. A few primers were identified which could distinguish the *E.oleifera* palms from *E.guineensis* palms. Two random primers OPM-06 and OPP-08 could amplify a unique fragment specific to *E.oleifera*. Similarly, three SSR primers SSR-44, SSR-132 and SSR-204 could distinguish *E.oleifera* from *E.guineensis*. *Eg* and *Eo* specific bands was amplified by SSR-44 primers, where as *Eg* specific band was amplified by SSR-132 and *Eo* specific band could be amplified by SSR-204. These could effectively be used in MAS of interspecific hybrids.

Development of mapping population for traits like shell thickness and fruit colour has been initiated.

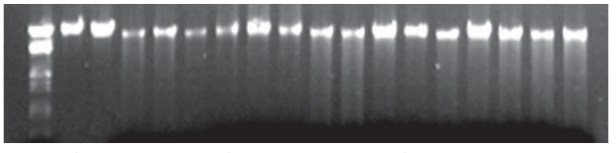
Time and cost saving method developed for DNA extraction from palm leaves: Modified protocol for DNA extraction, which is efficiently working for oil palm, coconut and arecanut palms (reported earlier) is being used as a routine procedure for oil palm for any DNA extraction from leaves at DOPR. As in the case of above palms, this protocol is effectively working for date palm and palmyrah palms also. Sufficient quantity of DNA could be extracted from all the palms (Fig. 3 and Fig. 4). After purification, these DNA samples were successfully used for molecular application like restriction digestion (Fig. 5) and PCR amplification (Fig. 6). A common protocol can be used for isolation of DNA from palm leaves. Special feature of the protocol is, no detergent and no TRIS buffer was required.

Fig. 3: Crude DNA extracted from different palms by the novel method developed at DOPR



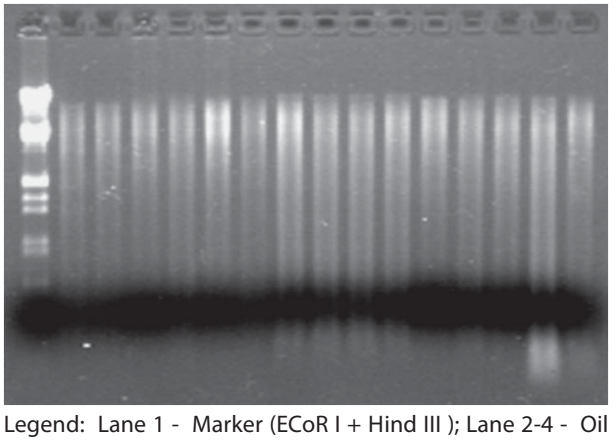
Legend: Lane 1 - Marker (ECoR I + Hind III); Lane 2 – L-DNA (150 ng); Lane 3-5 - Oil palm; Lane 6-8 – Palmyrah; Lane 9-11 - Coconut; Lane 12-14 – Date and Lane 15-17 - Arecanut

Fig. 4: Purified DNA extracted from different palms by the novel method developed at DOPR



Legend: Lane 1 - Marker (ECoR I + Hind III); Lane 2 – L-DNA (100 ng); Lane 3 – L-DNA (150 ng); Lane 4-6 - Oil palm; Lane 7-8 – Palmyrah; Lane 10-12 - Coconut; Lane 13-15 – Date and Lane 16-18 - Arecanut

Fig. 5: Restriction digestion of purified DNA extracted from different palms by the novel method developed at DOPR

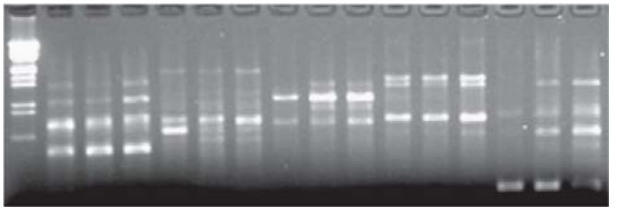


Legend: Lane 1 - Marker (ECoR I + Hind III); Lane 2-4 - Oil palm; Lane 5-7 – Plamyrah; Lane 8-10 - Coconut; Lane 11-13 – Date and Lane 14-16 - Arecanut

IX. DEVELOPMENT OF TISSUE CULTURE PROTOCOL FOR OIL PALM

Media standardized for spear leaf was retested with spear leaf from two palms viz. palm no. 271 and palm no. 71. There was an excellent response for callus induction in palm no.71 with

Fig. 6: PCR amplification of purified DNA extracted from different palms by the novel method developed at DOPR using random primer OPM-06



Legend: Lane 1 - Marker (ECoR I + Hind III); Lane 2-4 - Oil palm; Lane 5-7 – Plamyrah; Lane 8-10 - Coconut; Lane 11-13 – Date and Lane 14-16 - Arecanut

around 25% of the cultures forming embryogenic calli. The callus was nodular and found along on the edges of mid veins. Fig. 7 shows the callus induction obtained within three months on Y3 media with auxins - 2,4 D, picloram along with 2,4,5 T and 2 % activated charcoal and 3 % sucrose.

Embryogenic callus induction from spear leaf of mature palm –Palm No. 71

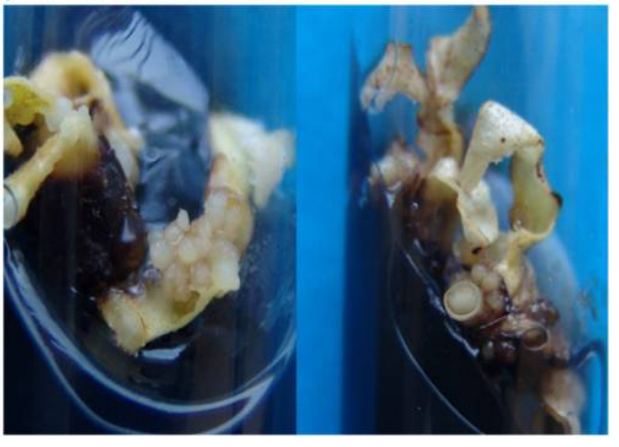


Fig. 7:

Callus induction and somatic embryo formation has been obtained from inflorescence of all the palms inoculated on to the modified media of Texeira *et al.* (1994). Y3 media with a combination of auxins like 2,4-D, picloram and dicamba was found to induce callus within a month or two as compared to 6 months in the above reported media for inflorescence. Somatic embryos also could be induced from this callus. Fig. 8 shows callus and somatic embryos obtained with inflorescence of pisifera 15. Some of the

inflorescence also showed direct shoot formation. An experiment was conducted to find out the response to the position of inflorescence (9th to 12th inflorescence) and genotypes to callus induction. It was found that 9th inflorescence is giving a better response than 12th inflorescence in all the genotypes and the internal inflorescence near the spear leaf is the best for culture giving around 80-85 % response for callus induction in all genotypes.

Embryogenic callus induction from inflorescence of Pisifera 15

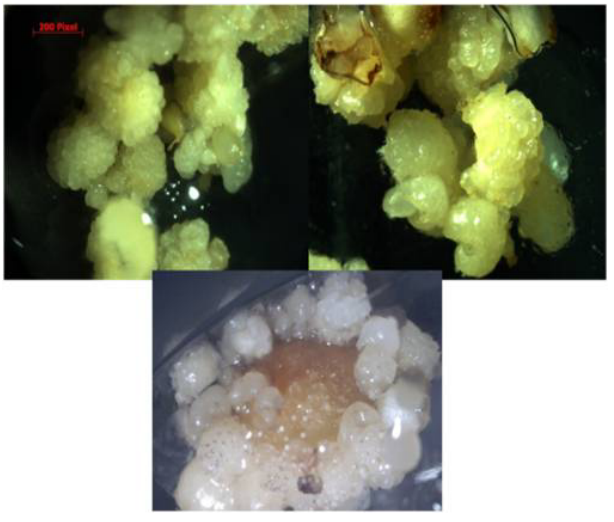


Fig. 8:

Direct embryogenesis was obtained with cotyledonary node tissues of several hybrids like DN23, DG3, M9 and D136 and it was found that all of them produced direct somatic embryos and embryos ranging from 11-47. These somatic embryos are having clear suspensor region and they have the potential to regenerate into complete plantlets. The experiment is also being carried out with immature embryos. The following figures (Fig. 9) show direct embryogenesis and plantlet regeneration from cotyleodany nodes of embryos.

It was found that the response of tissues to callus induction and somatic embryogenesis is very specific. The response of the basal tissues and the apical tissues to callus induction media is different. This response may be triggered by specific proteins and hence the total proteins were

Direct embryogenesis and plantlet regeneration from plumular culture

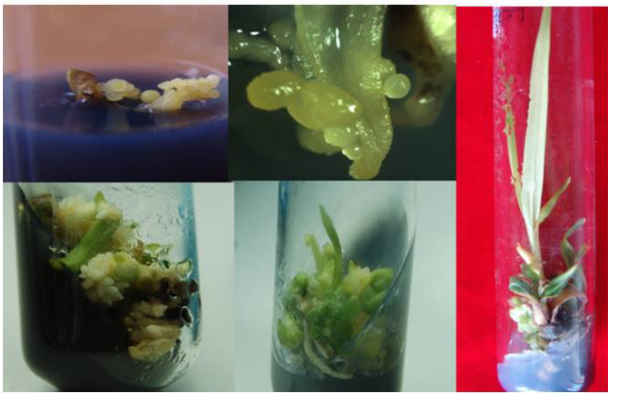


Fig. 9:

extracted and a SDS page was done to find the specific proteins. It was found that the concentration of the protein is more in tip when compared with base portion. The tip portion of germinated embryo is showing a band of molecular weight 85.9 kD which is not present in base portion where as at least 7 protein fractions of germinated embryo base and tip portions show the similar banding pattern of molecular weight 90.2 kD, 75.8 kD, 41.6 kD, 33.1 kD, 9.5 kD ,9.1 kD. The following figure (Fig. 10) shows the pattern of proteins obtained with the basal and tip region.

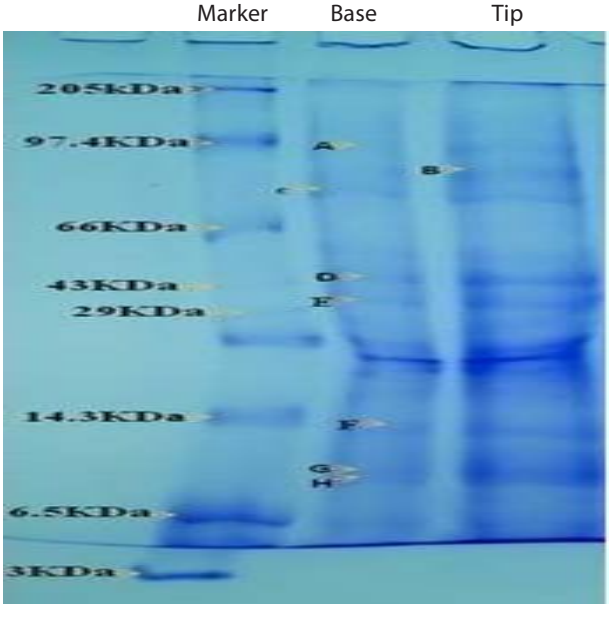


Fig. 10:

Genetic fidelity of tissue cultured clones using random/SSR primers: Twenty custom made SSR primers were used in this study to find out genetic fidelity of Tornado clones. Out of the 20 primers, only two primers gave monomorphic bands and polymorphism given by other primers ranged from 20 to 88. Maximum polymorphism was given by primer 171. The representative pattern of these amplifications is given in Fig. 11. Details of the amplification obtained are also presented in Table 27. The plants in the field are also showing genetic variability in terms of abnormal flowers confirming that SSR primers can be used to test genetic fidelity of tissue cultured clones.

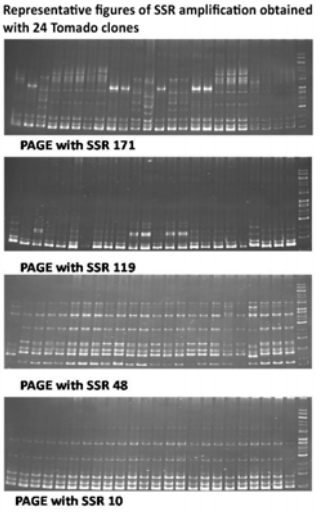


Fig. 11.

Table 27. Details of microsatellite amplification obtained with Tornado clones

Primer no.	Left primer sequen	Right primer sequence	Total bands	No. mono-morphic	No. poly-morphic
8	GGAAGAGGAGATGGGAGAGTGG	CTTTCCCCTCTTTTTGTCGG	3	3	0
10	GTCAAGTTCAGTTAAGACCACC	CACCTCTCTCACTATAGCTCG	5	5	0
41	CCAAGCACAGCAATGCC	GGTATAAGAGCCCAAAAGCG	4	2	2
48	TGAAAACAGCCTAGTGGACCC	ATACACAGCAGGATTACTGACC	10	6	4
105	AGC CCA TCA GAA CAT GGA C	CTA AAT TCT GAG CCC ATG CC	7	3	4
119	GTG AGG TGT GAT GCT GAA GGC	GGA TCG GTT ATA GCT TCC TCC	4	1	3
132	CTGGCGTACTTCCGGTACGG	TCCATGGCTCCATGCAAGGC	4	2	2
138	ACAGTCAAAGCCGAAGGTCC	TTGCATGTTGTCTGCTAGCTCC	4	3	1
140	GATTTAGCAGGGACTTCGC	CATGAAGGACCCTTCCCTCG	2	1	1
163	GGAGAAGCGTGGCTTGAG	GCCCACCAAAAGAAAGTAGTCC	8	5	3
168	ACCAAGCCAATACGCTG	GCATTACTTGGTTATACTTGTTCC	5	2	3
171	GAG TTA TGG AGA TGT AGG AAG G	CTG GAT CCA ATT CAC AAA CC	8	1	7
176	GATGCCCATCGATGACAG	AATTGGAAACTATGCCACCC	2	1	1
185	TGTGCAAGTACATGCGTGCG	AGACCTGATCTGAACTCGACCC	5	3	2
204	GGA CCA AAA CTA GGT AAT GGC	TTA TGA GCA GGA TGG CGA G	4	2	2
215	ACTCAGGGG CAA GGT AGG	CGA ACT CCC TTC AAA TGT CAG C	5	2	3
221	TGT CTA CAA CAA GCC ATG CAC C	ATC CAG GAA ATC CAC CTG GG	5	4	1
225	CCA TGT GCA ATG CTT GTG TGG	ACA CCC AGC TTG GCC TA	3	2	1
226	AAGGAGCTTCGCCCTCGAGC	CCGGAGCAGAGCGGTAAGGG	3	1	2
230	TGT GTA ACG GCA AAT CAC CG	ACC TCT GTT CAC CAG GCT	10	6	4
			101	55	56


Crop Production
Source manipulation in oil palm

CROP PRODUCTION

I. IRRIGATION MANAGEMENT IN OIL PALM

Pre-experimental data revealed that bunches per palm were ranging from 4.8 to 5.8 and FFB yield was ranging from 15.0 to 16.8 t/ha. Soil analysis indicated that soil pH and EC were normal, organic carbon was low, P_2O_5 was very high and potash varied from low to high. Software was developed for entering morphological and yield data.

II. NUTRIENT DYNAMICS IN OIL PALM UNDER DIFFERENT FERTILIZER LEVELS

Pre-experimental data on growth and yield parameters were collected. Similarly, pre-experimental soil samples were collected and analysed. The data revealed that bunches per palm ranged from 4.2 to 6.4 and FFB yield ranged from 12.8 to 19.9 t/ha. Soil analysis indicated that pH and EC were normal, organic carbon was low, P_2O_5 was very high and potash was low to medium.

III. STUDIES ON REPLANTING TECHNIQUES IN OIL PALM

Work under this project was started during 2007 at Oil Palm India Limited estates, Bharathipuram , Kollam district, Kerala in the palms planted during 1972. One third of the palms retained in treatment T_3 were cut and removed. Morphological observations were recorded from selected seedlings and the performance of seedlings was almost comparable among treatments. The young palms in T_2, where alternate palms were removed during first year and rest of the palms during second year, recorded maximum girth, leaf production, leaf area of 9th leaf and number of female flowers. Soil samples collected from two depths 0-15 cm and 15-30 cm and leaf samples from 3rd leaf were analysed for nutrient status. In general, organic carbon was high, available nitrogen, low to medium, available phosphorus in medium range and available potassium, low in all the treatments (Table 28). However, there was a build up of organic carbon and nitrogen with depth in T_4, where palm parts have fallen and decayed gradually.

IV. UTILIZATION OF BIOGAS SLURRY FROM POME FOR NUTRIENT MANAGEMENT OF OIL PALM

A biogas plant with 6 m^3 capacity was constructed for utilizing POME from palm oil mill of the station for biogas production and utilization of nutrients. Since palm oil mill at the station was not functioning, POME from OPIL was transported and fed into the plant regularly and gas production was found satisfactory. Fresh effluent samples, fresh slurry after digestion and slurry retained in open tanks at different intervals were analysed for BOD, COD, nutrient and other biochemical parameters. Both BOD and COD could be brought down to safer limits for soil application by subsequent retention of biogas digested slurry in open tank for one month. Biogas production

Table 28. Nutrient status of soil in different replanting treatments

Treatments	Organic carbon (%)		Available Nitrogen (ppm)		Available Phosphorus (ppm)		Available Potassium (ppm)	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
T_1	2.49	1.65	121.1	112.0	11.7	10.9	45.2	42.6
T_2	2.43	1.63	119.0	106.4	14.0	12.3	42.6	40.6
T_3	2.26	1.67	130.2	106.4	14.0	13.4	45.2	41.2
T_4	2.51	1.88	117.6	121.1	12.3	12.3	42.0	37.6

potential from POME was assessed. On an average, 1.4 m^3 of biogas was produced for every 100 litres of POME fed to the plant. The value could go high, when its capacity utilization is better. Trials on composting empty fruit bunches with digested slurry and fresh POME were carried out with and without urea as starter. Periodical sampling was done and samples were analysed for C/N ratio and nutrient values. The initial C:N ratio of 90 could be brought down to less than 20 in a period of four months. Field experiment was initiated with seven sets of treatments in young palms. Biogas slurry and slurry compost were applied to palms depending upon the treatments.

V. PERFORMANCE OF OIL PALM IN KARI LANDS OF KERALA

Observations on growth performance and flowering characters of palms in the selected blocks in kari lands were recorded (Table 29). Soil samples collected from different depths were analysed for physical properties and available nutrient status. Organic carbon was very high, available phosphorus low and available potassium high and decreased with soil depth. Foliar analysis showed that nutrients were in optimum range wherever the palms are well managed. However, continuous rains and flood during the year affected crop stand. Data were compiled and compared with that of normal mineral soils.

VI. STUDIES ON NUTRITIONAL DISORDERS IN OIL PALM UNDER IRRIGATED CONDITIONS

Thirty eight nutrient deficient palms were selected at the DOPR Research Farm with the help of apparent visual symptoms on leaves. Leaf analysis data from the selected palms indicated that potassium content varied from 0.40% to 1.34%, whereas, phosphorus is deficient in almost all the samples. Calcium and magnesium contents were normal. Zinc is deficient in all the palms. Soil samples revealed that pH ranged from acidic to normal, electrical conductivity was normal while, organic carbon was very low. Phosphorus and potassium contents were very high.

VII. STUDIES ON SOURCE SINK RELATIONSHIP IN OIL PALM

Two trials were undertaken during 2005 by manipulating the source (pruning of fronds – 9, 17, 25, 33 and control) and sink (removal of floral buds – 25, 50, 75, 100 % and control). During report period, regular imposition of source and sink treatments were done every month. Morphological observations along with yield were also undertaken at monthly intervals. Among the sink manipulation treatments, bunch number was highest when 25 percent sink were removed followed by 50 and 25 percent removal. The lowest number of bunches were recorded when 75 percent sinks were removed. Similarly, the bunch weight was maximum with 25 percent removal of sinks followed by 50 percent removal. The lowest bunch weight was recorded when 75 percent removal of sinks were done. In the source manipulation experiment, when fronds were pruned from 9th frond onwards, yield was zero. The bunch number was maximum when fronds were pruned from 25th frond closely followed by 17th frond. The lowest number of bunches were observed when fronds were pruned from 33rd frond onwards. The bunch weight was maximum when fronds were pruned

Table 29. Performance of palms in kari land compared to mineral soils

Years	4 yrs		5 yrs		6 yrs	
	Kari land	Mineral soil	Kari land	Mineral soil	Kari land	Mineral soil
Sex ratio	0.44	0.32	0.43	0.29	0.47	0.23
Number of bunches	6.01	3.38	9.00	5.38	13.15	7.01
FFB yield (kg palm^{-1})	32.5	16.51	93.00	23.11	169.00	36.62

from 33rd frond onwards followed by 25th and 17th fronds. The lowest bunch weight was recorded when fronds were pruned from 17th frond onwards. Among the different treatments, highest FFB yield was obtained when fronds were pruned from 25th onwards followed by 33rd frond and 17th frond. The experiments are being continued.

A faster indirect method of estimating leaf area index in oil palm: Leaf Area Index (LAI) indicates leafiness of a crop and is the ratio of total upper leaf surface of crop divided by surface land area on which crop grows. Leaf area index is used in simulation models based on efficiency of conversion of radiation into biomass and to predict photosynthetic primary production. Oil palm is a highly productive crop under well managed systems and converts a relatively high proportion of the available solar energy to harvestable dry matter. However measurements of LAI in oil palm are usually done by direct methods, which are destructive, time consuming and expensive. A faster indirect method of measuring LAI in oil palm has been developed for oil palm. LAI will be measured with the help of Li-Cor PCA. It comprises of an optical sensor connected to a data logger. The sensor has a fish eye lens that receives radiation within an angle of 148^{O}, a mirror and an optical filter that transmits diffuse radiation to five silicon rings. The data transmitted from sensor will be logged to a logger, which in turn makes necessary calculations for determining LAI and mean angle of inclination of foliage. LAI was determined in individual palms by taking one above canopy observation in open area followed by eight under canopy observations at 2 m distance from palm. The LAI in whole plant canopy was measured diagonally between six palms by taking five transects. For each transect, one above canopy observation in open sky is taken followed by six equidistant observations below canopy. The direct method was also done by taking direct measurements on a sample of leaflets and leaves and LAI determined. Comparison of indirect measurement of LAI with direct one indicated a strong correlation ($R^2 = 0.98$) between them. Hence the present indirect method of estimating LAI using plant canopy analyzer is faster, amenable to automation and allows for a larger number of spatial samples to be obtained over that of traditional direct method.

VIII. CARBON SEQUESTRATION POTENTIAL OF OIL PALM

Two adult palms (Palm No 606 and 621) were destructed to analyze biomass and carbon distribution among the different plant parts. Biometric parameters like plant height, girth, number of fronds, rachis length, petiole length, width, leaf width and breadth was taken for all the fronds. Fresh weights of trunk, rachis, leaflets and roots were taken and representative samples of them were dried in hot air oven and later taken their dry weights. The biomass in palm no 606 consisted of 270 kg of trunk, 73.27 kg of fronds and 11.3 kg of roots. While the biomass in palm no 621 consisted of 173 kg of trunk, 124 kg of fronds and 8.24 kg roots. In general, carbon contents were low in younger leaves and higher in older leaves. The carbon contents in oil palm trunks, fronds and roots ranged from 192-327 kg, 402-627 kg and 20.6-28 kg respectively.

IX. LEAF BREAKING IN OIL PALM

Drought susceptibility indices were calculated for four populations in MFS experiment. Morphological parameters like broken fronds, dried and yellow leaves were recorded in all populations. Non destructive estimation of leaf area and dry matter production was also done for all the sources. Palms from Palode populations recorded lower drought susceptibility indices indicating their better tolerance to drought. Plant moisture status and chlorophyll stability indices were also calculated for all the sources. A perusal of chlorophyll stability indices in different sources indicated that it was high in source with lowest drought susceptibility indices. Hence these indices could be used as markers for palms affected with leaf breaking symptoms.

X. ESTABLISHMENT OF LEAF ANALYSIS LABORATORY - NUTRIO-PHYSIOLOGICAL CHARACTERISTICS OF OIL PALM UNDER IRRIGATED CONDITIONS

1. Soil testing and Leaf analysis – Advisory service to oil palm farmers

Soil and leaf samples received from oil palm growing farmers, samples received through oil palm factories and samples of on-going research projects at DOPR were analyzed for various parameters/ nutrient elements. Appropriate advisory service was extended for suitable soil and fertilizer management in oil palm gardens of Andhra Pradesh. Details of samples analysed are given below:

A perusal of the nutrient status of oil palm growing soils in different mandals of East Godavari district of Andhra Pradesh indicated that the pH was high (alkaline) in KT-1 and UGM mandals, very low (normal) in CL mandal. The organic carbon is high in KT-1 mandal, Low in KT-1, BV-1, BEL-1 and BEL-2 mandals. The available phosphorus levels are high in K1 mandal and low in KT-1 mandal. The available potassium levels are high in BL-1 mandal and low in BV-1 mandal.

2. Standardization of chlorophyll meter for evaluating foliar nutrition and health in relation to nutrient and environmental stresses.

The CCI values obtained in CCM-200 is an index that indicates green colour of tissue and can be utilized in estimation of the chlorophyll content of leaves. In the current study, we are trying to establish correlation between CCI index of CCM-200 and its concurrent spectrophotometric values of chlorophyll a, chlorophyll b, and total chlorophyll as well as carotenoids. For this purpose, 88 leaf samples from palms of various sources available at DOPR were collected and were done in triplicate. Among these samples, lowest CCM-200 value (72.4) was recorded in *tenera* population and highest (146.3) in Palode *Dura*. For leaf samples in which total chlorophyll content (> 520 µg/mg) estimated by spectrophotometric method, CCM-200 could not record the values as it was too dense.

3. Standardization of digital color analysis for evaluating foliar nutrition and health in relation to nutrient and environmental stresses.

Changes in foliar colour are a valuable indicator of plant nutrition and health. Digital colour analysis is cost-effective method for evaluating foliar nutrition and health in response to environmental stresses. So a new method of digital image analysis that uses Scion Image or NIH image public domain software to quantify leaf colour is being used for the percentage of green colour for assessment of chlorophyll content. Comparisons of results from digital analyses images of leaves and its concurrent spectrophotometric measures of chlorophyll *a*, chlorophyll *b*, and carotenoids is being carried out to attain reliable quantitative measure of leaf colour and the relative concentrations of underlying plant pigments. For this purpose, 100 leaf samples from palms of various sources available at DOPR were collected. Among these samples, the lowest CCM-200 value (85.4) was recorded in *tenera* population and highest (136.8) in *Dura* population.

S.No	Sample	Samples received from	Samples analyzed	Parameter/ nutrient elements analysed
1	Leaf	Farmers, Oil Palm Entrepreneurs & Research Projects	437	P, K, Ca, Mg, Fe, Mn, Cu and Zn
2	Soil	Farmers, Oil Palm Entrepreneurs & Research Projects	257	pH, EC, Organic carbon, P, K, Ca, Fe, Mn, Cu and Zn
3	Water	Farmers	5	pH and EC

4. Training programme on Oil Palm leaf analysis

A series of lectures on importance of nutrients, leaf sampling techniques, fertilizer recommendation etc was imparted to trainees during training programme on "Oil Palm Leaf Analysis" held during December 14-15, 2010 at DOPR, Pedavegi.

XI. BIOCHEMICAL BASIS FOR GROWTH AND YIELD OF OIL PALM

(i) Comparative studies on *virescens* and *nigrescens* bunches of oil palm : The objective of experiment was to study bunch components and oil quality of green fruit type (*virescens)* bunches in comparison with purple fruit type (*nigrescens)* bunches of oil palm. Different parameters like bunch weight, stalk weight %, spikelet weight %, fruit / bunch %, mean fruit weight, nut / bunch %, mesocarp/ bunch %, moisture content in the mesocarp %, oil in the dry mesocarp %, oil in the fresh mesocarp % an oil/ bunch % as bunch component analysis were studied. Free fatty acid content and fat acid composition of the oil were analyzed as oil quality parameters.

It was observed that there is no significant difference between the two fruit types, both in terms of bunch components as well as FFA and fatty acid composition except for mean fruit weight. This was significantly higher in case of *virescens* than that of *nigrescens*. Other two parameters namely stalk/bunch % and spikelet/ bunch % showed significant difference. Further analysis was carried out for interaction between the fruit type and variety. It was observed that there is no significant difference in FFA and fatty acid composition among the combinations. Most of the bunch components were on par except oil/ bunch %, mesocarp/bunch % and nut/ bunch % (Fig. 12, 13 & 14). Oil/ bunch % was highest in Vir-DN combination which was on par with Vir-DG and Nig-DN combinations, however, significantly higher than that of Nig-DG combination.

Fig. 12 : Mesocarp/bunch % in *virescens* and *nigrescens* bunches in interaction with DN and DG hybrids

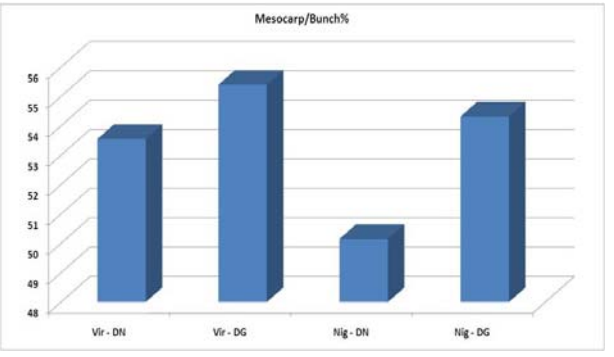


Fig. 13: Nut/bunch % in *virescens* and *nigrescens* bunches in interaction with DN and DG hybrids

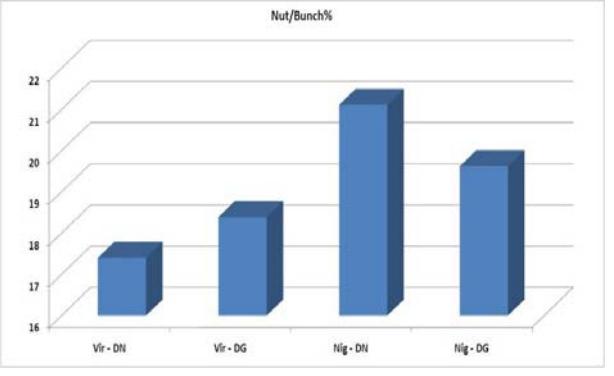
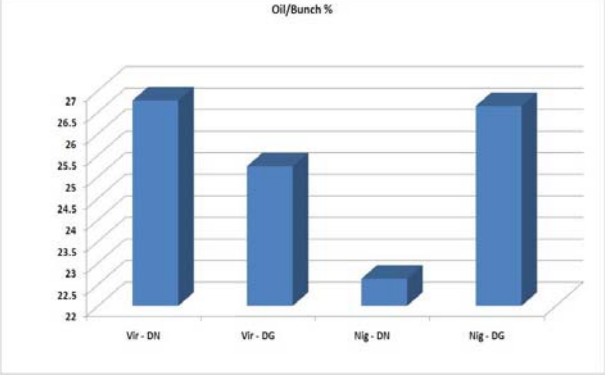


Fig. 14 : Oil/bunch % in *virescens* and *nigrescens* bunches in interaction with DN and DG hybrids



Mesocarp/bunch % was highest in Vig-DG followed by Nig-DG combinations, but no significant differences were observed. Vir-DN was on par, but Nig-DN showed significant difference. And this lower amount of mesocarp content in Nig-DN combination resulted in lowest level of oil/bunch %.

As there were two hybrids involved and several bunches from each hybrids were analyzed, the data was utilized to have a comparative study between the two hybrids (DN and DG). However, none of the parameters showed any difference between the two hybrids except for linoleic acid %.

(ii) Seasonal changes in oil formation and fatty acid composition (pollination to maturity) in fruits of *tenera* hybrid under irrigated conditions: An experiment has been initiated during this year to know the oil formation and fatty acid composition of the mesocarp oil during bunch development under irrigated conditions of coastal Andhra Pradesh during different seasons. *Tenera* bunches (female flowers) were tagged every month during flower opening. Fruit samples were collected four weeks after pollination on weekly basis. Till 11 weeks after pollination, no oil formation was observed.

XII. STUDIES ON INTER CROPPING IN BEARING OIL PALM PLANTATIONS

The trial has been initiated in 2007 to evaluate the performance of inter crops in oil palm gardens and study interaction between the base crop and test crops and it's impact on the base crop. Cocoa, banana, bush pepper, vine pepper, betel vine, heliconia and red ginger were planted. Data on yield of oil palm and inter crops i.e., heliconia, red ginger and bush pepper were collected. Red ginger and heliconia produced 16.5 and 12.2 commercial grade spikes/plant/year respectively. Light intensity was measured at monthly intervals and mean light intensity in the block was 20 percent. More FFB yield/palm/year (48.73kg) was recorded in inter cropped area as compared to control (16.55kg). Interaction between inter crops and oil palm has been found synergistic when compared to mono cropping. The yield of helioconia was under decline. However, the yield of red ginger got increased when compared to last year.

XIII. MULTILOCATION TRIAL ON THE PERFORMANCE OF COCOA VARIETIES

A study has been initiated in December 2007 to evaluate the performance of 13 cocoa varieties of CPCRI under shade of oil palm in comparison with coconut. Mean light intensity (PAR) measured at monthly intervals in oil palm (21 year old) garden and coconut (21 year old) garden were 23.4 and 38.8 percent respectively. Among the varieties, highest number of pods/tree was recorded in I-14 (11.3) whereas the lowest was observed in II-67 (1.74).

XIV. STUDIES ON MIXED FARMING IN IRRIGATED OIL PALM PLANTATIONS

Nine varieties in guinea grass and 3 varieties in napier grass have been collected and planted in inter space of oil palm and open conditions and observations on growth and yield of varieties are under progress. Initiated work on vermi-composting and mushroom culture using farm waste and EFB, respectively. Oil palm has been integrated with dairy (2 buffaloes) and recording of milk yield has been in progress. Quantification of biomass of the system is in progress. The mean light intensity in oil palm garden (7 yr) was 20.58 percent. Among four sources (Malaysia, Palode, Deli x Ghana and Deli x Nigeria) of oil palm, DxG recorded the highest number of bunches (7.88) and maximum bunch weight (120.2 kg) while Malaysia recorded the lowest number of bunches (4.74) and minimum bunch weight/palm (72.2 kg).

XV. NURSERY MANAGEMENT IN OIL PALM

(i) Effect of biofertilizers on growth and vigour of oil palm seedlings: A study on effect of biofertilizers on growth and vigour of oil palm seedlings has been started in November 2010 to cut down the use of chemical fertilizers. The experiment was laid out in CRD with 11 treatments and five replications. Soil:Manure: Sand (2:1:0.5),

Azotobacter chroococcum, Azospirillum brasilense, Bacillus megaterium, Glomus agregatum, Frateuria aurantia, Mixture (Azoto+Azospi+Baci+Glomus+ Frat), 100% RDF, BIO+ 75% RDF, BIO+50%, BIO+255 and Control are the treatments used for the study. Observations at 3 month interval on various morphological and physiological parameters, soil and leaf analysis, microbial count and destructive analysis are under progress.

(ii) Studies on fertigation in oil palm nursery : A study on effect of fertigation on growth of oil palm seedlings has been initiated in October 2009. There were five treatments (194 g, 145.5 g, 97 g, 48.5 g and control-manual application of 194 g of DAP and complex fertilizers(19:19:19). Results indicated that the seedling height (137.25 cm), number of leaves/seedling (21.75) and stem girth (29.67 cm) and total seedling biomass (798.73 g) have been found the maximum in seedlings treated with 97g of NPK fertilizer whereas the minimum seedling height (95.50 cm), number of leaves (18.25) stem girth (22.20 cm) and total seedling biomass (513.64 g) were observed with 194 g of NPK applied through fertigation.

(iii) Effect of POME sludge on growth and vigour of oil palm seedlings

A study on effect of POME sludge on growth and vigour of oil palm seedlings was conducted during 2010-11. There were 7 treatments namely soil+POME (4:0.5), soil+POME (4:1), soil+POME (4:1.5). soil+POME (4:2), soil+FYM+NPK and soil+NPK. Among the treatments, the best results for all the characters studied were noticed with soil+POME (4:1). The maximum values for main characters like seedling height (185.34 cm), stem girth (38.23 cm) and number of functional leaves/ seedling (19.50) were recorded with soil+POME (4:1) while the minimum values were recorded (141.75 cm, 28.64 cm and 15.75) for the said characters in soil+NPK.

XVI. YIELD MAXIMIZATION IN OIL PALM UNDER RAINFED CONDITIONS

The experiment was initiated during 2010 to assess the production potential of oil palm in terms of bunch yield and oil yield under rainfed conditions. The palms comprised of five promising combinations of *dura* and *pisifera* as 120D x 111P, 65D x 111P, 12D x 310P, 7D x 266P and 35D x 310P. The technical programme consists of timely cultural operations, fertilizer application based soil and leaf analysis, split application, correction of deficiency symptoms as and when required, organic manure application through nutrient recycling, mulching etc. Soil and leaf samples were collected, analysed for nutrient status and fertilizers were applied. $MgSO_4$ was applied to correct Mg deficiency. Biogas slurry and composted slurry with empty bunches were applied. Yield data recorded. Bunch analysis was done for random samples of different combinations to assess the initial yield parameters.

XVII. MEGA SEED PROJECT: SEED PRODUCTION IN AGRICULTURAL CROPS AND FISHERIES

Oil palm seed sprouts (15000) sent from DOPR, RC, Palode were raised in nursery for 5 months and 8600 seedlings were supplied to M/s. MSN Raju Oils Pvt Ltd, Bandur, Ananthpur, AP.


Crop Protection
Scaring devices for avian pests

CROP PROTECTION

I. STUDIES ON INSECT PESTS OF OIL PALM AND THEIR MANAGEMENT

(i) Roving surveys :

Roving survey was carried out in oil palm plantations and nurseries located in all the districts of Andhra Pradesh, parts of Orissa and Karnataka. Moderate incidence of rhinoceros beetle was observed in all the states. Moderate to heavy incidence of leaf web worm was observed in all the plantations surveyed in West Godavari, Krishna and East Godavari districts of Andhra Pradesh. The pest was found very active causing defoliation during winter months which was extended till March. Negative correlation was observed between pest incidence and sun light penetration into the plantation. Psychid incidence was found increasing in plantations treated with insecticides against leaf web worm indicating secondary pest out break condition. The pest was found causing a loss of 3.88 % of leaf area by means of defoliation. Incidence of slug caterpillar was found moderate to heavy in Krishna district making palms completely dried. Inundative release of *Trichogramma embryophagum* was carried out against leaf web worm but not found any impact on its management. Close spacing leading to intermingling of leaves of adjacent palms and flood irrigation were found as congenial conditions for the attack.

In the nursery, grass hoppers and psychids were observed causing moderate damage. The new pest, *Silvanus* sp., which was observed for the first time during 2009-10, was found to cause defoliation on oil palm during the current year also, but to a lesser extent. The infestation was observed till September in West Godavari and Vizianagaram districts of Andhra Pradesh. In all the cases, incidence was coupled with leaf rot fungus, *Glomerella* sp.

In a field survey it was recorded that leaf web worm, *Acria* sp.was parasitized by both larval and pupal parasitoids. Moreover the pest was infected by entomopathogens. However, their identity is yet to be ascertained after consulting with the taxonomists. These parasitoids and entomopathogens may be tapped for the management of this pest in the coming years.

(ii) Studies on preferential difference of rhinoceros beetle incidence on arecaceae palms:

The percent incidence and infestation of rhinoceros beetle on both oil palm and coconut observed at monthly intervals revealed that the pest prefers to cause more damage to coconut rather than oil palm (Table 30 & 31). The symptoms observed in oil palm are not seen in case of coconut. Correlation studies made between per cent infestation and chemical composition of palm fibres clarifies the difference with more lignin content in coconut compared to oil palm. Whereas oil palm is having more cellulose and holocellulose contents. In spite of this reason, the pest was found to prefer coconut causing more damage compared to oil palm. Symptoms of damage reveal that pest is attacking only leaf silhouette in case of coconut, where as it prefers to attack petiole portions in oil palm. This could be the reason for low incidence and infestation on oil palm as the petiole portions have more lignin compared to leaf silhouette. These observations conclude that pest feeding area makes the difference in intensity as well as incidence. Since both the palms are side by side, the pest is found to change its preference to coconut compared to oil palm causing more percent incidence and infestation even though more food material in form of more number of leaves are available in oil palm. Similar is the case with palmyrah palm where the incidence and infestation was less compared to coconut.

Table 30. Comparative infestation (%) of rhinoceros beetle on Arecaceae palms

Month	Oil palm	Coconut
June, 2010	6.60	22.97
July	13.32	24.80
August	6.07	24.40
September	3.99	24.03
October	2.58	11.30
November	2.30	13.39
December	2.70	16.39
Jan. 2011	3.64	19.82
February	0.96	18.88
Mean	4.68	19.55

Table 31. Rhinoceros beetle incidence and infestation in different arecaceae palms

Palm	Incidence (%)	Infestation (%)
Palmyrah	40.9	8.2
Coconut	65.0	10.2
Oil palm	62.0	5.6

(iii) Bioefficacy studies on leaf eating caterpillars:

Injecting the insecticide into the stem using saline pouches was found effective and easy method for controlling lepidopterous pests of oil palm. This method could effectively control psychids and leaf web worms and proved easy and safe for pollinating weevils compared to others. Experiments were carried out in farmers' fields to study efficacy of different methods of insecticide application viz., stem injection, root feeding and soil application against oil palm leaf web worm, *Acria sp*. and psychids. Stem injection method using imidacloprid @10 ml per palm recorded highest change over control followed by soil application method. (Table 32)

In the other experiment that was carried out against leaf web worm, soil application of phorate granules at the rate of 100 g/palm was effective in bringing down the population to 87.1 % over control (Table 33).

Table 33. Percent change of leaf web worm incidence in different treatments

Treatment	Percent reduction over control
Stem injection	48.2
Root feeding	36.3
Phorate- soil application	87.1
Control	-

II. STUDIES ON AVIAN AND MAMMALIAN PESTS OF OIL PALM AND THEIR MANAGEMENT

Roving survey carried out in oil palm plantations and nurseries located in all districts of Andhra Pradesh, parts of Orissa and Karnataka indicated heavy incidence and infestation of avians including crows and mynahs. Incidence was observed in isolated gardens of Krishna district causing more than 10% loss. An experiment was

Table 32. Percent psychid incidence in different treatments

Treatment	Incidence (%)				
	Pre treatment	15 DAT	% change	25 DAT	%change
Stem injection (Monocrotophos 20 ml per palm)	168	36	78.57	44	73.80
Stem injection (Imidacloprid 10 ml per palm)	150	32	78.66	22	85.33
Soil application (Phorate 100 g per palm)	187	20	89.30	36	80.74
Soil application (Carbofuran 100 g per palm)	149	20	86.57	36	75.83
Control (Water spray)	162	140	13.58	212	-30.86

carried out to scare or repel avian pests in *dura* block and MFS oil palm plantations of DOPR. The treatments include specially designed scarring CDs, egg emulsion (1 egg/5 l water). The CDs were hung on ripening fruit bunches. The egg emulsion was sprayed on fruit bunches. Before imposing treatments, the number of fruits damaged in ripening bunches were counted. They were monitored regularly and observations on post treatment effect were made at the time of harvesting those bunches. Among the treatments, CDs having yellow and red images scarred the birds very effectively. Egg emulsion treatment did not have any appreciable effect in controlling the pests.

III. COMMERCIAL PRODUCTION OF GREEN MUSCARDINE FUNGUS *METARHIZIUM ANISOPLIAE* FOR CONTROL OF INSECT PESTS

Experiments were conducted to observe the effect of different bioagents namely *Metarhizium anisopliae* and *Trichoderma viride* on water fern (Table 34). It was observed that mixing growing media with powdered form of bioagents was effective in enhancing growth and yield of Azolla compared to broth material. Of different bioagents, *Metarhizium anisopliae* was found to record more growth compared to *Trichoderma viride*.

Twelve consignments of egg parasitoid, *Trichogramma embryophaga* were procured from NBAII, Bangalore and released in the leaf web worm endemic field to study the effect of parasitoids on the pest management. The release was however not found effective as the pest out break was again observed.

IV. STUDIES ON POLLINATING WEEVIL, *ELAEIDOBIUS KAMERUNICUS* (FAUST) IN IRRIGATED OIL PALM GARDENS

Preliminary studies were carried out to observe the activity of pollinating weevils in Vizianagaram (Dt), A.P. and Rayagada (Dt), Orissa. Abundance of weevil population and their natural enemies viz., spiders, reduvid bugs were commonly seen in all the gardens. Maximum activity of weevils visiting female inflorescences was observed during 9.00 and 12.00 hours. It was also observed that whenever insecticides like monocrotophos were sprayed for control of leaf web worm, weevils either abandoned the gardens or activity was minimal.

Flubendiamide was tested along with other insecticides for their selectivity against pollinating weevils and found safe by not causing any mortality to pollinating weevils as well as its predators.

Table 34. Comparative efficacy of bioagents on the growth and yield of *Azolla pinnata*

S.No.	Treatments	Weight of host material (g)			
		Initial	10 DAT	Net gain	Gain over control (%)
1	FYM	25	196	171	56.88
2	FYM+ Carrier material ($MgCO_3$)	25	190	165	51.37
3	FYM+ Ground cake broth	25	185	160	46.78
4	FYM+*T . viride(powder formulation)*	25	225	200	83.48
5	FYM+ *M. anisopliae (P.F.)*	25	250	225	106.42
6	FYM+*M. anisopliae*+*T. viride(P.F.)*	25	300	275	152.29
7	FYM+*M. anisopliae(broth)*	25	170	145	33.02
8	FYM+*T. viride(broth)*	25	176	151	38.53
9	Control (water alone)	25	134	109	-

V. STUDIES ON DISEASES OF OIL PALM AND THEIR MANAGEMENT

Experimental plots of DOPR, Pedavegi were surveyed for disease incidence. Bud rot, bunch end rot, leaf rot and orange spotting were observed and necessary control measures were taken. Diseases like early leaf disease, leaf spots and leaf rot were observed in nursery. Further, survey was done in farmer fields in the districts of West Godavari (bud rot, orange spotting, BSR, stem wet rot) , East Godavari (BSR, bud rot), Krishna (bud rot, BSR) Khammam (USR, orange spotting), Vijayanagaram (bud rot, bunch rot), Visakhapattanam (BSR) of Andhra Pradesh and in Gunupur district of Orissa (bud rot, BSR, bunch rot). A survey on incidence of basal stem rot was taken up in Visakhapatnam, East Godavari, West Godavari, Krishna, Khammam Districts of Andhra Pradesh. The incidence varied from 2.9 % to 52.85 %.

Five bacterial isolates from bud rot affected palms and five bacterial isolates from stem wet rot affected palms were isolated. The pathogenic studies in *in vitro* and *in vivo* are going on. In *in vitro* hydroponic cultures, culture filtrate inoculations were done. In *in vivo,* soil and foliar inoculations were done with bacteria and are being observed periodically for development of symptoms.

Genetic diversity study of native *Trichoderma* isolates: Fifteen native *Trichoderma* isolates were collected and subjected to RAPD analysis for their genetic diversity. During the reporting period, work has been completed and data analysis was carried out. 370 loci were scored using 46 primers with a mean of 5.87 loci/ primer. However, most of the loci were polymorphic (97.84 %) and 8 loci were monomorphic. A representative photograph is presented in Fig. 15.

Fig. 15 : Genetic variability of *Trichoderma* isolates

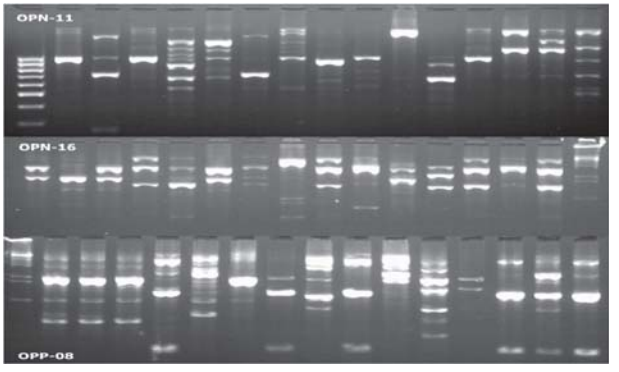
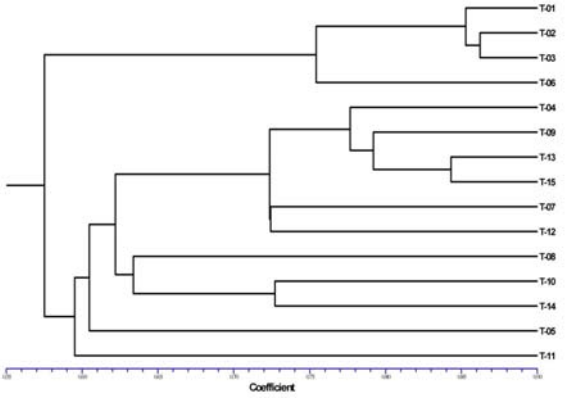


Fig. 16 : Dendrogram showing clusters of 15 native *Trichoderma* isolates



Clustering by UPGMA method showed three clusters with 4, 6 and 3 isolates respectively and two isolates, T-05 and T-11 did not form any cluster (Fig.16). Similarity value was maximum between T-02 and T-03 (0.862) and lowest between T-02 and T-14 (0.511). Results showed that all 15 isolates were genetically different.

Post Harvest Technology

Harvesting with motorised sickle

POST HARVEST TECHNOLOGY

I. DEVELOPMENT OF GRADING SYSTEM FOR OIL PALM FFB AND ESTIMATION OF FACTORY LEVEL OER

The work on developing grading system was continued with *nigrescens* and *virescens* bunch types.

Fruit type - *Virescens*: Fifty six bunches of varying ripeness stages were evaluated for biochemical as well as color parameters (Table 35 & 36). Analysis of the data revealed significant variation in all the parameters with ripeness stage.

Carotene content varied from 9.93 ppm in unripe fruits to 407.49 ppm in ripe fruits, showing increasing trend with ripeness. Oil to dry mesocarp was 7.63 % in unripe fruits, 57.71 % in under ripe and 73.2 % in ripe fruits. Oil to wet mesocarp was 2.15 % in unripe, 38.5 % in under ripe and 48.64% in ripe fruits. Mean moisture content was highest in unripe fruits (61 %) and it was 41.8 % in under ripe and 33.4 % in ripe fruits. Percent weight of mesocarp to fruit was 49.15 in unripe fruits, 77.67 in under ripe and 73.55 in ripe fruits.

Images of bunches were acquired with digital camera and converted to color values on RGB scale. The red colour value was 140.87 in unripe, 159.25 in under ripe and 134.87 in ripe fruits. The green colour value was 141.97 in unripe, 114.5 in under ripe and 79.06 in ripe fruits. The blue colour value was 108.24 in unripe, 67.7 in under ripe and 48.25 in ripe fruits. The red to green ratio was 0.985 in unripe, 1.39 in under ripe and 1.76 in ripe fruits. The prediction models for loose fruits for oil to dry mesocarp are :

148.882-1.445G+0.918R-50.165R/G: where R^2=0.71
78.714-0.676G+0.330R: where R^2=0.64
108.111-0.5G: where R^2=0.50

The L*a*b* values for whole bunch samples were measured in D 25LT Hunter colorimeter. The L value increased from 21.1 in unripe fruits to 23.94 in under ripe and 28.41 in ripe fruits. The a* value also increased with ripeness of the fruit. The b* values also showed increasing trend from under ripe to ripe. The L*/a* was -22.25 in unripe fruits, 35.85 in under ripe fruits and 3.16 in ripe fruits. The L*/b* was 6.625 in unripe, 3.09 in under ripe and 2.33 in ripe fruits. The unripe fruits recorded a*/b* value of -0.673 and under ripe and ripe fruits recorded 0.285 and 0.673 respectively. The prediction model for loose fruit samples for oil to wet mesocarp=10.858+1.25 a* where, R^2=0.63

Fruit type - *Nigrescens*: One hundred and thirty five bunch samples were analyzed for biochemical and color parameters during the period (Table 37 & 38). Analysis of variance indicated that there was significant difference for all the parameters with the stage of ripeness.

Carotene content was 18.13 ppm in unripe fruits, 237.94 ppm in under ripe and 320.21 ppm in ripe fruits. The free fatty acid (FFA) content was the lowest in unripe fruits (0.494) which increased to

Table 35. Variation in biochemical parameters in different bunches of *virescens*

Ripeness stage	Carotene (ppm)	Oil to dry mesocarp (%)	Oil to wet mesocarp (%)	Moisture (%)	Mesocarp to fruit ratio
Unripe	9.93	7.62	2.14	61.00	49.15
Under ripe	313.90	57.71	38.50	41.80	77.66
Ripe	407.49	73.20	48.64	33.40	73.55

Table 36. Variation in colour parameters with ripeness stage in *virescens*

Ripeness stage	Red	Green	Blue	Red/Green	L*	a*	b*
Unripe	140.86	141.97	108.23	0.98	21.10	-1.81	9.11
Under ripe	159.25	114.50	67.70	1.39	23.94	6.41	18.41
Ripe	134.87	79.06	48.25	1.76	28.41	12.86	25.54

Table 37. Variation in biochemical parameters with ripeness stage in *nigrescens*

Ripeness stage	Carotene (ppm)	FFA (%)	Density	Oil to dry mesocarp (%)	Oil to wet mesocarp (%)	Moisture (%)	Mesocarp to fruit
Un ripe	18.13	0.49	1.08	12.37	2.73	75.02	61.96
Under ripe	237.94	2.50	0.97	54.74	28.77	47.98	69.32
Ripe	320.21	2.44	1.02	71.23	44.52	35.89	74.48

above two percent at under ripe and ripe stages. Oil to dry mesocarp was 12.37 % in unripe stage, 54.74 % in under ripe stage and 71.24 % in ripe stage. Oil to wet mesocarp was 2.73 % at unripe stage, 28.77 % in under ripe stage and 44.52 % in ripe stage. The moisture content decreased with fruit ripeness. The percent weight of mesocarp to fruit was 61.96 in unripe stage, 69.33 in under ripe stage and 74.48 in ripe stage.

Analysis of color values indicated significant variation with respect to stage of ripeness. The L* value was 16.03 in unripe stage, 16.72 in under ripe stage and 21.14 in ripe stage. The a* values showed increasing trend with ripeness where it was 1.57 for unripe fruits, 4.49 for under ripe fruits and 6.85 for ripe fruits. The b* values were 6.56 in unripe, 7.83 in under ripe and 12.03 for ripe fruits. The L*/a* were -10.65 in unripe, 6.38 in under ripe and 2.32 in ripe fruits. The variation was not significant with regard to L*/b* & a*/b*values. The prediction models for loose fruits for oil to dry mesocarp are :

95.08-18.991L*/b* where R^2=0.56

77.313-20.104 L*/b*+26.524 a*/b*where R^2=.66
60.212-16.358 L*/b*+27.235 a*/b*+.555b* where R^2=.68

50.847-19.411 L*/b*+58.265 a*/b*+1.923 b*-2.509a* where R^2=.70

Estimation of moisture loss of FFB between time of harvest and arrival at factory:

Harvested bunches were stored for one week period under room temperature and the loss of moisture along with other parameters was estimated (Table 39 & 40). This was done from January to December 2010.

Mean monthly moisture loss from ripe bunches varied from 8.58 to 11.24 % during different months with an annual mean of 10.44 %. Moisture loss was high during April to June when the temperature was high. Again in November,

Table 38. Variation in biochemical parameters with ripeness stage in *nigrescens*

Ripeness stage	L	a	b	L/a	L/b	a/b
Unripe	16.03	1.57	6.56	-10.64	2.85	0.18
Under ripe	16.72	4.49	7.83	6.38	2.39	0.59
Ripe	21.14	6.85	12.03	2.32	2.03	0.57

Table 39 . Variation in moisture loss for ripe bunches from Jan to Dec 2010

Month	Day 2	Day 4	Day 6	Day 7	Total moisture loss (%)	RH (%)	Temp (°C)
JAN	4.82	1.65	1.31	1.86	11.24	89.48	24.50
FEB	1.35	1.96	2.41	2.09	9.21	87.29	24.45
MAR	1.52	1.47	0.37	2.45	8.68	89.71	29.79
APR	3.93	-	8.34	1.54	9.23	68.29	32.38
MAY	2.16	1.35	1.44	1.77	10.76	63.81	34.76
JUN	1.87	1.51	1.65	1.76	11.30	71.75	29.64
JUL	1.24	1.38	0.96	1.30	8.58	79.43	29.23
AUG	2.49	1.23	1.87	3.17	10.78	75.62	29.13
SEP	-	-	-	-	-	-	-
OCT	1.86	1.61	2.42	1.98	11.16	72.25	28.15
NOV	2.15	2.06	2.17	6.58	13.88	72.82	30.68
DEC	2.29	1.80	1.94	1.62	10.02	90.24	23.65

moisture loss was more which could be more due to low relative humidity than temperature.

The lowest mean moisture loss with respect to over ripe bunches was 8.49% and the maximum loss was 18.04% with an annual mean of 13.69%. The moisture loss showed same trend as that of ripe bunches, where weight loss was more during April to June and gain in November coinciding with the rain fall, high temperature and low relative humidity. The moisture loss for over ripe bunches was on the lower side in the month of August as well as in February.

II. POST HARVEST STUDIES ON PALM OIL

(i) Microbial presence and change of oil quality in sterilized fruits during storage in factory

An experiment was taken up with the objective of studying quantitative and qualitative changes in oil extracted from the bunches (fruits), which are stored in the factory premises after sterilization and also to study the microbial growth on the above samples. Bunches were heaped in the factory premises for 3 weeks. Before and after sterilization, fruit sample was collected for studying

Table 40. Variation in moisture loss for over ripe bunches from January to December 2010

	Day 2	Day 4	Day 6	Day 7	Total moisture loss (%)	RH (%)	Temp (°C)
JAN	4.052	1.606	1.628	2.432	10.835	89.48	24.50
FEB	2.466	2.400	2.661	1.521	12.347	87.29	24.45
MAR	0.706	1.621	1.567	2.156	8.490	89.71	29.79
APR	2.531	0.000	10.005	2.186	18.042	68.29	32.38
MAY	4.819	2.011	2.100	1.746	15.985	63.81	34.76
JUN	2.505	1.819	1.929	2.012	11.123	71.75	29.64
AUG	1.382	1.868	2.351	5.257	13.757	75.62	29.13
NOV	2.830	1.983	2.522	5.983	16.351	72.82	30.68
DEC	3.838	2.736	3.022	3.929	16.236	90.24	23.65

the oil quality and microbes present in it. The fruit samples were collected from heaped bunches twice, one week after sterilization (WAS) and two weeks after sterilization for further study. The fruits were water washed and taken for culturing to know the presence of microbes on the fruit surface. The sampled fruits were examined for associated mycoflora by 'serial dilution and pour plate' technique. Later, fruits were scraped for estimating moisture and oil content in mesocarp. Simultaneously, mesocarp oil was extracted using mini press (laboratory scale) and the oil was subjected to estimation of free fatty acid (FFA).

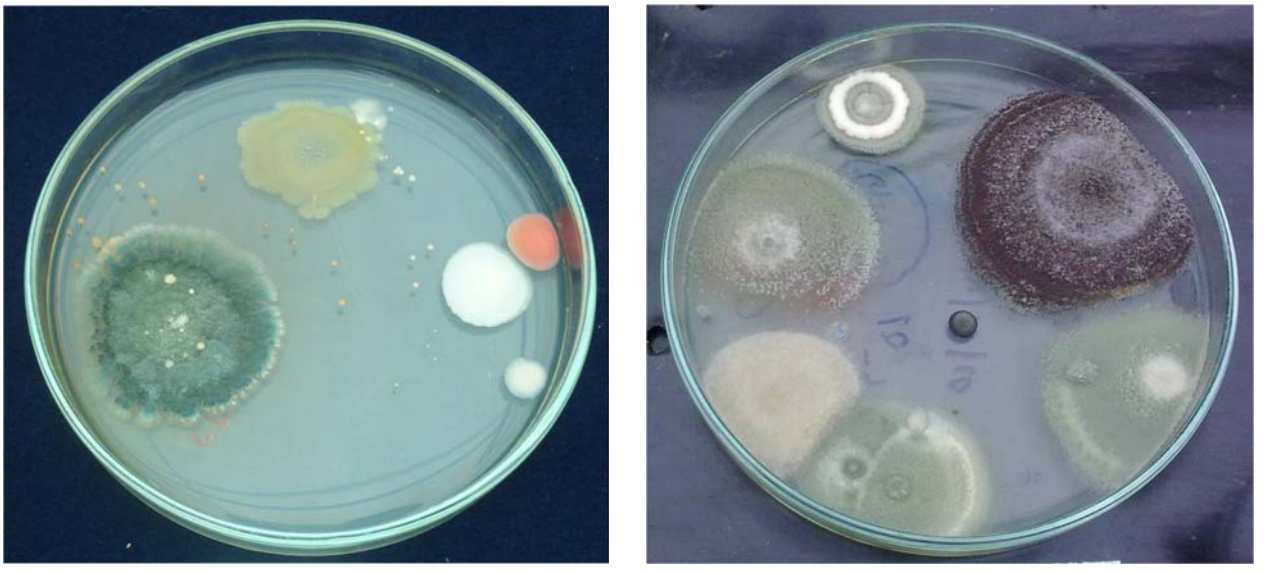
Visual observation showed yellow colour growth of moulds from first week onward, which was spreading gradually with time. However, the intense yellow colour with active mycelial spread was noticed 1WAS, which was dull and bright colour was also not that intense during 2WAS. During second week after sterilization, the fruits were softer in texture and having foul smell and many fruits were detached from the bunch. Culturing the water wash showed presence of *Rhizopus stolonifer, Aspergillus niger, Penicillium* sp, *Aspergillius flavus, Curvularia, Glomerella, Fusarium* sp *and Cladosporium* sp (before sterilization) (Fig. 17 a & b).

However, after 1st and 2nd week of sterilization, fruits were having *Neurospora* sp growth (Fig. 18 a & b). No other organism was observed in culture. Visual observation of the bunch also showed the yellow mould (*Neurospora* sp.) growth on the fruits.

It was observed that there was a significant decrease in mesocarp content (weight basis) in the fruit. Moisture content of the fruits s also decreased after sterilization and this continued upto one week after harvesting. The sterilization process ruptured the cells and allowed moisture loss faster, which in turn reduced the relative weight of the mesocarp in the fruits as the nut weight would be almost constant. Subsequently, on 2nd week after sterilization, there is a significant increase in mesocarp weight as well as moisture content in comparison to 1WAS.

As there is loss in mesocarp content, mainly due to loss of moisture, there was a significant increase in oil content after sterilization and also significant increase after 1WAS. Subsequently there is a decrease in oil content, because moisture content and the proportion of mesocarp increased during 1WAS to 2WAS. Significantly higher FFA content was observed at 2 WAS than that of 1 WAS which was mainly due to splitting of oil and resulting in reduction in oil content (dry mesocarp

Fig. 17 a & b: Microorganisms in unsterilized fruits of oil palm



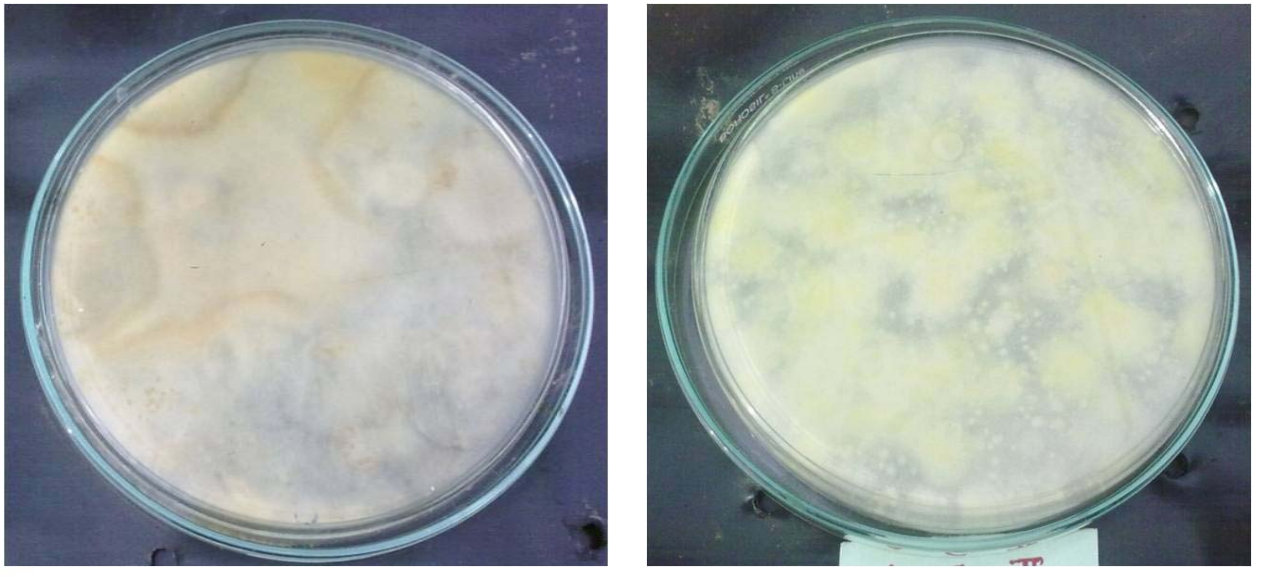
basis). There is a significant amount of increase in C 18:1 after sterilization. This resulted in increase in total amount of unsaturated fatty acid content after sterilization. Among the saturated fatty acids, the minor fatty acid C14:0 increased significant after sterilization. Similarly, the major significant decrease after sterilization was observed in case of C16:0. Among the minor fatty acid, C18:3 decreased significantly after sterilization. Thereafter, two major fatty acids, C16:0 and C18:1 respectively increased and decreased significantly during 2WAS. Also there was a significant decrease in C18:2 percentage, resulting in decrease in total unsaturated fatty acid content. Though C18:0 decreased significantly, but total contribution to the saturated pool by this fatty acid was not much. Two minor fatty acids, C14:0 and C18:3 did not show any significant change during the process.

(ii) Lipase in oil palm fruit and its effect on storage at different temperatures

Lipase is an important enzyme which breaks the triglycerides of oil palm fruits into fatty acids and glycerol. Its activity starts from harvesting onwards. Fully ripe bunches were harvested and spikelets were stored at 55°C, 10°C and at room temperatures (in natural conditions) for a period of three weeks. Weekly samples were collected for analysis. The FFA is increasing in lower temperature much higher than that of natural conditions during May-June. In incubator at or above 50°C, the increase in FFA is insignificant and this is mainly due to degradation/ inactivation of lipase enzyme. It appeared from the present experiment that both external and internal enzymes could be involved. Result showed that FFA increase is more in case of unsterilized oil than that of incubated fruits in almost all the conditions (temperature of storage) during entire period of incubation. Unsterilized oil might contain the mixture of external enzyme and internal enzyme, if present. However, this might also be due to the availability of more enzyme-substrate combination in case of unsterilized oil.

To further clarify the fact, two separate experiments were set up. In the first experiment, undamaged fully ripe fruits were separated from bunch and incubated in palm oil at different temperature. Same palm oil samples were incubated with crushed fruit (damaged fruits) and in control no fruits were immersed. The palm oil got completely frozen (solidified) in refrigerated condition, which had to be heated every time to sample for analysis. In the second experiment, refined sunflower oil (purchased from market) was used as media instead of palm oil and damaged and undamaged fruits were incubated in it.

Fig. 18 a. *Neurospora* sp. ; b. *Neurospora* sp. (2 WAS)



Social Sciences

Training programme to farmers & officers

SOCIAL SCIENCES

I. PRIORITIZATION OF RESEARCH NEEDS IN OIL PALM BASED ON FARMERS PERCEPTION

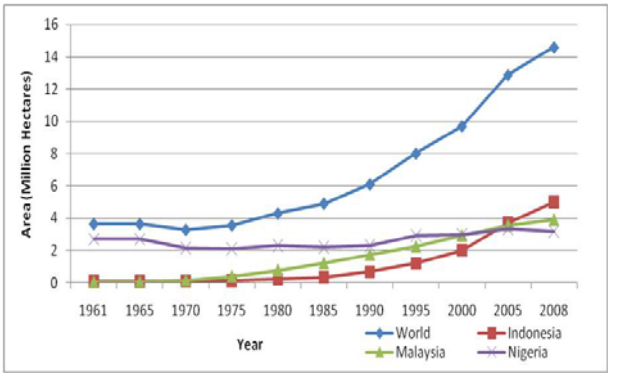
Data were collected from 25 oil palm growers on technical problems faced by them in oil palm cultivation. Perceived technical constraints were collected, based on which they identified research needs and timeliness of availability of research results for 26 major cultivation practices. Majority of the perceived constraints were in research need category of most needed (56 %) followed by very much needed (33 %), needed (11 %). Timeliness of availability of research results were in the category of immediately required (50 %) followed by required with in short time (43 %) and can take long time (11 %). Total scores obtained for perceived constraints, research needs and timeliness of availability of research results were calculated.

II. OIL PALM DATABASE MANAGEMENT SYSTEM

(i) Global oil palm scenario

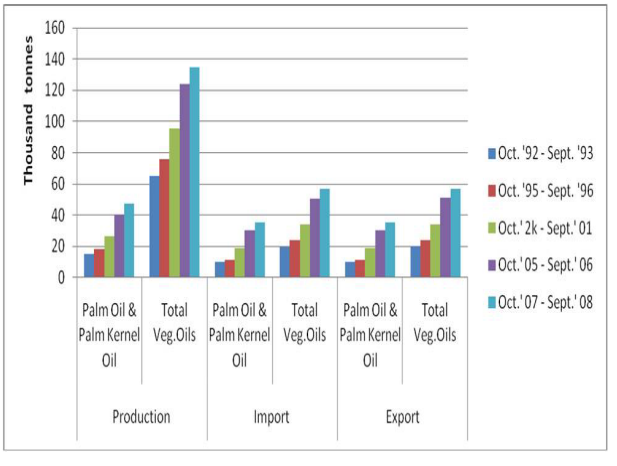
Data on global scenario were obtained from FAO website and collected from the year 1961 to 2008 on oil palm fruit harvested area, production of FFB, yield, production of palm oil, palm kernel oil, import and export details of palm oil and palm kernel oil. The world area of oil palm in 1961 was 3.625 m ha and this increased more than four times to 14.586 m ha in the year 2008. The production of oil palm fresh fruit bunches increased from 13.670 million tonnes in 1961 to 205.362 million tonnes in 2008. The productivity of oil palm in world increased from 3.77 tonnes/ha in the year 1961 to 14.08 in the year 2008. Major contributors to the growth of oil palm cultivation were Malaysia, Indonesia and Nigeria (Fig. 19). World production of palm oil has increased from 1.47 million tonnes in 1961 to 41.29 million tonnes in 2008 while production of palm kernel oil has increased from 0.48 to 5.37 million tonnes.

Fig. 19 : Harvested area of oil palm in the World and major countries



Data on global production, import and export of palm oil and vegetable oils for the years 1992 to 2008 showed that production of vegetable oils increased by 2.12 times and palm oil and palm kernel oil together increased by 3.45 times in the year 2008-09 when compared to year 1992-93. The percent contribution of palm oil and palm kernel oil together to the vegetable oil production was 23.29 percent during 1992-93 and this increased to 35.62 percent during 2008-09. Palm oil and palm kernel oil together constituted about 64 percent of the total trade of vegetable oils in the world (Fig. 20).

Fig. 20 : Global production, import and export of vegetable oils vs palm oil and palm kernel oil



(ii) Oil palm scenario in India

Import of edible oils in India has increased from 1.750 million tonnes during the oil year 1996-97 to 8.183 million tonnes during 2008-09. During these years, the composition of palm oil and its products together constituted 60 to 80 percent. While the import of RBD Palmolein decreased from 70 percent share of edible oil import in 1996-97 to 15 percent constitution during 2008-09. Crude palm oil import increased from 18 percent during 1998-99 to 72 percent during 2007-08 and decrease to 63 percent during 2008-09.

District-wise information was collected from state departments on planting area from eight districts and production of FFB from six districts of Andhra Pradesh, Andaman and Nicobar Islands, Goa and Kerala. Oil palm was taken up in Kerala and Andaman and Nicobar Islands during 1970's to 1985 under the rainfed conditions and showed good progress. In other states under irrigated conditions, oil palm cultivation was taken up during late 80's and early 90's and the cumulative planting area showed a gradual increase during initial years and steep increase from year 1994-95. The increase in FFB production under irrigated conditions was rapid from year 1998-99 onwards. This was seen in various entrepreneur zones of oil palm in Andhra Pradesh, Karnataka and Goa.

Adoption of package of practices was studied for 150 high yielding plantations of which 97 percent of the plantations were in the age group of 11 to 16 years. It was observed that majority of high yielding plantation farmers are applying farm yard manure or poultry manure / vermi compost and applied different dose of fertilizers in two to four splits in their oil palm plantations. The size of land holding, age of plantation, quantity of the manure applied, application of nitrogen, phosphorous, potassium and boron had no effect on high yields achieved. A significant correlation between manure application, fertilizer applied in number of splits, application of magnesium and yield was observed, hence these three variables are significantly affecting the high yield levels in oil palm. It was observed that most of the farmers are following basin method of irrigation with a frequency of 7-10 days.

A software was developed to store the data collected. For the purpose of development, Visual Basic 6.0 was used as front end and Microsoft Access was used as a backend. The main screen consisted of main menu called Static Information, Detail Information, Queries, Reports, Statistical Analysis and Graphs. The static information has a submenu with the options of Continent, Country, Oilseed, Vegetable oils, Oil year, Reference and the various parameters required to store and retrieve the data. These options were static, in the sense, the data was not changing with reference to time or unit. The Detail information has two options in the submenu which are the Global Scenario and National Scenario. The Global Scenario enables to store all the data pertaining to various countries and the world as a whole. The National Scenario enables to enter data pertaining to India. The Queries, Reports, Statistical Analysis and Graphs enables one to retrieve, analyse and view the data that is stored in the database.

III. DESIGN AND DEVELOPMENT OF DATABASE ON OIL PALM PLANTATIONS IN INDIA

Production of oil palm fresh fruit bunch (FFB) data of 1482 farmers having 1704 oil palm plantations in the zone of Foods Fats and Fertilizers (FFF), Andhra Pradesh was validated for correctness of data. Month-wise, year-wise yield of these plantations was entered into MS Access format for the purpose of designing the database. The data thus entered was validated for its correctness. Of the total data, 5015 entries pertained to six mandals

of West Godavari district of Andhra Pradesh for the period 1998 to 2009 and 29 entries pertained to two mandals of Vijayanagaram district of Andhra Pradesh for the period 2004 to 2009.

Oil palm area expansion in the FFF zone showed an increasing trend from the year 1990-91 to 2005-06 to 2731 hectares. Production of FFB showed a steady increase from 1998-99 and obtained 38,155 MT during 2008-09. 1704 oil palm plantations in FFF zone were categorized based on age of plantations. Most of the plantations were in the age group of 3 to 5 years (57 percent) followed by age group of 6 to 10 years (28 percent). 15 percent of plantations were in the age group of 11 to 18 years.

IV. DESIGN AND DEVELOPMENT OF WEB BASED INTERACTIVE COMMUNICATION SYSTEM FOR SHARING OF INFORMATION ON OIL PALM

Tables in MS Access database for storing questionnaire on oil palm cultivation were designed. Queries were classified into various categories like crop production, nutrient management, pest management, disease management, harvesting etc.

V. OIL PALM INFORMATION SYSTEM

The modules developed for seed garden block, parent palm selection and hybridization process were integrated. Prototype of the screens to be developed for pest and disease symptoms / control, sprout production and indenting information was prepared.

Glimpses of Achievements

Basic planting material for new seed gardens developed at DOPR, Pedavegi

Collection of fruit samples at Bhadravathi Reserve Project, Shimoga, Karnataka

Severe incidence of leaf web worm

Stem injection for control of psychids

Officers' training programme

Farmers' training programme

5. TRANSFER OF TECHNOLOGY AND EDUCATION

MULTIDISCIPLINARY APPROACHES FOR TRANSFER OF TECHNOLOGY AND AREA EXPANSION IN RELATION TO OIL PALM DEVELOPMENT IN INDIA

Feasibility studies taken up:

Andhra Pradesh: Four mandals were surveyed in East Godavari district and new areas were identified for oil palm cultivation.

Karnataka: Feasibility of oil palm cultivation was studied in Dakshina Kannada and Udupi districts.

Other activities:

Surveyed oil palm plantations and investigated the abnormal fruit formation in oil palm fresh fruit bunches in Mizoram.

Recommended the perils for weather based crop insurance for oil palm - a pilot project launched in West Godavari District, A. P.

Field visits were made to different oil palm plantations of Andhra Pradesh, Odissa and Karnataka and suggested the remedial measures for the pest problems.

Supplied the sample packets of commercial formulations of microbial organisms namely *Metarhizium anisopliae, Beauveria bassiana* and *Trichoderma viride* to various oil palm growers of Andhra Pradesh to tackle the problems of rhinoceros beetle, basal stem rot and leaf eating caterpillars of oil palm.

TRAINING OF RESEARCH AND EXTENSION WORKERS AND FARMERS INVOLVED IN OIL PALM PRODUCTION

Training programmes to officers

A training schedule was circulated to 35 State Agricultural Universities/ Research Institutes, 47 Directors of Agriculture/ Horticulture, 31

Programme	Date	State	No. of participants
Oil Palm Production Technology	27 August to 3 September 2010	Andhra Pradesh, Karnataka, Gujarat and Bihar	16
	22-23 April 2010	Mizoram, Andhra Pradesh	03
	18-25 January 2011	Gujarat and Andhra Pradesh	07
Plant Protection in Oil Palm	20-22 October 2010	Karnataka and Andhra Pradesh	03
Oil Palm Production	30 October 2010	Andhra Pradesh	35
	21 July 2010	Andhra Pradesh	43
Oil Palm Cultivation	15 November 2010	Mizoram	16
Nursery Management in Oil Palm	23-25 November 2010	Tamil Nadu, Kerala, Karnataka and Andhra Pradesh	04
Soil and Leaf Nutrient Analysis	14-15 December 2010	Andhra Pradesh	03
Oil Palm Hybrid Seed Production	4-6 January 2011	Kerala, Karnataka and Andhra Pradesh	03

Entrepreneurs and 18 AICRP centers in the states identified for oil palm cultivation in India. Training programmes on Oil Palm Production Technology, Hybrid Seed Production in Oil Palm, Plant Protection in Oil Palm, Nursery Management in Oil Palm, Oil Palm Cultivation and Soil & Leaf Nutrient Analysis were organised to officers belong to Department of Agriculture, Horticulture, State Agricultural Universities, ICAR institutions and Oil Palm entrepreneurs.

A total of 133 officers belonging to Andhra Pradesh, Gujarat, Karnataka, Kerala, Tamil Nadu, Bihar and Mizoram participated in these training programmes.

Three contractual training programmes were organised on oil palm production to 80 officers of different entrepreneurs involved in oil palm development programme in Andhra Pradesh and Mizoram.

Training programmes to farmers

Six training programmes were organised on "Oil Palm Cultivation" at DOPR, Pedavegi to 92 farmers from Gujarat, Mizoram, Andhra Pradesh and Chattisgarh.

Date	State	No. of participants
19 April 2010	Mizoram	18
25 October 2010	Mizoram	18
27 October 2010	Gujarat	30
19 January 2011	Mizoram	14
25 January 2011	Anantapur, Andhra Pradesh	04
28 January 2011	Chattisgarh	08

Student exposure visits

Five exposure visits were organized on "Oil Palm" at DOPR, Pedavegi, A.P. to 433 students from different colleges and universities of the Andhra Pradesh.

Training Programmes organized at DOPR, RC, Palode

One day training programme on 'Oil Palm Production Technology' was conducted to 20 officers, 158 students and 67 farmers.

EXHIBITIONS

DOPR, RC, Palode participated in:

'Grand Expo 2010' conducted by AKG Samskarika Samithi, Andoorkonm, Trivandrum during April 11-15, 2010 - received second best stall award.

Horticulture exhibition conducted during Global Conference on Banana held from December 10-13, 2010 at Tiruchirappalli, Tamil Nadu - adjudged as best stall.

'Karshika Mela' at Palode during February 7-15, 2011

Mannikode Karshika Viapaara Mella at Venjaranmoodu during February, 2011

Agricultural Industrial Exhibition held at Thachonam, Kallarra from February 20-26, 2011

Exhibition conducted during National Seminar on Climate Change & Food Security: Challenges & Opportunities for Tuber Crops held during January 20-22, 2011 at CTCRI, Trivandrum

ACADEMIC ACTIVITIES

Dr. P. Kalidas guided five M.Sc. students of Andhra University and Acharya Nagarjuna University for their project work in Biotechnology/Microbiology

Dr. P. K. Mandal guided five M.Sc students belonging to ANGRAU, Bapatla; VIT, Vellore and Andhra University for their project work in Biotechnology

Dr. M. Jayanthi guided four M.Sc students of Andhra University for their project work in Biotechnology

Dr. K. L. Mary Rani guided three students for their project work in Computer Applications for the degree of Master of Computer Applications

Training Programmes organized at DOPR, RC, Palode

S. No	Date	Officers	Students	Farmers
1	25.09.2010		4 Post graduate students from College of Agriculture, Vellayani, Trivandrum	
2	25.09.2010			23 (Perambalur, Tamil Nadu)
3	28.09.2010		67 (Govt. VHSS, Kallara)	
4	27.10.2010 to 30.10.2010			22 (Kolasib & Mamit District, Mizoram)
5	19.11.2010 to 21.11.2010	20 (Mizoram)		
6	22.01.2011 to 26.01.2011			22 (Serchhip, Lunglei & Lawngtlai Districts, Mizoram)
7	24.01.2011		44 (Dr. Yashvant Singh Parmar University of Hort. & Forestry, Nauni, Solan, HP)	
8	17.02.2011		23 (ASPEE college of Hort & Forestry, Navsari, Gujarat)	
9	15.03.2011		20 (Tenkasi, Tamil Nadu)	

6. AWARDS / RECOGNITION

Ph.D awarded

Dr. K. L. Mary Rani was awarded Ph.D in the discipline of Computer Science from Sri Padmavathi Womens University, Tirupati, Andhra Pradesh

Dr. Shinoj Subramannian was awarded Ph.D in the discipline of Food and Agricultural Process Engineering from Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu

Dr. K. P. Deepthi

Secured Sri.G. Sri Ramulu memorial Gold medal for having completed Ph.D with over all University highest O.G.P.A (overall grade point average) in the Faculty of Agriculture, Acharya N. G. Ranga Agricultural University, Hyderabad, Andhra Pradesh

Dr. P. Kalidas

Received best paper award for "Effect of new methods of insecticides application on the management of psychids of oil palm" in the 4th Indian Horticulture congress-2010 held during November 18-21, 2010 at New Delhi

7. LINKAGES AND COLLABORATION

Directorate of Oil Palm Research is maintaining linkages with the following National and International Institutes / Agencies:

A. National

- Department of Agriculture and Cooperation
- National Agricultural Innovation Project (NAIP)
- State Departments of Agriculture/ Horticulture, Govt. of Andhra Pradesh, Tamil Nadu, Karnataka, Kerala, Goa, Gujarat, Orissa, Mizoram and Tripura
- State Agricultural/Horticultural Universities of Oil palm growing states
- Entrepreneurs involved in oil palm development
- Agricultural Finance Corporation
- Oil Palm India Ltd (OPIL), Kottayam, Kerala
- Other ICAR institutes

B. International

- Malaysian Palm Oil Board, Malaysia
- ASD Costa Rica
- IDEFOR, Ivory Coast
- DAMI, Papua New Guinea
- CIRAD-CP, Montpellier, France
- BUROTROP - Paris, France
- UNIVANICH, Thailand

Technical advice

DOPR has been providing technical advice to Department of Agriculture & Cooperation (DAC) and State Agriculture/Horticulture Departments on all aspects of oil palm cultivation

Director, DOPR was nominated as Chairman of the Committee to review Fresh Fruit Bunches (FFB) of oil palm pricing formula

Director, DOPR and a Principal Scientist from DOPR were nominated as members of the committee constituted to assess additional potential area for oil palm cultivation in India

Externally funded projects

DAC funds are being utilized for the following programmes through Integrated Scheme on Oilseeds, Pulses, Oil palm and Maize(ISOPOM) :

- Strengthening of oil palm seed gardens for indigenous seed production which is aimed at improving the indigenous oil palm hybrid seed production
- Multilocation evaluation of African oil palm germplasm (Research cum demonstration of oil palm genotypes under varied environments)
- Leaf nutrient analysis laboratory meant for analyzing the leaf samples for effective scheduling of fertilizers.
- Establishment of tissue culture laboratory for oil palm to strengthen the infra structure facilities for tissue culture programme.
- Strengthening of Training on Oil palm Production through which the staff involved in oil palm development as well as farmers are trained.

Collaborative project

An inter-institutional research project 'Development of Harvesting tools for oil palm' was initiated by Directorate of Oil Palm Research and Central Institute of Agricultural Engineering, Bhopal. In this connection, a Brain Storming Session was held on 25th November 2010 at DOPR,

Pedavegi. Based on the discussions in the Brain Storming Session, the following decisions were made:

- Initial efforts shall concentrate on developing harvesting tools for oil palm trees of 5 to 35 years old, planted in plain terrain (without much undulation) & grown as a monocrop. Variations in the developed tools could be attempted at a later stage for location-specific problems.
- Development of a self propelled hydraulically operated high raise platform for harvesting oil palm bunches in tall trees - to be carried out by DOPR.
- Development of an improvised sickle with light weight & high strength poles - to be taken up by CIAE, Bhopal. DOPR would provide the required logistic assistance.
- Development of a motorized sickle for use in medium tall palms and also for use in combination with high rise platforms - to be taken up by CIAE-IEP Centre, Coimbatore.
- Testing, evaluation and demonstration of the improved tools and equipments - to be accomplished by DOPR, CIAE and AICRP on FIM Scheme Centre, Maruteru, A.P.
- Safety to the operator and ergonomics need to be taken care while developing the tools.

A field Demonstration of hydraulic lifting platforms for harvesting from tall oil palms was done on 9th February 2011. Scissor lift of 12 m reach manufactured by M/s. Vanjax sales Pvt. Ltd., Chennai and Telescopic lift of 12 m reach manufactured by M/s. Vanjax sales Pvt. Ltd., Chennai were demonstrated.

8. AICRP/CO-ORDINATION UNIT/NATIONAL CENTRES

DOPR is providing technical advice to the six AICRP (Oil Palm) centres located at Vijayarai (Andhra Pradesh), Mulde (Maharahstra), Gangavathi (Karnataka), Aduthurai (Tamil Nadu), Pasighat (Arunachal Pradesh) and Madhopur (Bihar).

9. PUBLICATIONS

Research Papers

Kalidas Potineni, Saravanan, L. and Deepthi, K. P. 2011. Incidence of *Silvanus sp* (Silvanidae: Coleoptera) in oil palm plantations in Andhra Pradesh, India: A study. The Planter 87(1018): 15-20

Murugesan, P., Haseela , H. , Gopakumar , S. and Shareef , M.V.M.S . 2011. Fruit and seed development in *Elaeis oleifera* (HBK) Cortes of Surinam origin. Indian Journal of Horticulture 68(1): 28-30

Murugesan, P and Gopakumar, S. 2010. Variation in phenotypic characteristics of ASD Costa Rica hybrids of oil palm in India. Indian Journal of Horticulture 67 (2): 152-155

Potineni Kalidas and Pinnamaneni Rajasekhar. 2010. Effect of gibberlic acid on the yield of oil palm. Biosciences, Biotechnology Research Asia 7(1): 433-436

Prasad, M. V., Ananta Sarkar and Jameema, J. 2010. Performance of oil palm production technologies. Indian Research Journal of Extension Education 10 (3): 10-15

Rajasekhar Pinnamaneni and Potineni Kalidas 2010. Growth of *Beauveria bassiana* on the naturally available resources for commercial formulation. J. Appl. Biosci. 36(1):48-50

Rajasekhar Pinnamaneni, Kalidas,P. and Sambasiva Rao, K. R. S. 2010. Studies on the effect of varied physico-chemical parameters on the growth of *Beauveria bassiana*. Research Journal of Biological Sciences 2(1): 20-29

Rajasekhar Pinnamaneni and Kalidas Potineni. 2010. Mechanisms involved in the entomopathogenesis of *Beauveria bassiana*. Asian Journal of Environmental Science 5(1):65-74

Rajasekhar Pinnamaneni, Kalidas,P. and Sambasiva Rao, K.R.S. 2010 Cloning, expression and characterization of chitinase from *Beauveria bassiana* NIM1225. The Open Entomology Journal 4: 6-11

Rajasekhar Pinnamaneni and Potineni Kalidas. 2010. Exploring Biocontorl potential of fungal entomopathogen, *Beauveria bassiana* against lepidopteran pests of oil palm. Indian Journal of Plant Protection 38(2): 155-58

Shinoj, S., S. Panigrahi, R. Visvanathan. 2010. Water absorption pattern and dimensional stability of oil palm fiber–linear low density polyethylene composites. Journal of Applied Polymer Science 117: 1064–1075

Shinoj, S., R.Visvanathan, S.Panigrahi. 2010. Towards industrial utilization of oil palm fibre: Physical and dielectric characterization of linear low density polyethylene composites and comparison with other fibre sources. Biosystems Engineering, 106: 378-388

Shinoj, S., R.Visvanathan, S.Panigrahi, M. Kochubabu. 2010. Oil palm fiber (OPF) and its composites: A Review. Industrial Crops and Products 33(1): 7-22

Suresh, K., Nagamani, C., Ramachandrudu, K., Mathur, R, K. 2010. Gas exchange characteristics, leaf water potential and chlorophyll a fluorescence in oil palm (*Elaeis guineensis* Jacq.) seedlings under water stress and recovery. Photosynthetica 48 (3): 430-436

10. DETAILS OF TRAINING/REFRESHER COURSE/SUMMER/ WINTER SCHOOLS/WORKSHOPS/MEETINGS ATTENDED WITHIN INDIA AND ON DEPUTATION ABROAD

TRAININGS/WORKSHOPS

Dr. P. K. Mandal

Deputed for a three months training programme on 'Marker assisted selection (Horticultural Crops)' at Michigan State University, USA from March 1, 2011 to May 30, 2011

Dr. K. Suresh

Sensitization cum training workshop on 'Project Information and Management System of ICAR (PIMS-ICAR)' organized by IASRI, New Delhi at NAARM, Hyderabad on October 25, 2010

Dr. K. L. Mary Rani

Orientation training cum workshop on 'Installation of SAS Software' for the Consortia-based Research Project 'Strengthening Statistical Computing for NARS' for the nodal officers organized at NAARM, Hyderabad during June 16-17, 2010

'Training on SAS for Trainers' during June 28 to August 2, 2010 at NAARM, Hyderabad

Dr. K. Ramachandrudu

Training course on 'Research Station Management' organized by ICRISAT, Hyderabad during January 17-22, 2011

Dr. K. Sunil Kumar

Training programme on 'Data analysis using SAS' from March 3-9, 2011 organized by CTCRI, Trivandrum in collaboration with Hub Centre at UAS, GKVK, Bangalore under the auspices of NAIP consortium 'Strengthening Statistical Computing for NARS' funded by NAIP

Regional work shop of FAO project on 'Establishment of National Information Sharing Mechanism (NISM) on the implementation and monitoring of the Global Plan of Action for conservation and sustainable utilization of Plant Genetic Resources for Food and Agriculture (PGFRA)' on July 9, 2010 at NAARM, Hyderabad

Dr. L. Saravanan

Training programme entitled 'Sensitization training workshop on bioinformatics and its various applications' under NABG project during November 8-12 2010 at NBAII, Bangalore

Mr. A. Gopalakrishna Reddy

92nd Foundation Course for Agricultural Research Services (FOCARS) programme at NAARM, Rajendranagar, Hyderabad for a period of 120 days from September 1 to December 29, 2010

11. LIST OF ONGOING PROJECTS

Project Code	Title of the Project	Name of PI and Co-PI(s)
EFP III	Strengthening of seed gardens for indigenous seed production	R K Mathur, P Murugesan
GEN III	Multilocation evaluation of oil palm germplasm	R K Mathur, P Murugesan
EFP XII	Establishment of a tissue culture laboratory for oil palm	M Jayanthi , PK Mandal
GEN I	Collection, conservation, cataloguing and evaluation of oil palm germplasm	R K Mathur, P Murugesan, K Sunilkumar, AGK Reddy
GEN II	Production, evaluation and improvement of oil palm hybrids	R K Mathur, P Murugesan, PK Mandal, K Suresh
GEN V	Breeding for high yield and drought tolerant oil palm	R K Mathur, P Murugesan, PK Mandal, K Suresh
GEN VI	Studies on performance of different oil palm planting materials	R K Mathur, P Murugesan
GEN VII	Cryopreservation of different oil palm germplasm	P Murugesan
BIO II	Molecular characterization of oil palm germplasm	P K Mandal, M Jayanthi, R K Mathur
BIO IV	Development of tissue culture protocol for oil palm	M Jayanthi, P K Mandal , R K Mathur, K Sunilkumar, AGK Reddy
BIO V	Development of molecular markers for variety identification in oil palm	M. Jayanthi, P K Mandal
SST I	Acceleration of germination in oil palm hybrid seeds	P Murugesan, R K Mathur
RF	Indigenous production of oil palm hybrid seeds	P Murugesan, RK Mathur
	CROP PRODUCTION	
EFP VI	Nutrio-physiological characteristics of oil palm under irrigated conditions- Establishment of leaf analysis laboratory	K Suresh
AGR VI	Atudies on the mixed farming in the irrigated oil palm plantations of A.P	K Ramachandrudu, B Narsimha Rao, K P Deepthi, L Saravanan
AGR IX	Studies on replanting techniques in oil palm	S Sunitha
AGR XII	Fertigation in oil palm plantations	B Narsimha Rao, K Ramachandrudu, K Suresh

Project Code	Title of the Project	Name of PI and Co-PI(s)
AGR XIII	Biogas production from POME and utilization of slurry as nutrient source for oil palm	S Sunitha
AGR XIV	Performance of oil palm in peat soils of Kerala	S Sunitha
BIO III	Biochemical basis for growth and yield in oil palm	P K Mandal, M Jayanthi
PHY III	Effect of different levels of fruiting activity on growth and yield of oil palm	K Suresh, K Ramachandrudu
PHY IV	Carbon sequestration potential in oil palm plantations	K Suresh
PHY V	Leaf breaking in oil palm	K Suresh
HORT I	Studies on intercropping in bearing oil palm gardens	K Ramachandrudu, B Narsimha Rao
HORT II	Multi location trial for cocoa varieties (inter-institute proj. -CPCRI)	K Ramachandrudu
HORT III	Nursery management in oil palm	
	i. Effect of biofertilizers on growth and vigour of oil palm seedlings	K Ramachandrudu, K P Deepthi
	ii. Studies on fertigation in oil palm nursery	K Ramachandrudu
HORT IV	Irrigation management in oil palm	B Narsimha Rao, K Suresh, AGK Reddy, KL Mary Rani
HORT V	Studies on ablation in oil palm	A Gopalakrishna Reddy, K Suresh
HORT VI	Studies on nutritional disorders in oil palm under irrigated conditions	Goutam Mandal, AGK Reddy
	CROP PROTECTION	
PATH II	Studies on diseases of oil palm and their management	K P Deepthi, L Saravanan
ENT I	Studies on insect pests of oil palm and their management	P Kalidas, L Saravanan
ENT III	Studies on avian and mammalian pests of oil palm and their management	P Kalidas, L Saravanan
ENT V	Studies on pollinating weevil E*laeidobius kamerunicus* (faust) in irrigated oil palm gardens	L Saravanan, P Kalidas
	POST HARVEST TECHNOLOGY	
PHT VII	Development of a grading system for oil palm FFB and estimation of factory level OER	K Sunil Kumar
PHT VIII	Post harvest studies on crude palm oil	P K Mandal, K P Deepthi

Project Code	Title of the Project	Name of PI and Co-PI(s)
	SOCIAL SCIENCES	
EFP IX	Training of extension, research workers and farmers involved in oil palm production	M V Prasad, SIC (Palode)
EXT IV	Multidisciplinary approaches for TOT and area expansion in relation to oil palm development in India	M V Prasad
EXT V	Prioritization of research needs in oil palm based on farmers perception	M V Prasad
CA II	Oil palm information system	K L Mary Rani, RK Mathur
CA III	Design and development of database on oil palm plantations in India for collection, cataloguing and communicating information on oil palm technology	K L Mary Rani, M V Prasad
CA IV	Design and development of web based interactive communication for sharing of information on oil palm	K L Mary Rani, M V Prasad

12. CONSULTANCY, PATENTS AND COMMERCIALIZATION OF TECHNOLOGY

The Consultancy Processing Cell gives broad guidelines for consultancy work, prepares and processes the Training / Consultancy /Contract Research/ Contract Service proposals, identifies the team for taking up the assignments, coordinates the work related to consultancy assignments and monitors the progress of work. The facilities offered by DOPR are as under:

1. Training programmes (National and International)

Training programmes in the following areas to the officers involved in oil palm development.

- Oil palm nursery management
- Oil palm production and processing technology
- Harvesting of oil palm FFB
- Oil palm hybrid seed production
- Plant protection in oil palm

2. Consultancy services

- Oil palm hybrid seed production
- Production of quality planting material
- Oil palm tissue culture
- Setting up of oil palm nurseries and their management
- Designing of experiments and data analysis
- Oil palm crop feasibility studies/surveys
- Techno - advisory services
- Project preparation, evaluation and management
- General consultancy for oil palm development
- Agronomic aspects of plantation management
- Intercropping in oil palm plantations
- Soil and nutrient management
- Assessment of soil fertility status and advisory services on nutrient disorders.
- Plant health centre for pest & disease management
- Molecular and biochemical characterization of plants, fungi, bacteria
- PCR based detection of oil palm diseases
- Pollinating weevils
- Maturity, harvest, post harvest management
- Oil palm processing
- Oil quality analysis
- Value addition of palm oil and EFB fibre
- Management of oil palm plantation and mill wastes
- Impact studies, socio economic studies, SWOT analysis, case studies, diffusion studies, constraint analysis in oil palm

3. Contract Research

- Testing of Agro-chemicals, Fertilizers, Bio-Fertilizers, Bio-Pesticides and Growth regulators suitable for oil palm
- Projects on all aspects of Water, Nutrient, Pest and Disease Management in oil palm /oil palm based cropping system

4. Contract services

- Analysis of water and soil to test the suitability for oil palm
- Leaf nutrient analysis
- Lab and field evaluation of fertilizers, herbicides, agro-chemicals/plant protection against fungi, bacteria and insect pests of oil palm
- Diagnosis of damages caused by insect pests and diseases in oil palm plantations and suggest control measures
- Oil analysis
- Bunch analysis

Consultancy proposals taken up:

Contractual training programmes on "Oil palm production" were organized to development officers of Ruchi soya Industries Ltd., Palmtech India Ltd., and Mac oil palm Ltd., and details are as follows :

Organisation	Duration/date of training	Participants	Consultancy fee (₹)
M/s. Ruchi Soya Ltd.	22-23 April, 2010	3 (Mizoram)	17,216
M/s. Palm Tech India Ltd.	21 July ,2010	42 (Andhra Pradesh)	42,600
M/s MAC Oil Palm Ltd	30 October, 2010	35 (Andhra Pradesh)	40,900

"Feasibility study for identification of new areas for oil palm cultivation in non-identified mandals of East Godavari Dt.," with M/s Subrahmanyeswara Agro products Pvt., Ltd.,

"Production of quality oil palm hybrid seeds and management of seed garden at Rajahmundry, A.P" with Department of Horticulture, Govt. of Andhra Pradesh

INSTITUTE TECHNOLOGY MANAGEMENT UNIT

Data on IP assets of the Institute has been compiled and submitted to Zonal Technology Management Unit, South Zone for preparation of ICAR database on Intellectual Property.

'Deed of Licence cum Agreement' with respect to manufacturing 'Oil palm empty fruit bunch fibre extractor' was signed with M/S Process Ekuipment Engineers, Process nagar, Coimbatore, during Dec 2010.

Monthly reports on success stories, transfer of technology/ commercialization of technologies and other related aspects at the Institute level are being submitted regularly to ZTMC-BPD, South Zone.

Seventeen books have been purchased to strengthen the literature available on IP management at Institute and efforts are under progress to purchase the software for patent search.

Dr. K. Suresh attended ICAR-Zonal Technology Management and Business Planning and Development Meeting-cum-workshop 2010-11 during March 4-5, 2011 at Central Institute of Fisheries Technology, Cochin and made a presentation on status of ITMU and experiences in the management on IP of DOPR.

13. RAC, IMC AND IRC MEETINGS

Research Advisory Committee

Eleventh Research Advisory Committee meeting was held duirng June 21-22, 2010 at Directorate of Oil Palm Research, Pedavegi under the chairmanship of Dr.N.N.Singh, Vice Chancellor, Birsa Agricultural University, Ranchi, Jharkhand. This was the first meeting of the fifth RAC constituted with effect from 15-11-2009 for a period of 3 years.

Dr. P. Balasubramannian, Director, Centre for Plant molecular biology, TNAU; Dr. J. J. Solomon, Retd., Pr. Scientist (Pl. Pathology), CPCRI; Dr.Veeraraghavathatham, Retd. Dean of Horticulture, TNAU; Dr.L.V.Kulwal, Akola, Maharashtra; Dr.K.Purushotham, Director of Research, APHU; Dr.S.Rajan, ADG (Hort.-I), ICAR, New Delhi, Dr. M. Kochu Babu, Director, DOPR and Scientists of DOPR attended the meeting.

Institute Management Committee

The 21st meeting of Institute Management Committee of Directorate of Oil Palm Research, Pedavegi was held on September 18, 2010 under the Chairmanship of Dr. S. Arulraj, Director, DOPR. Dr. P.Chowdappa, Principal Scientist (Pathology), IIHR, Bangalore; Dr. P.Sundararaju, Principal Scientist (Nematology), NRC for Banana; Dr. P.Murugesan, Principal Scientist, DOPR-Regional Station, Palode; Dr. K. Suresh, PME Incharge & Senior Scientist

(Physiology), DOPR, Pedavegi; Mr. T.D.S.Prakash, Asstt. Finance & Accounts Officer, DOPR, Pedavegi and Mr. B. Satish, Assistant Administrative Officer, DOPR, Pedavegi attended the meeting.

Institute Research Committee

Thirteenth Institute Research Committee meeting of the Directorate was held during June 23-24, 2010 at DOPR, Pedavegi. Dr. P. Balasubramannian, Director, Centre for Plant molecular biology, TNAU and Dr. J. J. Solomon, Retd., Pr. Scientist (Pl. Pathology), CPCRI were the outside experts. A total of 40 projects were presented in five Technical Sessions of which 5 are Externally Funded Projects. Nine new projects were proposed of which 7 were approved. Four projects were deferred as the Project Leaders got transferred. Technical programme for the year 2010-11 was discussed and finalized.

14. WORKSHOPS, SEMINARS, SUMMER INSTITUTES, FARMERS' DAY AND OTHER MEETINGS ORGANISED

National Oil Palm Seed Meet-2010: "Oil Palm Seed Meet" was conducted on 22.05.2010 in the committee room of DOPR, Pedavegi. The meet was attended by scientists of DOPR, officials and research personnel of seed gardens. Dr. M. Kochu Babu, Director, DOPR chaired the programme. There were two technical presentations viz., i) Present scenario of oil palm planting materials at national level by Dr. M. Kochu Babu, Director, DOPR and ii) Issues in oil palm hybrid seed production and presentation of requirement of sprouts-companies/departments wise by Dr. R.K. Mathur, Sr. Scientist. It was followed by presentation of annual progress reports on oil palm hybrid seed production- achievements, problems faced and future action by officials of respective seed gardens. There was detailed discussion on various issues related with seed production, supply etc. There was also discussion on proceedings of the meeting of seed garden officials held on 28.01.2009. Sprouts supply schedule was discussed and finalized. Seed meet proceedings were brought out.

National Oil Palm Seed Meet-2011: The meet was conducted on 07.01.2011 at DOPR-RC, Palode (Kerala). The meet was attended by scientists of DOPR, officials and research personnel of seed gardens; and was chaired by Dr. S. Arulraj, Director, DOPR. In his opening remarks, Director highlighted the need for gearing up for targeting higher level of seed production by all seed gardens in light of the decision taken by GOI to allocate ambitious target of covering about 60,000 ha area during 2011-12. He also emphasized the need for establishment of new seed gardens on priority at national level. There were two technical presentations - Quality control measures in oil palm seed production by Dr. P. Murugesan, SIC, Palode; and Strengthening of existing seed gardens for increased seed production by Dr. R.K. Mathur, Pr. Scientist. It was followed by presentation of annual progress reports on oil palm hybrid seed production- achievements, problems faced and future action by officials of respective seed gardens.

Sprouts supply schedule was discussed and finalized.

National Consultation on Oil Palm Research and Development

To address the issues on oil palm research and development and discuss the problems being faced by oil palm farmers and entrepreneurs in various states, a "National Consultation on Oil Palm Research and Development" was organized by Horticulture Division of ICAR on 07.06. 2010 at NASC Complex, New Delhi. The meeting was attended by representatives of oil palm farmers, entrepreneurs, officers from Department of

Agriculture and Cooperation, Govt. of India, Departments of Agriculture/Horticulture of the States and Scientists from Directorate of Oil Palm Research, Pedavegi. The meeting was chaired by Dr. S. Ayyappan, Secretary (DARE) & Director General, ICAR and co-chaired by Dr. H.P.Singh, DDG (Hort), ICAR. Dr. M. V. Rao, former Special DG, ICAR and Honourable Member of Legislative Council, Govt., of A.P, was the Chief Guest. Dr. K.L.Chadha and Dr. P. Rethinam also attended the meeting.

District Level Seminar on Cocoa

A district level seminar on Cocoa was organized at DOPR, Pedavegi on 21.12.2010. A total of 230 personnel comprising farmers, officials of Department of Horticulture, staff of oil palm processors, technical staff & scientists of DOPR participated in the seminar.

Inauguration of Tissue Culture Laboratory

Dr. H. P. Singh, Deputy Director General (Horticulture), ICAR visited Directorate of Oil Palm Research during December 27-28, 2010 and formally inaugurated "Tissue Culture Laboratory". Dr. H. P. Singh, also addressed the scientists and staff of DOPR. He emphasized the importance of oil palm for national economy and significant role expected from DOPR for enhancing oil palm production in the country by improving the production potentials. He further assured that Council would provide all the required support to the Institute to maximize its output. Suggestions for overall maintenance and improvement of the campus were also offered.

Foundation Day at DOPR, Pedavegi

Seventeenth Foundation Day of the Institute was celebrated on February 19, 2011 at DOPR, Pedavegi. Institute website was launched as a part of its celebrations.

15. कार्यालयीन भाषा क्रियान्वयन गतिविधियाँ

भारत सरकार की राज भाषा नीति के अनुसार राज भाषा हिन्दी को बढावा देने की दृष्ठिकोण से केन्द्र के मुख्यालय, पेदवेगी तथा क्षेत्रीय स्टेशन, पालोड़ में कार्यरत सभी अधिकारियों तथा कर्मचाारी गणों में हिन्दी के प्रति जागरूकता बढायी गयी। इस संदर्भ में हिन्दी कक्ष से चलाई गयी गतिविधियां निम्न प्रकार हैं:

1) हिन्दी में ज्ञान बढाने के लिए प्रति दिन एक शब्द के नाम से कार्यप्रणाली अभ्यासित की जा रही है, जिसके अंतर्गत तीनों भाषाओं में - हिन्दी, अंग्रेजी तथा क्षेत्रीय भाषा तेलुगु में रोज एक शब्द स्वागत कक्ष के नजदीक लगाये गये बोर्ड पर नियमित रुप से लिखा जा रहा है।

2) केन्द्र के सभी अधिकारियों को भेजने की डाक की मार्किंग हिन्दी में की जा रही है।

3) फाईल में टिप्पणी भी हिन्दी में चलाने का प्रयास किया जा रहा है।

4) हिन्दी में प्राप्त सारे पत्रों को नियमित अधिकारियों की जानकारी के लिए अंग्रेजी में अनुवाद करके भेजे जा रहे है। उसके पश्चात उनके जवाब उचित रुप से हिन्दी में दिये जा रहे हैं।

उपर्युक्त गतिविधियों के अलावा, प्रतिवेदन वर्ष में 14 सितंबर, 2008 से 14 अक्तूबर, 2008 तक अवधि में हिन्दी चेतना माह का आयोजन किया गया इस अवसर पर हिन्दी-अंग्रेजी अनुवाद, हिन्दी समाचार पठन, हिन्दी अन्ताक्षरी, हिन्दी में निबन्ध लेखन, हिन्दी में वार्तालाप, आदि प्रतियोगिताएं भी आयोजित की गयी। इस कार्यक्रम के समापन के दिन मुख्य अतिथि के कर कमलों से विजेताओं को पुरस्कार प्रदान भी किये गये।

16. DISTINGUISHED VISITORS

The following scientists / officers visited DOPR, Pedavegi during the year 2010-11

Details of the Visitors	Date of Visit
Dr. K.Purushotham, Director of Research, APHU, Tadepalligudem.	21.06.2010
Dr. N.N.Singh, Vice Chancellor, Birsa Agricultural University, Ranchi	22.06.2010
Dr. D.Veeraragavathom, Former Dean (Hort.), TNAU, Coimbatore	22.06.2010
Prof. K.V.Thomas, Minister of State for Agriculture, Government of India, New Delhi	27.06.2010
Dr. C.V.Kulival, Former Director, Extension Education, Punjab Rao Deshmukh Krishi Vidyapeeth, Akola	27.06.2010
Dr. H.P.Singh, Deputy Director General (Hort.), ICAR, KAB-II, Pusa, New Delhi	28.12.2010
Mrs. Rani Kumudini, IAS, Commissioner, Department of Horticulture, Govt. of AP, Hyderabad	24.01.2011
Dr. Anindo Majumdar, Joint Secretary, Dept. of Agriculture and Cooperation, Government of India, New Delhi	19.03.2011

Dr. H. P. Singh, DDG (Hort.), ICAR visited DOPR

17. PERSONNEL

RMP Dr. M. Kochu Babu, Director till 30-07-2010 (Transferred to NAIP, New Delhi)

Dr. S. Arulraj , Director from 30-07-2010 (Additional charge)

STAFF POSITION AT HEAD QUARTERS - PEDAVEGI

Scientific Staff

Dr. P. Kalidas, Principal Scientist (Agril. Entomology)

Dr. R.K. Mathur, Principal Scientist (Plant Breeding)

Dr. B. Narsimha Rao, Principal Scientist (Horticulture)

Dr. M.V. Prasad, Senior Scientist (Agrl. Extension)

Dr. P.K. Mandal, Senior Scientist (Biochemistry)

Dr. K. Suresh, Senior Scientist (Plant Physiology)

Dr. G. C. Satisha, Senior Scientist (Soil Science) (transferred to IIHR, Bangalore on 22-04-2010)

Dr. M. Jayanthi, Senior Scientist (Biotechnology)

Dr. Goutam Mandal, Senior Scientist (Horticulture)

Dr. K. Ramachandrudu, Scientist Senior Scale (Horticulture)

Dr. K.L. Mary Rani ,Scientist Senior Scale (Computer Applications)

Dr. K. Sunil Kumar, Scientist Senior Scale (Horticulture)

Dr. Shinoj Subramannian, Scientist (AS&PE) (completed study leave and joined on 28-07-2010)

Dr. Ananta Sarkar, Scientist (Agril. Statistics) (transferred to NAARM, Hyderabad on 27-04-2010)

Dr. L. Saravanan, Scientist (Agril. Entomology)

Dr. K. Praveen Deepthi, Scientist (Plant Pathology)

Mr. A. Gopalakrishna Reddy, Scientist (Horticulture) (Joined on 07-05-2010)

Administrative Staff

Smt. B. Swarna Kumari, Administrative Officer (joined on 28-01-2011)

Sri B. Satish, Assistant Administrative Officer

Sri T.D.S. Prakash, Assistant Finance & Accounts Officer

Sri K.S.N.D. Mathur, Assistant

Sri P. Gowrishankar, Assistant

Mr. T.V. Rama Krishna, Private Secretary

Mr. P. Sai Kishore, Personal Assistant (joined on 28-02-011)

Mr. S. Siva Rama Krishna, Personal Assistant (joined on 07-03-011)

Mr. S. K. Saida, Lower Division Clerk

Technical Staff

Mr. B. Parthasaradhi T-6
Mr. C.K. Devadathan T-5 (transferred to RS, Palode on 07-01-2011)
Mr. K. Soman T-5
Ms. A. Bhanu Sri T-5
Mr. K. V. Rao T-4
Mr. J. Mohan Rao T-3
Mr. M. Ananda Rao T-3
Mr. V.V.S.K. Murthy T-2
Mr. V. Sunil Dutt T-2
Mr. M. Rambabu T-1
Mr. Ch. Subba Raju T-2 (Driver)
Mr. P.R.L. Rao T-2 (Driver)
Mr. E. Perayya T-2 (Driver)
Mr. A. Papa Rao T-1 (Tractor Driver)

Supporting Staff

Mr. K. Ananda Rao Skilled Support Staff
Mr. G. Raju SSS
Mr. G. Venkateswara Rao SSS
Mr. A. Dhana Raju SS
Mr. A. Joji Showri SSS (retired on 15-07-2010)
Mr. U. Rama Rao SSS
Mr. A. Ganga Raju SSS
Mr. S. John SSS
Ms. Y. Chaitanya SSS
Mr. A. Nagarjuna Rao SSS
Mr. G.S.N. Babu SSS
Ms. N.V.V. Sathya Lakshmi SSS
Mr. K. Satyanarayana SSS
Mr. Ch. Venkata Durga Rao SSS
Mr. M. Appa Rao SSS
Mr. B. Gopala Krishna SSS

STAFF POSITION AT DOPR, RESEARCH CENTRE, PALODE

Scientific Staff

Dr. P. Murugesan, Principal Scientist (Horticulture) and Scientist-in-charge
Dr. S. Sunitha, Senior Scientist (Agronomy)

Administrative staff

Ms. E.J. Mary, Asst. Admn. Officer

Mr. P. Prasad, Personal Assistant (retired on 01-12-2010)

Mr. K. Ravindran, Assistant

Technical Staff

Ms. N. Sujatha Kumari T-6

Mr. V. G. Sasidharan T-5

Ms. I.C. Rajamma T-5

Mr. B. Muralidharan Pillai T-1

Supporting Staff

Mr. G. Rajappan SSS (retired on 31-12-2010)

Ms. M. Rebecca SSS

Ms. A. Raceena SSS

Mr. P.K. Rethnakaran SSS

Mr. S. Sudhakaran Nair SSS

Mr. P. Anil Kumar SSS

Ms. P. Rema SSS

Mr. C. Ravi SSS

18. METEOROLOGICAL DATA

Meteorological data at RC, Palode (2010)

Parameters	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
No. of rainy days	23	11	13	14	11	23	28	17	23	27	26	16
Total rainfall (mm)	41	2.6	23.8	50.8	97.6	278.2	293	263.2	271	525	638	212
Mean max. temp(^{0}C)	26.33	27.81	29.33	29.03	29.63	28.51	26.72	26.61	26.28	25.97	26.18	25.63
Mean min. temp. (^{0}C)	23.52	24.53	25.69	25.54	25.38	23.79	23.63	23.39	23.91	23.65	23.37	23.50
Mean relative humidity (%)	81.55	77.14	75.39	89.38	92.84	93.67	94.48	92.00	90.87	93.94	93.07	92.82

Meteorological data at ARS, Vijayarai, West Godavari District, Andhra Pradesh (2010)

Month	Temperature (^{0}C)		Mean relative humidity (%)	Total rainfall (mm)
	Mean maximum	Mean minimum		
January	26.6	13.6	67.2	0.0
February	28.5	15.8	68.3	0.0
March	40.8	22.5	65.7	3.0
April	40.3	22.4	65.4	163.6
May	37.8	22.6	64.0	138.5
June	37.7	19.4	72.2	270.1
July	37.5	19.9	73.2	266.7
August	36.9	19.3	73.2	266.7
September	36.7	19.3	75.1	468.4
October	36.7	19.3	72.6	92.0
November	35.6	18.4	73.1	183.5
December	34.2	15.4	68.5	96.3

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