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ANNUAL REPORT 2014-15

भाकृअनुप-केन्द्रीय रोपण फसल अनुसंधान संस्थान
कासरगोड़, केरल - 671 124, भारत
ICAR-Central Plantation Crops Research Institute
Kasaragod 671 124, Kerala, India




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Dr. P. Chowdappa
Director

ICAR-Central Plantation Crops Research Institute
KASARAGOD 671 124, Kerala, India
Phone : 04994 – 232893, 232894, 232895
Fax: 04994-232322
Email: directorcpcri@gmail.com, chowdappa.p@icar.gov.in
Website: http://www.cpcri.gov.in/

Compiled and edited by

Dr. K.P. Chandran
Dr. V. Krishnakumar
Dr. Vinayaka Hegde
Dr. B. Augustine Jerard
Shri S. Jayasekhar
Shri John George
Shri H. Muralikrishna

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Preface

The coconut scenario of 2014-15 unfurls two startling realities on the production and price fronts. As per the estimates by the Coconut Development Board, coconut production in the country declined by 10 % in 2014-15 compared with the previous year. Notably its production in Andhra Pradesh fell by a staggering 53.45 %, in Kerala by 17.48 %, and declined marginally by 4.87% in Karnataka; whereas, partially offset by the improvement in Tamil Nadu (3.90 %), Odisha (19.75 %), West Bengal (11.34 %) and Maharashtra (15.85 %). Concomitantly, there is a complementary downward spiral in productivity also. The major reasons attributed to this decline in production are the decrease in cropping area, shortfall in monsoon/prevailing drought in major tracts, and the devastating cyclonic storms on the east coast. In the case of Kerala, the high proportion of old and senile palms in the absence of systematic replanting over a long period of time, long-term neglect and poor management of palms without timely adoption of management practices and severe incidence of pests and diseases are the major reasons for the low productivity of coconut plantations. On the other hand, the present market prices for coconut, arecanut and cocoa are highly remunerative and at all-time high, compared to the competing crops like rubber.

Nevertheless, adversities open up opportunities; only that, we should grab it up with both hands. If we can arrest this disturbing trend in short term and possibly reverse it in the long run, it can make a phenomenal difference. The silver lining is that the all-time high prices will surely motivate the farmers to adopt systematic agro-management and plant health management practices which will indubitably enhance the productivity and profitability.

ICAR-CPCRI, one of the premier research institutes in India, has been instrumental over the past hundred glorious years in developing several technologies and innovations with over 35 varieties in coconut, arecanut and cocoa, highly remunerative and sustainable coconut/arecanut based cropping/farming system models, INM, IDM, IPM and organic farming packages and an impressive array of products and processes for value-addition, product diversification and agri-business entrepreneurship, with the recent kalparasa technology being the icing on the cake.

Envisioning the multiple challenges ahead and formulating a proactive and anticipative research programme to address them manifest our commitment and preparedness to deliver the best against all odds. Towards our vision of ushering in an era of science and technology led development of plantation crops sector in India, we have identified a few core research priorities for development of technologies/ products like tissue culture protocol for coconut, soil-less media for nursery, granular biofertilizers/biopesticides, fertilizer mixtures for the mandate crops, fertigation-solubles and post harvest handling & processing of coconut kalparasa including bottling and spray-drying technologies. In affirmation of our commitment to addressing the pressing problems being faced by the farming community like management of coconut root (wilt) disease, yellow leaf disease and fruit rot disease of arecanut etc., six core research teams have been identified and entrusted with accomplishing the mission in a time-targeted manner, which I am sure will pay rich dividends in the near future.

In this backdrop, I am greatly privileged to present the Annual Report of ICAR-CPCRI, showcasing the research activities and achievements of this institute for the year 2014-15, presented in a thematic mode. I am grateful to Dr. S. Ayyappan, Secretary, DARE and Director General, ICAR for the encouragement and guidance. I place on record my sincere gratitude to Dr. N.K. Krishna Kumar, Deputy Director General (Hort. Science) for his support, guidance in the activities and progress of the institute. I thank Dr. T. Janakiram, ADG (Hort. Science-I.) for the unstinting support received. I remember with gratitude the services rendered by Dr. George V. Thomas, my predecessor from whom I have taken over the reins. I owe great debt to the editorial committee for bringing the annual report on time. I thank the Scientists, Officers and all staff members of this institute for the significant contributions made in fulfilling the mandate of the institute.

17-06-2015

17-06-2015

P. Chowdappa
Director

कार्य सारांश

भारतीय कृषि अनुसंधान परिषद - केंद्रीय रोपण फसल अनुसंधान संस्थान को भारत में नारियल, सुपारी और कोको पर अनुसंधान करने और समन्वयन करने का अधिदेश दिया गया है। वर्ष 2014-15 के दौरान पादप आनुवंशिक संसाधन, फसल प्रबंधन, समीकृत कीट एवं रोग प्रबंधन, शरीरक्रिया विज्ञान, कटाई उपरांत प्रौद्योगिकी, सामाजिक विज्ञान जैसे पाँच क्षेत्रों के अधीन सहित बाह्य निधि प्रदत्त परियोजनाएँ 8 कार्यक्रम क्षेत्रों के अधीन संस्थान में किए गए अनुसंधान कार्य की प्रगति इस रिपोर्ट में प्रस्तुत की गई है।

पादप आनुवंशिक संसाधन

भा कृ अनु प - केंद्रीय रोपण फसल अनुसंधान संस्थान में 306 देशीय और 132 विदेशी प्रजातियों को मिलाकर 438 नारियल प्रजातियाँ और सुपारी के 23 विदेशी प्रजातियाँ और 141 देशी प्रजातियों को सम्मिलित कर 164 सुपारी प्रजातियाँ और कोको की 344 देशी प्रजातियों का बड़ा संग्रहण है।

जीन बैंक को अधिक समृद्ध बनाने के लिए केरल, अण्डमान और लक्षद्वीप द्वीपों के 16 गुण विशेष जननद्रव्य संग्रहण किए गए जिन्हें जीन बैंक में संरक्षित किया गया है। केरल की स्थानीय प्रजातियों के अतिरिक्त कोको की 22 प्रजातियाँ रीडिंग विश्वविद्यालय लंदन से परिचित कराया गया जो स्वाद घटकों की दृष्टि से सफेद बीन की तरह है, क्लोन वास्कुलर स्ट्रीक प्ररोहमरण, काला फली रोग और मुर्झा के प्रति प्रतिरोध है। रोपाई के 19 वर्ष के बाद नारियल के पहली पीढ़ी सन्ततियों के निरीक्षण से यह देखा गया कि जड़ मुर्झा रोग लक्षण स्वयं संगमित संततियों की तुलना में (63%) आपस में संगमित संततियों में केवल 47% है।

नारियल में निलम्बन संवर्द्धन में कोशिका बहुगुणन सहित वृद्धि मीडिया के प्रभाव पर किया गया अध्ययन से यह देखा गया कि अन्य मीडिया संयुक्त की तुलना में 2, 4-डी (30 मि ग्रा प्रति लीटर) के साथ अनुपूरित वाई 3 बेसल मीडिया से अधिक संख्या की सक्रिय कोशिकाएँ प्राप्त की गई। सुपारी में लंबी/बौनी विशेषता भेद दिखलाने में योग्य सीक्वेन्स कैरक्टराइज्ड एम्प्लिफाइड रीजियन मारकर का रुपांकन किया गया और मान्यकरण किया गया। पौध miRNAs के बडे पैमाने पर पहचान, विश्लेषण और पूर्वानुमान के लिए जैव सूचना क्षेत्र में एक सॉफ्टवेयर पैकेज का विकास किया गया।

डाब के लिए उपयुक्त दो बौनी नारियल प्रजातियाँ (कल्प ज्योति, कल्प सूर्या) खोपडा और डाब, दोहरे प्रयोजन के लिए उचित एक लंबी प्रजाति कल्पा हरिता विमोचन और बागवानी फसलों के फसल मानक अधिसूचना एवं प्रजातियों के विमोचन पर केंद्रीय उप समिति द्वारा अधिसूचित करने के लिए स्वीकृत किया गया। नारियल संकर बौनी x लंबी, कल्पा श्रेष्ठा (उच्च उपज प्रदत्त) 167 गुठली/ताड़/वर्ष औसत उपज के साथ और आकलित खोपड़ा आय 35.9 कि ग्रा प्रति ताड प्रति वर्ष केरल और कर्नाटक में रोपाई के लिए सिफारिश किया गया और विमोचन एवं अधिसूचना की केंद्रीय उप समिति को प्रस्तुत किया गया। बौनी x लंबी संकर जैसे सी ओ डी x डब्ल्यु ए टी और सी ओ डी x एल सी टी संस्थान स्तर पर विमोचन के लिए संस्थान अनुसंधान समिति द्वारा गुठली उपज खोपड़ा उपज और डाब विशेषता के आधार पर पहचाना गया है। कोन्कन क्षेत्र से संग्रहित सुपारी संग्रहणों के मूल्यांकन के आधार पर उच्च उपज (3.82 कि ग्रा/ताड/वर्ष और 62.5% पहली श्रेणी संसाधित मृदु फल संस्थान स्तर पर विमोचन के लिए सिफारिश किया गया है। संस्थान से विमोचित और अधिसूचित नारियल प्रजातियाँ पी पी वी एवं एफ आर प्राधिकार के पास पंजीकृत करवाया गया और कल्पा प्रतिभा, कल्पा धेनु, कल्पा मित्रा, कल्पा रक्षा कल्पाश्री और कल्पा संकरा के लिए विदेशी किस्मों की श्रेणी के तहत पादप किस्म संरक्षण के लिए पंजीकरण प्रमाण पत्र प्राप्त किए गए। सुपारी के लिए डी यु एस - दिशा-निर्देश तैयार करने हेतु 36 विशिष्ट गुणधर्मों की संवीक्षा की गई।

फसल प्रबंधन

नारियल आधारित समीकृत कृषि पद्धति का आर्थिक विश्लेषण से यह देखा गया कि पद्धति से उत्पादित जैविक और 50 प्रतिशत अजैविक के संयुक्त प्रयोग से उच्चतम कुल आय प्राप्त किया गया। संसाधन उपयोग क्षमता के लिए नारियल आधारित फसलन पद्धति के विश्लेषण से यह देखा गया कि उपज और खोपड़ा मात्रा के संबंध में उपचारों के क्रम में कोई खास भिन्नता नहीं है। नारियल बाग में औषधीय पौध के साथ मिश्रित सस्यन में, परीक्षण के पूर्व उपचारित पैदावार की तुलना में गुठली उपज में 21% वृद्धि पायी गयी। मोहितनगर में किए गए सुपारी आधारित फसलन पद्धति में सर्वाधिक उत्पादकता सुपारी + काली मिर्च + ऐसिड लाइम + हल्दी मॉडल में पायी गयी।

नारियल में परिशुद्ध कृषि के संबंध में नारियल कृषि के लिए तमिलनाडु के प्रमुख नारियल वर्द्धित जिलों अर्थात कायम्बत्तूर तिरुप्पुर, तंजावूर और डिन्डिगुल के लिए नारियल की खेती हेतु मृदा से जुड़ी समस्याओं के मानचित्र बनाए गए। मृदा की गहराई, पीएच और मृदा की मिश्रण से संबंधित समस्याओं की गंभीरता और दायरे को दर्ज किया गया। यह पाया गया कि अधिकतर नारियल खेती के लिए मृदा पी एच से संबंधित समस्याएँ हैं।

कर्नाटक और केरल के मुख्य रुप से सुपारी वर्द्धित प्रक्षेत्रों में छत्र विगलन, झुकाव और क्रोस नोड्स जैसी विकृतियाँ पायी गयी हैं। दानेदार मिट्टी में 0.1-0.3 प्रतिशत ज़िंग सल्फेट या प्रति ताड़ 10 ग्रा ज़िंग सल्फेट मृदा प्रयोग और नाईट्रोजन/फोसफोरस प्रयोग न करने करने से विकृतियों के लक्षणों में कमी आई और 10 वर्ष से कम आयु के ताड़ों में उभरती पत्तियों का सामान्य विकास पाया गया। 15 वर्षों से अधिक की आयु वाले ताड़ों की तुलना में 5 से 6 वर्ष आयु की तरुण ताड़ों में द्रुतगति में (चार महीने के अंदर ही) रिकवरी पायी गयी। बोराक्स के रुप में बोरोन का प्रयोग का

प्रभाव समझने के परीक्षण से यह देखा गया कि छिलका सडाना के साथ 120-180 ग्रा प्रति ताड की दर में बोराक्स के प्रयोग से 65 प्रतिशत विकृति वाले ताडों में बोरोन कमी लक्षण का घटाव पाया गया।

जैव संसाधन प्रबंधन पर किए गए अध्ययन से यह देखा गया कि मृदा स्वास्थ्य सुधार के लिए डाब छिलका और बयोचार के रुप में सुपारी छिलका जैवभार अवशेष (मृदा योजक) को पुनः चक्रमण करने की काफी संभावाना है। इसके अतिरिक्त यह निरीक्षण किया गया कि नारियल पत्ते के साथ *प्लूरोटेर फ्लोरिडा* के ज्वार आधारित अंडों के साथ माध्यमिक परत के रुप में कायर गूथा का समावेशन से पोटासियम मात्रा में और वर्मीकम्पोस्ट की सूष्माणुवीय गुणों में वृद्धि पायी गयी। राइनोसेरस भृंग के प्रजनन प्रबंधन के लिए वर्मीकंपोस्ट बनाने की टंकी के ऊपरी तल पर पार्श्व भागों में ताजा नीम केक का प्रयोग प्रभावी रोगनिरोधी नियंत्रण विधि पायी गयी।

ए एम ए ए एस मैकोराइजे परियोजना के अधीन पाँच वर्षीय अध्ययन पर आधारित मृदा आधारित ए एम एफ बायोइनोक्युलेंट के इ आर ए एम का विमोचन किया गया। बायोइनोक्युलेंट में क्लारोइडोग्लोमस एटुनिकाटम सम्मिलित है, नारियल सस्य परिस्थिति से एकलित ए एम प्रभावी जातियों में से एक है और इसमें नारियल पौदों के विकास प्राचलों की वृद्धि हेतु काफी ज्यादा क्षमता है।

समीकृत कीट एवं रोग प्रबंधन

सुपारी के फल सड़न कारक *पी. मीडियाइ* के पहचान के लिए एक तात्कालिक पी सी आर नयाचार का विकास किया गया है। राइबोसोमल डीएनए के आंतरिक टान्स्क्रैब्डस्पेसर भाग के अनुक्रमणों से ओलिगोन्यूक्लियोटिड प्राइमर प्राप्त किए गए। सुपारी बाग में इनोकुलम की प्रारंभिक स्थापना के लिए *पी मीडियाइ* के लिए एक वैकल्पिक परपोषी के रुप में सुपारी बाग में स्व विकसित कोलोकेसिया पहचान की गई। स्व जीवे परिस्थिति के अधीन *फाइटोफ्थोरा मीडियाइ* के विरुद्ध पंजीकृत कवक नाशकों की प्रभावकारिता पर किए गए अध्ययनों में यह पाया गया कि मैंडिप्रोपमिड, मैटलैक्सिल + मांकोजेब अमिटोक्ट्राडिन + डैमेथोमोर्फ को 125 पीपीएम पर काफी प्रभावकारी पाया गया। सुपारी में फल सडन रोग पर प्रक्षेत्र परीक्षण से यह देखा गया कि 1 प्रतिशत बोर्डो मिश्रण और बाद में मन्डिप्रोपमिड 250 एससी के साथ छिड़काव किए जाने से रोग का आपतन व प्रकाप कम देखा गया।

नारियल का जड मुर्झा रोग और सुपारी का पीला पत्ता रोग के साथ संबंधित फाईटोप्लाज़्मा का पहचान के लिए जेने लैम्प प्रणाली, ओप्टिजीन, का प्रयोग करते हुए तथा फाईटोप्लास्मा 16 SrDNA का उपयोग कर, एक तत्कालिक लैम्प (आरटी लैम्प) पद्धति का विकास किया गया।

जैविक नियंत्रण, कृषक भागीदारी अभिगमों तथा वनस्पतिक सम्मिश्रणों पर खास ध्यान देकर ताड एवं कोको के मुख्य कीटों के उन्मूलन के लिए समीकृत कीट प्रबंधन रणनीतियाँ सुदृढीकरण किया। रासायनिक कीटनाशकों का आवश्यक आधारित उपयोग और उनके अवशिष्टों की सीमा को निर्धारित किया गया। नाशी-कीटों के प्रवेश के सभी संभावित मुख्य क्षेत्रों में अक्राणकारी नाशीकीटों की उपस्थिति पर अन्वेषणात्मक निगरानी सर्वेक्षण किए गए और आपातकालीन स्थितियों से निपटने हेतु एक मोड्युल बनाने के लिए ताड़ों में संभाविक जैव सुरक्षा जोखिम आकलित किया गया। राईनोसेरस भृंग के विरुद्ध रोगनिरोधी पत्ता नाली भरने के लिए टेबलेट रुप एवं आकार में एक वनस्पतिक केक को (जिसका प्रत्येक का वजज 1.9 ग्रा, व्यास 2.5 से.मी. एवं मेटाई 0.4 से. मी थी) विकसित किया गया। अत्यावश्यक तेल जैसे तुलसी तेल, अदरक तेल, सिट्रियोडोरा तेल, थैमॉल तेल, और थाइमॉल तेल तथा अजवायन तेल जैसे महत्वपूर्ण एवं मूल तत्वों में राईनोसेरस भृंग का वाई-ट्यूब प्रतिक्रिया 70-75 प्रतिशत निरोधक क्षमता देखी गई। तीन पंचायतों जैसे देविकुलंगरा, कन्डल्लूर और कृष्णपुरम में राइनोसेरस भृंग का क्षेत्रवार जैव-उन्मूलन में राईनोसेरस भृंग द्वारा पत्ती को नुकसान पहुँचाये जाने में भारी कमी पायी गयी। जो कि 62.5-85.5 प्रतिशत के बीच में थी। वर्ष 2010-2014 के दौरान मौसम प्राचलों तथा मासिक राईनोसेरस भृंग संक्रामण के लॉग मानों के बीच नाशीजीव-मौसम समाश्रयण मॉडल स्थापित किया गया।

सीडेक, तिरुवनन्तपुरम के सहयोग के साथ लाल ताड घुन पहचानक का ध्वनिक पद्धति पर आधारित एक आदिप्ररुप जो मोबाइल फोन से जोडा जा सकता है, का विकास किया गया। लाल ताड घुन पर कीट रोगाणुमूलक कवक के संबंध में किए गए मूल्यांकन से यह पाया गया कि 0.002 प्रतिशत इमिडाक्लोप्रिड के प्रयोग के बाद पत्ता नाली पर 12-15 हेटिरोहाब्डिटिस इन्टिका संक्रमित जी मैलोनेला कैडावर वाले तीन छन्ना कागज़ थैली स्थापित किए जाने से 60 प्रतिशत संक्रमित ताडों का पुनः स्वास्थ्य प्राप्त किया जा सकता है। तटीय बलुआर मृदाओं में मूल भृंग की समष्टि पर ईपीएन के प्रभाव पर किए गए अध्ययनों से यह देखा गया कि जून-जुलाई तथा सितंबर-अक्तूबर के दौरान $0.5 = 10^6$ IJs प्रति ताड सहित *एस. कार्पोकाप्से* (100-200 मि.ली. घोल) के ईपीएन तरल सम्मिश्रण में पादप के जड़ भाग को डुबोये जाने से जड़ भृंग के प्रकोप में 61 प्रतिशत की गिरावट देखी गई।

शरीरक्रिया विज्ञान, जैव रसायन एवं कटाई उपरांत प्रौद्योगिकी

नारियल पौध (गंगाबोटम प्रजाति) पर ओटीसी के तहत संवर्धित कारबनडायऑक्साइड और ताप के प्रभाव पर किए गए अध्ययन से यह देखा गया कि संवर्धित कारबनडायऑक्साइड (ईसीओ2) के तहत पौदो में विकास और परिशुद्ध प्रकाश संश्लेषण के लिए महत्वपूर्ण कोई ज्यादा अंतर नहीं देखा गया जबकि पत्ता भाग में मामूली वृद्धि पायी गयी। संवर्धित तापमान के तहत 50 प्रतिशत से अधिक की गिरावट आई, क्लोरोफिल से 40 प्रतिशत से अधिक गिरावट आई और परिशुद्ध प्रकाशसंश्लेषण में काफी कमी पायी गयी जबकि कारबनडायऑक्साइड और इ टी के लिए कुल शक्करा काफी ज्यादा पायी गयी जबकि इ टी और इ टी के तहत प्रति-ऑक्सिकारक क्रियाशीलता में गिरावट देखी गई।

जल उपयोग दक्षता, जड बायोमास तथा जड प्ररोह अनुपात में 7

लंबी (एफएमएसटी, टीपीटी, एजीटी, डब्ल्युसीटी, सीसीएनटी, क्लप हरिता और पीएच ओटी तथा पाँच बौनी (एलसीओडी, सीजीडी, सीओडी, एमवाईडी और एमओडी) सहित 12 नारियल जीन प्ररुपों में काफी ज्यादा भिन्नताएँ देखी गई, जो सूखा सक्षमता से संबंधित है।

सीजीडी, एमजीडी, एमवाईडी, एमओडी और डब्ल्युसीटी प्रजातियों पर किए गए परागण अंकुरण अध्ययनों से यह देखा गया कि समस्त तापमान के दौरान डब्ल्युसीटी में सर्वाधिक अंकुरण था और जिसके बाद एम जी डी में पाया गया और एम वाई डी में अंकुरण सबसे कम था।

कारकला, कर्नाटक के एक किसान श्री अगस्टिन जॉसफ ने के रो फ अ सं के वैज्ञानिकों के साथ परामर्श कर ताजा स्वच्छ नारियल फूल रस (कल्पारस) के संचयन के लिए एक उपकरण (कोको-सैप चिलर) को विकसित किया है। यह उपकरण हल्का जलरोधी है इसे स्पेडिक्स के साथ आसानी से जोडा जा सकते है इसमें बर्फ की ज़रुरत कम पड़ती है तथा लंबी अवधि तक तापमान निम्न स्तर पर बनाए रखता है। किसानों/उद्यमियों को इस प्रौद्योगिकी को व्यावसायीकरण किया गया है। जैव रासायनिक अध्ययनों से यह पाया गया कि के रो फ अ सं तकनीकी द्वारा प्राप्त किया गया नीरा पारंपरिक नीरा की तुलना में श्रेष्ठ है सभी गुण जैसे स्वाद, घुलनशील, ठोस पदार्थों, जीवाणुज भार तथा रोगाणुमूलकों सहित बाह्य पदार्थों, की दृष्टि से उत्कृष्ट है। इस प्रौद्योगिकी को दक्षिण भारत के सभी राज्यों में 12 कम्पनियों को हस्तांतरित किया गया। मुलायम चूर्ण बनाने हेतु कल्परस पर माल्टोडैक्सट्रिन और अकेसिया गम जैसे योगजों से विभिन्न अनुपातों पर सूखा छिड़काव किया गया, जबकि शुष्क छिडकाव वाले पाउडर बनाने के लिए 7.5 प्रतिशत माल्टोडैक्सट्रिन को प्रभावी पाया गया।

निर्जीवीकरण किया गया नीरा के भण्डारण के लिए प्लास्टिक बोतलों की 0.1 प्रतिशत नाइसिन प्रयोग के साथ जांच की गई और 15 दिनों तक गुणवत्ता को कायम रखने हेतु उसे अनुकूल एवं प्रशीतित स्थिति में भाण्डारित किया गया। वरजिन नारियल तेल उत्पादन के उपोत्पादों का जैव रासायनिक विश्लेषण से यह देखा गया कि वरजिन नारियल तेल के प्रोटीन फिनोलिक्स और प्रतिऑक्सिकारक काफी अच्छा था जबकि कारबोहाईट्रेट और दैनिक आहार या आहारीय फाइबरों में अच्छे दूगध अपशिष्ट पाए गए। वरजिन नारियल तेल उत्पादन के उपोत्पादों से बहिर्वेधित उत्पाद और मीठे स्नैक्स जैसे मूल्य वर्द्धित उत्पादों के उत्पादन के लिए प्रयास किया गया। हाथ से शल्क निकालने में हो रहे समय और कड़ी मज़दूरी कम करने के लिए नारियल शल्क निकाने का एक आदिप्ररुप यंत्र का विकास किया गया। जल संरक्षण उपाय प्रबंधन पर किए गए अध्ययनों में यह पाया गया कि संरक्षण उपाय जैसे अर्ध चन्द्र बाँध, गड्ढा, खाई जैसे संरक्षण उपायों तथा कम लागत के भण्डारण संरचनाओं का व्यापकरुप से में स्वीकार किया जाए तो सुरंगमों की जल लभ्यता बढ़ाने के लिए यह एक उपयुक्त समाधान हो सकता है।

प्रौद्योगिकी हस्तांतरण और सामाजिक विज्ञान

केंद्रीय रोपण फसल अनुसंधान संस्थान, कासरगोड, क्षेत्रीय केन्द्र विट्टल और कायम्कुलम तथा मोहितनगर और काहिकुची अनुसंधान केंद्रों में विभिन्न केन्द्रीय/राज्य सरकार एजेंसियों के सहयोग के साथ नारियल, सपारी और कोको के लिए उत्पादन एवं प्रक्रमण प्रौद्योगिकियों पर प्रशिक्षण कार्यक्रम आयाजित किए गए। कें रो फ अ सं में आयोजित किसान मेला का उद्घाटन माननीय मंत्री, विधि एवं न्याय श्री सदानन्दा गौड़ा द्वारा किया गया। अनुसंधान विस्तार अभिमुख कार्यक्रम के लिए वीडियो सम्मेलन सुविधा प्रभावी रुप से उपयोग किया जाता है। सुपारी समीकृत रोग प्रबंधन को और कोको कृषि और मृदा जल संरक्षण में मूल्य वर्द्धन सहित विभिन्न विषयों पर हितधारक अभिमुख कार्यक्रम आयोजित किए गए। अनुसंधान गतिविधियों की दृश्यता को गति देने तथा संस्थान द्वारा विकसित प्रौद्योगिकियों के लिए की गई पहल के रुप में एक अनुसंधान-मीडिया अंतर्वाता कार्यक्रम का आयोजन किया गया। नियमित नैदानिक प्रक्षेत्र दौरों, प्रदर्शनियों में भागीदारी करने, एक्सपोजर दौरों, प्रौद्योगिकियों का प्रक्षेत्र स्तरीय प्रदर्शन भी आयोजित किए गए।

लाल ताड़ घुन प्रबंधन पर आलप्पुष्ा में किसानों की जानकारी से पता चला कि उन्हें नाशीकीटों के उन्मूलन तथा नाशीजीव संक्रमण की पहचान के बारे में काफी कम जानकारी है। किसानों के उद्यानों/खेतों में नाशीजीवों के प्रक्षेत्र स्तरीय आपतन की प्रकृति के विश्लेषण में समेकित प्रकृति का पता चला है जिसके संक्रमण का दर 4 से 11 प्रतिशत के बीच है। प्राचल घटक के रुप में डिजाइन मैट्रिक तथा नॉन-पैरामैट्रिक घटक के रुप में सहचर के साथ सेमी-पैरामैट्रिकरिग्रेशन को फिट करने हेतु एक उत्कृष्ट विधि विकसित की गई जो कि डाटा में अस्पष्ट आंकडों की मौजूदगी से प्रभावित नहीं है। रिग्रेशन फंकशन को फिट करने के लिए उत्कृष्ट एम-केरनल भारित स्थानीय रैखिक समारयण रंदे का उपयोग किया जाता है। प्रक्षेत्र परीक्षणों में सुपारी की उपज उपलब्धता के आधार पर नमूने आकार को फिक्स करने के लिए किए गए अध्ययनों में यह पाया गया है कि किसी भी परिशुद्ध स्तर के लिए दो वर्षों के लिए संचयी डाटा के लिए अपेक्षित नमूना आकार एकल वर्ष डाटा के 50 प्रतिशत कम था। रोपण फसलों में रोग आपतन के आकलन हेतु सीमित संसाधन समय और जनशक्ति के साथ प्रक्षेत्र सर्वेक्षण के लिए एक कार्यप्रणाली विकसित की गई। कर्नाटक के तीन जिलों के विभिन्न तालुकों में पीली पत्ती रोग के आपतन व प्रकोप का आकलन किया गया। सर्वेक्षण के परिणामों में यह पाया गया है कि कोप्पा और सामपाजे सबसे ज्यादा प्रभावित तालुक थे जहाँ लगभग 70 प्रतिशत रोग आपतन और 30 से 40 प्रतिशत रोग तीव्रता पाई गई। सांख्यिकी तकनीकों के कार्यान्वयन के लिए कम्प्यूटर कार्यक्रमों को विकसित करने हेतु फज्जी लॉजिक और बूटस्ट्रैप तकनीकों के लिए विशिष्ट कार्यक्रम विकसित किए गए।

मूल्य अस्थिरता विश्लेषण में यह पाया गया है कि यद्यपि घरेलु कोको के मूल्य में उतार-चढाव अपेक्षाकृत कम था, लेकिन यह अंतर्राष्ट्रीय कोको के मूल्यों से अधिक था। विश्लेषण में इस बात की ओर इशारा किया गया है कि घरेलू बाजार में मूल्य स्थिरता

कार्यपद्धति कमजोर है जिसे सही किया गया जाना चाहिए। ताड़ तेल के आयात प्रशुल्क संरचना के संबंध में हाल ही की नीतियों में परिवर्तनों पर किया गया। विश्लेषण एक स्पष्ट नीति की ओर इशारा करता है जबकि आयातशुल्क 7.5 प्रतिशत से कम है। हालांकि मूल्यों में गिरावट जारी है। ताड़ तेल के मूल्यों के दौर से सभी खाद्य तेलों के मूल्यों पर भी दबाव बना हुआ है और घरेलू उत्पादन पर इसका प्रतिकूल प्रभाव पड़ा है और ताड़ तेल के आयातों में बढ़ोत्तरी के कारण आयातशुल्क संरचना को पुनः रुपरेखा देने की जरुरत है।

वर्ष के दौरान लगभग 7 लाख इकाईयों (बीजो/पौधों/कलमों/फलियों) के उत्पादन के कारण अधिदेशित फसलों में रोपण सामग्री उत्पादन को और ज्यादा बढ़ाया गया है। कें रो फ अ सं ने कृषि विभाग केरल तथा नारियल विकास बोर्ड के सहयोग से नारियल में हाइब्रिड उत्पादन को बढ़ाने हेतु किसानों के खेतों में उपलब्ध उत्कृष्ट मातृत्व ताड़ों का उपयोग करते हुए भागीदारी प्रक्रिया में उच्च गुणवत्ता वाली पौधों के लिए मांग की पूर्ति हेतु उचित कार्यनीतियों बनाई गई है।

संस्थान के तहत अवसंरचनात्मक सुविधाओं और विकसित प्रौद्योगिकियों को और ज्यादा बढ़ावा दिया गया है। प्रशासनिक और लेखांकन प्रणाली की दक्षता और पारदर्शिता को बढ़ाने हेतु संस्थान में समेकित प्रबंधन सूचना प्रणाली का कार्यान्वयन किया गया है।

Executive Summary

ICAR- Central Plantation Crops Research Institute has been mandated to conduct and coordinate research on coconut, arecanut and cocoa in India. Progress of research work carried out under the eight programmes including the externally funded projects in the Institute during the year 2014-15 is presented in this report under five thematic areas *viz.*, Plant Genetic Resources, Crop Management, Integrated Pest and Disease Management, Physiology, Biochemistry & Post Harvest Technology, and Technology Transfer and Social Sciences.

Plant Genetic Resources

ICAR-CPCRI has the largest collection of coconut germplasm with 438 accessions including 306 indigenous and 132 exotic ones and in arecanut with 164 accessions including 141 indigenous and 23 exotic ones. The cocoa field gene bank is currently conserving 344 accessions. Explorations were undertaken in Kerala, Andamans, and Lakshadweep islands to enrich the gene bank with 16 trait-specific germplasm collections. Twenty two exotic accessions of cocoa, including white bean types rich in flavour components, clones resistant to Vascular Streak Dieback (VSD), Black Pod Disease (BPD) and wilt were introduced through International Cocoa Quarantine Centre, University of Reading, UK., in addition to the local accessions from Kerala. Observations recorded from first generation progenies of coconut after 19 years of planting revealed that root (wilt) disease incidence in the *inter se* mated progenies was only 47% compared to 63% in selfed progenies. Studies on the effect of growth media on inducing cell multiplication in suspension culture in coconut revealed that Y3 basal media supplemented with 2, 4-D (30 mg l^{-1}) produced large number of active cells compared to other media combinations. A Sequence Characterized Amplified Region (SCAR) marker capable of distinguishing tall/dwarf trait in arecanut was designed and validated. On the bioinformatics front, a software package (SmiRNA) was developed for large scale of discovery, annotation and prediction of plant miRNAs.

Two dwarf coconut varieties (Kalpa Jyothi and Kalpa Surya) suitable for tender nut purpose and a tall, dual purpose variety suitable for copra and tender nut (Kalpa Haritha), were accepted for release and notification by the Central Sub-Committee on Crop Standards, Notification and Release of Varieties of Horticultural Crops. A variety release proposal pertaining to a Dwarf x Tall coconut hybrid, Kalpa Sreshta (high yielding with average yield of 16 7 nuts $palm^{-1}$ $year^{-1}$ and an estimated copra out turn of 35.9 kg $palm^{-1}year^{-1}$), recommended for cultivation in Kerala and Karnataka was submitted to Central sub-committee for release and notification. Further, two D x T coconut hybrids *viz.*, COD x WAT and COD x LCT were identified for release at Institute level by the Institute Research Committee considering the better performance for nut yield, copra out turn and tender nut traits. Based on evaluation of the arecanut collections from Konkan region, a high yielding (3.82 kg $palm^{-1}year^{-1}$) selection, Kodinar with 62.5% recovery of first quality processed tender nuts, was recommended for release at institute level. The released and notified coconut varieties from the Institute were registered with PPV& FR Authority and registration certificates for plant variety protection under EXTANT variety category were received for Kalpa Pratibha, Kalpa Dhenu, Kalpa Mitra, Kalparaksha, Kalpasree and Kalpa Sankara. For developing DUS guidelines for arecanut, thirty six distinctive characteristics were short listed.

Crop Management

The economic analysis of coconut based integrated farming system (CBIFS) indicated that the net returns were the highest in the CBIFS receiving combined application of 50 per cent organics produced from the system and 50 per cent inorganics. The analysis of coconut based cropping systems for resource use efficiency revealed that there is no significant difference among treatments with respect to the yield and copra content. The mixed cropping with medicinal plants in the coconut gardens recorded 21% increase in yield of nuts in comparison with the pre-experimental yield. Arecanut based cropping system evaluation conducted in Mohitnagar revealed that the maximum total system productivity was obtained in arecanut+ black pepper + acid lime + turmeric model.

With regard to the precision farming in coconut, soil constraints maps for coconut cultivation were prepared for four major coconut growing districts of Tamil Nadu *viz.,* Coimbatore, Tiruppur, Tanjavur and Dindigul. The intensity and range of constraints related to soil depth, pH, and soil texture were recorded. It was observed that majority of the area is having soil pH related constraints for coconut cultivation.

In arecanut, disorders like crown choking, bending and cross nodes have been noticed in many plantations in major growing tracts of Karnataka and Kerala. In laterite soils, spraying of 0.1-0.3% $ZnSO_4$ or soil application of 10 g $ZnSO_4$ / palm and skipping of nitrogen/phosphorus application reduced the disorder symptoms and resulted in normal growth of emerging leaves in palms of below 10 years. The young palms aged 5- 6 years recovered faster (within four months) than palms aged above 15 years. Experiment to understand the effect of application of boron as borax in coconut revealed that the application of borax@120-180 g $palm^{-1}$ with husk burial recorded remission of boron deficiency symptoms in 65 % of the deficient palms.

Studies on bio-resource management indicated that there is good potential to recycle tender coconut husk and arecanut husk biomass residues as biochars (soil additives) for improving the soil health. Further, it was observed that addition of coir pith as intermediary layers along with sorghum based spawns of *Pleurotus florida* with coconut leaves resulted in improvement in potassium content and microbial properties of vermicompost. Application of fresh neem cake along the top inside borders in vermicomposting tanks was found to be an effective prophylactic control measure for managing the breeding of rhinoceros beetle.

Based on five years study under AMAAS-Mycorrhizae project, a soil based AMF bioinoculant, *Ker*AM, was released. The bioinoculant contains *Claroideoglomus etunicatum*, one of the dominant AM species isolated from coconut agro-ecosystem with high potential to increase the growth parameters of coconut seedlings.

Integrated Pest and Disease Management

A real-time PCR protocol has been developed for specific detection of *P. meadii*, causing fruit rot of arecanut. Oligonucleotide primers were derived from sequences of internal transcribed spacer region of ribosomal DNA. Self-grown *Colocasia* in arecanut garden was identified as an alternate host for *P. meadii* for initial establishment of inoculum in arecanut garden. Studies on effectiveness of registered fungicides against *Phytophthora meadii* under *in vitro* condition, indicated that mandipropamid, metalaxyl + mancozeb, ametoctradin + dimethomorph as most effective at 125 ppm. Field trials on fruit rot disease management in arecanut indicated lower incidence in plots sprayed with 1% Bordeaux mixture followed by Mandipropamid 250 SC.

A real-time LAMP (RT-LAMP) assay using the Genei II LAMP system, Optigene, was developed for detection of phytoplasma associated with RWD of coconut and YLD of arecanut using the phytoplasma 16Sr DNA as target for amplification.

Integrated pest management strategies were fine-tuned for the suppression of key pests of palms and cocoa with emphasis on biological control, farmer-participatory approaches as well as botanical preparations. Need-based use of chemical pesticides and their residual limit were also determined. Exploratory surveillance surveys were undertaken on the occurrence of invasive pests in all strategic points of entry and the potential bio-security risks in palms were estimated for evolving an emergency preparedness module. A botanical cake was developed in tablet-shape (each weighing 1.9 g with a dia 2.5 cm & thickness 0.4 cm) for the prophylactic leaf axil filling against rhinoceros beetles. Y-tube response of rhinoceros beetle towards essential oils *viz.,* basil oil, ginger oil, citriodora oil, thymol oil, and ajowan oil showed 70 to 75% repellency. Area-wide bio-suppression of rhinoceros beetle in three Panchayats *viz.,* Devikulangara, Kandalloor and Krishnapuram indicated significant reduction in leaf damage by rhinoceros beetle ranging from 65.2 to 85.5%. A pest- weather regression model (PWRM) between log values of monthly rhinoceros beetle (RB) infestation and weather variables during 2010-2014 was established.

A prototype of red palm weevil detector based on acoustic system, which could be linked to mobile phones, was developed in association with Centre for Development of Advanced Computing

(CDAC), Thiruvananthapuram. Evaluation of the entomopathogenic fungi on red palm weevil revealed that placement of three filter paper sachets containing 12-15 *Heterorhabditis indica*-infected *G. mellonella* cadavers on the leaf axils after application of 0.002% imidacloprid could recover 60% of infested palms. Studies on effect of EPN on root grub population in coastal sandy soils showed that root zone drenching of EPN liquid formulation of *S. carpocapsae* (100-200ml solution) containing 0.5×10^6 IJs palm^{-1} during June-July and September - October resulted in 61% reduction.

Physiology, Biochemistry & Post Harvest Technology

Studies on impact of elevated CO_2 and temperature under OTC on coconut (var.Gangabondam) seedlings revealed that under elevated CO_2 (ECO_2), seedlings did not show significant differences for growth and net photosynthesis while there was a marginal increase in leaf area. Under elevated temperature, leaf area reduced >50%, chlorophyll reduced >40% and significant reduction was found for net photosynthesis. Total sugar was significantly high for ECO_2 and ET, whereas, antioxidant activity was reduced under ET and ECO_2+ET. Wide variability was observed among twelve coconut genotypes comprising seven tall (FMST, TPT, AGT, WCT, CCNT, Kalpa Haritha and PHOT) and five dwarf (LCOD, CGD, COD, MYD and MOD) in water use efficiency (WUE), root biomass and root-shoot ratio which are related to drought tolerance.

Pollen germination studies on CGD, MGD, MYD, MOD and WCT indicated that across all the temperature, germination was the highest in WCT followed by MGD and was the least in MYD.

The device (Coco-sap chiller) for collection of fresh hygienic coconut inflorescence sap (Kalparasa) has been developed by a farmer, Mr. Augustine Joseph from Karkala, Karnataka in consultation with CPCRI scientists. The unit is lighter, water proof, easy to connect to the spadix, requires less ice and retains low temperature for longer period and the technology has been commercialized to farmers/ entrepreneurs. Biochemical studies revealed that Kalparasa from CPCRI technique is superior to the traditional neera in all the quality parameters like flavour, soluble solids, microbial load and extraneous matter including pathogens. The technology was transferred to twelve firms across the states in south India. Kalparasa was spray dried with additives like maltodextrin and gum acacia at different proportions in order to make free flowing powder wherein 7.5 % maltodextrin was found effective for making spray dried powder. Plastic bottles were tested for storage of pasteurized neera with 0.1 % Nisin and stored at ambient and refrigerated condition with good keeping quality till 15 days. Biochemical analysis of co-products of VCO production revealed that VCO cake was rich in proteins, phenolics and antioxidants, whereas, milk residue was rich in carbohydrates and dietary fibres. An attempt was made to produce value-added products namely extrudates and sweet snacks from VCO co-products.

A prototype of coconut shell removing machine was developed to reduce both time and drudgery involved in the manual de-shelling process. Studies on management of water conservation measures indicated that conservation measures like half moon bund, catch pit and trench and the low cost storage structures, if adopted in a large scale, would be an ideal solution to enhance the water availability of *surangams*.

Technology Transfer and Social Sciences

Training programmes on production and processing technologies for coconut, arecanut and cocoa were conducted during the year at CPCRI, Kasaragod, Regional Stations at Vittal and Kayangulam and Research centres at Mohitnagar and Kahikuchi, in collaboration with various Central/State Government agencies. Kisan Mela at CPCRI Regional Station, Vittal was inaugurated by Shri D.V. Sadananda Gowda, Hon'ble Minister for Law and Justice, Govt. of India. Videoconferencing facility has been effectively used for conducting Research-Extension Interface programmes. Stakeholder interface programmes were conducted on various topics including value addition in arecanut, integrated disease management, coconut and cocoa farming and soil water conservation. As an initiative in enhancing the visibility of research activities and popularizing the technologies developed by the institute, a Research-Media Interface programme was organized. Regular diagnostic field visits, participation in exhibitions, exposure visits, field level demonstrations of technologies were also conducted.

Knowledge profiling of farmers in Alappuzha district on red palm weevil management indicated that major knowledge gap is in the mode of destruction and early identification of the pest infestation. The analysis of pattern of field level incidence of the pest in farmers' gardens indicated an aggregate pattern with the infestation ranging from 4 to 11%. A robust method, not influenced by the presence of outliers in the data, is developed to fit the semi-parametric regression with design matrix as the parameter component and covariate as the nonparametric component. Robust M- kernel weighted local linear regression smoother is used to fit the regression function. Studies for fixing the sample size based on the yield variability of arecanut in field experiments indicated that for a given level of precision, the required sample size for two years cumulative data was less than 50% of the single year data. A methodology for field survey to assess the disease incidence in plantation crops with limited resource, time and man power was developed. Estimation of Yellow Leaf Disease (YLD) incidence in various taluks in three districts of Karnataka was conducted. The survey results indicated that Koppa and Sampaje were the most affected taluks with about 70 % incidence and 30-40% intensity. In an effort to develop computer programs for implementation of statistical techniques, customized programs were developed in R for fuzzy logic and bootstrap techniques.

Price instability analysis revealed that although the price volatility in domestic cocoa was comparatively at lower levels, it was higher than the international cocoa prices. The analyses show weak price stabilizing (procurement) mechanism in the domestic arena which should be corrected. Analysis of recent policy changes revealed a clear policy void regarding Import tariff structure of palm oil, wherein import duty is as low as 7.5% even though the prices are declining. A bearish trend in palm oil prices exerts downward pressure on prices of all edible oils with an adverse effect on domestic production and a further rise in palm oil imports necessitating re-calibrating the import duty structure.

The planting material production in mandate crops has been further augmented with the production of around seven lakh units (seeds / seedlings / grafts / pods) during the year. CPCRI in collaboration with the Dept. of Agriculture, Kerala and Coconut Development Board has formulated strategies for meeting the demand for high quality seedlings in participatory mode using elite mother palms available in farmers' fields for increasing hybrid production in coconut.

The infrastructural facilities and technologies developed under the Institute were further strengthened. Unified Management Information System was implemented in the institute for improving efficiency and transparency of the administrative and accounting system.

Introduction

Historical perspective

The Coconut Research Station at Kasaragod in Kerala was initially established in 1916 by the Presidency of Madras and subsequently it was taken over by the Indian Central Coconut Committee in 1948. The Central Plantation Crops Research Institute (CPCRI) has come into existence in 1970 as one of the agricultural research institutes in the National Agricultural Research System (NARS) under the Indian Council of Agricultural Research (ICAR) by merging Central Coconut Research Station, Kasaragod, Central Coconut Research Station, Kayamkulam as well as Central Arecanut Research Station, Vittal and its five substations at Palode and Kannara (Kerala), Hirehalli (Karnataka), Mohitnagar (West Bengal) and Kahikuchi (Assam).

Research on cashew and spices was undertaken from 1971 onwards with the establishment of All India Co-ordinated Spices and Cashewnut Improvement Project. Subsequently, the All India Co-ordinated Coconut and Arecanut Improvement Project (AICCAIP) started functioning from 1972 with its Headquarters at CPCRI, Kasaragod.

The CPCRI network was further expanded with the establishment of Seed Farm at Kidu (Karnataka) in 1972 to produce quality planting materials in coconut, arecanut and cocoa; a seed garden for cashew at Shantigodu (Karnataka) during the same year; acquiring the Research Centre at Appangala (Karnataka) for cardamom research in 1974; establishing a Regional Station at Calicut (Kerala) in 1975 for conducting research on spices; establishing a Field Station at Irinjalakuda (Kerala) to monitor the northward spread of coconut root (wilt) disease; initiating research on oil palm at Palode and taking over the administrative control of ICAR Research Complexes at Goa and Lakshadweep Islands. During 1986, research on spices and cashew was delinked from the institute with the establishment of National Research Centres at Calicut and Puttur, respectively. During 1989, the ICAR Research Complex for Goa was upgraded as independent Institute, delinking it from CPCRI. Research on oil palm was delinked from CPCRI after the establishment of National Research Centre for Oil palm at Pedavegi (Andhra Pradesh) and CPCRI, RC, Palode was transferred to NRC for Oil Palm in 1999. International Coconut Genebank for South Asia (ICG-SA) was established at CPCRI Seed Farm, Kidu in 1998 and the Farm was upgraded as Research Centre in 2002. In 2001, World Coconut Germplasm Centre, Sipighat, Andamans was handed over to Central Agricultural Research Institute, Andamans and in 2002, CPCRI, RC, Hirehalli was handed over to IIHR, Bangalore. In 2006, Research Centre of CMFRI at Minicoy was merged with Regional Station of CPCRI. In 2007, Research Centre at Kannara was phased out and handed over to Dept. of Agriculture, Govt. of Kerala. During the year 2012, Regional Station, Minicoy has been remandated to act as a centre for production of fruits and vegetables and demonstration of technologies for the same.

Mandate

- To develop appropriate production, protection and processing technologies for coconut, arecanut and cocoa through basic and applied research
- To act as a national repository for the genetic resources of these crops
- To produce parental lines and breeders' stock of plantation crops
- To develop improved palm-based farming systems through more effective use of natural resources to increase productivity and income from unit area
- To collect, collate and disseminate information on the above crops to all concerned
- To co-ordinate research on these crops within the country and execute the research programmes under the All India Co-ordinated Research Project on Palms
- To transfer technologies developed at CPCRI to the farmers through the co-operation of Developmental Departments/ Boards by sponsoring training programmes, workshops, demonstrations, etc.

Achievements at a glance

ICAR-CPCRI, one of the premier agricultural research institutes in India, maintains the world's largest repository of coconut germplasm with 438 accessions (consisting of 306 indigenous and 132 exotic genotypes) from 28 countries. Through intensive breeding experiments, eighteen high yielding coconut varieties including six hybrids with talls and dwarfs as parents have been released for commercial cultivation. These varieties are capable of yielding 1.63 to 6.28 tonnes of copra ha^{-1} annually. During the year 2014-15, two dwarf tender nut varieties (Kalpa Jyothi, Kalpa Surya) and a tall, dual purpose variety (Kalpa Haritha), were approved for release and notification. A proposal on Dwarf x Tall coconut hybrid Kalpa Sreshta, recommended for cultivation in Kerala and Karnataka was submitted to Central Sub-committee on Crop Standards, release and notification of varieties in horticultural crops. Besides, two D x T coconut hybrids *viz.*, COD x WAT and COD x LCT identified as better performing for copra yield with good tender nut qualities were recommended for release at Institute level.

In arecanut, 164 germplasm collections (23 exotic and 141 indigenous) are conserved at CPCRI,RS, Vittal. Eleven high yielding arecanut varieties including two dwarf hybrids were released for commercial cultivation. During this year, a high yielding (3.8kg $palm^{-1}$ $year^{-1}$) selection, Kodinar with 62.5% recovery of first quality processed tender nuts, was recommended at the institute level for release.

In cocoa, 344 germplasm collections are conserved and being evaluated. Softwood grafting technology has been standardised in cocoa and utilised for mass multiplication. One clone (VTLCC1) and four hybrids (VTLCH1, VTLCH2, VTLCH3 and VTLCH4) of cocoa giving high bean yield were developed, of which VTLCH3 and VTLCH4 are drought tolerant. Two selections VTLC-1 and VTLC-57 of cocoa based on their vigour, early, stable, high yielding potential (2.52 and 2.70 kg $tree^{-1}$ year, respectively), were recommended for release as national varieties.

Quality planting material of mandate crops are being produced to the extent of more than 1.2 lakh coconut seed nuts, 3 lakh arecanut seed nuts and 1.1 lakh cocoa grafts / seedlings. Nurseries at Kasaragod, Kidu and Vittal have been awarded with 'four-star' and Kayamakulam with 'three star' rating in the five-star scale by National Horticultural Board under the scheme to rate the horticultural nurseries in the country.

Achievements under biotechnology include standardization of embryo culture protocol for germplasm exchange, standardization of regeneration protocol from plumular tissue of tall and dwarf coconuts and regeneration protocol from inflorescence tissues of arecanut. Cryopreservation techniques have been standardized for mature coconut zygotic embryos and coconut pollen. Tissue culture protocol has been standardised for mass multiplication of arecanut from inflorescence explants and has been commercialized. Genetic fidelity of *in vitro* derived plantlets has been assessed using molecular markers.

DNA finger printing using molecular markers *viz.*, RAPD, AFLP, DAF and microsatellite analysis have been carried out in coconut and cocoa accessions to document the genetic integrity and diversity. These techniques are also being exploited to identify different biotic and abiotic stress tolerant genes in coconut particularly for root (wilt) disease and moisture streess tolerance. Coconut and cocoa accessions have been characterized using SSR markers. DNA extraction protocol of cocoa was standardized with modified SDS method. Genes induced during somatic embryogenesis in coconut *viz.* SERK (somatic embryogenesis receptor kinase) and BBM (BABY BOOM) have been cloned and characterized. SCAR markers for distinguishing tall / dwarf trait in arecanut was designed and validated. Also, SSR markers have been identified for confirming the hybridity of D x T hybrids (CGD x WCT) which will ensure supply of genuine hybrids to farmers.

The Distributed Information Sub Centre (Sub-DIC) under the Biotechnology Information System Network (BTISnet) and the Bioinformatics Centre, were established in 2000. Agri-bioinformatics Promotion Centre (ABPC) with four components including phytoplasma genomics, palms genomics, cocoa genomics and PGPRs was established in 2009. Various databases and software tools were also developed like PROMIT, to identify promoters in the -10 and -35 regions of sequences from the

Pseudomonas spp., MAPS (Microsatellite Analysis and Prediction Software for identification and characterization of microsatellites, SmiRNA for large scale discovery, annotation and prediction of plant miRNAs.

Production technologies for coconut, arecanut, cropping / farming systems involving annuals / biennials / perennials grown in different tiers by exploiting soil and air space more efficiently and integrating with poultry and animal husbandry were developed. Coconut and arecanut based inter / mixed, multi storied multi-species cropping systems developed at CPCRI are being widely adopted by the farmers. The high density multi-species cropping system and coconut based mixed farming system helps to maximise profits and can even buffer the price crash of the main crop. For maximising economic returns, high value medicinal and aromatic crops, vanilla and flower crops have been recommended in the palm based cropping system. Arecanut (Kahikuchi selection) + Pepper (Karimunda) + Banana (Chenichampa) + Citrus (Assam lemon) + Clove (Improved variety) with 2/3 rd recommended fertilizer application resulted in the highest returns under Assam conditions. Banana, Elephant foot yam (Gajendra), pineapple, vegetables were found to be suitable intercrops for coconut gardens in littoral sandy soil with coir pith and husk amendments.

Water requirement for coconut, arecanut and palm based cropping systems were standardized. Sprinkler irrigation or perfo irrigation with 20 mm (IW/CPE = 1) water was found to be the best suited for inter or mixed cropping systems where the entire surface requires wetting. Optimum fertiliser doses for mandate crops were standardised and recommended. Fertigation at 50 % of recommended NPK and 75 % of recommended NPK resulted in higher yield in coconut and arecanut, respectively. In coastal sandy soil management, pineapple, banana, elephant foot yam and vegetable crops like brinjal can be profitably cultivated as intercrop in coconut garden by adopting adequate soil moisture conservation methods. Soil constraints maps for coconut cultivation were prepared for four major coconut growing districts of Tamil Nadu *viz.,* Coimbatore, Tiruppur, Tanjavur and Dindigul. Using remote sensing and GIS map, coconut plantation area and coconut root (wilt) disease affected coconut palms were identified with > 98% accuracy. Carbon sequestration potential of coconut, arecanut and cocoa were estimated to be 8 to 32 t CO_2 ha^{-1} year in coconut, 5.14 to 10.94 t CO_2 ha^{-1} year in arecanut and 2.02 to 3.89 t CO_2 ha^{-1} year in cocoa depending on cultivar, agro-climatic zone, soil type and management practices.

A technology for vermicomposting coconut palm wastes by using a local earthworm, *Eudrilus* sp., closely related to the African night crawler, was standardized. Novel microbial bio-agents such as Kera Probio, Cocoa Probio and KerAM were developed in user friendly talc formulations. Coconut based wastes such as coir-pith and tender-nut husk wastes were converted to biochar using a simple kiln.

Integrated disease management practices were developed for major diseases like bud rot and stem bleeding of coconut, for black pod disease, cherelle rot and canker of cocoa and fruit rot and ganoderma wilt of arecanut. Management strategies for root (wilt) affected plantations were also evolved. ELISA for the detection of root (wilt) using polyclonal antibodies has been refined further to a simple and very rapid test. The phytoplasma associated with the root (wilt) disease was characterized as belonging to 16S rDNA XIV group. Diagnostic tool for detection of root (wilt) disease of coconut and yellow leaf disease of arecanut through molecular approaches was developed.

For management of bud rot disease, pouring phosphorus acid (Akomin) solution (0.5%) @ 300 ml/palm in the innermost leaf axil is very effective. A combined integrated management strategy was developed for black pod disease and stem canker disease (*Phytophthora* diseases) of cocoa. Copper oxychloride (Blitox 0.5%), Metalaxyl + Mancozeb (Ridomil Gold 0.5%) and Phosphorous acid (Akomin 0.5%) were found to be effective in prophylactic control of black pod disease of cocoa. Developed a technique using *Trichoderma* coir pith cake to manage cocoa stem canker disease. A pesticide slow release product developed using coir pith was found to be suitable for mancozeb treatment against bud rot disease of coconut based on field trials.

Pests and diseases management integrating IPM and IDM practices against leaf rot disease of coconut,

eriophyid mite of coconut, leaf eating caterpillar of coconut, red palm weevil of coconut was standardised. Application of 5 g Chlorantraniliprole mixed with 200 g sand per palm to inner most leaf axils was found to be a very effective prophylactic treatment for the management of rhinoceros beetle of coconut. A significant reduction in eriophyid mite incidence in coconut could be observed in palms treated with palm oil - sulphur emulsion. Research in pheromones / Semiochemicals for coconut pest management and chemoecological approaches in palm pest management was carried out. Assessment of trap density using the refined PVC traps with one trap in 1 ha to 5 ha area indicated the highest catch of beetles. Nanoporous matrix has been developed to load the pheromone to lure rhinoceros beetles by means of pheromone trap. A botanical cake was developed in tablet-shape (each weighing 1.9 g measuring dia 2.5 cm & thickness 0.4 cm) for the prophylactic leaf axil filling against rhinoceros beetles. A prototype of red palm weevil detector based on acoustic system, which could be linked to mobile phones, was developed in association with Centre for Development of Advanced Computing (CDAC), Thiruvananthapuram.

Physiological and biochemical processes underlying drought tolerance mechanism in coconut has been delineated. Drought management strategies were devised to manage the drought under field condition. Carbon sequestration potential of coconut, arecanut and cocoa are very high and is promising to obtain higher carbon credit under elevated CO_2 in the atmosphere in cultivated areas for clean development mechanism. An infocrop – coconut model was developed to simulate the growth and production of coconut under present and future climate scenarios. Coconut cultivars/ hybrids were characterized based on fatty acid profiles for edible and industrial purposes. Chandrasankara was found to be more susceptible to drought under sandy and sandy loam soil than laterite soil under rainfed condition.

Developed technologies for making value added products like snowball tender nut (SBTN) and coconut chips of various flavours and are being promoted among prospective entrepreneurs. Indigenous technology for virgin coconut oil production was standardized. Value added products mainly functional foods and functional drinks like atta fortified with VCO meal, pasta from VCO meal, vinegar and squash from coconut water etc. were prepared from coconut byproducts. A device (Coco-sap chiller) for collection of fresh hygienic coconut inflorescence sap (Kalparasa) has been developed.

Coconut and arecanut palm climbing device has been designed. Two safety gadgets were developed to protect the climber from accidental falling from coconut palm. Patents obtained for power operated coconut deshelling machine, coconut punch and cutter and telescopic sprayer. Coconut chips slicing machine, machinery for minimal processed nut, testa removing machine and modified table top snowball tendernut machine were developed by the Institute. Similarly, Coconut shell removing machine was developed to reduce both time and drudgery involved in the manual de-shelling process. Storage tanks for run-off collection as a low cost water harvesting intervention were commissioned. Coconut dryers of various sizes and using different types of fuels *viz.*, solar, electrical and agricultural waste, were developed to produce quality copra in all seasons.

For technology transfer, efforts have been made to adequately promote the mandate crops of the Institute through effective extension activities including trainings, farmer participatory approaches in technology development and dissemination, participation in exhibitions and conducting kisan melas, and production and distribution of planting materials of mandate crops. Training and frontline demonstrations on selected technologies, institutional and off campus training programmes for extension personnel and farmers and research-extension-farmer interface programmes were conducted. Besides, the institute has participated in exhibitions, radio talks, television interviews, phone-in programmes and press meets.

Application of ICT tools like videoconferencing to develop linkages with various stakeholders were implemented. Statistical Databases created, website regularly updated, technical bulletins, CD ROMs, extension pamphlets, information brochures published. Krishi Vigyan Kendras under CPCRI catered training needs of farmers of Kasaragod and Alappuzha Districts in Kerala State. Cyber extension programmes were further strengthened

with the addition of mobile video conferencing unit. Mobile video conferencing unit is being utilised for facilitating the Research-Extension-Farmer interface. Research-Farmer-Extension interface programmes facilitated through video conferencing were conducted. The Institute website (http://www.cpcri.gov.in) is being updated regularly with the latest information. Besides, several innovative steps were taken to meaningfully engage the visual and print media for disseminating the research accomplishments to the farming community. In economics and statistical studies, international and domestic price fluctuations have been critically analysed and forecasts were developed. Statistical methods as applicable to plantation crops have been refined. Large scale sample surveys were conducted for production forecasting and estimation of yield loss. Policy oriented sectoral vision document was prepared.

Intellectual property management and commercialization of technologies in partnership mode and through licensing are carried out at ITMU. Portfolio management related to IPR including patent, copyright, industrial designs, trademarks and geographical indicators are facilitated. Business Planning and Development (BPD) unit is functioning at the headquarters, which has all the basic facilities needed for business incubation on CPCRI technologies. Administrative and accounting activities of the institute were automated through centralised Management Information System.

The management system of CPCRI has been certified with ISO 9001:2008 for its mission on harnessing science and technology to enhance competitiveness in coconut, arecanut and cocoa through generation of appropriate technologies.

Profile of CPCRI

Headquarters

KASARAGOD (Estd.: 1916)

Crops: Coconut and Cocoa, Area 78 ha; 10.7m MSL

Priority areas of research: Genetic resources management, breeding, biotechnology, water and nutrient management, organic cultivation, cropping/ farming system, microbiology, pests and diseases management, physiology and biochemistry, value addition and farm mechanisation, economics, statistics and transfer of technology. Various activities are envisaged under five divisions viz., Crop Improvement, Crop Production, Crop Protection, Physiology, Biochemistry and Post Harvest Technology and Social Sciences.

Regional Stations

KAYAMKULAM (Estd.: 1947)

Crop: Coconut, Area 24.17ha, 3 m MSL

Priority areas of research: Etiology and management of root (wilt) and other diseases, pests and nematodes management.

VITTAL (Estd.: 1956)

Crops: Arecanut and Cocoa, Area 68.34 ha; 58 m MSL

Priority areas of research: Genetic resources management, breeding, production and protection, cropping systems and drought tolerance.

Research Centres

KAHIKUCHI
(Estd.: 1958)
Crop: Coconut, Area
Crop: Arecanut,
Area 15.76 ha; 48 m MSL

Priority areas of research: Cropping system, crop protection and production of quality planting materials.

MOHITNAGAR
(Estd.: 1958)

Crops: Coconut, Arecanut and Cocoa, Area 25.99 ha; 91.3 m MSL

Priority areas of research: Genetic resources management, cropping system, soil,water and nutrient management.

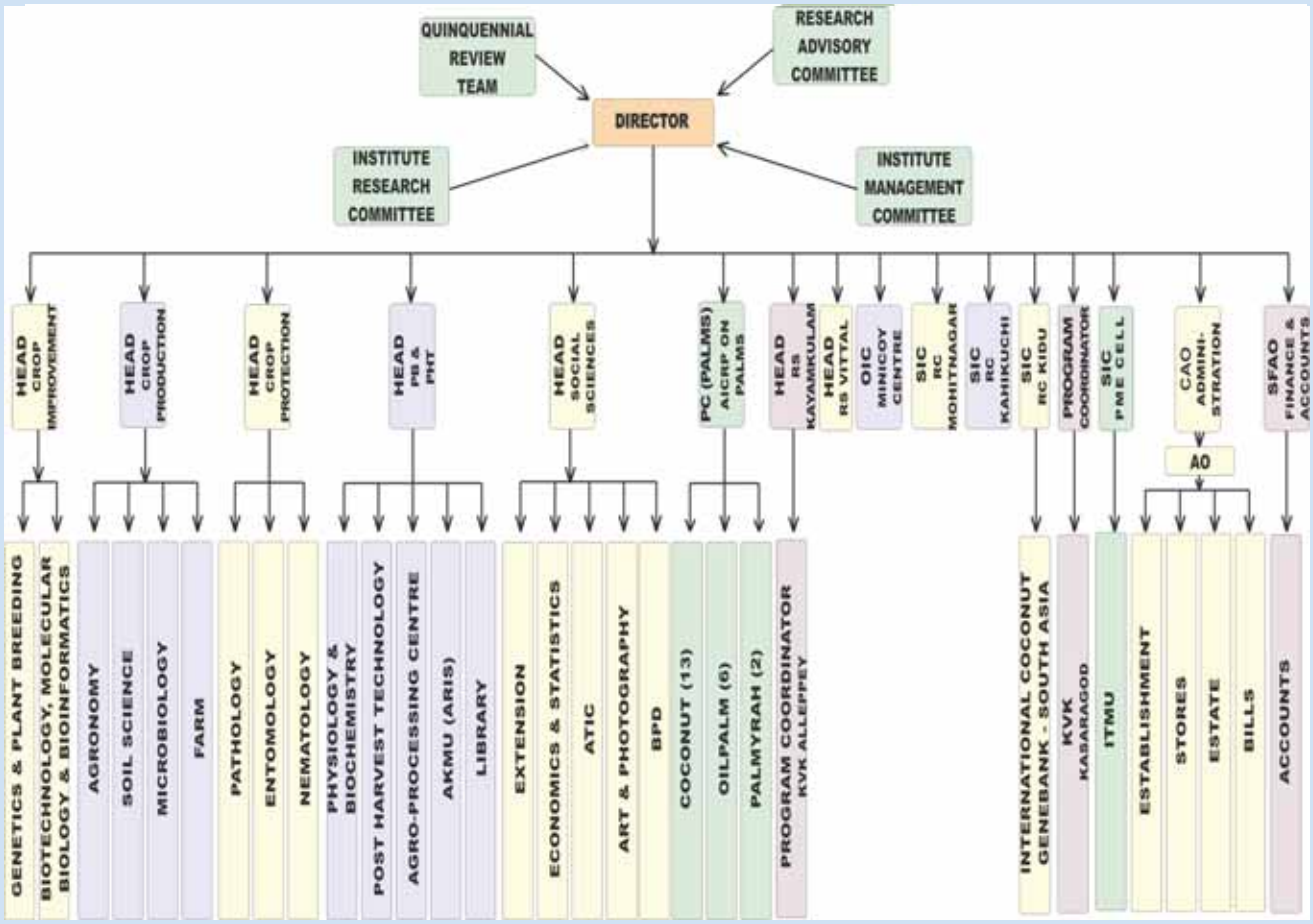
KIDU
(Estd.: 1972)
Crops: Coconut, Arecanut and Cocoa, Area 120 ha; 281 m MSL

Priority areas of research: National coconut gene bank, International Coconut Gene bank for South Asia (ICGSA), soil and water conservation, quality planting material production.

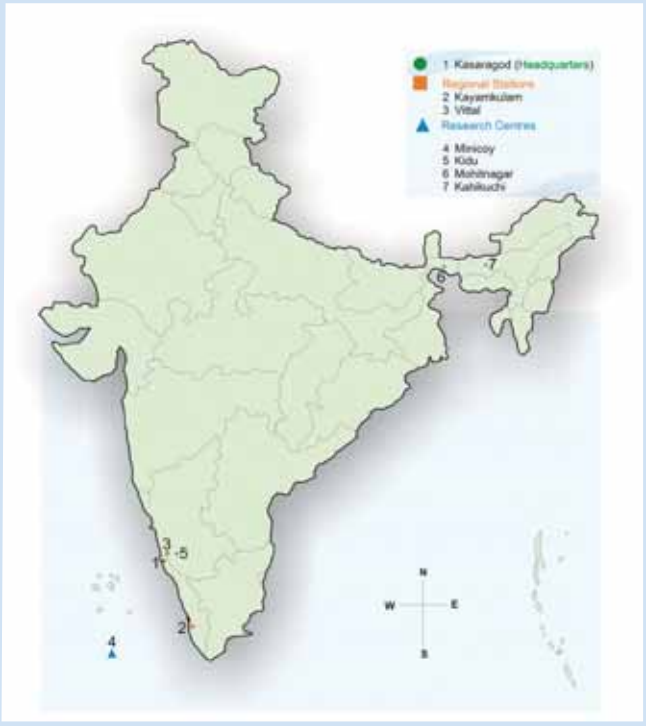
MINICOY
(Estd.: 1976)
Crop: Coconut,
Area 5.7 ha; 2 m MSL

Priority areas of research: Fruits and vegetables production and demonstration in the island, demonstration of production and processing technologies in coconut.

Organogram



Map Showing Locations of CPCRI Centres



Staff Strength

As on 31-3-2015

CPCRI

Category	Sanctioned	In position	Vacant
Scientific	83	61	22
Technical	116	95	21
Administrative	89	72	17
Supporting	258	143	115
Canteen	10	9	1
Total	**556**	**380**	**176**

KVK, KASARAGOD

Category	Sanctioned	In position	Vacant
Scientific	1	1	-
Technical	11	8	3
Administrative	2	1	1
Supporting	2	2	-
Total	**16**	**12**	**4**

KVK, ALLEPPEY

Category	Sanctioned	In position	Vacant
Scientific	1	1	-
Technical	11	10	1
Administrative	2	2	-
Supporting	2	2	-
Total	**16**	**15**	**1**
Grand Total	**588**	**407**	**181**

Budget and Expenditure 2014-15

(Rs. in lakhs)

Head	Allocation	Expenditure
Non-Plan	4806.72	4554.80
Plan	386.00	383.65
Total	**5192.72**	**4938.45**

Revenue generation	Target	Achievement	Expenditure
	406.70	383.28	249.52

RESEARCH ACHIEVEMENTS

PLANT GENETIC RESOURCES

GERMPLASM EXPLORATION

Enrichment of coconut germplasm with unique traits

Exploration was undertaken in Minicoy Island of Lakshadweep and an unique dwarf coconut accession with yellow coloured fruits, having green patch over pistil end, was collected (Fig.1).

Fig. 1. Promising LCYD accession from Lakshadweep Islands

Two explorations were undertaken in remote, unexplored areas in South and Middle Andaman, and 15 trait-specific accessions, for orange fruit colour, dwarfness, sweetness of kernel, tender nut traits, micro nuts with cluster bearing habit, robust stem to withstand heavy winds and tidal waves, fruit shape having six angles, giant sized fruits, thin husked and persistent leaves and peduncles over the stem and high copra content were collected (Fig. 2).

An exploration trip was conducted to collect fruits of soft endosperm coconut from Kozhikode district from identified palms. Out of 60 nuts, two nuts from a single palm exhibited the soft endosperm trait. The embryos were excised and cultured *in vitro,* for seedling development. The fruits were heavy, with husked fruit weight ranging from 1.67 kg to 2.2 kg. The average moisture content in soft endosperm was about 45%, whereas, it was about 62% in the normal endosperm. There was no significant difference for oil content (51%) in soft and normal endosperm. The total

Fig. 2. Diversity of coconut accessions collected from Andaman Islands

sugar (3.3g $100ml^{-1}$), total protein (122mg $100ml^{-1}$), free amino acids (227mg $100ml^{-1}$) and phenolics (9.5mg $100ml^{-1}$) were higher in soft endosperm coconut when compared to normal endosperm coconuts (total sugar - 2.2g $100ml^{-1}$, total protein - 330mg $100ml^{-1}$, free amino acids - 140mg $100ml^{-1}$, phenolics - 4.35mg $100ml^{-1}$).

The institute also facilitated submission of passport information on four hybrids identified for release by AICRP Palms, in addition to hybrids identified for release and new germplasm collected by the institute, for allotment of national identity numbers by NBPGR.

Cocoa

Twenty two exotic accessions, including white bean types rich in flavour components, clones resistant to Vascular Streak Die-back (VSD), black pod disease (BPD) and wilt, were introduced through International Cocoa Quarantine Centre, University of Reading, UK. A local accession, with 2.48g single dry bean weight, 5% shell and 95% nib recovery, was collected from Kottayam, Kerala (Table 1).

GERMPLASM CONSERVATION AND REGENERATION

Coconut

The total coconut germplasm collection at the Institute has increased to 438 accessions with the addition of new collections made during the year.

Twenty two germplasm accessions including collections from Bihar, Tripura, Lakshadweep, and improved selections from conserved germplasm of Kasaragod

Table 1. Cocoa germplasm introductions during the year 2014-15

S.No.	Clone	EC No.	S.No.	Clone	EC No.
1	MXC 67	EC 809262	12	PA 88	EC 809273
2	LCTEEN 302	EC 809263	13	EET 19	EC 809274
3	LCTEEN 37/A	EC 809264	14	PA 121	EC 809275
4	EET 399	EC 809265	15	UF 613	EC 809276
5	ICS 12	EC 809266	16	B 6/3	EC 809277
6	ICS 48	EC 809267	17	EET 162	EC 809278
7	ICS 75	EC 809268	18	ICS 41	EC 809279
8	POUND 10/B	EC 809269	19	ICS 63	EC 809280
9	UF 168	EC 809270	20	IMC 38	EC 809281
10	UF 676	EC 809271	21	IMC 50	EC 809282
11	PA 13	EC 809272	22	IMC 78	EC 809283

and WCGC were planted for conservation and evaluation in the field gene bank at Kasaragod in a replicated trial along with WCT and COD as control.

Pollination programme for *inter se* mating at WCGC, Andaman was continued in 19 selected Pacific Ocean collections and four Nicobari accessions for germplasm multiplication. About 960 seed nuts of nine Pacific Ocean coconut collections including four dwarf accessions were collected from the selected palms at World Coconut Germplasm Centre, CIARI, Andaman and sown at Kasaragod and Kidu for strengthening the conservation efforts. Seed nuts of Rangat Orange Dwarf from Middle Andaman and Andaman Green Dwarf from South Andamans were also sown for conservation and evaluation.

Additional nuts were collected from Minicoy Islands, in the accessions LCOD and Lakshadweep Mini Micro Tall for conservation in the field gene bank. The Mini Micro nuts were processed for embryo rescue and culture at the Institute.

Germplasm regeneration was undertaken in seven Indian Ocean Island, six Pacific Ocean Island collections and three accessions each from Sri Lanka and Bangladesh. Assisted pollination programme was implemented and 5275 female flowers were pollinated in 22 accessions for conservation / regeneration of germplasm and development of elite selections. In addition, 3284 female flowers were pollinated for production of breeder seed in released varieties. About 2000 *inter se* seed nuts of 22 accessions and 10 released varieties resulted from pollination programmes of previous year were sown for generation of planting material.

Arecanut

In the field gene bank at CPCRI, RS, Vittal, a total of 164 accessions including 23 exotic and 141 indigenous accessions are being conserved and evaluated for yield and economic traits. A total of 2430 *inter se* seed nuts of 13 Konkan batch-I and 17 exotic accessions were produced for germplasm conservation / regeneration.

Cocoa

A total of 344 accessions are being conserved in field gene bank at CPCRI, RS, Vittal under arecanut and coconut canopies.

CHARACTERIZATION AND EVALUATION

Coconut

Characterization of germplasm was undertaken in collections conserved in the field gene bank at Kasaragod and Kidu. The yield and related characters in different germplasm trials were also recorded. Accessions *viz.*, San Ramon Tall, Kappadam Tall, Markham Tall, Laguna Tall, Laccadive Orange Dwarf, Cameroon Red Dwarf, Niu Leka Dwarf, NGT, PLNT, FMST, EAT32, GUBT, JAMT, SUT, KTYT, NIGD, FJT, continued to show superiority for desirable traits such as palm morphology, nut yield, copra and tender nut water content and have been identified for further studies and multi-location evaluation (Fig. 3). Among the Pacific Ocean germplasm, Niu Hako, Niu Bulava Tall, Rennel Tall, Solomon Tall and Nikkore Dwarf were found promising for desirable traits of higher annual yield / tender nut quality / early flowering and have been identified for further evaluation. In the 2002 planted Orissa germplasm evaluation trial, accessions Dhanei, Goja, Gole and Jahaji recorded

higher annual nut yield. Tender nut studies indicated variation for tender nut traits with significantly higher volume of tender nut water in Dhanei Tall (476 ml), Jahaji (441ml) and Goja Tall (414 ml). Leaf samples of conserved germplasm of erstwhile Andhra Pradesh and Orissa were provided for molecular characterization at the institute.

Fifty per cent of seedling progenies of sweet kernel accession collected from Maharashtra and conserved at Kasaragod commenced flowering at the age of seven years and sweet kernel trait was recorded in a few palms.

Fig. 3. Coconut selection from Cameroon Red Dwarf with rich copra content

Among the indigenous collections in pre-stabilized yielding phase, Sendagan Tall, Barajaguli Tall, Chandan Nagar Tall from West Bengal, Chappadam Tall, Pinarai Tall, Mullasery Tall, Pallisery Tall from Kerala, Arasampatti Tall from Tamil Nadu, Champin Micro, Kodiaghat Green Tall, Katchal Micro, Nicobar Beak from Andamans and Laccadive Micro Small Round Nut from Lakshadweep, exhibited early bearing with higher yield potential.

In the ICG-SA, conserved germplasm *viz.* PAT, SSAT, SNRT, SKGT, BENT, ROT, NGT, ADOT, KYD, Kar Kar Tall, GUAT, BLIT, CCNT, BONT, PNT03, CART, FMST, LMT, LFT, MYD, WCT01, SKDT, TPT, WAT, Katchal, and WCT recorded higher initial yield. The Indian Ocean accessions *viz.*, SBGT, SMBT, CBLT, CMRT01 and PRD03 continued to show better performance for yield and bunch production. Among the South Asian accessions, KYKT, Rupidia Tall, BARI Narikel- I, BARI Narikel- II, CYD01 and SLRD01 recorded higher bunch production and nut yield.

Observations among the 17 dwarfs, planted during 2011, indicated early flowering in GBGD and Nikkore Orange Dwarf. The double dwarf showed precocity for flowering with very high rate of inflorescence production and higher female flower production and low fruit set. Among the 33 accessions conserved in 2011, vigorous vegetative growth was recorded in Mercara Tall, Annur Tall and Kundrakudi Tall, while early flowering was recorded in the Aromatic Green Dwarf accession.

Polybag nursery of over 3000 seedlings was maintained and observations on the germination and seedling parameters were recorded in germplasm collected from Bihar, Tripura, Tamil Nadu, Andaman, Lakshadweep and Indian Ocean and Pacific Ocean. Kurmadera Tall collection exhibited greater vigour with high collar girth, more number of leaves and longer leaf length. Among the tall accessions from Pacific Islands, early germination and leaf splitting was recorded in Solomon Tall and Rennell Tall, correlating with earliness in flowering and precocity in bearing. Among the conserved dwarf accessions of Pacific region, earliness in leaf splitting and shorter leaves in Nikkore Orange Dwarf, vigorous seedling growth with large leaves and early leaf splitting in Niu Leka Green Dwarf, earliness in germination in Hari Papua Orange Dwarf and relatively late germination and short leaf length in Niu Oma Yellow Dwarf, was recorded, indicating wide diversity in germplasm of the Pacific Islands.

Fruit component studies carried out on registered germplasm 'Lakshadweep Mini Micro', indicated considerable variability with a range of 0.27 g to 2.1 g of fruit weight and 1mm to 2.5mm of shell thickness.

Based on the fruit component analysis in COD and CGD palms of Chavakkad and Thrissur area in Thrissur district, three and four distinct groups, respectively, were observed in the populations. Clustering based on molecular markers showed three and four groups, respectively, in CGD and COD populations.

Anatomical studies have been initiated in 12 accessions under physiological screening for moisture stress tolerance and leaf tissues have been fixed from each of the seedlings under different levels of irrigation. Initial observations indicate differences in the size and distribution of stomata among the genotypes under evaluation (Fig. 4).

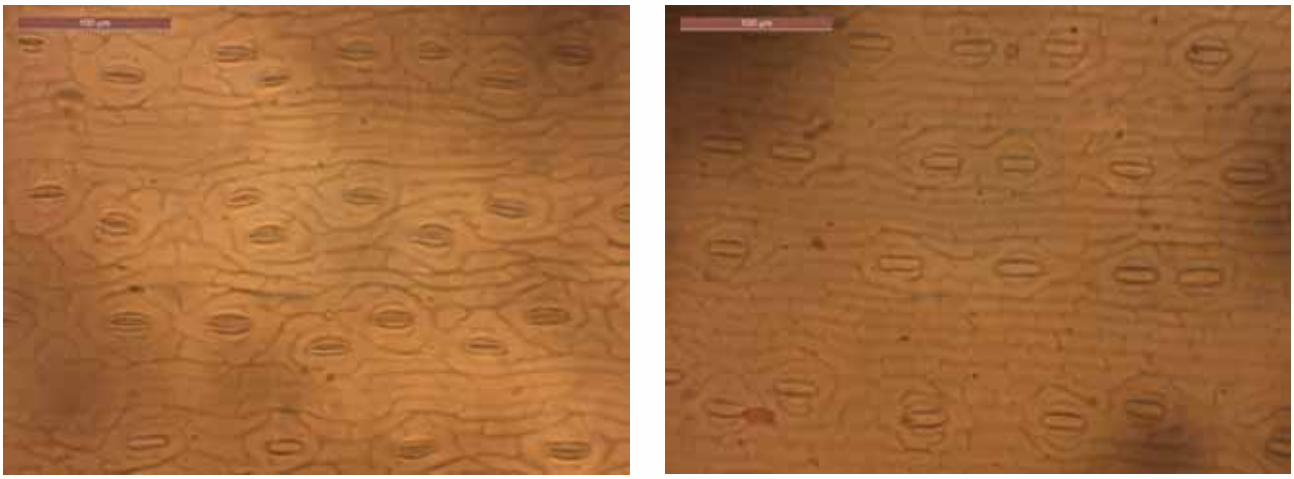


Fig. 4. Variation in size and distribution of stomata among the coconut genotypes

Arecanut

The conserved germplasm, comprising of 164 accessions including 23 exotic and 141 indigenous accessions, were evaluated for yield and economic traits. Accessions VTL-28I, VTL-13 and VTL-18-II recorded higher dry kernel yield of 3.92, 3.59 and 3.53kg palm^{-1}, respectively.

Among the indigenous (NE collection) accessions *viz.*, Badarpur-I, Darangeri, Tamsula and Dauki hills were found to be superior for dry kernel yield.

Among the collections from Konkan region, better performance was observed in accessions *viz.*, Deveagar-II, Shriwardhan B, Daboli, Shriwardhan-M and Kodinar for dry kernel yield which ranged between 3.12 and 3.96kg palm^{-1} year^{-1}. Evaluation of eight Gujarat collections for tender nut processing, indicated about 62.5% recovery of first quality processed tender nuts in Kodinar and Mahuva accessions. Kodinar selection with high yield and tender nut recovery was recommended for release at institute level for further exploitation.

Among the Calicut accessions, maximum dry kernel yield palm^{-1} (1.58 kg) was recorded in Calicut-27 followed by Calicut-29 (1.4 kg) and Calicut-20 (1.56 kg), in the alternate field gene bank at Mohitnagar. Among the NE collection planted during the year 1994, more inflorescence palm^{-1} was recorded in Nalbari (5) followed by K & J Hills and Borihat (4). Higher nut (346) and chali yield (3.11kg) per palm was recorded in Nalbari followed by Kahikuchi (2.57 kg).

Genomic DNA was extracted from spindle leaves of 24 accessions and screened with nine arecanut specific SSR primers for molecular characterization.

Growth parameters recorded in the YLD screening trial of three related species and one genus, revealed no symptoms of disease. *Inter se* seedlings of seven Gujarat collections were produced for screening in YLD hotspots.

Cocoa

The compiled yield data recorded from 14 to 18 years old trees of true Trinitario type, indicated superiority of clones TRIN-7, TRIN-1, TRIN-13 and TRIN-6 with high dry bean yields of 3.1, 3.0, 2.3 and 2.1 kg tree^{-1}, respectively, with optimal canopy of 15-23 m^2 in the arecanut intercropping system. Among the 10 to 17 year old trees of Wayanad collections, WYN-5, WYN-13, WYN-10, WYN-9 and WYN-6 yielded 2.78, 2.54, 2.43, 2.07 and 2.01 kg dry beans tree^{-1}, respectively. Both exotic and local clones were found to be suitable for small and medium sized farms to get additional income per unit area and their yield potential under coconut canopy is to be tested (Fig. 5).

Fig. 5. High yielding TRIN 6 and WYN 6 cocoa accessions

Screening of the 10 parents (Nigerian and Malaysian accessions) using nine microsatellite markers revealed a total of 43 alleles with an average of 4.77 alleles per locus. The observed heterozygosity was higher in Malaysian (0.43) as compared to Nigerian collections (0.36). The fixation index, in contrast, was lower in Malaysian (0.29) than the Nigerian collections (0.37). A total of 108 trees of cocoa, comprising of 10 parental and 10 hybrids, were analyzed for photosynthesis, leaf water potential, chlorophyll fluorescence and stomatal conductance. The parents, NC 23/43, NC 29/66 and NC 42/94 had drought tolerance potential and the hybrids, I-21 x NC 29/66, I-29 x NC 23/43, II-67 x NC 29/66 and II-67 x NC 42/94 exhibited positive physiological traits for drought tolerance along with high yield. Microsatellite analysis revealed a clustering of accessions showing drought tolerance.

GERMPLASM UTILIZATION

Coconut

Germplasm registration and development of superior genetic stock

A superior genetic stock, with dwarf plant habit and slender trunk was developed through selection from Coco Bleu Tall and named as Kidu Green Dwarf (Fig. 6). A few of the other features of Kidu Green Dwarf are: earliness in flowering, green medium sized fruits, higher initial nut yield, tender nut water content of 419 ml, very good taste of tender kernel and tender nut water with TSS of 6.5 ^{0}Brix, potassium content of 2682.14 ppm and sodium content of 34.62 ppm. Seedlings of Kidu Green Dwarf genetic stock have been planted in the field gene bank at Kasaragod for conservation and further evaluation.

Seed nuts were collected and sown for seedling production in a superior selection made from Gangabondam Green Dwarf (Fig. 7) population selected for its unique traits. The seedlings are produced for further evaluation.

Observations on floral biology were recorded in FMST, CGD, CRD, GBGD, LCOD, CYD, AYD, WCT01, TPT, WCT and the longest inflorescence with more than 162cm was observed in progenies of WCT01. Observations on the variability and diversity in floral traits in spicata progenies and horned coconut in the field gene bank revealed wide variability within the spicata progenies for nut component, inflorescence characters and stem morphology. The conserved

Fig. 6. Superior coconut selection from Coco Bleu accession

germplasm lines were screened for unique traits and it was found that floral morphology could be used to establish uniqueness of lines while registering the selected germplasm.

Fig. 7. A superior GBGD selection

Individual palms with unique traits were identified in accessions *viz.,* San Ramon Tall (green fruited with robust trunk characters and tender nut water content of 710-1130 ml with TSS of 6-6.2 °Brix), SS Apricot (large fruit size with Apricot colour and tender nut water content of 870 ml with TSS of 5.7 °Brix), urinam Brown dwarf (robust, early flowering, higher yield, intra and inter-spadix overlapping of male and female phases, tender nut water content of 775 ml with TSS of 5.7 °Brix) and Spicata tall (with very long inflorescence of 162 cm) for further development of genetic stock.

A putative dwarf selection was made from Tiptur Tall coconut population conserved at the Institute. Morphological characterization showed that the selected population is significantly different from the original population for stem girth, number of leaves, length of leaves and number of leaf scars. Seedling

production has commenced and further progeny studies will help in developing a dwarf genetic stock from the population.

Multi-location testing of varieties/ identified accessions

Towards evaluation of coconut germplasm selections for higher copra out turn and tender nut water under different agro ecological conditions and also to record their reaction to biotic and abiotic stresses, planting material was provided to different centres, including centres under the AICRP on Palms.

In addition, seedlings of coconut hybrid Kalpa Samrudhi was provided to AICRP centre in Ambajipetta for evaluation. Seedlings of Kalpa Haritha were provided to CPCRI (RS), Kayamkulam for evaluation in root (wilt) prevalent tract and for testing tolerance/ resistance to eriophyid mite infestation. Seedlings of coconut accessions *viz.*, AYD, LCGD, MOD and CRD were produced and provided for further technology evaluation trials (Table 2).

Evaluation of coconut hybrids

The hybrid combinations involving different talls (T) and dwarfs (D) were evaluated for fruit yield in different evaluation trials (HET VI, HET VII, HET IX, HET X, D x D and T x T trials) at Kasaragod and Kidu. Flowering, yield and morphological data were compiled in the trials.

Among the six hybrids planted in 1998 at Kidu under HET IX, the hybrid PHOT x GBGD continued to exhibit higher annual nut yield followed by the released hybrid COD x WCT. In HET X, planted in 1998- 99 at Kidu, the hybrids *viz.*, CGD x LCT, CGD x PHOT, and PHOT x CGD continued to show better performance for female flower production, bunch production and nut yield.

Morphological observations were recorded in the two D x T trials planted at Kasaragod during 2013 comprising 28 hybrids and parents. Preliminary observations indicated that the hybrids exhibited vigorous seedling growth as compared to tall and dwarf accessions. Among the hybrids, seedling collar girth and number of leaves produced did not vary significantly, whereas, seedling height and length of leaves significantly varied.

Dwarf x Dwarf trials at Kasaragod and Kidu were observed for bunch production and tender nut quality. Hybrids *viz.*, MYD x CGD, COD x GBGD, MYD x NLGD and MYD x GBGD showed superiority for bunch production and tender nut traits.

Table 2. Coconut selections/varieties provided for evaluation to CPCRI/ AICRPP centres

Variety/ selection	Bhuban-eshwar	Ambaji-peta	Arisi-kere	Aliyar-nagar	Vepan-kulam	Ratn-agiri	RC Mohit-nagar	RC Kahi-kuchi	RS Kayam-kulam
Verikkobari Tall	✓	✓	✓	✓	✓	✓	✓		
St.Vincent Tall		✓	✓			✓			
Guam-II Tall		✓	✓		✓				
Guam-III Tall	✓			✓		✓	✓		
Zanzibar Tall		✓				✓			
Straits Settlement Green Tall		✓	✓	✓		✓	✓		
Markham Tall			✓	✓	✓		✓	✓	✓
Laguna Tall	✓				✓		✓	✓	
Nigerian Green Dwarf	✓		✓	✓	✓	✓	✓	✓	
Palawan Tall	✓			✓	✓		✓		
Kenya Tall	✓	✓					✓		
San Ramon Tall							✓	✓	
Niu Leka Green Dwarf							✓	✓	
Kalpa Haritha							✓	✓	✓
Kalpatharu	✓				✓	✓	✓	✓	
Andaman Green Dwarf							✓		✓

Among the seven T x T hybrids and four parents being evaluated for drought tolerance, FJT x WCT recorded higher nut yield followed by WCT.

Early growth observations, in the technology evaluation trial in farmer's garden in Sivaganga district of Tamil Nadu involving 10 accessions *viz.*, WCT, FMST, LCT, ADOT, TPT, CCNT, ADGT, JVT, PHOT and ECT local, revealed longer leaves and higher leaf production in FMST, PHOT and CCNT, whereas, WCT, JVT and TPT showed lesser leaf production, shorter leaves and compact crown (Fig. 8).

Fig. 8. Coconut field at Sivaganga district

Two new hybrid evaluation trials comprising 23 crosses (using seven dwarf parents crossed with four tall parents) were established during July 2014 at CPCRI (RC), Kidu aiming for varietal development for tender nut purpose, soft endosperm trait and aromatic trait (Table 3).

Table 3. New hybrid trials established at Kidu

Parents	Trial I		Trial II	
	CCNT	SNRT	KWGT	PHLT
COD	✓	✓	-	✓
GBGD	✓	✓	✓	✓
MOD	✓	-	-	✓
MYD	-	✓	✓	-
CRD	✓	✓	✓	✓
CGD	✓	✓	✓	✓
MGD	✓	✓	✓	✓

Evaluation of coconut varieties/hybrids under Assam conditions

At RC Kahikuchi, in the evaluation trial of local coconut accessions, KKHC-1 recorded higher plant height, while more number of leaves was recorded in KKHC-8 followed by KKHC-4. Higher annual nut yield was recorded in KKHC-4. In the evaluation trial on germplasm and released varieties, LCT x GBGD recorded greater plant height, number of leaves and nut yield. Seed nuts of COD, GBGD, WCT, MYD, LCT, MGD, MOD and FJT were provided from Kasaragod for gap filling in the trials.

Evaluation of coconut varieties under sub Himalayan terai region

Observations on coconut accessions under evaluation for sub Himalayan Terai region at Mohitnagar indicated significant variation for trunk height and girth. Higher trunk height was recorded in IND 175 followed by IND 172 and IND 006S, whereas, lesser girth was recorded in IND 165 followed by IND 038S and IND 035S, among tall accessions. Among the five dwarfs, less trunk height was recorded in IND 007S followed by IND 048S, whereas, higher girth was recorded in IND 049S and lesser girth was recorded in IND 048S. Among the five hybrids under trial, greater trunk height was recorded in IND 008S x IND 007S followed by IND 069S x IND 003S whereas, girth was recorded lesser in IND 008S x IND 007S followed by IND 008S x IND 003S.

Among talls, higher number of nuts palm^{-1} year^{-1} was produced by IND 175 followed by IND 031S and IND 165. Higher nut yield was recorded in IND 048S followed by COD among the dwarf accessions and in IND 069S x IND 003S among the hybrids.

Among the NE coconut collections, under evaluation, plant height ranged from 455 to 510 cm. Among the 15 local cold tolerant collections planted for field evaluation, significant differences for plant height, girth and number of leaves was observed. Greater plant height was recorded in Lataguri-II followed by Mohitnagar II and Jalpaiguri Tall, while more girth was recorded in Lataguri-II.

Germination and seedling observations were recorded in 20 coconut lines. Higher germination, within 60 days after sowing, was recorded in Kalpa Haritha (93%), followed by SLYD (87%), while 100% germination was recorded in Guam III and Markham Tall followed by WCT (98%) at 150 days after sowing. Higher seedling height was recorded in Kalpa Haritha (100.1 cm) followed by San Ramon (99.9 cm), whereas, more girth and number of leaves (6) was, recorded in Kalpa Haritha and San Ramon at 150 days after sowing.

During the year, seed nuts of germplasm *viz.* six conserved dwarf accessions, five Pacific Ocean accessions and five new germplasm collections from Andaman Islands along with ECT and WCT were provided from Kasaragod for evaluation in sub-Himalayan Terai region.

Production of new experimental hybrids

Pollination was continued at Kasaragod and WCGC, Andaman for production of experimental hybrids. Pollination programme for production of identified / released hybrids *viz.*, MYD x Kenya Tall, MYD x Tiptur Tall and Kalpa Samrudhi were continued, towards evaluation at localities under AICRP palm centres. Newly identified hybrid combinations COD x WAT and COD x LCT were also included in the pollination programme. Seedlings of MYD x NLGD and MYD x CGD were produced for establishing MLTs.

Pollen of Hari Papua and Niu Leka Green Dwarf were received from WCGC Andamans for production of experimental hybrids at Kasaragod. Pollen of SNRT and CCNT were sent from Kasaragod to WCGC, Andaman for production of new hybrid combinations viz., NLGD x CCNT, NLGD x SNRT, HPOD x CCNT, HPOD x SNRT, NOYD x CCNT, NOYD x SNRT, NLGD x HPOD, HPOD x NLGD and NOYD x NLGD using the three conserved Pacific Ocean dwarfs as female parents.

Seedling observations were recorded in about 3000 experimental hybrid seedlings of different combinations that are established in poly bag nursery on their morphological traits and vigour for effecting seedling selection.

New crosses commenced during the current year with six dwarf accessions *viz.*, SUBD, CYD, LCOD, RTB04, KTOD, CRD as female parents and two tall accessions ADOT and FMS as male parents aiming for development of more drought tolerant and high yielding D x T hybrids.

Crossing programme was continued with selected LMT and LCOD pair palms at Minicoy for development of mapping population. Selfing of MYD x NLGD and LCT x LMMT was also continued aiming to utilize the diverse nature of the parents in studying the segregating progenies. In a new attempt, crossing programme was initiated at Kasaragod between LMT and COD.

Studies on selfed progenies for development of inbred lines in coconut

Flowering observations undertaken in the performance trial planted at Kidu with S_1 inbred progenies and open pollinated (OP) progenies of five coconut accessions revealed early flowering in both selfed and OP progenies of MYD and GBGD. About 400 seedlings produced through selfing of S_2 palms available at Pilicode centre of KAU and progenies of MYD x S_2 were observed for morphological traits and about 175 progenies were selected for field planting and further evaluation.

Among the selfed progenies of six dwarf cultivars *viz.*, COD, MOD, CGD, MYD, CRD and GBGD evaluated at Kasaragod, observations on floral morphological traits for occurrence of hermaphrodite flowers indicated the production of hermaphrodite flowers in progenies of CGD in higher proportion and MYD in lower proportion. Evaluation of progenies indicated wide variation for annual nut yield ranging from 18 to 245 nuts per palm among the dwarf palms.

From among the selfed progenies of WCT and CGD planted in Kidu during 1999, one individual palm each was identified for selfing to produce S_2 progenies. Two selfed progenies of COD planted in 1981 at Kasaragod were also identified for producing S_2 progenies. A fresh set of selfed progenies from selected individual palms of accessions *viz.*, CYD, MGD, KOD, MYD, CGD and GBGD were produced and the seedlings are ready for planting.

Breeding for resistance / tolerance to root (wilt) disease

Survey continued in 'hotspots' of root (wilt) disease and completed characterization of 155 mother palms including West Coast Tall and Chowghat Green Dwarf with GPS tagging. Hybridization was carried out on 94 CGD palms located in farmers' plots of Alappuha and Pathanamthitta Districts involving 321 inflorescence and 8,665 female flowers. A total of 600 CGD x WCT hybrid seed nuts were sown in nursery.

Observations recorded from first generation progenies after 19 years of planting revealed that root (wilt) disease incidence in the *inter se* mated progenies was only 47% compared to 63% in selfed progenies. Among the diseased palms of selfed population, the number of palms in the 'disease middle' category was significantly higher (28) compared to such palms in

the *inter se* mated population (14). The *inter se* mated progenies were superior with regard to nut characters. The average copra content of *inter se* progenies was also higher (214 g) compared to selfed population (165 g).

Observations on 170 second generation progenies of WCT (85 selfed and 85 *inter se* mated) raised from disease-free first generation palms, planted during November 2012, revealed both populations are par for vigour although initially vigour of *inter se* seedlings was better.

Among the green dwarfs (Andaman Green Dwarf, Chowghat Green Dwarf, Gudanjali Green Dwarf, Gangabondam Green Dwarf, Malayan Green Dwarf and Niu Leka Green Dwarf) planted during June 2013, one Gudanjali Green Dwarf palm flowered 20 months after planting.

In the experiment planted during 2009 to evaluate the performance of different dwarfs and its hybrids, CGD x WCT and CGD x MGD recorded lower root (wilt) disease incidence of 4.4% and 11.1% respectively, compared to MGD x WCT and MYD x WCT with 24.4% disease incidence. Among the dwarfs, MOD recorded 29% disease incidence compared to MGD and MYD with 17% disease incidence. The initial trend with regard to nut yield, five years after planting, indicates higher nut yield of 39 nuts palm^{-1} year^{-1} in CGD x WCT and MGD x WCT as compared to other hybrid combinations.

A new evaluation trial was planted during Oct-Nov 2014 in Randomized Block Design with 13 tall accessions *viz.*, Andaman Ordinary, Federated Malay States, Guam, Kalpa Dhenu, Kalpa Haritha, Kalpa Mitra, Kalpa Pratibha, Philippines Laguna, Philippines Lono, Philippines Ordinary, San Ramon, St. Vincent and Tiptur Tall.

Studies on coconut tissue culture

Combinations and sequences of various growth regulators were attempted to improve the efficiency of callus induction, multiplication and regeneration for somatic embryo development in coconut. The response of plumular explants to high concentration of auxins *viz.*, 2,4-D (425 μM, 650 μM) and picloram (450 μM) were evaluated using six Y3 media combinations, and different sub-culturing intervals. High dose of picloram was found to be beneficial for sustained growth and maintenance of embryogenic nature of the callus after 150 days of initial culture. Subculturing the calli to lower concentration of picloram (40 μM) resulted in the formation of meristematic zones on the calli periphery.

In order to avoid abnormal development of somatic embryos and to enhance its normal conversion into plantlets, a temporary immersion system was tried. The embryogenic calli were placed in the top compartment and the medium in the lower compartment and the medium was forced to the top compartment twice daily for one minute with the help of pressure pump. It was felt that there will be uniform distribution of medium to the tissues and with sufficient gas exchange that may enhance normal conversion of somatic embryos into plantlets than that of using solid medium alone. The initial studies showed improvement in growth rate when embryogenic calli, at different stages of development, were subjected to temporary immersion.

Cell suspensions were initiated from 60 and 90 days old embryogenic calli using three methods (chopping, crushing and without any injury to the callus). By crushing method, using 60 days old cultures, cell dissociation and multiplication was observed in more than 70% of the cultures.

Various growth regulators such as 2, 4-D (10, 20, 30 mg l^{-1}) and picloram (10, 20, 30 mg l^{-1}) in combination with BAP (0.5 mg l^{-1}) were studied to induce cell multiplication in suspension culture. Y3 basal media supplemented with 2, 4-D (30 mg l^{-1}) showed large number of active cells compared to other media combinations.

Supplementing Y3 media with various amino acids / cytokinins *viz.*, glutamine (100 mg l^{-1}), biotin (10 mg l^{-1}), kinetin (2mg l^{-1}) and malt extract (100 mg l^{-1}) resulted in more number of round meristematic cells with high nucleo-cytoplasmic ratio that led to the formation of cellular aggregates. Growth evaluation was undertaken using PCV (Packed Cell Volume) test that revealed cell mass increase from 0.98 μl (30 days) to 3.6 μl (60 days) (72%) per one ml of suspension (Fig. 8).

Coconut embryo rescue of soft endosperm types

The growth of plantlet developed from zygotic embryos collected from soft endosperm type in coconut was found to be slow compared to embryos of normal nuts from the same palm. Supplementation of media with TDZ (1mg l^{-1} for one week) and glutamine (20 mg l^{-1}) improved further growth.

Fig. 8. Growth evaluation of coconut cell suspension cultures using packed cell volume test

Cryopreservation

For optimization of pre-growth media for encapsulation vitrification, the plumules were treated with various sucrose concentrations (0.25, 0.4, 0.5, 0.75 and 1M) at fixed duration (2 days) and thereafter cultured in Y3 medium for germination. 0.4- 0.5 M sucrose pre-growth was found to be optimal for plantlet recovery. Experiments were also conducted for optimisation of pre-growth treatment duration (0.4 M and 0.5 M sucrose for 3, 6, 9 and 12 days) for plantlet recovery.

Embryos from five released coconut varieties (Kalpa Haritha, Kalpa Samrudhi, Kalpa Mitra, Kalpatharu and Kalpasree) were subjected to cryopreservation by PVS3 vitrification protocol for validation with wider range of cultivars.

Long term conservation of pollen

Pollen from 11 coconut accessions namely, Cochin China Tall, Java Tall, Tiptur Tall, Laccadive Ordinary Tall, West Coast Tall, Andaman Giant Tall, Chowghat Orange Dwarf, Malayan Yellow Dwarf, Malayan Orange Dwarf, Chowghat Green Dwarf, and Gangabondam Green Dwarf have been stored in liquid nitrogen for long term storage. For long term storage of coconut pollen, the minimum standard for germination after cryopreservation was set at 25-30%.

Allele mining of gibberellic acid biosynthetic genes in coconut accessions

Allele mining of gibberellin-20-oxidase (*GA-20-ox*) gene was carried out in tall and dwarf accessions of coconut. A 342 bp fragment of GA 20-ox gene was isolated from tall and dwarf coconut accessions, cloned and sequenced. A single SNP could be detected between the tall and dwarf coconut accessions, which was used for creating Virtual RFLP image as the dwarf accessions could be cleaved by *HindIII,* while the tall accessions were not. The result will help in understanding the molecular mechanism controlling plant height in coconut and provide a diagnostic marker for tall and dwarf coconut accessions (Fig.9).

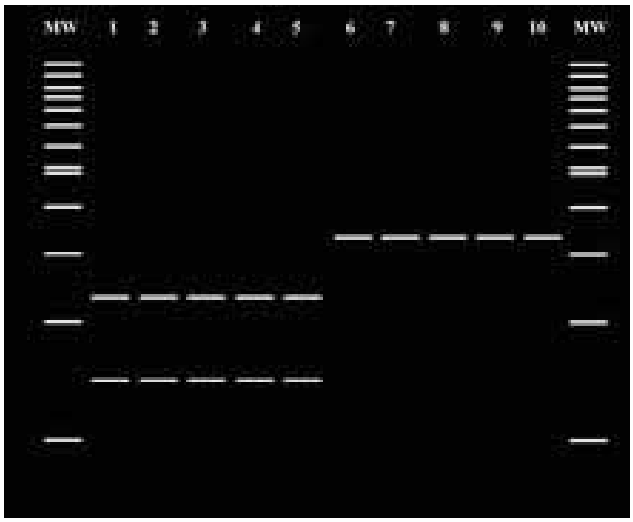


Fig. 9. Virtual RFLP image showing cleaving of dwarf coconut accessions by *Hind III*, while the tall coconut accessions were not cleaved

Validation of new molecular markers in coconut for genetic diversity studies

Coconut transcriptome from leaf tissue of Chowghat Green Dwarf cultivar was sequenced using Illumina paired-end sequencing technology. The cleaned raw reads were assembled into a total of 130942 unigenes with an average length of 658 bp. To further evaluate the assembly quality and develop new molecular markers, the 130942 unigenes generated in the study were used to mine potential SSRs. Using MISA tool, a total of 318528 potential SSRs were identified. The number of SSR containing sequences was 89820. The number of sequences containing more than one SSR was 57578. Dinucleotide SSRs were the dominant repeat motif followed by trinucleotide and tetranucleotide repeats. Eighty EST-SSRs were randomly selected to validate amplification and to determine the degree of polymorphism in the coconut genomic DNA pools. All the primer pairs successfully amplified coconut DNA fragments. Fifteen polymorphic EST-SSRs were

used to assess genetic diversity in a subset of coconut accessions (12 each of tall and dwarf accessions). The primers could detect significant amounts of polymorphism among the coconut accessions and could be used for genetic diversity studies (Fig. 10).

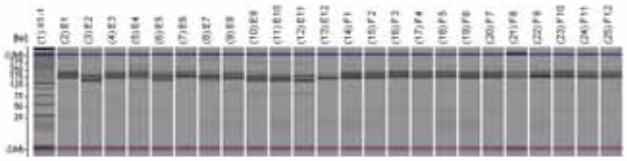


Fig10. PCR amplification of EST-SSRs in tall and dwarf accessions of coconut

Hybrid authentication: Microsatellite markers were utilized to screen four parents *viz.*, GBGD (Gangabondam Green Dwarf), Fiji Tall (FJT), Malayan Yellow Dwarf (MYD) and Tiptur Tall (TPT) using an automated microchip electrophoresis system. Microsatellite prime pairs, which could detect polymorphism among the parental lines, were then used to screen the progenies of two crosses, *viz.*, GBGD x FJT and MYD x TPT. True hybrids possessed the banding pattern of both the parents, while selfed progenies possessed the banding pattern of only the female parental line. Use of this technique would allow accurate and rapid identification of true coconut hybrids in the nursery stage and would facilitate removal of selfed progenies, thus, substantially saving time and resources.

Transcriptomic analysis of root (wilt) disease resistant and susceptible genotypes

Transcriptome analysis (RNA-Seq) of root (wilt) disease resistant and susceptible CGD palms revealed 1266 transcripts to be unregulated in disease resistant palms. The expression pattern of fourteen of these transcripts, known to be important in plant defence *viz,. TINY transcriptional factor, glutathione-S-transferase, RING zinc finger protein, serine/threonine-protein kinase receptor, early elicitor protein CMPG1, cysteine-rich receptor-like protein kinase, major latex protein 22, class IV chitinase and AP2/ERF domain-containing/bZIP MYB transcription factor*, was validated using quantitative real-time PCR (qRT-PCR), with *α-tubulin* gene as the reference gene. The results revealed significantly higher levels of 14 defense-related transcripts in the disease resistant palms when compared to the susceptible palms.

Arecanut

Evaluation of hybrids

Interspecific hybridization between *A. catechu* and *A. triandra, A. concinna* and *A. normanbyi* has been initiated to develop hybrids / varieties resistant to biotic stresses such as YLD and fruit rot disease of arecanut.

Crossing programme was carried out in eight new combinations *viz.* HD x Shriwardhan, Shriwardhan x HD, HD x Thirthahalli, Thirthahalli x HD, Nalbari x HD, HD x Nalbari, Kodinar x HD, HD x Kodinar and a total of 3468 female flowers were pollinated.

Observations on nut yield among dwarf arecanut hybrids revealed the combinations HD x Mohithnagar, HD x Sumangala, HD x Mangala as superior with dry kernel yield ranging from 2.42 to 2.58kg palm^{-1} year^{-1}.

Morphological characters were recorded in six dwarf hybrids planted in YLD endemic area and none of the palms have contracted YLD for the past four years.

Among the tall hybrids, Shriwardhan x Sumangala, Mangala x Shriwardhan and Mangala x Mohitnagar recorded higher dry kernel yield of 3.65, 3.73 and 3.94 kg palm^{-1} year^{-1}, respectively. Higher heterosis of 40.28 and 31.50 per cent was observed for dry kernel yield in Shriwardhan x Sumangala and Shriwardhan x Mangala, respectively.

Observations on growth parameters and disease index among the tissue cultured material (produced from YLD free mother palms from hotspots) planted at YLD endemic area of Sampaje in three farmers' gardens revealed no symptoms of disease so far and a few palms commenced bearing normal fruits without any kernel discolouration (Fig. 11).

Fig. 11. Tissue cultured arecanut palms free from YLD symptoms in fruits and leaves

Multi-locational trial of arecanut hybrids under Assam conditions

A multi-locational trial consisting of eight hybrids and six parental lines of arecanut were planted during 2007 with Mangala, Sumangala, Sreemangala, Mohitnagar, Kahikuchi, Mangala x Hirehalli Dwarf, Hirehalli Dwarf x Mangala, Sumangala x Hirehalli Dwarf, Hirehalli Dwarf x Sumangala, Sreemangala x Hirehalli Dwarf, Hirehalli Dwarf x Sreemangala, Mohitnagar x Hirehalli Dwarf and Hirehalli Dwarf x Mohitnagar. Among the parental lines, Kahikuchi recorded the maximum plant height (4.21 m) and number of leaves (9.06). However, the maximum circumference was recorded with Hirehalli Dwarf (46.16 cm). Among the hybrids, Sumangala x Hirehalli Dwarf produced the maximum plant height (1.33 m) and number of leaves (8.60).

In order to increase the germplasm availability for North Eastern Region, eighteen arecanut germplasms were collected from different parts of Assam (Bongera, K and J hills, Borihat, Kamalpur, Moralpara, Auniati-2, Chaygoan-1, Auniati -1, Kahikuchi, Sarugoan, Pancha, Shalshella, Chaygoan-2, Sarugoan-2, Nalbari, Dongapara, Thargia and Berubari) which were planted during 2011. Borehat recorded the maximum plant height (83.33 cm), circumference (27.78 cm) and number of leaves (7.0) during 2014.

Multi-locational trial of arecanut hybrids

Observation on annual growth and reproductive traits in MLTs of Dwarf hybrids at Kahikuchi revealed lesser height than tall parents and higher girth in HD parent followed by HD x Sumangala. No significant differences were observed for leaf production. Initial production of bunches was more in HD x Sreemangala.

A total of 1850 selfed progenies of Hirehalli Dwarf parent, released varieties and dwarf hybrids have been generated for establishing mother blocks of Hirehalli dwarf and MLT of promising varieties and hybrids of arecanut in AICRP centers.

Cryopreservation of pollen

Pollen from Hirehalli Dwarf palms were cryostored in liquid nitrogen for viability and fertility studies. Normal nut set has been observed with 24 hours cryo stored pollen.

Identification of markers for assessing hybrid purity in arecanut

Twenty five Start Codon Targeted (SCoT) primers were utilized to screen tall cultivars of arecanut *viz.*, Mangala, Sumangala, Sreemangala, Mohitnagar, Swarnamangala and Hirehalli Tall and the dwarf, Hirehalli Dwarf. One of the primers, SCoT11, produced an amplicon of around 1300 bp band, which was present in tall cultivars, but absent in the dwarf. The DNA fragment was purified, cloned and sequenced. A Sequence Characterized Amplified Region (SCAR) marker capable of distinguishing tall / dwarf trait in arecanut, was designed and validated (Fig. 13).

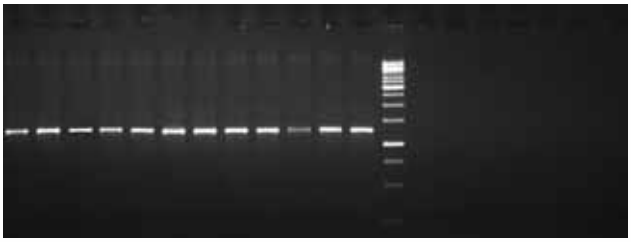


Fig. 13. SCAR markers for hybrid purity in arecanut

Cocoa

Comparison of grafts and seedlings

A comparative study on 12 genotypes as grafts and seedlings showed significant difference for growth habit and yielding behaviour. Seedlings were taller and more vigorous, jorquette at >1 m height, whereas, grafted plants jorquette at lesser heights with more branches producing larger canopy area. Early and high yielding nature was observed in clones over 5 to 10 years of bearing period. The parents VTLC-5 and VTLC-1A and the progenies of four hybrids exhibited high dry bean yields in the range of 1.5 to 2 kg tree^{-1} which can be used both as clones and seedlings for the immediate requirement of area expansion programs.

Screening for tea mosquito bug tolerance

Pod surface smoothness and husk thickness were used for screening. WYN 6, WYN 13 and TRIN 7 were observed as tolerant to tea mosquito bug attack and produced smooth pods with husk thickness of 1.3 cm and pentrometer readings of 4.54, 4.21 and 5.75, respectively.

Screening for abiotic stress tolerance

Hybrids of cocoa as seedling progenies were tested for morpho-physiological parameters contributing to moisture deficit stress under green house conditions. The parameters such as water status (leaf water potential), gas exchange (net photosynthesis, stomatal conductance), photosynthesis related parameters (transpiration rate, water use efficiency)

and photochemical activity (chlorophyll fluorescence) were studied under 100% watering and 50% and 20% induced hydric stress levels. Three different behavioral groups under water stress were distinguished. The first group showed small reduction in photosynthesis, followed by maintaining good water use efficiency with low conductance and a low transpiration rate in hybrids VTLCP-22, VTLCP-24 and VTLCH-4. The second group, with hybrids VTLCP-27, VTLCP-25 and VTLCP-26, showed adequate functioning of PSII, net photosynthetic activity, reduced transpiration rate and high stomatal resistance, exhibited vegetative vigour. In the third group, reduction in the photosynthesis activity is associated with high transpiration rate, reduction of PSII photochemical activity and a low CO_2 content. These results showed that cocoa exhibits significant genotypic variation with respect to physiological parameters at young age both under stress and non-stress situations (Table 4).

Multi – locational trial of cocoa varieties / hybrids under Assam conditions

A multi-locational trial consisting of 13 cocoa varieties/ hybrids were planted under arecanut garden during 2011. VTLCC 66 recorded the maximum plant height (2.75 m) and circumference (27 cm) after three years of planting. In all the varieties/hybrids, branching started 15 cm above the ground.

Varietal development in coconut and arecanut

Proposals of two dwarf tender nut varieties (Kalpa Jyothi, Kalpa Surya) and a tall, dual purpose copra and tender coconut variety (Kalpa Haritha), were accepted for release and notification by the Central Sub-Committee on Crop Standards, Notification and Release of Varieties of Horticultural Crops.

Proposal for release of a dual purpose, high yielding Dwarf x Tall coconut hybrid Kalpa Sreshtha was submitted to Central Sub-Committee on Crop Standards, Notification and Release of Varieties of Horticultural crops for release and notification.

From HET VI, two D x T coconut hybrids *viz.*, COD x WAT and COD x LCT were identified for release at Institute level by Institute Research Committee considering the better performance for nut yield, copra out turn and tender nut traits. The committee, in its 43rd meeting held during February 2015 recommended the varieties for release based on the results of field evaluation trial conducted over 24 years. The salient features of the hybrids are as follows.

COD x WAT: Palms of this hybrid are high yielding, commence flowering six years after planting, under rain fed conditions, and are regular bearers. The fruits are medium-sized and oval in shape, while the

Table 4. Photosynthesis and water relation parameters among cocoa hybrids

Hybrids	Photosynthesis (μmol/m^2/s)		Stomatal conductance (mole/m^2/s)		Transpiration (mmol/m^2/s)		$CO_{2\ int}$ (ppm)	
	NST	ST	NST	ST	NST	ST	NST	ST
VTLCP-22	26.7 a	17.3 a	0.26 h	0.27 g	0.71 i	0.73 f	363.3 a	332.7 a
VTLCP-11	9.22 b	7.38 ed	0.49 d	0.39 d	1.31 d	1.04 cd	294.3 f	290.4 c
VTLCP-24	7.99 b	13.7 ab	0.36 g	0.33 e	0.95 h	0.87 e	340.3 b	332.5 a
VTLCP-25	7.48 b	4.86 e	0.41 ef	0.34 e	1.09 f	0.90 e	298.8 e	297.6 c
VTLCP-26	20.7 ab	7.35 ed	0.39 gf	0.20 h	1.03 g	0.67 f	365.5 a	310.2 b
VTLCP-27	10.9 b	8.16 cde	0.45 e	0.30 f	1.20 e	0.96 ed	329.2 c	312.4 b
VTLCP-28	11.2 b	6.17 e	0.55 c	0.41 c	1.48 c	1.09 c	291.4 f	290.3 c
VTLCP-29	9.36 b	11.1 bcd	0.64 b	0.48 b	1.65 b	1.26 b	286.5 g	277.5 d
VTLCH-3	11.5 b	8.03 cde	0.70 a	0.53 a	1.88 a	1.43 a	271.6 h	270.7 d
VTLCH-4	16.5 ab	12.3 bc	0.40 f	0.34 e	1.08 f	0.91 e	304.1 d	295.9 c
Mean	13.14	9.62	0.46	0.36	1.24	0.99	314.5	301
CV%	53.62	3.37	4.4	0.16	1.64	0.86	0.86	1.6

NST- non-stress, ST- stress
Means followed by the same letter are statistically same at the threshold of 5% (LSD)

husked fruits are round in shape. The average annual bunch production is about 11 bunches palm^{-1}, with average yield of 154 nuts palm^{-1} year^{-1}, and estimated annual copra yield of 32.95 kg palm^{-1}, under irrigated conditions with average copra content of 214 g. The average weight of tender fruit is 2058g with 430 ml of tender nut water having good tender nut quality with TSS of 5.8° Brix.

COD x LCT: Palms of this hybrid are comparatively short-statured with compact spherical canopy. The palms are regular bearers and commence flowering 5 years after planting, under rain fed conditions. The average annual bunch production is about 11 bunches palm^{-1}, with average yield of 142 nuts palm^{-1} year^{-1}, with an estimated annual copra yield of 27.12 kg palm^{-1}, under irrigated conditions. The average fruit weight is 1555 g with copra content of 191 g. The weight of tender fruit is 2252g with tender nut water content of 344 ml and good tender nut quality with TSS of 5.8 °Brix. The nutritive value of tender nut water is as follows: total sugars – 5.44 g 100 ml^{-1}; free amino acids - 3.05 mg 100 ml^{-1}; potassium - 2322 ppm; sodium - 34.2 ppm (Fig. 14).

Evaluation of the arecanut collections, indicated high yield performance by Kodinar selection for dry kernel yield. The Institute Research Committee has recommended this variety for release and cultivation in Karnataka and Gujarat, considering the suitability for dry kernel production and tendernut processing (Fig. 15). The variety is a high yielding selection from germplasm line IC557397 collected from Gujarat. The palms of the variety are regular bearing with good kernel quality and suitable for tendernut processing. The variety has exhibited better performance for yield over the released varieties *viz.*, Mangala, Sumangala, Sreemangala, Madhuramangala and SK Local, with high recovery of first quality processed tendernut (68.4%). The palms possess medium thick stem, shorter internodes, particularly drooping crown and semi tall. The fruits are round shaped with high recovery of chali (26.8%). The average dry kernel yield and tendernut yield was 3.82 kg palm^{-1} year^{-1} and 3.10 kg palm^{-1} year^{-1}respectively.

Plant variety protection

The released and notified coconut varieties from the Institute were registered with PPV & FR Authority and registration certificates for plant variety protection under EXTANT variety category were received for Kalpa Pratibha (830 of 2014), Kalpa Dhenu (828 of 2014), Kalpa Mitra (832 of 2014), Kalparaksha (761 of 2014), Kalpasree (818 of 2014) and Kalpa Sankara (814 of 2014). The applications filed for registration of varieties *viz.*, Kera Chandra, Kalpa Samrudhi, Kalpa Surya, Kalpa Haritha and Kalpa Jyothi were accepted for registration process after DUS testing.

Thirty six distinctive characteristics were short listed for developing DUS guidelines for arecanut. The project

Fig. 14. High yielding coconut hybrids - COD x LCT, COD x WAT and Kalpa Sreshtha

Fig 15. Kodinar: A promising arecanut selection

has been approved by PPV& FRA for developing draft guidelines for further discussions.

PPV & FRA-DUS CENTRE FOR COCONUT

Growth parameters were recorded on seedlings of 11 reference varieties field planted during 2013, for generation of DUS test data. About 40 seed nuts of reference/ released /extant varieties *viz.,* COD, WCT, Kalpa Pratibha, Kalpa Dhenu, Kalpa Mitra, Kalpa Haritha, Kalpatharu, SNRT, Chandra Kalpa, Kera Chandra, Kalparaksha, GBGD, LMT, Spicata Tall, MOD, CGD and MYD, were sown in polybags for generation of seedlings for DUS testing and seedling observation. To identify new descriptor traits suitable for DUS characterization, a study on inflorescence characters was undertaken in the dwarf reference varieties *viz.,* COD, MYD, MOD, GBGD and CGD. Analysis of variance indicated significant differences among the varieties, indicating scope for utilization in varietal discrimination. MYD was found to have significantly more number of spikelets, more male flowers and heavier male flowers while GBGD was distinct with reference to spikelet characteristics. The length of spikelet bearing portion was found to be significantly distinct in MOD, while COD and CGD had distinctly different inflorescence stalk girth.

BIOINFORMATICS

Genome-wide analysis and prediction of genes for biotic and abiotic stresses

Modules were developed and validated using machine learning algorithms for prediction of domains of mitogen activated protein kinases (MAP Kinases), DELLA proteins, Lipid Transfer Proteins (LTPs) and Ethylene Responsive factors (ERF) from genome/ transcriptome sequences.

Homology modelling of coconut ent-copalyl diphosphate synthase

Gibberellic acids are diterpenoid phytohormones required for many aspects of plant growth and development. The gibberellic biosynthetic pathway starts with the conversion of geranyl geranyl diphosphate (GGDP) to *ent*- kaurene by a two-step cyclization reaction catalyzed by *ent*-copalyl diphosphate synthase (CPS) and *ent*-kaurene synthase (KS), with *ent*-copalyl diphosphate as the intermediate. A full length *ent*-copalyl diphosphate synthase cDNA was identified from coconut transcriptome (KJ647163)

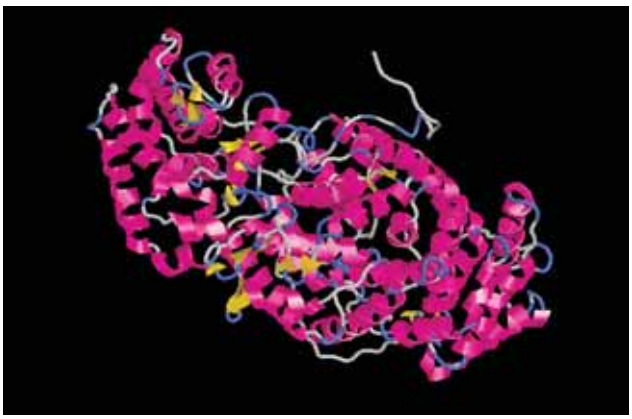


Fig. 16. 3-D structure of protein ent-copal synthase

(Fig. 16). *In silico* analysis of the translated protein revealed coconut CPS comprised of 793 amino acids and a molecular weight of 89.95 kDa. The secondary structure of the protein was composed of 42.62% of α- helix (338 amino acids), random coils 41.87% (332 amino acids) and extended strand 15.51% (123amino acids). 3-D structure predicted using Modeller V 9.12 and Schrödinger Molecular Modelling Environment. The structure contained 43 helices, 11 strands and 63 turns. According to Ramachandran plot validation of protein structure, most of the amino acids residues were present in allowed region (87.6%), some of them in the allowed region (10.1%), 1.8% in generally allowed region and only 0.5% residues in disallowed region.

Isolation, *in silico* characterization and expression analysis of a full length lipoxygenase cDNA

A full-length cDNA (KJ647166), encoding lipoxygenase (*LOX*) from leaf transcriptome of root (wilt) disease resistant CGD coconut cultivar had an ORF of 2976 bp, which encoded a peptide of 852 amino acids. Homology search results (blastp) indicated that coconut LOX shared 72% identity towards other plant species. Various physical and chemical parameters of the protein were identified using Protparam tools. It showed the presence of a high concentration of Asp residue (93 amino acids: 10.9%), with an aliphatic index, hydropathy (GRAVY) and theoretical pI values of 92.23, -0.315 and 5.63, respectively. SOPMA (secondary structure prediction software) analysis indicated the presence of helical structures (37.44%) in the protein. Conserved domains were identified by CDD search and it included a single N –terminal PLAT/LH2 β barrel, known as membrane associating C2 domain, a major C-terminal catalytic domain

composed for the most part of long α helices and the redox–active iron necessary for catalyzed reaction. Further, three dimensional model of the protein was predicted by homology method and validated using Ramachandran plot. Most of the amino acids residues were present in allowed region (87.5%), some of them were in the allowed region (11.1%) and 0.7% were in generally allowed region and only 0.7% residues were in disallowed region. The overall quality factor (Errat) was 81.709. Expression levels of *LOX* gene, estimated using qRT-PCR, indicated differential expression between disease resistant and susceptible CGD palms.

SmiRNA for data mining and annotation of plant miRNAs

'SmiRNA' - a ready-made software package for the large scale discovery, annotation and prediction of plant miRNAs was designed and implemented using Perl programming language and can be run in Ubuntu /Linux operating system. SmiRNA is freely available at http://210.212.229.52/SmiRNA. The developed tool possesses many advantages: (i) the software is easy to install with all-in-one programs and packaged databases; (ii) it is user friendly and users can identify, annotate, and explore the detailed results from each step (iii) homology searches with all plant mature miRNAs available in miRBase database are possible (iv) it predicts plant miRNA with more accuracy, compared to existing programmes, using WEKA machine learning approaches, where all training sets are developed using pre-miRNAs available in miRBase database.

Identification of genes involved in root (wilt) disease resistance by suppression subtractive hybridization

Total RNA was isolated from spindle leaves of ELISA tested healthy and root (wilt) affected selfed progenies of WCT located in disease 'hotspots' using RNeasy Plant Mini kit (Qiagen). Poly (A+) mRNA was purified from total RNA using NucleoTrap poly (A+) RNA isolation kit (Machery-Nagel, Germany). Suppression subtractive hybridization was performed to create forward and reverse subtracted cDNA libraries using PCR Select cDNA subtraction kit (Clontech, USA). For forward subtraction, mRNA from healthy palms was used as tester and root (wilt) affected mRNA was used as driver. Poly $(A)^+$ RNA from human skeletal muscle provided with the kit was used as a control. Tester and driver cDNA were digested separately with *RsaI* to generate short, blunt-ended cDNA fragments, following which specific adaptors were ligated to tester cDNA, but not the driver cDNA. This was followed by two rounds of hybridization reactions to enrich for differentially expressed sequences and two subsequent PCR amplifications to selectively amplify differentially expressed cDNA.

PLANTING MATERIAL PRODUCTION

Coconut

About 900 WCT, 50 COD and 200 palms of other varieties at Kasaragod and 1,100 WCT, 1,000 COD and 800 palms of other varieties at Kidu were selected for seed production. At Kasargod, 48,208 hybrid seed nuts produced from 1,61,929 flowers that were pollinated last year in 4,916 bunches were sown. During November 2014 to March 2015, 98,000 female flowers from 2,876 bunches were pollinated in 600 WCT palms for production of hybrid seed nuts. At Kidu, 11,145 hybrid seed nuts from last year's pollination were sown. During the year, 7,000 female flowers in 80 WCT palms were pollinated and 900 COD palms were used for hybrid seed nut production through emasculation and open pollination method in the seed garden with WCT. Besides, 36,771 and 35,635 seed nuts of different coconut varieties were produced at Kasaragod and Kidu, respectively and sown in the nursery for distribution to farmers / development agencies / NGOs / stakeholders. A total of 15,458 seed nuts including 805 hybrid nuts were produced at Kayamkulam through participatory mode and sown for distribution in root (wilt) affected tract. Seedlings of seven released varieties were planted at Mooladkam in Kasaragod District in farmer's garden that can be used to produce seven varieties and three hybrids.

Arecanut

At Kidu, 612 palms of Mohitnagar, 131 palms of Sumangala, 110 palms of Sreemangala, 25 palms of Swarnamangala and 126 palms of Mangala are used for seed nut production. 3,80,205 seed nuts and 40,685 seedlings were produced and distributed to farmers. At Vittal, 50,612 seedlings of different varieties were produced and distributed.

Cocoa

At Kidu, 8,205 seed pods and 1,841 seedlings were produced. At Vittal, 20,829 seed pods and 50,006 seedlings were produced.

Planting material production for NE region

Arecanut and coconut

At Kahikuchi, Research centre, 15,764 arecanut seedlings of five varieties *viz.*, Kahikuchi (11,150), Mohitnagar (2,072), Mangala (1138), Sreemangala (552) and Sumangala (852) and 500 coconut seeds of local Kamrupa Tall were produced (Fig. 17).

Cinnamon and Lemon

Two thousand air layers of cinnamon varieties *viz.*, Navasree and Nithyasree and 2,000 rooted cuttings of lemon *var*. Gandharaj and Assam lemon were raised at Kahikuchi, Research centre.

Black pepper

A total of 10,000 black pepper cuttings were raised during the period. Thirteen black pepper accessions collected from different parts of Assam and planted in 2004 were evaluated for growth characters, yield and recovery percentage. Data recorded during 2014 showed that KKHP-8 recorded the maximum vine height (7.16 m) and fresh yield (6.94 kg) per vine. The passport data of these conserved black pepper accessions were submitted to NBPGR, New Delhi and IC numbers were obtained.

Fig. 17. Production of arecanut seedlings for North Eastern Region

CROP MANAGEMENT

CROPPING / FARMING SYSTEM

Coconut based farming systems for sustainable productivity

The sustainability and profitability of coconut based farming system comprising coconut, pepper trailing on the coconut trunk, banana in the border of the plots, fodder grass (hybrid Bajra Napier Co 5) in the interspaces of coconut, dairy unit (7 cows of Holstein Friesian and one Jersey cross breed), poultry (100 broiler birds/batch) and aquaculture (1,000 finger lings) are assessed. The result revealed that from one ha of coconut based integrated farming system, 23,100 coconuts, 15,626 litres of cow milk, 234.4 kg live weight of goat, 470 kg of live weight of broiler birds, 1,167 numbers of hen eggs, 2,360 kg of banana and 369 kg of pepper were obtained. The economic analysis indicated that the net returns were the highest in the CBIFS receiving combined application of 50 per cent organics produced from the system and 50 per cent inroganics. The coconut palms maintained under CBIFS receiving integrated nutrient management practices *i.e.*, organic recycling and 50% of the recommended chemical fertilizer recorded higher yield (132 nuts palm^{-1}) which was comparable with other nutrient management treatments and also higher than coconut monocropping (104 nuts palm^{-1}) (Fig. 18).

Fig. 18. A general view of coconut based high density multispecies cropping system with pepper and banana

Coconut based cropping system

The average yield recorded was 158 nuts per palm with fully organic treatment, 165 nuts per palm with 1/3rd recommended chemical fertilizer and recycling biomass (vermicompost) + biofertiliser + green manuring + vermiwash and 156 nuts per palm with 2/3rd recommended chemical fertilizer and recycling biomass (vermicompost). However, there was no significant difference among the treatments. The copra content of coconut also did not differ significantly among the treatments. Growth observations and yield data of component crops were recorded. Black pepper yield ranged from 2.4 to 3.0 kg vine^{-1} and it was at par among the treatments. The yield of Banana (Njalipoovan variety) ranged from 6.9 to 8.4 kg bunch^{-1} and that of Grand naine variety ranged from 12.5 kg to 16.3 kg bunch^{-1}. However, the treatments were at par with respect to the banana yield.

Performance of medicinal plants as inter/ mixed crops in a coconut plantation

Performance of medicinal plants was evaluated in coconut plantation during 2003-04 to 2014-15. Perennial tree species were harvested and the stem yield of medicinal plants *viz., Stereospermum sauveolens* (poopathiri), *Oroxylum indicum* (palakappayani), *Gmelina arborea* (Kumizhu), *Saraca asoca* (Asoka), *Aegle marmelos* (Koovalam) and *Premna serratifolia* (munja) were 54.06, 6.39, 25.52, 1.66, 12.71 and 3.47 t ha^{-1}, respectively. The root yield were recorded as 9.69, 3.22, 17.89, 0.35, 5.46 and 3.25 t ha^{-1}, respectively. The coconut yield in the experimental plot during the period (2013-14) was 128 nuts palm^{-1} which showed 21% increase in yield over the pre-experimental yield of 101 nuts palm^{-1} during 2000-02 indicating the positive effect of mixed cropping with medicinal tree species.

Areca based mixed farming system (ABMS)

The project initiated during 2007 at ICAR-CPCRI, Regional Station, Vittal studies the feasibility and efficiency of resource management in arecanut based mixed farming. There was 5 to 47% yield reduction in intercropped fodder in arecanut plantations of different age group (2-21 years) over sole fodder on unit area basis. Land use by fodder crop per each cow was estimated as 600 m^2 in sole situation and 1700 m^2 in intercropping situation with arecanut to

meet the year round demand of green fodder for each cow. Rearing milch animals was economical due to availability of fresh fodder throughout the year and the contribution of livestock to total outflows was high (82 to 87%) except in the establishment year of dairy unit (54%). A dairy unit with minimum of four milching cows was required to generate sufficient income to sustain a small farmer. When compared to economic benefit from sole arecanut, though the net return was negative during the first year (2007-2009), it increased later on by 22 % to 169% in ABMS. Profits per unit area and time were increased by as much as 90% in small holdings by adopting mixed farming system over sole arecanut.The estimated availability of recyclable organic biomass from arecanut+dairy was 13.7 t ha^{-1} yr^{-1} with dairy unit contributing 87% of manure production. The total water use was higher in sole cropping of arecanut (2340-3280 m^3) compared to the ABMS (1178-1546 m^3) per unit area.

Plantation based cropping system for sub Himalayan terai region

At ICAR-CPCRI, Research Centre, Mohitnagar, five medicinal crops *viz., Swertia sp., Rauwolfia serpentina, Mentha arvensis, Aloe vera* and *Asparagus recemosus* were planted under different conditions like arecanut, coconut plantation and open condition. Growth and yield data were recorded for all the combination. *Swertia sp*. and *Aloe vera* performed better under arecanut compared to coconut and open conditions. Dry plant weight of *Swertia* sp. was maximum (155.5 g) in arecanut condition followed by open condition (148.3 g) and coconut condition (110.5 g). The maximum number of leaves (9 $clump^{-1}$) was produced by *Aloe vera* under arecanut followed by open condition (8 $clump^{-1}$). Performance of *Rauwolfia serpentina, Mentha arvensis* and *Asparagus recemosus* was better under open condition compared to under arecanut and coconut. Maximum total system productivity was noticed with arecanut + Asparagus system (8.86 t ha^{-1}) followed by arecanut + *Aloe vera* (7.18 t ha^{-1}). The productivity in control (Arecanut alone) was only 3.82 t/ha. In case of coconut and medicinal crop combinations, coconut + Asparagus produced maximum system productivity (8.99 t ha^{-1}) compared to control i.e. coconut monocrop (2.89 t ha^{-1}). Arecanut based cropping system models (Model I- arecanut + black pepper + banana+ acid lime; Model II-arecanut+ black pepper + acid lime + turmeric; Model III- arecanut+ black pepper + acid lime; Model IV - arecanut + black pepper + banana; Model V- arecanut + black pepper + acid lime+ Jute and Control) were evaluated for the performance of different crop combinations. The system productivity can be increased by growing different types of inter/ mixed crops along with arecanut. The maximum total system productivity was obtained in Model II (11.77 t ha^{-1}) with 247% increase over control followed by Model I (10.70 t ha^{-1}) with 215 % increase and in Model III and Model V about 203% increase of total system productivity was achieved over control. Among the different component crops, maximum share on productivity was contributed by black pepper followed by arecanut and other inter crops. Besides the enhancement of system productivity, arecanut yield also increased with intercropping than mono cropping system.

Organic fodder grass cultivation in root (wilt) disease affected coconut gardens

Standardization of organic nutrient management for Hybrid Napier Var. Co.3 when grown as intercrop in root (wilt) disease affected coconut gardens has been taken up since 2013 at ICAR-CPCRI, Regional Station, Kayamkulam. The study aims to increase the unit income from coconut plantations affected with root (wilt) disease by recycling the cowshed wastes. The highest fodder yield was recorded from application of cow dung slurry+ vermicompost+ biofertilizer with an average yield of 26.7 t ha^{-1} of intercropped area per harvest. The peak yield was recorded during August (25.2 t ha^{-1}) (Fig. 19).

Fig. 19. Coconut intercropped with napier grass var., Co3

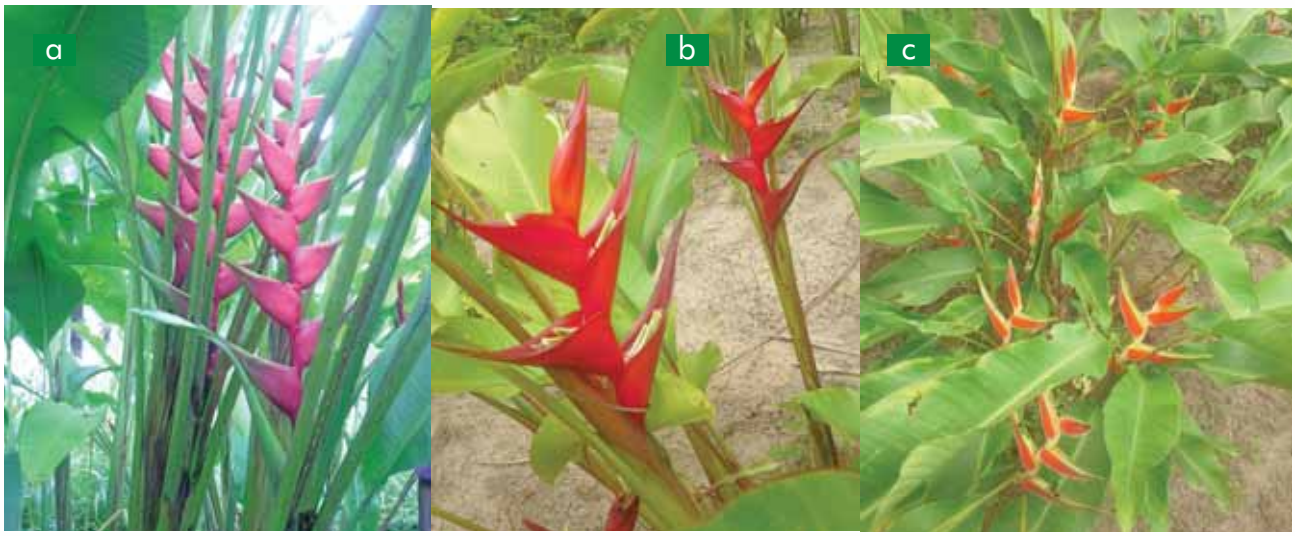


Fig. 20. Heliconia varieties under coconut (a) var. Kawauchi, (b) var. Sunrise (c) var. She

Commercial *Heliconia* varieties as intercrop in coconut garden

Evaluation of growth and flowering habit of six commercial *Heliconia* varieties under coconut canopy is being taken up from September 2012 at ICAR-CPCRI, Regional Station, Kayamkulam. *H. stricta* 'Iris', *H. bihai* X *H. caribaea* 'Kawauchi', *H. stricta* 'Sunrise' and *H. orthotropica* 'She',(Fig.20) were suitable as intercrop in coconut plantations, whereas, *H. caribaea* x *H. bihai* 'Jacquini' and Caribbean Red were poor performers. The quality of inflorescences produced in Iris and Kawauchi varieties were of Grade I with inflorescence length of more than one meter and peduncle girth of more than 9cm, whereas, the inflorescences of 'She' and 'Sunrise' were of lesser quality which can be used for value addition such as bouquet making. The coconut palms in the intercropped area recorded increased nut yield from 28.3 nuts palm^{-1} (2012) to 37.3 nuts palm^{-1} (2014) in two years time mainly due to reduced button shedding.

Growth and flowering pattern of *Heliconia*

Performance of *Heliconia stricta* 'Iris' as an intercrop in coconut plantations with varying shade intensities is being evaluated since 2013 at ICAR-CPCRI, Regional Station, Kayamkulam. The growth and performance of the *Heliconia* variety was found to be positively related to shade intensity. The plants grown under 50% and 75% shade levels produced inflorescences of higher quality with more than one meter length, 6-8 bracts and 9 cm inflorescence girth. The total chlorophyll content of leaves produced under open condition was 0.48%, whereas, under 30%, 50% and 75% shade intensities, it was recorded as 0.73%, 1.01% and 1.03%, respectively.

NUTRIENT AND WATER MANAGEMENT

Evolving site specific management practices

The soil constraints maps for coconut cultivation were prepared for four major coconut growing districts of Tamil Nadu *viz.,* Coimbatore, Tiruppur, Tanjavur and Dindigul using the soil map at 1:50000 scale developed by TNAU (Fig. 21). The soil depth related constraints (under marginal or not suitable condition) for coconut cultivation were observed in 22%, 19%, 17% and 36 % of the total geographical area of the districts Coimbatore, Tiruppur, Tanjavur and Dindigul, respectively. Similarly, pH related constraints were observed in 55%, 64%, 41% and 28%, soil texture related constraints were found in 17%, 18%, 19% and 6 %, and soil drainage related constraints were observed in 20%,16%,14% and 12 % of the total area in the Coimbatore, Tiruppur, Tanjavur and Dindigul districts of Tamil Nadu, respectively. Majority of the area is having soil pH related constraints for coconut cultivation in these districts.

Soil depth was found to be highly or moderately suitable for coconut cultivation in 72%, 79%, 76 % and 60 % of the total geographical area of the Coimbatore, Tiruppur, Tanjavur and Dindigul districts of Tamil Nadu, respectively. Likewise, the soil pH in 40%, 33%, 52% and 68 % area, soil texture in 77%, 80%, 74% and 89 % area and soil drainage condition in 74%, 81%, 78% and 83 % area were found to be

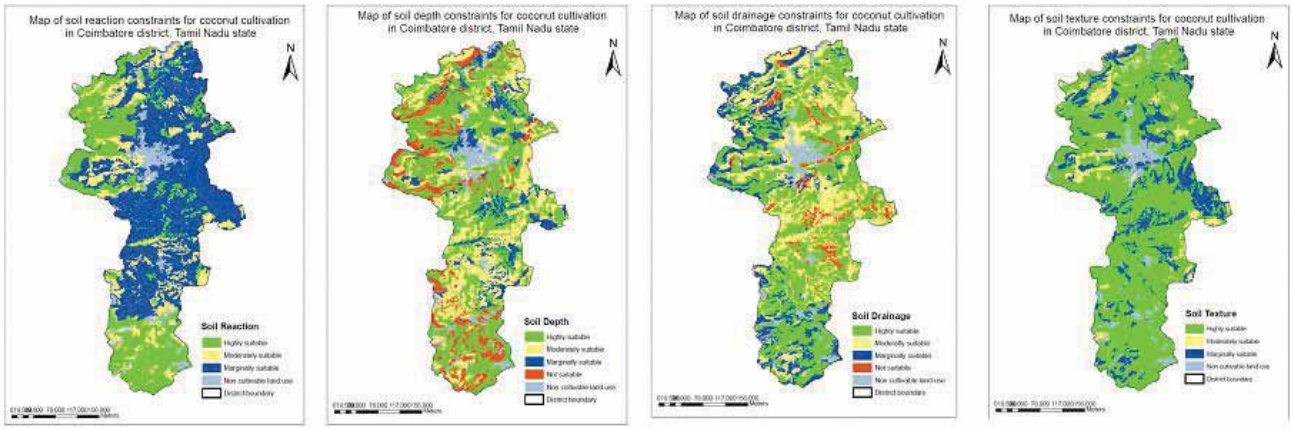


Fig. 21. Soil related constraints for coconut in Coimbatore district of Tamil Nadu

highly or moderately suitable for coconut cultivation in these districts.

Cultural cum Manurial Trial: Long term effect of cultivation, herbicide and manure

The palms under the cultivation + organic + inorganic fertilizer application recorded significantly higher nut yield (131 nuts palm^{-1}) over other treatments *viz.*, cultivation + inorganic fertilizer application (103 nuts palm^{-1}); forking in the basin+ inorganic fertilizer application (102 nuts palm^{-1}); cultivation alone (89 nuts palm^{-1}); weed control using herbicide(68 nuts palm^{-1})and no cultivation, no manuring (38 nuts palm^{-1}).

Impact of harvesting tender nut and mature nut on the sustained productivity of coconut

The impact of different harvesting time and sequence on tender nut and mature nut production is being continued from year 2012. Harvesting of tender nut throughout the year recorded higher yield (155 tender nuts palm^{-1}) which is significantly different from all the other treatments. Harvesting mature nuts throughout the year recorded the lowest nut yield (81 mature nuts palm^{-1}).

Management strategies for health, production and nutrition of arecanut palms

In arecanut, disorders like crown choking, bending and cross nodes have been noticed in many plantations. In laterite soils, spraying of 0.1-0.3% $ZnSO_4$ or soil application of 10 g $ZnSO_4$ / palm and skipping of nitrogen/phosphorus application reduced the disorder symptoms and resulted in normal growth of emerging leaves in palms of below 10 years. The young palms of 5- 6 years recovered faster within four months than palms above 15 years.

Leaf nutrient status of YLD affected arecanut palms in Sringeri indicated deficiency of NPK irrespective of apparently healthy and palms showing yellowing symptoms. But, the soil nutrient status was above optimum with high SOC status.

Drip fertigation in arecanut + cocoa mixed cropping system

The feasibility of supplying organic and inorganic fertilizers through drip irrigation, the effect of drip fertigation on growth and yield of arecanut and cocoa as well as the effect of fertigation on soil quality indicators are being evaluated in the study initiated during 2007. The experiment was laid out in split plot design with three replications. The main plots include two systems i.e., arecanut and arecanut + cocoa mixed cropping system and the sub plots include (changed from 2012) six nutrition treatments such as recommended manurial practices, 75% NPK fertigation, 100% NPK fertigation, 10% N Vermiwash + 75% NPK, 10% N Vermiwash + 100% NPK and vermicompost on N equivalent basis + P & K supplementation. Differential response to drip fertigation was noticed in arecanut and cocoa. Arecanut responded to drip fertigation level of 75% NPK, while cocoa responded up to 100% NPK.

Integrated nutrient management of arecanut under sub Himalayan region

At ICAR-CPCRI, Research Centre, Mohtinagar, performance of four improved arecanut varieties (Mangala, Sumangala, Sreemangala and Mohitnagar)

under five fertilizer doses of organic, inorganic and their combination (no fertilizer; recommended fertilizers; 100% N substitution with vermicompost; 50% N substitution with vermicompost and 50% N by inorganic, and 75% N substitution with vermicompost and 25% N by inorganic) was evaluated for yield and yield attributing characters. Average 5-6 leaves/palm/year were collected from the experimental plots and about 850 kg of vermicompost was produced and applied to the palms.

Control treatment (no fertilizer) resulted in the lowest number of inflorescence, number of nuts and chali yield/palm indicating that fertilizer either organic or inorganic or their combinations has beneficial effect on yield of different arecanut varieties.

The maximum inflorescences/palm was produced by Mangala and Sumangala varieties (3.7 and 3.9, respectively) with 75% N through vermicompost and 25% N through inorganic source, whereas, Sreemangala and Mohitnagar (both 3.6) produced maximum number of inflorescences with 100 % N through vermicompost and 50% N through vermicompost + 50% N through inorganic sources. The maximum number of nuts/palm was produced by Mangala (358) with 100% N supplied through vermicompost, Sumangala (339) with application of recommended dose of fertilizers, Sreemangala (358) with 75% N supplied through vermicompost + 25% N with inorganic source and Mohitnagar (368) with 50% N supplied through vermicompost + 50% N by inorganic source.

The maximum chali yield (3.83 kg palm^{-1}) was recorded in Mohitnagar at T4 level (50% N supplied through vermicompost) followed by Sumangala (3.29 kg palm^{-1}) at the same level of manuring, Mangala (3.15 kg palm^{-1}) at T3 (100% N supplied through vermicompost) and Sreemangala (3.13 kg palm^{-1}) at T2 level (recommended dose).

Nutritional requirement of dwarf varieties of coconut in root (wilt) affected area

The experiment was started during 2008 with three dwarf varieties; Kalparaksha, Chowghat Orange Dwarf and Kalpasree (main plots); four nutritional treatments (sub plots) with four replications in strip plot design.The average number of bunches with nuts above fist size was higher in Kalpasree (7.6 palm^{-1}) followed by Kalparaksha (6.4 palm^{-1}). The highest number of nuts above fist size was recorded in Kalpasree (69 palm^{-1}) followed by Kalparaksha (42 palm^{-1}) and COD (44 palm^{-1}). Nuts below fist size was higher in Kaplasree (76 palm) followed by COD (52 palm^{-1}). Among the nutritional treatments, 100% STBNR + green manure + vermicompost + neem cake (M_2) recorded the highest number of nuts above fist size (62 palm^{-1}). M_2 and M_4 (GM + vermicompost + biofertilizer) recorded higher number of nuts below fist size *i.e.,* 64 and 68 per palm respectively (Fig. 22).

Fig.22.Nutrient management for Kalparaksha, Kalpasree and COD under root (wilt) affected area

Nutrient release pattern as influenced by different silica sources

An incubation study was conducted at ICAR-CPCRI, Regional Station, Kayamkulam during 2014 for a period of 75 days to understand the dissolution and nutrient release pattern as influenced by the application of different silica sources in Onattukara sandy soil of Kerala (Fig. 23). Among the seven treatments, application of potassium silicate@ 400 ppm per kg soil recorded available silicon content of 6.85 ppm followed by the application of calcium silicate @ 400 ppm per kg soil (6.03 ppm). The highest exchangeable calcium content of 532.67 ppm was recorded with the application of calcium silicate@ 200 ppm per kg soil and was on par (519.05 ppm) with its application @ 400 ppm per kg soil. Pot culture studies with different silica sources revealed that the highest per cent increase in leaf thickness was observed with application of sodium silicate @ 200 ppm per kg soil followed by potassium silicate @ 200 ppm per kg soil.

Effect of boron on the nutrition of coconut

Experiment to understand the effect of application of boron as borax @ 0, 60, 120 and 180 g/ palm with and without husk burial, in four split doses was

initiated during 2011 at ICAR-CPCRI, Regional Station, Kayamkulam. Application of borax@120-180 g/palm with husk burial recorded remission of boron deficiency symptoms in 65 % of the deficient palms.

Fig. 23. Effect of silica on the nutrition of coconut

Production technologies for North Eastern states

Integrated nutrient management for arecanut

A field experiment to study the effect of substitution of chemical fertilizers with vermicompost was laid out with five released varieties of arecanut (Mangala, Sumangala, Sreemangala, Mohitnagar and Kahikuchi) and seven nutrient combinations. The treatments are: T_1: Control (no fertilizer), T_2: 100% Vermicompost (8 kg), T_3: 200% Vermicompost (16 kg), T_4: 100% chemical fertilizers (100:40:140 g NPK/palm/year), T_5: 50% chemical fertilizers + 50% Vermicompost, T_6: 2/3rd chemical fertilizers + 1/3rd Vermicompost and T_7: 1/3rd chemical fertilizers + 2/3rd Vermicompost. Palms fertilized with 1/3rd chemical fertilizers + 2/3rd vermicompost produced the maximum yield (2.96 kg chali palm^{-1}) and among the varieties, Kahikuchi performed well in terms of yield (3.36 kg chali palm^{-1}) under the same treatment (T_7).

Development of arecanut based cropping system model

An experiment to develop new model of arecanut based HDMSCS is in progress since 2014 with different crop components and treatments (T_1- 2/3rd recommended dose of fertilizer + recycling of biomass; T_2- 1/3rd recommended dose of fertilizer + recycling of biomass + biofertilizer + green manuring crops; and T_3- recycling of biomass + biofertilizer + green manuring crop + husk burial). The different crop components tried for the new model are: arecanut (Kahikuchi) + black pepper (Panniyur- 1) + banana (Jahanji) + citrus (Assam lemon) + pineapple (Kew type) + turmeric (Lakadong).

Coconut based cropping system for island conditions of Lakshadweep

Taking into consideration of the revised mandate of the Research Centre at Minicoy as a Demonstration-cum-Production Centre for vegetables and fruits to increase their production and supply in the island, various activities were undertaken.

Technology evaluation of improved varieties of vegetables and fruits

High yielding and improved varieties of fruits (banana: nendran, robusta, udayam, njalipoovan and saba; papaya: Arka Surya and Arka Prabhat) as well as vegetables (tomato: TNAU Hybrid; brinjal: IIHR - Neel kant, IIHR - Kesav, IIHR Nidhi, IIHR Anand & Arka Shirish; bhendi: Mahyco 10; chillies: Ananya-Mahyco hybrid, Jawa, IIHR - Haritha, IIHR - Lohit; amaranth: Arka Arunima and Arka Suguna; cabbage: Harirani; cauliflower: IARI Pusa Sradh; Onion: CO5; coriander: CO3; bitter gourd: Arka Harit, Preethi; Snake guard: White Short) were introduced and successfully grown and their performance evaluated in the Island ecosystem.

A total of 5.98 t and 1.81 t of different vegetables and fruits, respectively were produced and made available to the islanders. The total revenue generated was Rs.1,75,580/- (1,34,506/- from sales of vegetables and Rs.41,074/- from fruits). An amount of Rs.3,01,205/- was also generated on account of sale of mature and tender coconuts to Islanders.

Location specific technologies/planting materials for Lakshadweep islands

Seed kits and seedlings of various vegetables such as brinjal, tomato, chilli, bitter gourd, bottle gourd, pumpkin, bhendi etc. sourced from IIHR, Bengaluru; KAU, Vellayani and TNAU, Coimbatore were supplied to farmers for cultivation in their homestead farms. Besides, 542 coconut seedlings and 95 seed nuts were also made available to the farmers. The total revenue generated from supply of planting materials was Rs.38,675/-

Demonstration of protected cultivation of vegetables such as tomato, bhindi, chilli and sponge gourd using insect proof cage taken up both at the Centre and farmer's homesteads (Shri U.Muhamad, Uday village and Shri Ismail, Aoumagu Village of Minicoy Island) was continued. The seeds of various vegetables are sourced from TNAU, Coimbatore, IIHR, Bengaluru and KAU, Vellayani. The utility of drip and sprinkler irrigation methods for various vegetables and banana is also being demonstrated at the Research Centre.

Training programmes on "Organic cultivation of fruits and vegetables for nutritional security" (one day: 27.10.14 for 28 participants) (Fig. 24) and "Neera Tapping - CPCRI technology, preparation of coconut sugar and other post harvest technologies" (one day: 9.1.15 for 25 tribal youths) were organized at the Research Centre, Minicoy during 2014-15.

Fig. 24. Training farmers on vegetable production at Minicoy

Bioresource management in coconut, arecanut and cocoa

Biochar studies

Biochars prepared using tender coconut husk and arecanut husk were added in combination with coconut leaf vermicompost in graded doses to potting mixture sown with cow pea seeds. Their effect on plant growth in terms of dry matter and arbuscular mycorrhizae colonization were recorded. The biochar + vermicompost treatments gave the highest dry matter weight increase in cow pea seeding as well as arbuscular mycorrhizae spore numbers compared to biochar application alone and recommended inorganic fertilizer treatments (as per KAU POP for cowpea and other vegetables). Areca husk biochar + vermicompost gave the highest increase in the plant dry matter weight, whereas, coconut biochar + vermicompost produced more AM root colonization compared to control (Fig. 25). This study indicated that there is good potential to recycle tender coconut husk and arecanut husk biomass residues as biochars as soil additives for improving the soil health.

Potassium enrichment of vermicompost

Addition of coir pith as intermediary layers along with sorghum based spawns of *Pleurotus florida* with coconut leaves resulted in improvement in potassium content and microbial properties of vermicompost. The populations of function-specific bacteria, *viz.*, fluorescent pseudomonads (> $300x10^2$ cfu g^{-1}) phosphate solubilizing(>$50x10^3$ cfu g^{-1}) and free living diazotrophs (>$400x10^2$ cfu g^{-1}) were found significantly higher in vermicompost produced by mixing coir-pith and mushroom spawn. An overall value addition in terms of nutrient content and microbial properties of the coconut leaf vermicompost is achieved with the addition of coir-pith and *Pleurotus florida* mushroom spawn to the vermicomposting substrates of coconut leaf and cow dung (Fig. 26).

Compatibility of neem cake with coconut leaf degrading earthworm

Fresh neem cake was applied along the top inside borders in vermicomposting tanks as prophylactic control for managing the breeding of rhinoceros

Fig. 25. Effect of tender coconut husk and arecanut husk biochar and vermicompost on growth of cow pea seedlings.

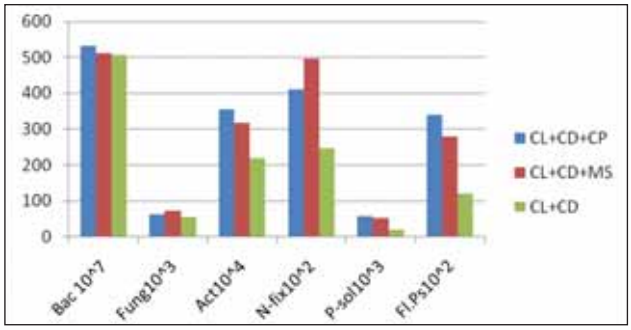


Fig.26. Microbial load in the coconut leaf vermicompost

beetle. Application of neem cake has shown to largely prevent rhinoceros beetle entry into the tanks. Their impact on earthworm population and activity (in terms of vermicompost production) was recorded in 14 tanks. No detrimental effect of the neem cake addition was observed on the earthworm activity as there was 50-70% conversion of the substrates to vermicompost at the end of the composting cycle. The population of the earthworms also doubled in most of the tanks indicating that the neem cake was not influencing their multiplication capacity.

Screening of different methods for composting arecanut husk

Arecanut husk possesses a very high C: N ratio above 100 that makes it recalcitrant to be composted into manure. Studies were initiated to assess the possibility of its composting using *Pluerotus florida* or *Phanerochaetae chrysosporium* along with cow-dung slurry or *Glyricidia* leaves. The addition of cow dung slurry or glyricidia leaves was aimed at bringing down the C:N ratio of the husk and make it amenable to microbial composting. The study indicated that it was possible to compost the arecanut husk even though the time taken was more than four months.

Production and supply of bioresources to end users

About 220 farmers from Kerala, Karnataka, Tamil Nadu and Maharashtra, several school and college students were given lecture, demonstration and training on bioinoculant production, vermicompost and mushroom production from coconut leaves. During the period, 3.5 lakh earthworms, 26 t of coconut leaf vermicompost, 200 l of coconut leaf vermiwash, 30 kg of *Pleurotus florida* mushroom spawn and 100 kg of Kera Probio / Cocoa Probio inoculant were produced and sold to farmers, women entrepreneurs and self employed youths.

Application of microorganisms in agriculture and allied sectors

Release of Arbuscular Mycorrhizae inoculant for coconut

Based on five years study under AMAAS-Mycorrhizae project, a soil based AMF bioinoculant, *KerAM*, was released in August 2014 during the "National Conference on Sustainability of coconut, arecanut and cocoa farming: Technological advances and way forward" (Fig. 27). The bioinoculant contains *Claroideoglomus etunicatum*, one of the dominant AM species isolated from coconut agro-ecosystem with high potential to increase the growth parameters of coconut seedlings.

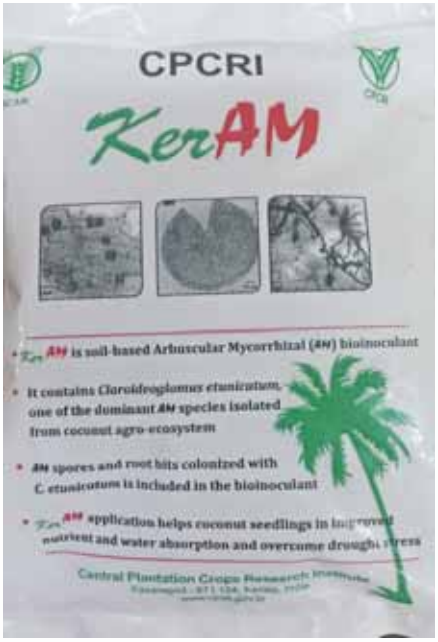


Fig. 27. The *KerAM* bioinoculant for coconut

Cultures deposited at NBAIM, Mau

A total of 41 bacterial isolates, 18 PGPRs from coconut and cocoa and 23 mycorrhizae helper bacteria (MHB) along with their passport data have been deposited at the National Agriculturally Important Microbial Culture Collection (NAIMCC), NBAIM, Mau.

INTEGRATED MANAGEMENT OF DISEASES AND PESTS

Disease Management

Phytophthora diseases

Collection and characterization of *Phytophthora* infecting arecanut

A total of 54 *Phytophthora* isolates were collected from the disease-prone areas of four districts (Dakshina Kannada, Shimoga, Udupi and Uttara Kannada) of Karnataka, three districts (Kasaragod, Kannur and Thrisur) of Kerala and also from northern and southern parts of Goa state during 2013 to 14 monsoon season. Among the 54 isolates, 52 were collected from fruit rot infected arecanut samples and two isolates from crown rot affected arecanut samples. Among the disease endemic areas, the highest incidence of fruit rot was observed in Karkala of Udupi district followed by Sirsi of Uttara Kannada Districts of Karnataka.

Morphological characterization of *Phytophthora* isolates revealed significant variation in colony growth rate and majority of the isolates exhibited stellate to rosaceous pattern of growth. Out of 54 isolates, 52 isolates were heterothallic and produced caducous, ovoid to ellipsoidal sporangia with conspicuous papilla and were identified as *P. meadii*. Two isolates were homothallic and produced non caducous, ovoid and distorted sporangia with papilla and were identified as *P. heveae*. Identity of the species was further confirmed by sequencing PCR amplified internal transcribed spacer (ITS) region of ribosomal DNA. Mating type study showed that 52 heterothallic isolates were of A2 mating type, indicating the predominance of A2 type in arecanut *Phytophthora* population.

Genetic diversity in *Phytophthora meadii*

Random amplified polymorphic DNA (RAPD) analysis

Cultural, morphological and pathogenic characterization of *Phytophthora* isolates of arecanut collected from different locations of South India revealed distinct variations not only between species but also among the isolates within a species, especially *P. meadii*. The diversities were further confirmed by random amplified polymorphic DNA (RAPD) analysis of selected isolates of *Phytophthora* spp. Based on initial screening of RAPD primers, 12 primers were selected for analysis of genetic variation on 28 isolates of *P. meadii* and two isolates of *P. hevea* of arecanut fruit rot disease. Both of the *P.hevea* could easily be distinguished with the 12 selected primers (Fig. 28). Thirty *Phytophthora* isolates falls into two distinct main clusters. There were two sub clusters under the first main cluster. *P. meadii* isolates formed one group, whereas, the two *P. hevea* formed a separate cluster. The patterns within *P. meadii* were usually quite similar with some intra-specific variations. The *Phytophthora* isolates did not cluster according to geographical origin, virulence or morphological variations (Fig. 29).

Fig. 28. RAPD profiles of *Phytophthora meadii* isolates causing fruitrot of arecanut

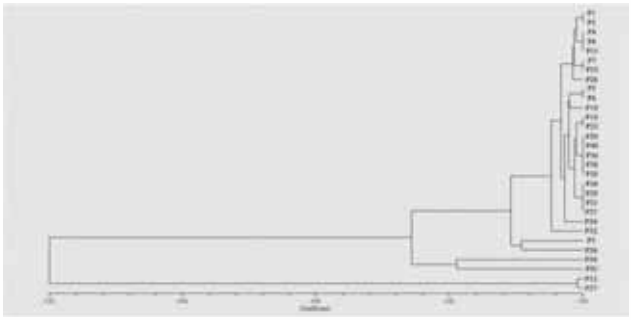


Fig. 29. Clustering pattern of *Phytophthora meadii* isolates, based on RAPD, causing fruitrot of arecanut

Real- time PCR for detection of *P. meadii*

A real-time PCR protocol has been developed for specific detection of *P. meadii*. Oligonucleotide primers were derived from sequences of internal transcribed spacer region of ribosomal DNA. A total of five pairs of primers were designed using Primer 3 software. Under optimal conditions, the primer PM1F and PM1R specifically amplified a 180 bp sequence of DNA. Real time PCR with Syber Green dye, was carried out in a Biorad Mini Opticon Real time PCR system. The primer pair PM1F & PM1R specifically amplified *P. meadii* and was able to distinguish from other *Phytophthora* species which did not give amplification with the same pair of primers. However, the primer pairs also amplified the closely related species in the Clade II viz. *Phytophthora citrophthora* and *P. colocasiae* but did not amplify other species of *Phytophthora* (Fig. 30).

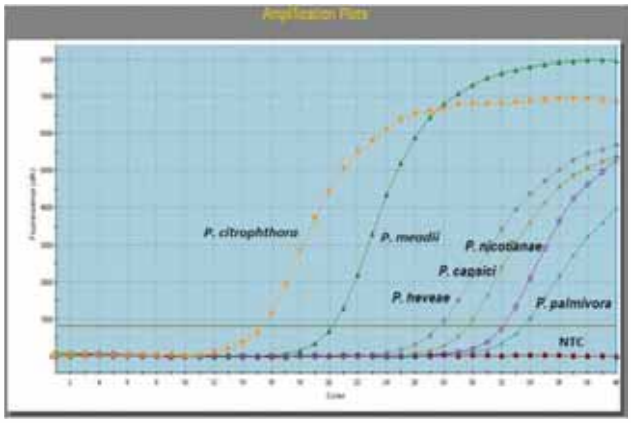


Fig. 30. Real-time PCR amplification profiles of *Phytophthora meadii*, *P. citrophthora* and *P. colocasiae*

Cultural and morphological characterization of selected *Trichoderma* isolates

Cultural and morphological characters of 18 *Trichoderma* isolates were studied. The colony morphology was depressed, cottony to fluffy with aerial mycelium and the colony color varied from green, yellowish green to white mycelial growth.

Antagonistic activities of 18 isolates of *Trichoderma* spp. against common pathogens of arecanut, cocoa and coconut namely *Phytophthora meadii*, *P. palmivora, Ganoderma lucidum*, *Theilaviopsis paradoxa* and *Lasiodiplodia theobromae* were analyzed. Even though, *Trichoderma harzianum* isolate CPCRI-TD-28 was the most promising isolate, there was wide variability among the *Trichoderma* isolates in their antagonistic potential against the pathogens tested. *L. theobromae* was effectively inhibited by isolate CPCRI-TD-03 (76.23%), whereas, *T. paradoxa* by isolate CPCRI-TD-04 (72.76%), *P. meadii* by isolate CPCRI-TD-07 (75.47%) and *Ganoderma lucidum* showed 95.60% inhibition by isolate CPCRI-TD-28.

Screening of *Trichoderma* isolates for cellulase enzyme activity and their effect on plant growth promotion

Trichoderma have attracted scientific attention in their plant growth promotion in addition to their role in resisting the growth of plant pathogens by producing defence related proteins. Growth promoting activities of 18 *Trichoderma* isolates were studied on green gram by evaluating shoot lenght, root length, fresh weight, dry weight, germination percentage and vigour index. Significantly positive effects on germination were found in treatments with *Trichoderma* isolates *viz.*, CPCRI-TD-28, TD-13, TD-11, TD-16, TD-03, TD-02 and TD-06. There was wide variability among the *Trichoderma* isolates in promoting seed germination which ranged from 66.66 to 100.0%. But all the *Trichoderma* isolates showed significant effect on shoot length, root length, fresh weight, dry weight and vigour index. *Trichoderma* isolate CPCRI-TD-16 was found to be superior in plant growth promoting activity compared to the other *Trichoderma* isolates (Fig. 31).

Fig. 31. Effect of seed treatment of green gram with *Trichoderma* (CPCRITD-16) on germination and growth promotion

Cellulase enzyme activity of all the *Trichoderma* isolates was quantitatively measured by DNS spectrophotometric assay. The highest cellulase activity was recorded by *Trichoderma harzianum* isolate CPCRI-TD-16 followed by CPCRI-TD-28 and CPCRI-TD-3. Lower cellulase activities were detected in CPCRI -TD-13 and CPCRI-TD-15.

Fruit rot incidence in relation to climatic factors

Climatic factors like daily temperature, relative humidity, rainfall and fruit rot disease incidence data were collected from three locations *viz.*, Kidu, Vittal and Dharmasthala, and correlated with the disease incidence. The fruit rot disease incidence was noticed from 1st week of August in Kidu and Vittal and 3rd week of August in Dharmasthala and the disease reached

to maximum during 4th week of August in Kidu and Vittal by 2nd week of September in Dharmasthala. Self grown *Colocasia* in arecanut garden was identified as alternate host for *P. meadii* for initial establishment of inoculum in arecanut garden.

Management of fruit rot disease of arecanut

Screening of new fungicides against *P. meadii*

Among eight new registered fungicides tested against *Phytophthora meadii* under *in vitro* condition, mandipropamid, metalaxyl + mancozeb, ametoctradin + dimethomorph were very effective (100 cent percent inhibition) at 125 ppm concentration and were selected for testing under field condition.

Field trial on management of fruit rot disease of arecanut was conducted in CPCRI, RC, Kidu, Vittal and farmer's field at Dharmasthala with nine treatments. The observation on fruit rot disease incidence was recorded on alternate days. Lower fruit rot disease incidence was observed in 1% Bordeaux mixture sprayed plots followed by Mandipropamid 250 SC in all three locations (Fig 32).

Fig 32. Management of fruit rot disease of arecanut

Management of bud rot of coconut

Demonstration trial on bud rot disease management using *Trichoderma* coir pith cake was conducted at Manjeshwar and Westl Eleri panchayaths after recording pretreatment bud rot disease incidence of 7.3% and 20% respectively. In post treatment observation, no fresh infection was observed in Manjeshwar but in West Eleri panchayath, fresh bud rot infection was noticed in 14 palms out of 160 palms.

Management of basal stem rot or *Ganoderma* wilt of coconut

Among the six vegetable and three pulse crops artificially inoculated with *Ganoderma lucidum* for identification of indicator host for *Ganoderma* disease, only Bengal gram plants were infected and showed yellowing and drying type of symptoms on 12 days after inoculation.

Field trial on management of *Ganoderma* wilt disease was conducted with six treatments after recording pretreatment *Ganoderma* disease index. Reduction in Ganoderma disease index was noticed in bimonthly application of *Trichoderma* enriched neem cake @ 5 kg per palm compared to other treatments (Fig. 33).

Fig. 33. Management of basal stem rot of coconut with bimonthly application of *Trichoderma harzianum*

Diagnostics and management of root (wilt) disease (RWD) in coconut and yellow leaf disease (YLD) in arecanut

The severity and pattern of yellowing of palms in Edava (Thiruvananthapuram district, Kerala) and Cumbum (Theni district, Tamil Nadu) were documented and categorized. In Edava, severe yellowing with orange tinge was prominent in outer and middle whorl of leaves in affected palms. Out of 40 palms observed, 65.87 % showed typical RWD symptoms such as flaccidity, yellowing and marginal necrosis of leaflets. In 17.5% of the palms, yellowing was confined to the outer whorls of leaves only. Yellowing of the outer and middle whorls was observed in 30.0% of the palms, while 36.5 % showed severe yellowing in all the leaf whorls. All the 37 leaf samples showed positive reaction to ELISA. In Cumbum, 44% of the yellowing-affected palms showed typical symptoms of the RWD and 16% of the palms showed leaf rot disease. DNA was extracted from the healthy and diseased coconut leaf samples collected from Cumbum and Edava regions. None of the DNA samples showed amplification by PCR using universal and custom designed primers.

A total of 329 coconut spindle leaf samples were subjected to ELISA using polyclonal antisera against

coconut root (wilt) disease phytoplasma. Out of the 329 leaf samples tested, 122 were found to be negative and the serologically negative palms were selected as mother palms for seed nut collection. For the evaluation of nutrition in synergy with induced resistance for the management of RWD, 42 WCT seedlings bio-primed with *Pseudomonas fluorescens* were planted at Kayamkulam. Under *in vitro* conditions, Tebuconazole 25.9% EC, Tebuconazole 50% + Trifloxystrobin 25%WG @ 100 ppm effectively inhibited the mycelial growth of leaf rot pathogens. In the exploration of PGPR in arecanut ecosystem, 14 endophytic fungi and 32 endophytic bacteria were isolated from apparently healthy areca palms in YLD endemic areas.

Insects and weeds as reservoir of phytoplasma in coconut ecosystem

Seasonal diversity of auchenorrhyncha fauna was observed in light trap catches in coconut ecosystem. The planthopper, *Nisea nervosa* (Motschulsky) [Fam: Meenoplidae] was encountered throughout the year. The leafhopper *Orosius albicinctus* (Distant) and zigzag leafhopper, *Maiestas dorsalis* (Motschulsky) were intercepted predominantly during summer period (March-May). Agallini and cixiid hoppers (*Oliarus* sp.) were recorded during monsoon season. Establishment of common weeds such as *Cynadon dactylon* and *Urochloae distachya* as well as rice, *Oryza sativa* in Yoshida medium was successful. The established plants in flexi cages could be used for rearing putative insect vectors.

Phytoplasma could be detected in putative insect vectors *viz.*, *N. nervosa*, *O. albicinctus* and *M. dorsalis* using phytoplasma-specific universal primers (P1/ P7 nested IF7/7R2). Sequencing of PCR products revealed the occurrence of sesamum phyllody phytoplasma in *O. albicinctus* and molecular characterization of phytoplasma in other putative vectors is in progress (Fig. 34).

N. nervosa *Oliarus* sp *O. albicinctus*

Fig. 34. Putative insect vectors associated with weeds in coconut gardens

Lace bug, *Stephanitis typica* and *Proutista moesta* exposed to different A+I period on root (wilt) diseased palms could not be amplified for phytoplasma using phytoplasma-specific (P1 / P7 nested IF7 / 7R2) as well as custom designed primers. *P. moesta* exposed to different pre-acquisition fasting ranging from 30 min to 6.0 h at 30 min intervals and released on RWD palms for a period of 5-30 days could not amplify for phytoplasma at the desired base pair level.

Molecular characterization of phytoplasma was accomplished in two weeds in coconut gardens *viz.*, *Pedalium murex* phyllody and *Urochloa distachya* white leaf. The phytoplasma causing *Pedalium* phyllody as well as *U. distachya* whiteleaf was identified as ''*Candidatus* Phytoplasma *australasiae*"-related strain belonging to subgroup 16SrII-A and ''*Candidatus* Phytoplasma *cynodontis*" related strain belonging to subgroup 16SrXIVA, respectively (Fig. 35). Furthermore, phytoplasma was detectable in weeds such as *Cleome* sp., *Mollugo* sp., *Melochia* sp. and *Sesamum* sp. with typical phytoplasma disease symptoms (Fig. 36).

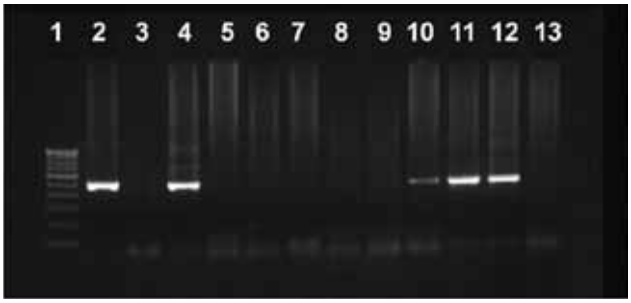


Fig. 35. Molecular detection of phytoplasma in putative insect vectors
Lane 1: 100 bp DNA ladder, 2: Grassy shoot disease of sugarcane, 3: *P. moesta* (A+I-30days), 4&13:N. nervosa, 5,7,11,12: *O. albicinctus*, 6: *E. indicus*, 8-10: *Maiestis sp.*

Cleome sp. *Mollugo sp.*

Fig. 36. Phyllody in weeds caused by phytoplasma in coconut plantation

About 500 virulent *P. moesta* after completion of A+I period was released on challenge inoculation cage with potted MGD, CGD and WCT coconut seedlings. None of the seedlings contracted the disease so far.

Loop mediated isothermal amplification (LAMP) assay for detection of phytoplasma associated with coconut root (wilt) disease and arecanut yellow leaf disease

A real-time LAMP (RT-LAMP) assay using the Genei II LAMP system, Optigene, was developed for detection of phytoplasma associated with RWD of coconut and YLD of arecanut using the phytoplasma 16Sr DNA as target for amplification. This assay was further refined by confirmation of fidelity of amplicons by restriction analysis of LAMP product, and sequencing of DNA amplified through RT-LAMP.

Direct PCR was performed with LAMP external primers, F3/B3. Amplicons of expected size (205 bp) were obtained for the diseased samples. These were purified and sequenced.

Restriction analysis of the DNA amplified through RT-LAMP was carried out with restriction enzyme, HpyCH4V, having internal cutting site in the amplified DNA. The restriction enzyme digested DNA of LAMP when run on agarose gel, two prominent bands were obtained, one at 50bp and another at 80bp region.

Arecanut YLD samples from disease affected arecanut gardens in Sringeri, Karnataka and coconut RWD samples from Kayamkulam, Kerala were screened using the real-time LAMP assay. All the samples were collected from typical symptomatic palms from diseased area. Twenty out of twenty nine areanut samples and eighteen out of twenty five coconut samples were found positive for phytoplasma. No amplification was observed for healthy samples collected from disease free area.

Standardization of sampling for phytoplasma detection

Different coconut samples like spindle leaf, root and trunk borings were sampled for the detection of phytoplasma and DNA was prepared with phytoplasma enrichment protocol and CTAB protocol. CTAB protocol was suited for trunk borings. Good quality DNA could be obtained from coconut trunk borings. Though positive amplification was obtained through nested PCR, there was no consistency in detection of phytoplasma.

Production of polyclonal antisera against phytoplasma protein

The *secA* gene (420 bp) of arecanut YLD phytoplasma was cloned into pTZ57RT vector and sequenced. The *secA* gene (420 bp) was further sub-cloned into pET vector and expressed protein was purified. The expected protein size (20 kD) was confirmed on SDS-PAGE. The purified SecA protein has been injected in to a rabbit and antiserum is produced.

Pest Management

Integrated pest management strategies were fine-tuned for the suppression of key pests of palms and cocoa with emphasis on biological control, farmer-participatory approaches as well as botanical preparations. Need-based use of chemical pesticides and their residual limit were also determined. Exploratory surveillance surveys were undertaken on the occurrence of invasive pests in all strategic points of entry and the potential bio-security risks in palms were ascertained to evolve an emergency preparedness module.

Rhinoceros beetle *(Oryctes rhinoceros)*

Botanical cake was refined to tablet-shape (each weighing 1.9 g measuring dia 2.5 cm & thickness 0.4 cm) for the prophylactic leaf axil filling against rhinoceros beetles. In comparison to cubical, cylindrical or wedge-shaped modules, botanical cake in tablet-shape was found ideal for placing within the coconut leaf axil. Placement of two such botanical cakes (tablet-shape) on the top most leaf axils reduced 53% leaf damage (Fig. 37).

Fig. 37. Botanical cake for management of rhinoceros beetle

Y-tube response of rhinoceros beetle towards essential oils *viz.*, basil oil, ginger oil, citriodora oil, thymol oil, and ajowan oil showed 70% to 75% repellency. Citriodora oil @ 1 ml admixed with pheromone lure exhibited higher (69%) repellency to rhinoceros beetle in comparison with thymol oil (60%), basil oil (49%) and ajowan oil (35%). Though ajowan oil exhibited higher repellency in Y-tube bioassay, its repellency in synergy with pheromone lure was marginal. However,

polymer matrix embedded with ajowan oil recorded the lowest beetle catch (40 beetles) than control (64 beetles) in a period of 145 days. Therefore, essential oil forms a good repellent source for rhinoceros beetle. Nearly 40-45% recovery of leaf damage due to rhinoceros beetle was observed in palms placed with chlorpyrifos @ 2-5 ml embedded polymer sheets in spindle region.

In a wind tunnel bioassay, fermented groundnut cake and castor cake attracted 80% and 55% of rhinoceros beetle, respectively in a period of 10 days. At Kayamkulam, Chemtica lures could trap 5 beetles month^{-1}, whereas, CPCRI-nanolure trapped 9 beetles month^{-1}. Intensity of beetle damage was relatively higher on the palms around the pheromone traps.

A coconut-based crop-habitat diversification model of rhinoceros beetle was refined (Fig. 38). Habitat manipulation with crop diversity (nutmeg, rambutan, papaya, banana, glyricidia, curry leaf, coral vine, sunflower) along with coconut (Kalpa sankara -39 nos.) subdued rhinoceros beetle attack to 53.2% in inner whorls than that of outer whorls. Ninety per cent of Kalpa sankara have started flowering and 15% palms were harvested for mature nuts in 31 months after planting.

Pest- weather regression model (PWRM) between log values of monthly rhinoceros beetle (RB) infestation and climatic factors during 2010-2014 was established as $log\ RB = -1.12 + 0.006T_{max} + 0.050T_{min} + 0.042RH_1 - 0.032RH_2 + 0.015RF$ ($R^2 = 0.86$). The model was further modified as $log\ RB = -0.921 + 0.054T_{min} + 0.042RH_1 - 0.032RH_2 + 0.015RF$ ($R^2 = 0.85$) by eliminating T_{max}. This PWRM will be validated in the ensuing season.

Nuclear culture of *Metarhizium anisopliae* as well as *Oryctes rhinoceros* nudi Virus was maintained *in vitro* and *in vivo* on infected grubs in the laboratory. Need based delivery of *M. anisopliae* multiplied in semi-cooked rice was provided to all requested farmers and Krishi Bhavans where eco-friendly bio-management of rhinoceros beetle is attempted in farmer participatory approach. Molecular characterization of two strains of *Metarhizium* spp., was studied using ITS-1 and ITS-4 primers and the PCR products subjected to BLAST analysis were identified as *Metarhizium majus* and *Metarhizium guizhouense*, respectively with 99% similarity. Identity needs further confirmation through multi-locus sequencing.

Area-wide bio-suppression of rhinoceros beetle in three Panchayats *viz.,* Devikulangara, Kandalloor and Krishnapuram indicated significant reduction in leaf damage by rhinoceros beetle ranging from 65.2% to 85.5%. Palm damage was also reduced in these locations ranging from 21.9% to 34.3%. Large scale mass multiplication of *M. anisopliae* in semi-cooked rice-based media was undertaken and 899 breeding sites of rhinoceros beetle were treated in the project area. Farmer's club and Milk Societies were also actively linked for distribution of GMF.

Fig. 38. Components of crop habitat diversification (a) Maize, (b) Banana, (c) Coral vine, (d) Nutmeg, (e) Rambutan (f) Coconut (g) Sunflower, (h) Gliricidia, (i) birds perch) and (j) Papaya

The entomopathogenic nematode, *Steinernema carpocapsae* infected *Galleria mellonella* cadaver @ one / 500 cm^3 was found effective in the bio-management of rhinoceros grubs in vermicompost.

Red palm weevil *(Rhynchophorus ferrugineus)*

Systematic laboratory evaluation of the entomopathogenic fungi showed that, *Beauveria bassiana* infected 50% of red palm weevil grubs in coconut-petiole based bioassay. Placement of three filter paper sachets containing 12-15 *Heterorhabditis indica*-infected *G. mellonella* cadavers on the leaf axils after application of 0.002% imidacloprid could recover 60% of infested palms.

Laboratory evaluation of Lesenta (imidacloprid +fipronil) @ 10 mg induced 90% mortality of red palm weevil grubs in petiole-based bioassay. A semi-synthetic artificial diet containing 0.06% cholesterol was standardized for rearing red palm weevil in Falcon tubes (50 ml) and the grubs attained at least four times more weight gain than those reared on coconut petiole. While the grubs fed on coconut petiole attained 0.28g, the grubs of similar stage weighed about 1.05 g when maintained on the artificial diet.

Imidacloprid residue was not detectable in both nut water and meat from all samples taken from a period of 2-30 days after crown pouring of imidacloprid @0.02% on red palm weevil infested palm. This indicates the food safety limit of imidacloprid @ 0.02% for use in the management of red palm weevil

A prototype of red palm weevil detector based on acoustic system was developed in association with Centre for Development of Advanced Computing (CDAC), Thiruvananthapuram and this gadget could be linked to mobile phone for timely and instantaneous alert based on the bite signals of feeding grubs. The gadget needs further refinement.

Citridora oil (0.1%) and CNSL (0.1%) induced 70% and 55% repellency, respectively in Y tube choice assay, whereas, betel leaf oil and methyl chavicol could repel 40% of *R. ferrugineus* at 0.1 % concentration. The CPCRI-Kayamkulam lure as well as CPCRI-nano-kairo lure could trap 32 and 30 weevils, respectively, whereas, Chemtica lure could catch only 10 weevils/ month.

Chowghat Green Dwarf was highly susceptible (8.7%) to red palm weevil infestation and Malayan Orange Dwarf (3.5%) was relatively tolerant.

Coconut eriophyid mite *(Aceria guerreronis)*

Palms sprayed with spiromesifen (Oberon) (1 ml $litre^{-1}$) during April-May and September-October reduced coconut eriophyid mite incidence (61.2%) followed by coconut oil +sulphur (5 g) (52.6%). Application of neem oil (0.2%) evinced 68% reduction in mite incidence.

Field application of *Hirsutella thompsonii* in combination with neem oil/garlic/soap or alternating with botanicals during summer was found superior in suppressing mite population. Molecular characterization of *Hirsutella* sp. was studied using ITS-1 and ITS-4 primers and the PCR products subjected to BLAST analysis were identified as *Hirsutella thompsonii* with 99% similarity.

Among the four dwarf cultivars Malayan Green Dwarf (MGD), Malayan Orange Dwarf (MOD), Malayan Yellow Dwarf (MYD) and Chowghat Green Dwarf (CGD) evaluated, CGD was found to be relatively tolerant to mite infestation (15%). MYD was highly susceptible to mite attack followed by MGD.

Coconut leaf eating caterpillar (*Opisina arenosella)*

Complete recovery of *Opisina arenosella* infestation was realized in the demonstration plot at Arsikere. There was no fresh feeding damage by the pest and this forms a model plot for nearby farmers to emulate the IPM strategies in the management of *O. arenosella*.

White grub *(Leucopholis coneophora /L.burmeisteri)*

Green muscardine fungus (*Metarhizium anisopliae*) was isolated from naturally infected cadaver of *Leucopholis coneophora* from Kasaragod which could infect first and second instar, *L. coneophora* @ 6.92×10^{11} spore concentrations. An unidentified *Cordyceps* spp. from naturally infected *L. coneophora* was cultured on artificial (PDA and PCA) media which morphologically and microscopically resembled to that of anamorphic *Paecilomyces* spp. Soil temperature affected the emergence of *L. coneophora* adults directly and rain fall played an indirect role in emergence by reducing soil temperature. Beetle emergence was absent in dry spells between rainy days when soil (10 cm depth) temperature crossed 35^0C.

Median lethal concentration of imidacloprid, chlorpyrifos, bifenthrin and fipronil was found to be 47.6 ppm, 57.1 ppm, 63.1 ppm and 68.3 ppm

respectively against third-instar, *L. burmeisteri* Brenske indicating imidacloprid as the most toxic chemical.

Field evaluation studies indicated 80.5% reduction of first-instar grubs of *L. burmeisteri* by blanket application of Bifenthrin @ 4 kg ai ha^{-1} followed by chlorpyrifos (76.35 %). Imidacloprid @ 0.24 kg ai ha^{-1} induced 73.89 % reduction (Fig. 39).

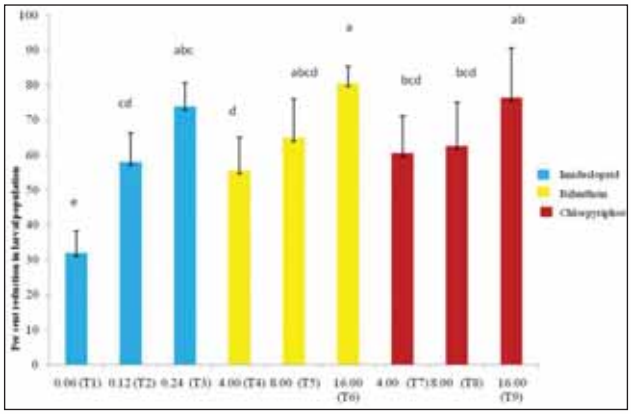


Fig. 39. Field evaluation of insecticides against *Leucopholis burmeisteri* early instar grubs

In dissipation studies, bifenthrin was reduced to 7.29 ppm, whereas, chlorpyrifos got reduced to 0.96 ppm, ten days after application inferring bifenthrin as more persistent than chlorpyrifos. Bifenthrin did not affect *Trichoderma viridae,* whereas, chlorpyrifos affected the colony growth of *T. viridae*. Identity of three species of *Leucopholis viz., L. coneophora, L. burmeisteri* and *L. lepidophora* was established through molecular characterization of Cox gene.

ENTOMOPATHOGENIC NEMATODES (EPN)

Nuclear culture of EPN isolates (*Steinernema* and *Heterorhabditis* sp.) was maintained on Greater wax moth (*Galleria mellnella*) in the laboratory and nearly 1.8 billion nematodes were mass multiplied and supplied for field experiments and demonstration plots (KVK, Kasaragod). One *Steinernema* sp. was intercepted from Kerala and no EPN could be collected from hot zones of Karnataka (Fig. 40).

Molecular characterization of native EPN isolates

Severe damage of arecanut and coconut palms by white grub was reported in Karnataka and Kerala. As eco-safe belt concept is emerging in these states, the biological (EPN) based integrated management of white grub is attracting many growers. One native

Fig. 40. Prominent golden yellow color spicules in male of *Steinernema carpocpasae*

isolate of *Steinernema* sp. was identified as *Steinernema carpocpasae* based on key morphological diagnosis and molecular resolution based on 16s rRNA and *COXII* genes (Fig. 41).

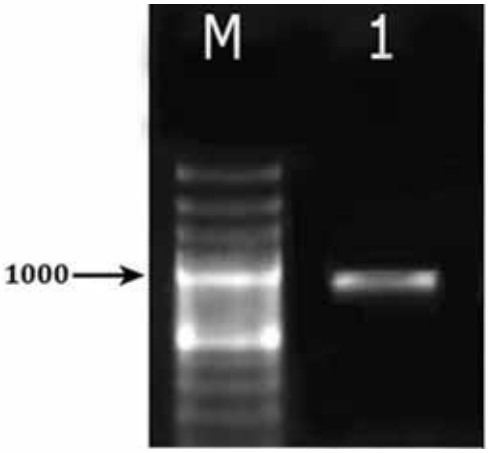


Fig. 41. PCR amplification of cytochrome oxidase II (COXII) of *Steinernema* sp.

Evaluation of EPN liquid formulation against late instar root grub, *Leucopholis burmesteri* larvae in Arecanut

Field trial conducted in root grub infested garden during 2012 - 2014 at Chikmaglore district of Karnataka with one round soil application of liquid formulation (100-200 ml solution) of EPN, *Steinernema carpocapsae* @ 1.0 x 10^7 infective juveniles (IJs) $palm^{-1}$ basin during September - October reduced root grub population to the tune of 43%. Nematodes in combination of (1 ml $5L^{-1}$ water $palm^{-1}$) imidacloprid (17.8 SL) found synergistic and reduced root grub population to the tune of 60%. The nematodes establishment was

checked continuously by *Galleria* baiting technique, however, nematodes re-isolated in 65 - 80% soil samples collected from treated palms (Fig. 42).

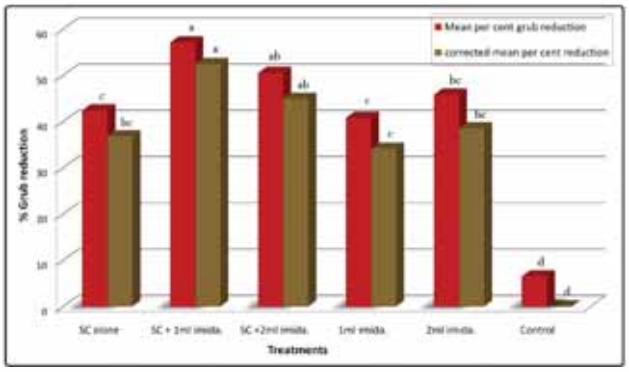


Fig. 42.Differences in mean per cent root grub reduction in EPN alone and in combination with imidacloprid.

Field evaluation of EPN augmentation against early instar root grub larvae (*L. coneophora*) in coconut

Root zone drenching of EPN liquid formulation *S. carpocapsae* (100-200ml solution) containing 0.5 x 10^6 IJs palm^{-1} during June-July and September - October resulted in 61% reduction of root grub population in coastal sandy soils of Kasaragod. The nematodes establishment was found in 75% of the palms treated with approximately 1.2 - 1.5 x 10^7 IJs. during the two year period of nematode application. The reduction of root grub population increased with increase in nematode density per palm and increase in the years of the treatment (Fig. 43 & 44).

Fig. 43. Nematodes spreading on soil surface

Fig. 44. Nematodes emerging out from root grub

Bio-suppression of neonate grubs of rhinoceros beetle

S. carpocapsae infected *G. mellonella* cadaver @ one / 500 cm^3 was found effective in the bio-management of rhinoceros grubs (neonates) in vermicompost.

Management of Root-knot nematodes in coconut/arecanut cropping system

Noni plants in coconut cropping system were severely infested by root-knot nematodes, *Meloidogyne incognita* (incidence 50-55% & gall index 3.8). Raising marigold and soil application of *Trichoderma* enriched neem cake @ 1 kg plant^{-1} subdued nematode population to 27-30%. Severe incidence of root-knot nematodes (50% incidence & gall index 3.2) was observed in betel vine-arecanut cropping system at Tarikere Taluka of Chikkmagaluru district of Karnataka.

Tea mosquito bug (*Helopeltis* spp.)

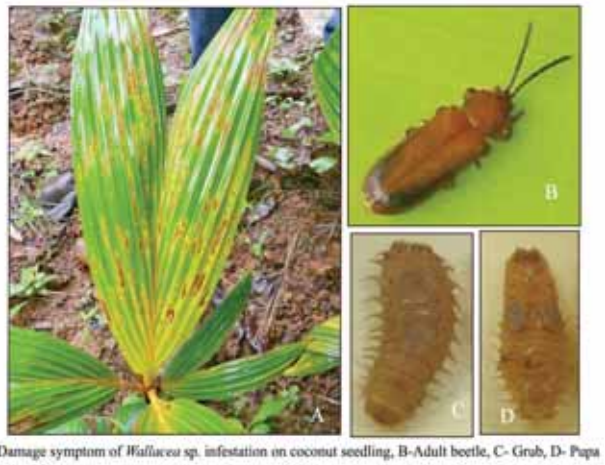
In cocoa plantation, the highest reduction in tea mosquito bug (TMB) damage (74.7%) was recorded in plots treated-with Lambda-cyhalothrin (0.003%) followed by 0.004% imidacloprid (54.4%). At least six pathogens *viz., Colletotrichum gloeosporioides, Aspergillus niger, Aspergillus flavus, Curvularia* sp., *Rhizoctonia* sp. and *Fusarium* sp. were isolated from TMB infested pods predominated mainly by *C. gloeosporioides*. Two Trinitarian cocoa clones *viz.*, TRIN 1 & TRIN 7 and three Wyanad clones *viz.,* Wayand 6, 10 & 13 evinced no infestation on pods by TMB. However, the young flushes and flowers in all genotypes were infested by the pest.

Surveillance and monitoring

Brontispa longissima was not encountered in the surveillance surveys and one more threatening invasive pest, *Aspidiotus rigidus* is reported from Philippines. Emergence of coconut scale insects, *Aspidiotus destructor* and *Vinsonia stellifera* was

noticed in Cumbum, Theni district, Tamil Nadu. The chrysomelid, *Callipsa kerum* was found in coconut nursery at negligible level. Sporadic incidences of ash weevils, *Myllocerus curvicornis* and *Myllocerus undatus* was noticed in root (wilt) diseased zones in Kerala both in the main field and nursery. *Rhynchophorus* sp. collected from North-East hilly regions infesting arecanut is likely to be a new *Rhynchophorus* species. Incidence of cycad butterfly *Chilades pandava* (Lycaenidae: Lepidoptera) on ornamental (sago) palm, *Cycad revoluta* was reported from Kasaragod.

A Chrysomelid beetle, *Wallacea* sp. was found in South and Little Andaman feeding on the tender spindle regions of coconut seedlings causing longitudinal brown lesions. Though 80-90% of seedlings were infested by the pest damaging 40% leaf area, seedling mortality was not observed. *Wallacea* sp. could not be located from adult palms, but was prevalent in abandoned, unattended and old nurseries. Basal stem rot infection was found in isolated pockets in Harminder Bay and RK Pur villages of Little Andaman. Minor incidences of slug caterpillar, bag worms, aphids and scale insects were also observed in Andaman Islands.



A-Damage symptom of *Wallacea* sp. infestation on coconut seedling, B-Adult beetle, C- Grub, D- Pupa

Fig. 44a. *Wallacea* damage on coconut seedlings in Andamans

Physiology, Biochemistry and Post Harvest Technology

Phenotyping for Climate Resilient Adaptation and Mitigation Strategies

The effect of climate change variables CO_2 [ambient (380 ppm), 550 ppm and 700 ppm] and high temperature (ambient and 3ºC above ambient) was studied in OTC grown coconut seedlings (Gangabondam Cultivar, planted on June 2013). Growth got significantly reduced under elevated temperature (ET) (Fig. 45 & 46). Under elevated CO_2 (ECO_2), Gangabondam seedlings did not show significant differences for growth and net photosynthesis while there was a marginal increase in leaf area. Under elevated temperature, leaf area reduced >50%, chlorophyll reduced >40% and significant reduction was found for net photosynthesis as compared to control. There was deposition of epicuticular wax in ET treatment.

Fig. 45. Coconut seedlings grown under elevated CO_2

Fig. 46. Coconut seedlings grown under elevated temperature

Among the biochemical constituents studied, total sugar was significantly high for ECO_2 and ET compared to other seedlings. Reducing sugar was significantly high in seedlings grown under ET. Significant reduction in antioxidant activity was found in seedlings grown under ET and E CO_2+ET. No significant difference was observed in phenolic content (Fig. 47).

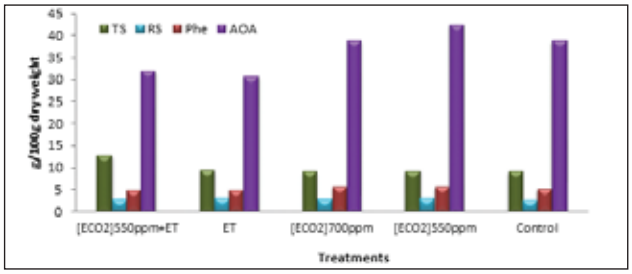


Fig. 47. Biochemical responses of coconut seedlings grown in OTC

Phenotyping for drought

Twelve coconut genotypes comprising 7 tall (FMST, TPT, AGT, WCT, CCNT, Kalpa Haritha and PHOT) and 5 dwarf (LCOD, CGD, COD, MYD and MOD) varieties known to be contrasting for their drought tolerance were grown in large pots of 100 kg soil capacity and exposed to 100%, 50% and 25% field capacity (FC). Growth, physiological and biochemical observations were recorded at regular intervals (Fig. 48 & 49).

Fig. 48. Coconut seedlings under different moisture regime

Fig. 49. Measurement of soil moisture

Physiological changes

The whole plant water use efficiency (WUE) measured showed wide variability amongst the genotypes for water use. Significant difference was observed for shoot and root biomass and root to shoot ratio (Fig. 50 & 51). At 50% FC, WUE increased by 78% and shoot and root biomass reduced by 30%, whereas, in 25% FC, WUE increased by 182% and shoot & root biomass reduced to 47% over the seedlings grown

under 100% FC. Talls showed higher WUE under well watered condition, except AGT and TPT while dwarfs showed higher WUE except MYD. Genotypes with higher WUE also showed higher accumulation of above ground biomass. The root biomass under stress varied widely across the genotypes. In case of Kalpa Haritha, which has low WUE under stress, the root biomass decreased from 350 g to 75 g while the corresponding decrease in CGD was 265g to 170 g in control and 25% FC, respectively. The net photosynthesis was the highest in FMST and PHOT and low in all dwarf varieties studied. It was reduced by 34% and 60% at 50% FC and 25% FC, respectively. Stomatal resistance (RS) significantly increased under water stress and increase was more in talls compared to dwarfs. The highest stomatal resistance was recorded in FMST, PHOT and the least was in COD. Dwarfs at 25% FC have low RS (Fig. 50 & 51).

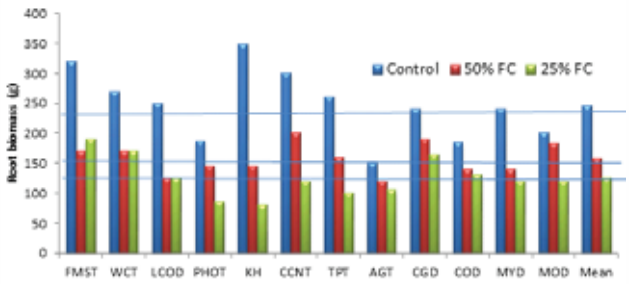


Fig. 50. Root biomass of coconut seedlings grown under different moisture regime

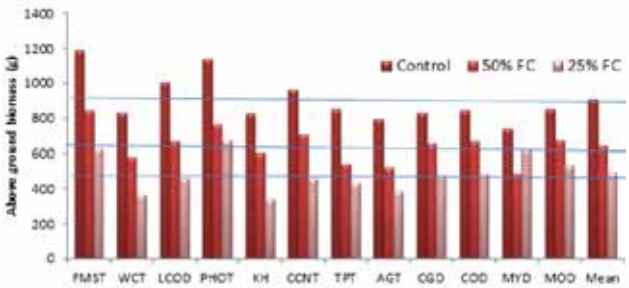


Fig. 51. Shoot biomass of coconut seedlings grown under different moisture regime

Biochemical changes

Significant differences were observed between cultivars / varieties for total sugar, phenolics content, antioxidant activity and lipid peroxidation. Among the tall cultivars, PHOT had higher total sugar followed by AGT and TPT. Talls, except WCT, had significantly higher total sugar compared to dwarfs. Among the tall cultivars, PHOT had higher phenolics. In dwarf cultivars, MYD had higher phenolics followed by CGD. WCT and COD had lesser phenolics compared to their counterparts. Among the talls, WCT had higher antioxidant capacity followed by FMST. AGT has less antioxidant capacity.

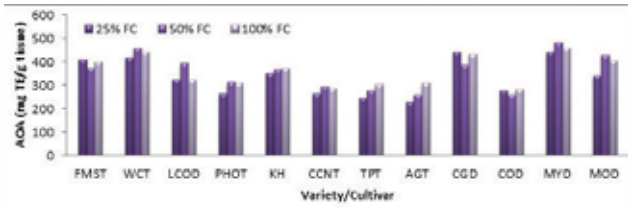


Fig. 52. Antioxidant capacity of coconut seedlings grown under different moisture regime.

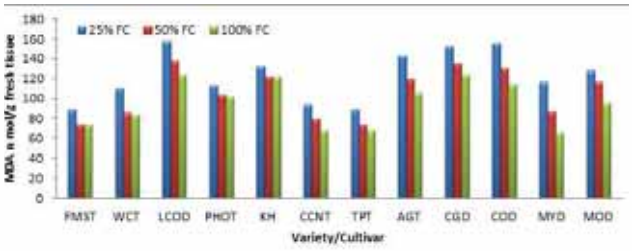


Fig. 53. Lipid peroxidation of coconut seedlings grown under different moisture regime

Dwarfs had higher antioxidant capacity than talls, it could be due to higher pigmentation in dwarfs (Fig. 52). Comparison using Duncan Multiple Range Test (DMRT) clearly indicated that among the treatments, moisture regime of 25% FC had lesser sugar, phenolics, antioxidant activity compared to higher moisture regimes. Lipid peroxidation was significantly high in dwarfs as compared to talls. Among the dwarfs, CGD had higher lipid peroxidation, whereas, MYD had the least. Among the talls, AGT had highest lipid peroxidation followed by PHOT, whereas, TPT had the lesser lipid peroxidation. Among the treatments, moisture regime of 25% FC had significantly higher lipid peroxidation followed by 50% FC and 100%.

In vitro screening of pollen for high temperature tolerance

Pollen grains in most of the crops are known to be highly sensitive to high temperature. In order to study the response of pollen grains in coconut, pollens from CGD, MGD, MYD, MOD and WCT cultivars were screened for germination studies at different temperature ranging from 10 to 50ºC on nutrient media. The pollen germination ranged from 0 to 100%. Pollen germination was studied from 1 to 7 hours and maximum was observed at 5 hours. There was a wide variability in germination percentage and the optimum temperature. WCT at 20ºC had a germination percentage of 90 and reduced to 42 at 45ºC. Across all the temperature, pollen germination

was the highest in WCT followed by MGD and was the least in MYD. It decreased significantly in the cultivars in the following order WCT>MGD≥CGD≥MOD≥MYD. Mean pollen germination was maximum (63%) at 25°C and least (16%) at 10°C. It decreased significantly at different temperatures in the following order 25≥40≥35≥20≥15≥30>45>50≥10 °C. The varieties x temperatures interactions were significant indicating that varieties showed different response in germination at different temperatures. The temperature and period of germination interaction was also significant indicating that the order of germination at different temperatures differed with the period of germination (Fig. 54-56).

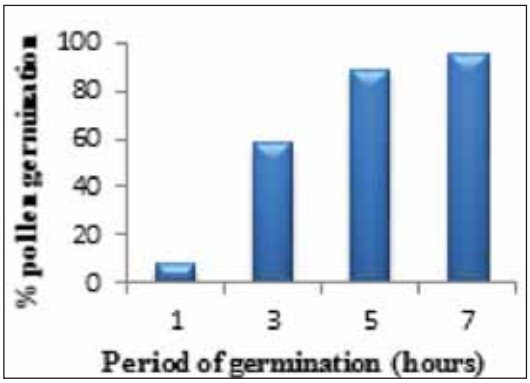


Fig. 54. Pollen germination (%) in WCT at different time interval

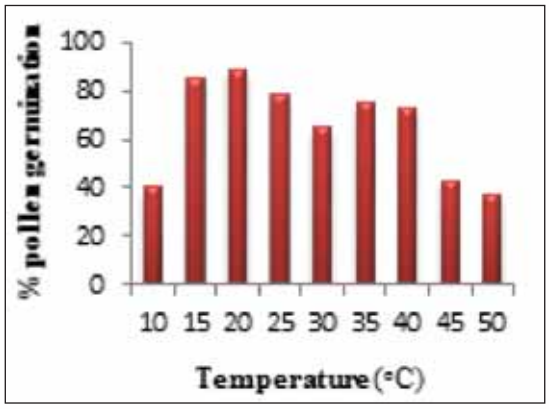


Fig 55. Pollen germination (%) at different temperature in WCT

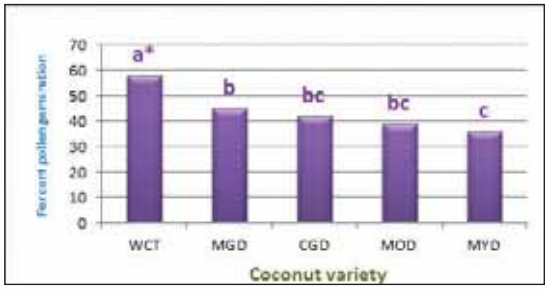


Fig 56. Pollen germination (%) of different coconut varieties

MECHANIZATION OF FARM OPERATIONS, POST HARVEST PROCESSING FOR VALUE ADDITION AND PRODUCT DIVERSIFICATION

Intervention in sap collection method

In order to collect farm fresh, hygienic and unfermented sap, a coco-sap chiller was developed at CPCRI, Kasaragod. In consultation with CPCRI scientists, a farmer, Mr. Augustine Joseph from Karkala, Karnataka developed an improved kalparasa collection box (Cocosap chiller) exclusively for coconut or palm trees. This new box is lighter, water proof, easy to connect to the spadix, requires less ice and retains low temperature for longer period (Fig. 57).

Fig. 57. Coconut sap collection using coco sap chiller

It is a novel method of collecting unfermented sap and preserving its flavor and aroma. In this method the sap from the cut end of spadix directly trickles to a container which is housed in the ice box. Ice cubes are placed around the sap collection container which maintains the internal temperature very low. Coco sap chiller is a portable device characterized by a hollow PVC pipe of which one end is expanded into a box shape to house a sap collection container bound by ice cubes and the other end is wide enough to insert and remove a collection container of 2 litres capacity. The cut end of the spadix is inserted to the pipe through a spadix holder and the sap dripping from the cut surface of spadix trickles through a funnel to the collection container. The collection container is bound by ice cubicles. Each side walls of the pipe from outside are covered with an insulating jacket excluding the portion of spadix holder. The sap, thus, collected is farm fresh, hygienic, chemical free and zero alcoholic. It can be stored as fresh liquid for any length of time under frozen condition.

Coconuts Sap (kalparasa) yield

Coconut sap yield ranges from 2 to 4 litres spadix^{-1} day^{-1}. It depends on the palm type, health of the palm and tapper's skill. Single spadix lasts for 30 to 45 days and can produce 90 to 120 litres of sap. A coconut tree produces 12 to 14 spadices year^{-1}, and even if 6 spadices are tapped it could produce approximately 500 to 700 litres of sap. The sap contains 15 to 16% sugar and through heat evaporation, good quality coconut sugar can be produced without the addition of chemicals. Sugar recovery is approximately 15%.

Sap quality

Distinct difference is seen between the neera collected by traditional and CPCRI technique (Table 5). Some of the perceptible and easily quantifiable differences are fresh neera is neutral to slightly alkaline in pH (7 to 7.5) and golden yellow in colour. It is sweet and delicious, free from contaminants like clay, dust, pollen, ants, insects, etc.

Kalparasa technology adaptation

The technology has been transferred to 12 firms, three each from Karnataka and Tamil Nadu and six from Kerala. The farm fresh, hygienic, unfermented Kalparasa is being sold as health drink under refrigerated condition in kiosks near National Highways, bus stands and railway stations. In Palakkad Coconut Producer Company Ltd., Kerala (PCPCL), Tejeswani Coconut producer Company a few more companies by adopting CPCRI technology for tapping and selling in road side kiosks clearly demonstrated that Kalparasa (Neera) as a natural non-alcoholic beverage, high in nutritional value and is an instant thirst quencher. This ensures that the person taking kalparasa will feel rejuvenated within minutes, thus making it a perfect health drink. It is demonstrated that a farmer tapping 15 coconut palms for Kalparasa could earn on an average ₹45,000 a month while a tapper can earn about ₹ 20,000 per month in addition to promotion of agri-preneurship. It is estimated that even if 10 per cent of the 2 million ha coconut trees in the country are tapped, with conservative yield of a litre a day, ₹ 36,000 crore can be generated annually of which 25 to 30 per cent will be the farmers' share. It is expected to improve the livelihood of coconut farmers, generate employment opportunity to youth and provide nutritional security.

Preservation of kalparasa by spray drying

Farm fresh coconut inflorescence sap collected using cocosap chiller technology developed at CPCRI is rich in nutrients and highly amenable to microbial fermentation. An attempt was made to preserve the kalparasa by spray drying technique. A laboratory model spray dryer (Spraymate model, JISL, Mumbai, India) was used in the experiments. Kalparasa was spray dried with additives like maltodextrin and gum acacia at different proportions in order to make free flowing powder. 7.5% maltodextrin was found effective for making spray dried powder.

Packaging and preservation technology for kalparasa

Plastic bottles were tested for storage of pasteurized coconut sap with 0.1% Nisin and stored at ambient and refrigerated condition. Biochemical, sensory and microbial analysis showed good keeping quality till 15 days. Sensory evaluation of 45 days stored sap was found with overall acceptability score of 6.3.

Table 5. Difference between Kalparasa collection by CPCRI technique and traditional method

Parameter	CPCRI Technique	Traditional method
Soluble solids (ºBrix)	15.5 to 18	13 to 14
pH	7 to 8	6 or low
Colour	Light orange & honey color	Oyster white
Defects, decay, insects, Pollen, dust	Absent	Present
Flavour	Sweet and delicious	Harsh odour
Pathogens, chemicals and extraneous matter	Absent	Present
Microbial load	Low	High

Effect of process parameters on recovery of hot process virgin coconut oil

Virgin coconut oil (VCO) is growing in popularity as functional food, cosmetic and pharmaceutical oil. The high production cost of VCO is due to its low recovery. In order to improve the recovery, the effect of milk expelling methods (manual and mechanical) and pre-treatments (slicing, pulverizing and blanching) on milk and hot process VCO recovery with respect to fresh coconut kernel weight was studied. The blanching and pulverizing processes yielded more milk and VCO recovery in both manual and mechanical expelling methods. The recovery of coconut milk and VCO ranged from 34.04 - 51.57 per cent and 14.18 - 22.37 per cent, respectively. Among the different treatment combinations, pulverized, blanched and double screw pressed coconut kernel yielded the highest milk and VCO recovery. The per cent recovery of two important co-products namely coconut milk residue and VCO cake was ranged from 38.48 – 55.60 and 6.26 – 8.76, respectively. An attempt was made to recover the oil from 8 per cent dried coconut milk residue and VCO cake in commercial oil expeller. The oil recovery from milk residue and VCO cake flour was 41.24±1.08 per cent and 25.72±0.96 per cent, respectively (Fig. 58-59).

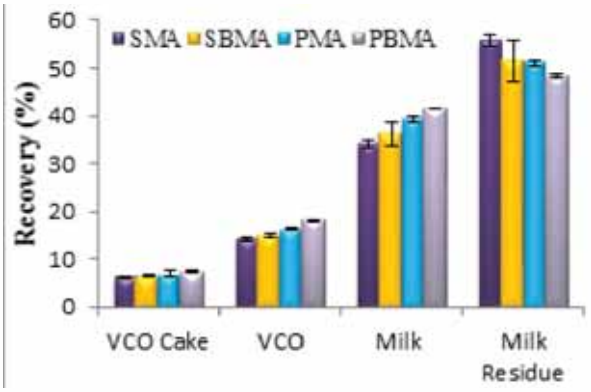


Fig. 58. Effect of pre-treatments on per cent recovery under manual extraction

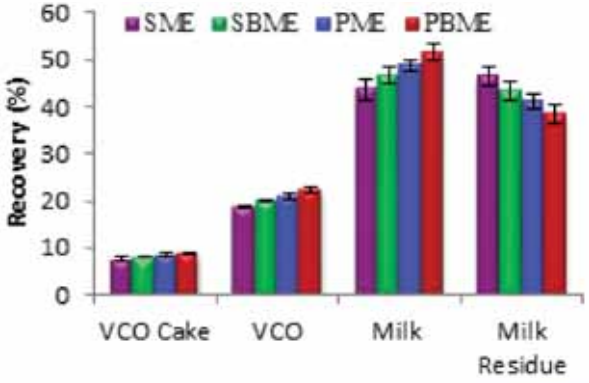


Fig. 59. Effect of pre-treatments on per cent recovery under mechanical extraction

Biochemical composition of coconut milk residue and VCO cake

During VCO production, coconut milk residue and VCO cake are the two important co-products. Presently, these are used mainly in animal feed production. As a source of dietary fibers and other nutrients, these co-products provide a number of health benefits. Biochemical constituents like sugar, available carbohydrate, phenolics and antioxidant activity was determined and found that VCO cake was rich in proteins, phenolics and antioxidants where as milk residue was rich in carbohydrates and dietary fibres (Fig. 60).

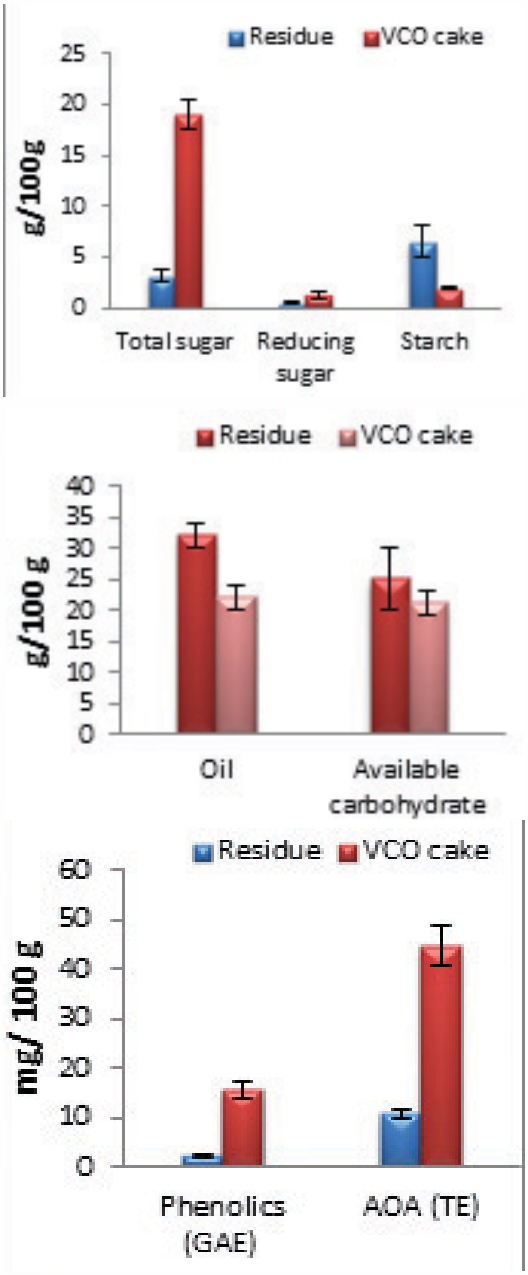


Fig. 60. Biochemical constituents in coconut milk residue and VCO cake

Development of pilot level process and technology for the production of health foods from coconut milk residue and VCO cake

Coconut milk residue and VCO cake are rich in nutrients. An attempt was made to produce value added products namely extrudates and sweet snacks. The coconut milk residue flour and VCO cake flour were incorporated with broken rice, maize and pearl millet at different proportions (0:100, 20:80 and 40:60) in the production of extrudates using co-rotating twin screw extruder (Fig. 61). The expansion index, crispiness work and sensory evaluation of the developed extrudates were determined using standard methods. The value of expansion index, crispiness and overall acceptability decreased with increase in the level of coconut milk residue and VCO cake flours. There were no significant differences in quality attributes were observed by the extrudates having 20 per cent incorporation of coconut milk residue flour, whereas, significant differences in expansion index and crispiness were observed for VCO cake flour based extrudates. Thus, broken rice, maize and pearl millet based extrudates can be made by incorporating 20 per cent coconut milk residue and VCO cake flour without significant changes in quality attributes.

Fig. 61. Extrudates from coconut milk residue and VCO cake

Extraction of phenolics and antioxidants from coconut testa using different solvents

Testa is the brown part covering coconut kernel, obtained from coconut processing industries as a by-product through paring of wet coconut during the preparation of products like desiccated coconut, coconut milk and virgin coconut oil. Testa is presently used as animal feed. Study was conducted to extract maximum phenolics and antioxidant compounds from coconut testa using different solvent system like water, ethanol and acetone with and without acidification. Among the different solvent systems with decreasing polarity from water to acetone, 80% acetone was found more efficient to extract phenolics and antioxidant compounds from the testa sample followed by 80% ethanol. Acidification of above solvents with HCl (0.3M) has led significant increase in extraction of the total phenol content as compared to their counterparts without acidification (Fig. 62). This clearly indicated that the testa contained more of bound phenolics complexes with other chemical compounds (for example phenolic glycosides), which otherwise was not extracted using solvents without acidification. This study also showed that the testa, a by-product of coconut processing industries, to be considered as a potential source of antioxidant, can replace the synthetic antioxidant in food formulations.

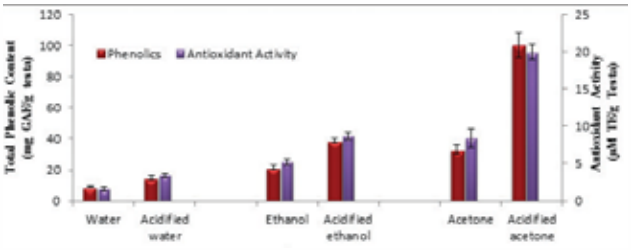


Fig. 62. Effect of solvents on extraction of phenolics and antioxidant activity

Developing machineries and gadgets for gender mainstreaming in palms and cocoa

Coconut shell removing machine

Removing shell from coconut is the second unit operation, after the removal of husk, in all the coconut processing industries. Traditionally shell is removed manually using either a chisel or a knife. By using a chisel, an experienced person can remove the shell without much breakage of the coconut kernel. When knife is used, the coconut after de husking is split into two halves and the kernel is scooped out. Often the kernel breaks into many pieces. Both these traditional methods are cumbersome and time consuming. Moreover, for high end products like virgin coconut oil, coconut chips, desiccated coconut etc. the testa needs to be removed from coconut kernel before further processing. Testa removing will be easier and faster when the shell is removed without breaking the kernel.

A coconut shell removing machine has been designed and fabricated to reduce both time and drudgery involved in the manual de-shelling process. It also

gives coconut kernel in single piece so that testa removing would be easy. Prime mover of the machine is an electrical motor. Two concentrically rotating multi pointed circular blades and a stationary pointed blade are the major components of the coconut shell removing machine. Power is transmitted to the rotating blades through a gear and chain to achieve the required speed reduction. Coconut after removing husk is pressed towards the rotating blades by firmly placing it on the stationary blade. Shell gets detached from the kernel due to the pressure exerted and the impact force of the rotating blade. The machine is quite gender friendly, even a lady can operate the machine with minimum experience. The machine has a capacity to remove the shell of 120 coconuts per hour. An experienced person could achieve a capacity of 150 coconuts per hour (Fig. 63).

Fig. 63. Coconut shell removing machine

Studies on Development and Management of Water Conservation Measures to Augment Water Availability of *Surangams*

Surangam is a unique indigenous method of harnessing ground water by many farmers in Kasaragod district in Kerala state and Dhaksina Kannada district in Karnataka state. It is a horizontal tunnel dug into a hillock to intercept the unconfined aquifer. However, during the last two to three decades many of them got dried up and the yield reduced considerably for the remaining ones. The main objectives of the project was to develop in-situ water conservation measures to enhance the ground water resource and thereby *surangam* yield and to evolve management strategies for the effective utilization of the limited but continuous supply of *surangam* water. Accordingly water conservations measures like half moon bund, catch pit and trench were taken up in the coconut gardens of the catchment of *surangams* to augment the ground water availability (Fig. 64).

Fig. 64 Surangam - traditional method of water harvesting

Effect of these water conservation measures was studied by monitoring the discharge rate of *surangams* before and after intervention.

The three water conservation measures implemented in the catchments of *surangams* could augment the ground water resources and thereby enhance the water availability of the treated *surangams*. Enhanced yearly water availability of *surangams* varied from 40.17% to 61.90% with an average value of 53.02%. The same for the irrigation season, December to May, varied from 51.41% to 282% with an average value of 138.31%.

Management strategies evolved in the study could reduce the transportation loss. The enhanced water availability because of the reduced transportation loss during the irrigation season was 234.5 m^3. Percolation/ seepage loss from storage tanks was reduced to very minimum by lining the tank with silpaulin and ferrocement. The enhanced water availability during the irrigation season was 786.24m^3

and 318.82m^3 respectively at the two sites where the intervention, storage tank, was made. The silpaulin proved to be a cost effective and durable, UV resistant, plastic sheet ideal for storage tanks (Fig. 65). The ferrocement storage tank developed would be as good as a permanent concrete structure with half the initial cost and negligible maintenance cost. This would be an ideal solution for a storage tank where there is a potential threat of mechanical damage to the other cheaper lining materials from burrowing animals and other wild / domestic animals. Together, the water conservation measures developed and the management strategies evolved, could enhance water availability of the existing surangams.

Fig. 65. Water conservation structures using plastic sheet

The water conservation measures taken up in the catchment of surangams not only enhanced the surangam yield but also could augment the soil moisture availability in the catchment. The better soil moisture availability translated to a yield increase from 55nuts palm^{-1} year^{-1} to 89nuts palm^{-1} year^{-1}, an increase of 60.79%. This indicates that there exists a vast scope of enhancing the productivity of coconut in rain fed area. The fact that coconut cultivation in the region is mostly under rain fed condition adds to the significance of the result.

The findings would be a great relief to the farmers who still depends on *surangam* water for domestic as well as irrigation but had to establish plantations in the catchment out of economic compulsions. The water conservation measures and the low cost storage structures, if adopted in a large scale, would be an ideal solution to enhance the water availability of *surangams* and to mitigate the effects of climate change in future.

TECHNOLOGY TRANSFER AND SOCIAL SCIENCES

Krishimela

Krishi Mela was conducted at CPCRI Regional Station, Vittal on 10th January 2015. Sri D.V. Sadananda Gowda, Hon'ble Union Minister for Law and Justice inaugurated the Krishi Mela (Fig. 66). About 2500 farmers and other stakeholders participated in the mela. Scientist-extension personnel-farmer interface progarmme on coconut, arecanut and cocoa farming, exhibitions, visit to experimental plots and quiz programme for farmers were organised as part of the Krishi Mela.

Fig. 66. Shri D.V. Sadananda Gowda, Hon'ble Minister for Law and Justice, Government of India inaugurating the Krishi Mela

Training programme on neera production technology

A programme on neera production technology for coconut climbers was conducted in collaboration with the Kerala State Coconut Development Corporation at Koorachundu in Kozhikode district during 20th to 30th September 2014, in which 20 coconut climbers from Palakkad, Malappuram, Kozhikode and Kannur districts participated. The training programme was inaugurated by Sri K.P. Mohanan, Hon'ble Minsiter for Agriculture, Govt. of Kerala (Fig. 67).

Fig. 67. Shri K.P.Mohanan, Hon'ble Minsiter for Agriculture, Kerala inaugurating the training programme

Awareness – cum - training programme on 'Protection of Plant Varieties and Farmers Right Act'

Awareness – cum - training programme on 'Protection of Plant Varieties and Farmers Right Act' was organised on 27th March 2015 at Choyangod in Kinanur-Karindalam grama panchayat by CPCRI Kasaragod. Shri. P. Karunakaran, Hon'ble Member of Lok Sabha, Kasaragod inaugurated the programme (Fig. 68). About 250 farmers attended the awareness-cum-training programme.

Fig. 68. Shri P. Karunakaran Hon'ble MP, inagurating awareness-cum-training programme on PPV&FRA

National training programme on 'Cocoa production and processing technologies'

The training was organized during 20th to 22nd November 2014 at CPCRI Regional Station, Vittal, in association with the Directorate of Cashew and Cocoa Development (DCCD), Kochi. Twenty four trainees (Developmental Officers) from Karnataka, Kerala and Tamil Nadu participated in the training (Fig. 69). Dr. Venkatesh N. Huballi, Director, DCCD, Kochi inaugurated the training. Practical training on soft wood grafting and pruning in cocoa and preparation

Fig. 69. Training on cocoa prodution and processing technology at Vittal

Fig. 70. Training on advanced cocoa prodution technology at Vittal

of Bordeaux mixture were also imparted. Exposure visits were arranged to CAMPCO and Cadbury processing units at Puttur, CAMPCO chocolate factory, Puttur and Farmers' gardens at Puttur.

Training programme on advanced cocoa production technologies

The training programme, sponsored by the Directorate of Cashew and Cocoa Development (DCCD), Kochi, was organized during 19th to 21st March 2015 at CPCRI Regional Station, Vittal. Fifty two trainees from Dakshina Kannada and Shivamogga districts of Karnataka participated in the training. Mr. Ravindra Rao, officer from M/s Mondelez International and Mr. Sunil Kumar, Manager, CAMPCO, Vittal offered felicitations. Scientists from CPCRI, RS, Vittal and Kasaragod took classes on crop improvement, nursery techniques, crop production, management of nutrient deficiencies, crop protection, safe use of pesticides, marketing and extension strategies (Fig. 70). Exposure visits were also arranged to various farmers' gardens at Puttur and Mangalore.

Training programmes

Kasaragod

Various institutional and off campus training programmes on production and processing technologies of coconut, arecanut and cocoa were conducted during the year for farmers, extension personnel and other stakeholders as part of the technology transfer initiatives of the institute. A total of 52 institutional and 15 off campus training programmes for the farmers and 15 training programmes for the extension personnel were organized.

Training programme on coconut based integrated farming was organized at CPCRI, Kasaragod in collaboration with ATMA Malappuram on 20th May 2014, in which 25 farmers and six extension personnel from Malappuram district attended.

A training programme on coconut production technology was organized on 20th December 2014 at CPCRI, Kasaragod for 50 farmers of Coconut Producers' Federation, Kunnamangalam, Kozhikode district (Fig. 71).

A training programme of one month duration during May 2014 on soil and water conservation techniques for west coast region was organized at CPCRI, Kasaragod for a team of final year B. Tech (Agrl. Engineering) students from Kelappaji College

Fig. 71. Training on coconut production technology

Fig. 72. Field visit of B. Tech. (Agri. Engg.) students from KAU

of Agricultural Engineering and Technology, Tavanur (Fig. 72). The training programme covered thematic areas related to the watershed delineation tools, agronomic and engineering methods of soil and water conservation, preparation of estimates for *in situ* water conservation measures, low cost water harvesting structures, and assessing impact of soil and water conservation measures in farmers' field.

Off campus training programme for farmers on coconut production technology was organized at Chemenchery in collaboration with Panthalayani Coconut Producers' Federaton on 9th December 2014, and at Mokeri in collaboration with ATMA-Kozhikode and Krishibhavan, Kunnummal on the same day.

Kayamkulam

On and off campus training programmes on crop health management technologies of root (wilt) disease affected coconut were conducted for farmers, extension personnel and other stakeholders as part of the technology transfer initiatives of the institute. A total of 15 training programmes on scientific plant protection of coconut, coconut climbing skill upgradation, and participatory group approaches for plant health management were conducted during the period in which 1036 participants attended. Nine trainings on Pest and Disease management in coconut and Rural marketing strategies and diversification of agricultural products were organized for extension personnel.

Training programme for nine batches of coconut climbers were conducted regarding skill up gradation on dwarf mother palm selection, seed nut selection, nursery management techniques as well as plant health management in coconut. Scientists of Plant Breeding section handled the sessions. The participants

Fig. 73. Training on hybridization techniques and plant health management to officials from Dept. of Agriculture and farmers

were equipped to meet the growing demand of root (wilt) tolerant seedlings in the programme being implemented by the Department of Agriculture, Kerala.

Training programme for selection of dwarf mother palms for seed nut collection, plant protection measures and hybridization techniques in coconut were conducted for 265 officials of Department of Agriculture to enable decentralized planting material production (Fig. 73).

Exposure visit to the institute

A total of 2,265 stakeholders of different categories such as farmers (459), extension personnel (70), students (1612) and others (124) visited the Regional Station, Kayamkulam during 2014-15 (Fig. 74 & Table 6).

Fig. 74. Special programme for attracting gifted students to Agriculture

Table 6. Overview of training progammes

Category	No of batches	Total
Farmers	17	459
Extension personnel	5	70
Students	31	1612
Others		124
	Grand total	**2265**

Vittal

A demonstration on arecanut palm climbing devices was organized at CPCRI, RS, Vittal on 10th April 2014 in collaboration with CAMPCO and ARDF, Mangalore, wherein four hundred farmers participated (Fig. 75). Climbing devices of arecanut and coconut were demonstrated by CAMPCO Mangalore, KTech Shimoga, VTech Coimbatore, and SRK Ladders Puttur. Officers from CAMPCO, interacted with farmers. Mr. N. M. Adyanthaya, Former MLA, Mr. Manchi Srinivas Achar, President, All India Arecanut Growers Association and Mr. Shankar Bhat, Trustee, ARDF were the guests of honour. Dr. K. S. Ananda, Head and scientists from CPCRI, RS, Vittal had interacted with the farmers.

Training on 'Integrated diseases and pests management in palms and cocoa' was organized on 27th May 2014 at CPCRI, RS, Vittal for 81 officials and farmers of Karnataka. Dr. George V. Thomas, former Director, CPCRI, Kasaragod inaugurated the programme. Dr. K. S. Ananda, Head and scientists of the station interacted with the farmers. Lecture-cum discussion on different topics were organized.

Fig. 75. Demonstration of arecanut palm climbing device at Vittal

Training on 'Integrated diseases and pests management in palms and cocoa' was organized on 3rd June 2014 at CPCRI, RC, Kidu for 129 officials and farmers of Karnataka. Dr. K. Muralidharan, Acting Head, Social Sciences, CPCRI, Kasaragod inaugurated the programme.

Rural Horticultural Work Experience (RHWE) Programme for 13 B.Sc. (Horti.) students of College of Horticulture, Mudigere, Chickmagalaur was organized during 9th to 28th June 2014 at CPCRI, RS, Vittal. The technologies on improvement, production and protection and post harvest processing of coconut, arecanut and cocoa were introduced to the students.

A training was organized on 18th July 2014 at Vittal for 25 officials of Excise department, Dakshina Kannada district. Lecture cum discussion on crop improvement, production, protection and processing technologies of arecanut and cocoa were covered in the training programme (Fig. 76).

Fig. 76. Dr. K. Muralidharan, Head, inaugurating training programme on integrated disease and pest management in palms and cocoa

Training programmes-cum exposure visits

Thirty eight training programmes-cum exposure visits on 'Arecanut and cocoa production technology' were organized at Vittal for the benefit of 1810 stakeholders. Lecture-cum discussion on crop improvement, production, protection and processing technologies of arecanut and cocoa were covered.

Frontline Demonstrations

Frontline Demonstration (FLD) on integrated management of Ganoderma wilt of coconut was conducted at Periya village in Kasaragod district (Fig. 77). The disease affetced palms were applied with *Trichoderma* enriched neemcake @5kg/palm in bi-monthly intervals. The disease index of affected palms was reduced to 15.2 compared to the pre-treatment disease index of 46. A field day was conducted on 12th

Fig. 77. FLD on integrated management of Ganoderma wilt at Kasaragod

January 2015 at Pukkalam in which 30 farmers and extension personnel participated.

Farmer participatory FLDs are being organized in 1.5 ha in four panchayaths on coastal sandy loam management and integrated root (wilt) disease management packages by Regional Station, Kayamkulam. FLDs on integrated management of root grubs in arecanut was conducted at CPCRI, RS Vittal. Demonstration on arecanut based cropping system was conducted at CPCRI RC Mohitnagar, West Bengal.

Stakeholder interface programmes

Interface programmes involving scientists, extension personnel, farmers, entrepreneurs and other stakeholders were organised during the year at various locations in the country on seleted themes related to the mandate crops as per the following details.

Research–Extension–Farmer interface programme on integrated management of diseases in coconut and arecanut

Interface programme on integrated management of diseases in coconut and arecanut with emphasis on bud rot disease of coconut and Mahali disease of arecanut was organized by CPCRI at Kasaragod and Kozhikode. The interface programme at Kasaragod was conducted on 24th May 2014 which was inaugurated by Mr Thirumaleswara Bhat, Principal Agricultural Officer and was attended by 100 farmers and extension personnel. The interface programme at Kozhikode was conducted on 26th May 2014 which was inaugurated by Dr. M.Anandaraj, Director, Indian Institute of Spices Research (IISR) and 150 farmers and extension personnel participated in the programme (Fig. 78).

Fig. 78. Dr M. Anandaraj, Director ICAR-IISR inaugurating the interface programme

Scientist-Farmer interface programme on soil and water conservation techniques

Scientist-Farmer interface programme on soil and water conservation techniques in coconut gardens was conducted as part of ICAR foundation day celebration on 16th July 2014 in which 40 selected farmers from Kasaragod district participated.

Stakeholders' interface programmes on coconut and cocoa farming

Stakeholders' interface programmes on coconut and cocoa farming were organized by CPCRI in Andhra Pradesh as part of the technology transfer activities. The first stakeholder meeting was conducted at Mukkamala near HRS Ambajipet on 3rd March 2015. About 200 stakeholders including farmers, entrepreneurs, extension personnel from the State Department of Horticulture, scientists from CPCRI and HRS Ambajipet attended. Dr P. Chowdappa, Director, CPCRI inaugurated the meeting (Fig. 79) and Dr. B.M.C. Reddy, Vice Chancellor, Dr YSR Horticultural University presided over the inaugural function. On 4th March 2015, the stakeholder interface meeting was conducted at IIOPR, Pedavegi. Dr. S. Arulraj, Director, IIOPR inaugurated the meeting. Dr. P. Chowdappa guided the discussions. Dr. Venkatesh Hubballi, Director, DCCD, Kochi delivered a lecture on cocoa developmental activities. About 200 farmers and other stakeholders attended the programme.

Fig. 79. Dr. P. Chowdappa, Director, CPCRI inaugurating the interface programme on cocoa at Mukkamala, Andhra Pradesh

Research-Media interface programme

Research-Media interface programme on 'Technological advances and future thrust of CPCRI' was conducted in collaboration with Kasaragod Press Club on 8th October 2014 at CPCRI, Kasaragod.

Interface progarmme on 'Enhancing productivity and value addition in arecanut'

The programme was organized on 29th October 2014 at CPCRI, RS Vittal, Karnataka. About 200 stakeholders representing farmers, scientists from CPCRI, UAHS, Shimoga and KVKs, Officials from Department of Horticulture, CAMPCO, ARDF, Dharmasthala Grama Abivridhi Yojana, Cadbury India Pvt. Ltd., and Media personnel participated to formulate strategies for enhancing the productivity and value addition in arecanut. Dr. P. Chowdappa, Director, CPCRI, Kasaragod in his presidential speech, highlighted the importance of fruit rot management, Yellow leaf disease management and mechanization in arecanut for enhancing the productivity. Shri. Konkodi Padmanabha, President, CAMPCO, Mangalore inaugurated the Stakeholders meeting (Fig. 80). Dr. Homey Cheriyan, Director, DASD, Calicut was the Chief Guest and he advised farmers to adopt multispecies cropping system to increase productivity and profitability from unit area. Dr. H. P. Maheswarappa, Project Coordinator (Palms), CPCRI, Kasaragod had urged the Department of Horticulture and KVKs to have strong linkage with CPCRI and other research institutes for serving the farmers with better technologies. Mr. Manchi Srinivasa Achar, President, All India Arecanut Growers Association, Puttur stressed the need for more field oriented programmes in different places to reach many clients. Dr. D. C. Chowta, Progressive farmer, Miyapadavu, Kasaragod highlighted the importance of cropping system approach to increase the productivity and profitability from unit area.

Fig. 80. Shri Konkody Padmanabha inaugurating the interface programme on arecanut at ICAR-CPCRI RS Vittal

Diagnostic field visits

As part of the technology transfer activities of the institute, diagnostic field visits were made by scientists to various localities and diagnosed field problems for which remedial measures were suggested. Details are given in the table 7 below.

Table 7. Details of diagnostic field visits

Station	No. of farmers' gardens visited
CPCRI, Kasaragod	98
CPCRI RS Kayangulam	74
CPCRI RS Vittal	65
CPCRI RC Kahikuchi	14
CPCRI RC Mohitnagar	06

As part of the interface programme at Mukkamala and Pedavegi in Andhra Pradesh, a team of scientists from CPCRI visited farmers' cocoa and coconut gardens during 1st and 2nd March 2015 and the team diagnosed field problems including pest and disease incidence and nutritional disorders for which remedial measures were suggested (Fig. 81).

A team of scientists including Dr. C. Thamban, Dr. V.H.Prathibha and Mrs. P.S. Prathibha visited coconut gardens in different locations in Kunnummal block in Kozhikode district on 23rd October 2014, diagnosed

Fig. 81. Scientist team at cocoa garden - Mukkumala, AP

various field problems and suggested technological interventions to solve them.

Participation in Exhibitions

CPCRI had participated in 17 exhibitions during the year as part of the technology transfer initiatives (Table 8, Figs. 83-85).

Publication of extension literature

Extension folders (8 nos.) on IPM/IDM (in Malayalam and Kannada), extension folder on scientific management of coconut seedlings, field guide for coconut farmers and training manual on research

Fig. 82. Field visit of scientists to Kunnummal, Kozhikode

Table 8. Details of participation in exhibition by ICAR-CPCRI

Sl. No	Exhibition	Date
1	Thrissur Pooram Exhibition, Thrissur	05- 23 April 2014
2	'Agri-Intex 2014' organized at CODISSIA Trade Fair Complex, Coimbatore	18-21 July 2014
3	"Young Enterpreneurs Summit 2014" organized at adlux international convention and exhibition centre, Kochi	12 Sep 2014
4	"Swasraya Bharath 2014" held at College of Agriculture, Padannakad	14-19 Oct 2014
5	"Karshika Mela 2015" held at Newman College Ground, Thodupuzha	26 Dec to 4 Jan 2015
6	International Symposium on Plantation Crops (PLACROSYM XXI) held at Kozhikode	10-12 Dec 2014
7	"Keral Kaumudi Expo 2014" held at Kanakakunnu, Trivandrum	12-25 Dec 2014
8	"Regional Agri Fair 2015" organized by Tamilnadu Agricultural University, Coimbatore	06-09 Jan 2015
9	'Krishi Mela" organized by CPCRI (RS), Vittal	09-10 Jan 2015
10	'Krishi Yantra Mela III - 2015" organized by CAMPCO, Puttur	24-26 Jan 2015
11	'Perumkaliyata Mahotsavam' held at Cheruvathur	1-10 Feb 2015
12	'Polika' Karshika Mela held at Chokli panchayath	13-19 Feb 2015
13	National Farmers Meet held at TNAU, RRS, Paiyur	14 March 2015
14	CONSUMER EXPO organized by Kerala Kaumudi at Gokulam Ground, Kayamkulam	03-15 Sep 2014
15	Karshakasree Farm Fair – 2014 at Thiruvananthapuram	24-28 Sep 2014
16	Exhibition organized by Kerala Kaumudi at Kanakakkunnu, Thiruvananthapuram	14-28 Dec 2014
17	Agri- Horti Industrial Exhibition 2014 at SDV Scool Ground, Alappuzha	20-28 Dec 2014

Fig. 83. Shri D.V. Sadananda Gowda Hon'ble Minister for Law and Justice, GOI visiting Krishi Mela exhibition at ICAR-CPCRI, RS Vittal

Fig. 84. Shri P. Karunakaran MP, visiting ICAR-CPCRI exhibition stall at Swasraya Bharath 2014 - College of Agriculture, Padannakad

Fig. 85. Karshakasree Farm Fair – 2014 at Thiruvananthapuram

methodologies, arecanut calendar (Kannada), extension folder on varieties of arecanut (Kannada) and Farmer Participatory techniques in Agriculture (Malayalam) were brought out during the year.

Agricultural Technology Information Centre (ATIC), Kasaragod

One day exposure visits for farmers, extension personnel and students

Various one day exposure visit programmes were organized for farmers, entrepreneurs, extension personnel and students to provide exposure to the

Fig. 86. Exposure visit of coconut farmers from Kunnamangalam to CPCRI, Kasaragod

Institute activities and research achievements. A total of 2040 farmers, 179 extension personnel and 1411 students were benefited by these programmes (Fig. 86).

Farm advisory service

Queries from farmers and other stakeholders on different aspects of production, protection and processing of palms and cocoa were replied through ATIC as per the details furnished below. During the year, a total of 12,055 queries were replied (Table 9).

Farmers' participatory research cum demonstration plots on arecanut based cropping system

Farmers were supplied with rooted cuttings of Panniyur varieties of black pepper for planting in demonstration plots on arecanut based multispecies cropping system. Proper monitoring of demonstration plots and technical guidance were provided to the beneficiaries. Farmers were supplied with critical inputs *viz.*, neem cake, rock phosphate, copper sulphate, lime, bio-fertilizers and bio-control agents for maintaining the demonstration plots. Interactive seminar on 'Arecanut based cropping system for enhancing profitability' was organized on 10th January 2015 for the benefit of 2500 stakeholders. Participatory tools were employed for collecting data on growth and yield from ten demonstration plots.

Assessment and characterization of coconut based cropping/farming systems adopted by farmers in major coconut growing tracts

During the year, primary data were collected on various aspects of adoption of coconut based cropping/farming systems from 63 farmers in different agro-ecological zones in Ernakulam (23) and Alappuzha (30) districts of Kerala state and Kamrup district (10) of Assam. Coconut + Nutmeg + Arecanut + Banana + Pepper

Table. 9. Details of services extended through ATIC to stakeholders

Sl. No	Topic	No. of queries replied			
		Telephone	E-mail	Postal	Total
1	Availability of planting materials	3026	463	4034	7523
2	Hybrids and improved varieties	1375	230	520	2125
3	Integrated nutrient management	80	23	5	108
4	Organic farming technologies	80	3	0	83
5	Irrigation and water management	14	6	8	28
6	Integrated pest management	521	18	3	542
7	Integrated disease management	621	4	3	628
8	Plant protection equipments	0	0	0	0
9	Post harvest technologies	487	7	4	498
10	Availability of printed farm literature	42	41	46	129
11	Availability of CD – ROMs	23	9	0	32
12	Training and other TOT programme	145	10	48	203
13	Consultancy programme	0	0	12	12
14	Crop statistics	0	0	0	0
15	Other items	112	3	17	132
	Total	6538	817	4700	**12055**

was the major coconut based cropping system adopted by farmers in Ernakulam district. Banana, vegetables, tuber crops and ginger were the important component crops in the coconut based cropping systems adopted by farmers in Alappuzha district. Animal husbandry was integrated in 46% of the holdings having coconut based farming systems in Alappuzha district. In Assam, coconut is mostly confined to the homestead farming system and arecanut, pepper and betelvine are the important component crops in the coconut based cropping systems. Four case studies were also conducted on the coconut based cropping/ farming systems adopted by farmers.

Farmers' experiences in using unregistered chemicals for the management of fruit rot disease in arecanut

During the year, data were collected from 47 arecanut farmers spread over five grama panchayats in Kasaragod district. Fourty three percentage of the farmers were having less than one acre of arecanut holdings. Seventy four per cent of the farmers used 1% Bordeaux mixture and unregistered chemicals on a sequential basis for the control of fruit rot disease. According to farmers, the most important advantage of using unregistered chemicals was that the effect of spraying of unregistered chemicals lasts for 60-70 days compared to 30 days in the case of Bordeaux mixture, and hence number of spraying reduced and need to pay climbers only twice per season. According to farmers, there was a reduction of Rs. 1300 per ha in expenditure for spraying of unregistered chemical once followed by one spraying of 1% Bordeaux mixture compared to three time spraying of 1% Bordeaux mixture as followed previously.

Area wide community approach for integrated management of red palm weevil of coconut

Red palm weevil is a destructive pest of coconut and reported as a major field problem. Area wide community extension approach for the management of the pest is being plot tested in 2100 ha of Bharanikkavu and Kandalloor grama panchayaths of Alappuzha district since 2014. The major activities

conducted are knowledge profiling of coconut farmers in red palm weevil management, on and off campus trainings, awareness campaigns, GPS plotting of red palm weevil infested palms, formation of social groups for sustainability, management campaigns for associated pest and diseases like rhinoceros beetle, leaf rot and stem bleeding, appraisal and monitoring group sessions for implementing corrective measures.

Area wide distribution of red palm weevil

Documentation of farmers and palm profile were completed in 4328 households covering 98577 palms through participatory survey procedures in the project areas. The average incidence of red palm weevil was 4.4% in Bharanikkavu and 11.2% in Kandalloor panchayaths. Out of the infested palms, 59.3 % were adult bearing and 40.7% were non bearing. The analysis of pattern of field level incidence of the pest in farmers gardens indicated aggregate pattern-except in Wards VIII & XIII - (index of dispersion) and clumped nature of infested palms (index of patchiness) (Table 10).

Knowledge level of the farming community on red palm weevil

Data were collected using pre tested questionnaire in 2014 from 110 farmers of 11 wards using random sampling method. The major knowledge gap in the management was recorded in the case of mode of destruction and early identification of the pest infestation. It was found that 84.6% of the farmers realize the incidence only after toppling of the palm crown, 7.3% (yellowing and wilting symptoms), 3.63% (extrusions and infestation in leaf axils), 2.73 % (wilting of spindle leaves) and 1.75 % (oozing out of viscous brown fluid from trunks). Recovery of treated palms was reported by 12 % of the farmers. None of the sampled farmer was aware of gnawing sound of grubs within trunk and emanation of foul smell. The correct knowledge of the farmers on recommended management of red palm weevil was below five per cent as per the data collected and it indicated the need of continuous and appropriate extension approaches and field level activities for increasing the knowledge of farming community.

Impact of social process in RPW community management – Case of Ward-1

The impact analysis of the social interventions done by visiting and recording observations in the infested gardens. The average number of palms infested per garden was 2.3. Thirty one per cent of the treated palms recovered and only two gardens out of the 137 infested gardens (pre interventions) reported the fresh incidences indicating the effectiveness of the social and technological interventions. The knowledge of the farmers also were found to be improved from 34% to 78% due to the extension interventions.

Community based bio-resource management for sustaining production and livelihood security under coconut based farming systems

The NABARD funded project on community based bio-resource management with the objective of increasing the productivity and income from coconut based farming system through integration of bio-resource management, soil moisture conservation techniques and crop diversification is being implemented in Kanjikuzhy Block of Alappuzha District. As part of the capacity development, four training programmes on INM, mass multiplication of bio-agents, farm level microbial enrichment of organics and EM composting of household and garden wastes were arranged for 138 members. From eight Coconut Producer Federations functioning in the project area, 52 farmers were selected for demonstration on technology integration. Household level demonstrations on microbial enrichment were undertaken in 14 households and plant protection in 52 households.

Table 10. Distribution pattern of red palm weevil in coconut gardens

Wards	Index of dispersion	Index of patchiness	Wards	Index of dispersion	Index of patchiness	Wards	Index of dispersion	Index of patchiness
I	20.52	9.33	VIII	0.56	3.94	XV	1.57	2.22
II	11.61	123.0	IX	2.41	3.50	XVI	5.15	3.13
III	40.96	27.31	X	7.41	5.76	XVII	0.26	0.47
IV	41.55	5.76	XI	4.02	7.67	XVIII	1.82	12.11
V	0.44	2.82	XII	27.11	11.00	XIX	9.59	13.50
VI	11.11	9.33	XIII	2.00	1.50	XX	1.55	1.88
VII	2.97	2.96	XIV	26.89	51.00	XXI	3.54	4.34

Two Farm Schools each Farm Schools were conducted at Thanneermukkam, Kanjikuzhy, Cherthala South and Mararikkulam North CPFs on IPM of Rhinoceros Beetle and Red Palm Weevil, in which 110 farmers participated.

Based on the soil test data, available phosphorus was found to be in the very high to high level, but leaf analysis indicated that P uptake is being limited or hindered which may be due to possible antagonistic nutrient interaction in soil. Soil and plant analysis indicated the limitation of micronutrients such as boron, Cu and Zn in majority of the areas and Magnesium and sulphur were limiting nutrients in a few areas. Based on the results of the soil and plant analysis, a site specific nutrient application has been initiated through green manure, organics along with micronutrients and chemical fertilizers.

All the manure pits in the demonstration plots have been treated with metarhizium for controlling grubs of rhinoceros beetle and need based plant protection against red palm weevil, beetle and leaf rot was undertaken in all demonstration plots. Farmers/ groups produced 6 MT of *Trichoderma*-enriched organics like coir pith compost /FYM/poultry manure/ goat manure, compost / mix of organics.

Development of Statistical and Computational Techniques for Improving Research Methodology

Robust experimentation technique in plantation crops

A robust method, which is not influenced by the presence of outliers in the data, is proposed to fit the semi-parametric regression with design matrix as the parameter component and covariate as the nonparametric component. Robust M- kernel weighted local linear regression smoother is used to fit the regression function. The proposed method is useful to compare the treatments after eliminating the covariate effect. The method is illustrated through simulated data. The nonparametric covariance model considered for the study is of the form $Y= X\beta + \varphi(U)+\varepsilon$

Where, Y is the observation vector, X is the design matrix, β is the treatment effect vector, $\varphi(U)$ is the nonparametric function representing the relationship between $(Y - X\beta)$ and the covariate U which is assumed to be a smooth function and is the error term assumed to be iid with mean zero and variance σ^2. Backfiting algorithm is used to estimate the treatment and covariate effect in the regression model and it is given by $\beta=[X^T(I-S)X]^T X^T (I-S)Y$ *and* $\varphi = S (Y - X\beta)$ where, S is the smoothing matrix derived using local linear regression. Robust M-type estimate $\hat{Y}$ of the regression function is obtained by minimizing the objective function $\sum_{i=1}^{n} \rho\left[\frac{y_i - \hat{y}_i}{s}\right]$ where, $\rho(.)$ is an even function with bounded first derivative $\psi(.)$ and a unique minimum at zero. The derivative $\psi(x) = \frac{d\rho(x)}{dt}$ is called the influence function and $w(x) = \frac{\psi(x)}{x}$ is the corresponding weight function. Iterated reweighted least squares technique is used to solve the minimization problem to obtain the robust estimate of the regression function. The estimate of the regression function in the k^{th} iteration is given by

$$\hat{Y}_{(k)} = X\hat{\beta}_{(k)} + \hat{\varphi}_{(k)}$$

$$\hat{\beta}_{(k)} = \left[X^T\left(I - S_{(k)}\right)X\right]^T X^T\left(I - S_{(k)}\right)Y$$

$$\hat{\varphi}_{(k)} = S_{(k)}\left(Y - X\hat{\beta}_{(k)}\right)$$

where, $S_{(k)}$ is the smoothing matrix in the k^{th} iteration derived using robust local linear regression. The estimate of the regression function in the k^{th} iteration can be written as

$$\hat{Y}_{(k)} = X\hat{\beta}_{(k)} + S_{(k)}\left(Y - X\hat{\beta}_{(k)}\right)$$

The iteration has to be continued till there is no significant improvement in the estimated values.

Sampling technique for data collection and analysis of various field and lab experiments

The distribution, sample variance, sampling error and data transformation of arecanut yield data have been studied. Based on the yield variability (both number and weight) of arecanut in field experiments, sample size for different levels of precision was estimated. It was observed that for a given level of precision, the required sample size for two years cumulative data was less than 50% of the single year data. The mean squared error can be reduced more than 20% by using the covariance technique. The best transformation of data for satisfying the normality and equality of variance were obtained by using the Box-Cox transformation (SAS 9.3). It was found that the square root transformation is the best for the analysis of yield data of arecanut (both number and weight of nut).

Survey of Yellow Leaf Disease (YLD) in Karnataka

A methodology for field survey to assess the disease incidence in plantation crops with limited resource, time and man power was developed. To cover large number of gardens with limited time and resources, purposive sampling method has been used in the YLD affected taluks in Karnataka (Table 12). To take observations, the gardens were selected systematically in each Hobli/Taluk. From each selected garden, 20 palms were selected at random and observations taken on presence of YLD symptom. Taluk/Hobli wise percentage incidence and percentage number of gardens affected by YLD were worked out. The survey was conducted in all the YLD affected villages/ panchayaths of Dakshina Kannada, Kodagu and Chikmagalur districts (six villages in Sullia taluk, four villages in Madikeri taluk, nine panchayths in Sringeri Taluk, 13 Panchayaths in Koppa Taluk, eight Panchayths in NR Pural Taluk and six Panchayaths in Mudigere Taluk).

Development of R/ MATLAB/ SAS tools for advanced data analysis

Computer programs were developed in MATLAB package for the analysis of robust semi-parametric regression and identification of outliers or extreme observations. Customised program in R for fuzzy logic using Fuzzy ToolkitUoN to model fuzziness. Developed programs for bootstrap techniques using boot() in R software to estimate the error variance wherever analytical solution is not possible. Price forecasting model for coconut oil using support vector regression is developed. MAP kinase prediction was undertaken employing SVM in R on coconut transcriptome data.

Socioeconomic dimensions and value chain dynamics in policy perspective

An econometric analysis of market and price transmission mechanism in mandate crops

The price instability analysis was conducted for three periods (2001-04; 2005-09; 2010-14). During these periods under consideration, coconut oil exhibited the highest price instability among the plantation crops. Although the price volatility in domestic cocoa was comparatively at lower levels, it was higher than the international cocoa prices. The analyses indicate weak price stabilizing (procurement) mechanism in the domestic arena which should be corrected (Table 13).

Phillips-Ouliaris method of cointegration analysis was carried out in major plantation crops (2004-2014) and it was found that tea and rubber markets (domestic and world) are cointegrated, while coconut oil and coffee is not (Table 13). The results point towards the domestic market/policy distortions which play a major role in the price fluctuations of coconut oil and cocoa.

International trade dynamics, trade agreements and their impact on domestic sector

Revealed Comparative Advantage Analysis (which is a measure of export competitiveness) indicates that among plantation crops, India has comparative advantage only in the case of tea exports. In the case of coconut, Indonesia marked the highest comparative advantage followed by Philippines. The results indicate that in the regime of export competition in plantation crops, India lags behind the major competing Asian counterparts (Table 14). Hence, it is imperative to take adequate preparedeness, especially while signing the regional trade agreements.

Tabel 12. YLD survey in Karnataka

Hobli/Taluk	No.of Panchayaths	Area (ha)	No. of gardens			Intensity (%)
			surveyed	with YLD	%	
Sringeri	9	2703	185	114	62	25
Koppa	13	4783	139	106	76	45
Balehanoor /NR Pura	8	2030	62	43	69	18
Kalasa/Mudigere	6	2184	64	41	64	16
Sullia	6*	1889	189	99	52	30
Sampaje/Madikeri	4*	1401	69	50	72	50
Total		**14990**	**523**	**339**	**65**	**32**

* Village

Table 13. Price instability indices of major plantation crops

	Tea		Coffee		Rubber		Coconut oil		Cocoa	
Period	India	World	India	World	India	World	India	World	India	World
2001-04	4.0	6.5	2.1	2.5	2.5	2.3	6.1	6.5	3.0	3.3
2005-09	3.3	8.9	2.4	2.4	4.5	4.0	5.0	7.2	3.1	2.6
2010-14	3.9	5.0	3.1	2.7	3.4	2.7	6.7	8.9	4.7	2.1

Table 14. Results of cointegration analysis

Crop	Result
Tea*	Cointegrated
Coffee	Not cointegrated
Cocoa	Not cointegrated
Rubber*	Cointegrated
Coconut	Not cointegrated

* at 5% level of significance

Table 15. Revealed comaparative advantage

Country	Coffee	Tea	Pepper	Rubber	Coconut
India	2.4	12.1	8.2	9.2	2.6
Indonesia	7.1	4.9	22.2	22.1	36.2
Malaysia	0.0	0.3	4.2	19.6	0.4
Philippines	0.2	--	--	3.8	26.2
Thailand	0.0	0.2	0.3	28.2	0.0
Vietnam	31.2	7.6	70.3	6.8	0.2

Analysis of the recent policy changes at the domestic level pertaining to the mandate crops and the effects thereupon

The import duties on edible oils have moved basically in counter-cyclical nature to the level of edible oil prices in global markets. This is a rational policy choice which is required to stabilize edible oil prices in the domestic market. But the analysis over a period of ten years revealed the clear policy void regarding Import tariff structure of palm oil, wherein import duty is as low as 7.5% even though the prices are declining. The import duty for palm oil has to be dynamically adjusted to its international prices as palm oil prices act as an anchor to all edible oil prices. A bearish trend in palm oil prices exerts downward pressure on prices of all edible oils with an adverse effect on domestic production and a further rise in palm oil imports. Therefore, there is an urgent need to re-calibrate the import duty structure.

In order to create an impact in the market and for the benefits of MSP to reach the genuine coconut farmers, adequate quantity of copra should be procured. The studies on pattern of distribution of annual yield of coconut indicates that the number of nuts harvested varied from harvest to harvest and 60% of the production of a coconut palm is harvested during the peak production period i.e., the first six months of the calendar year, and hence a stable price during these periods is of utmost importance for achieving profitability in coconut based farming system (Fig. 87). The copra procurement scheme should be designed keeping in view of this important aspect of coconut production in the country.

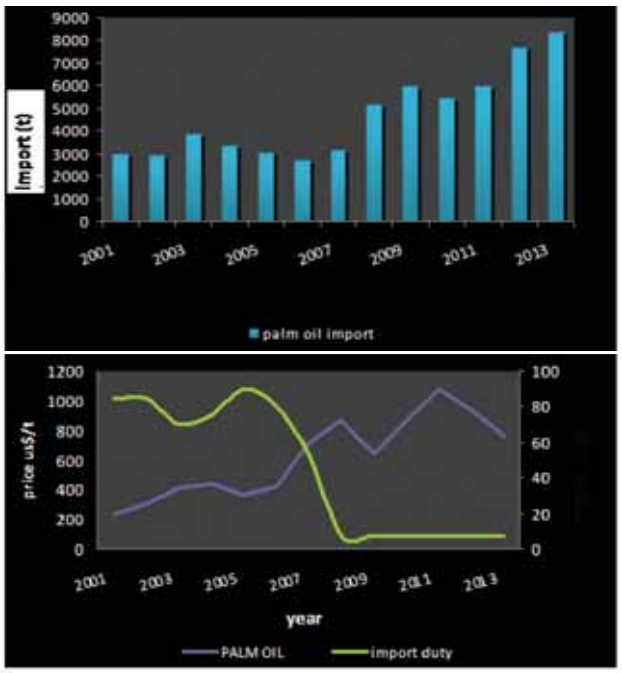


Fig. 87. Palm oil imports and tariff structure

KRISHI VIGYAN KENDRAS

KVK, KASARAGOD

KVK, Kasaragod had undertaken four on farm trials and 22 front line demonstrations during 2014-15 as a part of its mandatory activities.

On farm trials

Soil acidity management in vegetables: Application of liming materials based on soil test results was carried out to improve soil health, better plant uptake of soil nutrients as well as to enhance crop productivity. Results indicated that in bitter gourd (*var.* Preethi) application of dolomite performed better with increased yield (11.68 t ha^{-1}) and better growth parameters followed by application of lime (11.1 t ha^{-1}) with 17.98% and 13.69% increase in yield respectively as against farmers' practice (9.58 t ha^{-1}).

Performance of fodder grass varieties as intercrop in coconut garden: On farm trial on 'evaluation of fodder grass varieties as inter crop in coconut garden' was conducted with fodder grass varieties like Suguna, Supriya and Thumburmuzhy-1 along with Co-3 as control at Padanne panchayath.

Phytophthora foot rot disease management of black pepper: An On farm trial on *Phytophthora* foot rot disease management of black pepper was conducted in arecanut based pepper gardens at Badiadka and Kallar panchayaths of Kasaragod district. *Trichoderma* basal application with *Pseudomonas* spray and *Trichoderma* basal application with 1% BM spray completely controlled foot rot disease incidence.

Management of blue beetles in paddy: Rice blue beetle, *Leptispa pygmeae* management was carried out in Melbare. Neem based preparations, ie, Neem oil – soap emulsion (2%) and Nanma (20ml l^{-1}) were sprayed against the pest. Both were found to be effective and the damage reduced in comparison to farmers' practice.

Frontline Demonstrations

Micronutrient management in banana using Banana Shakthi: Demonstrations were conducted in Kinanoor-Karindalam, Uduma, Bedakam, Mogral Puthur and Badiadka panchayaths. Banana Shakthi comprising a mixture of zinc, iron, copper and boron is sprayed with suitable adjuvant (sticking agent) to the plants at 3rd, 4th and 5th month after planting as foliar spray. Results showed that micronutrient application resulted in better yields (28 t ha^{-1}) as compared against 23.25 t ha^{-1} in control.

Management of pseudostem weevil in banana using cassava bioformulations: The demonstrations were conducted at West Eleri and Ballal panchayaths in an area of 4 ha. comprising 10000 plants. The results of the demonstrations conclusively proved that this technology is feasible, viable, ecofriendly and cost effective with 0.6% pest incidence compared to 14.7% in control.

Management of root grub in arecanut using bio control agents: This FLD was initiated in an area of one ha in four arecanut gardens of Melbare village of Uduma panchayath demonstrating EPN isolate of CPCRI, *Steinernema carpocapsae*. There was substantial reduction in number of root grubs from 8.2 to 3.4. The EPNs were re-isolated from 20% of the soil samples collected from all treated plots which showed its slow establishment consequent to treatment.

Integrating bee colonies for better pollination and yield enhancement in coconut gardens: This FLD was carried out by integrating 20 bee colonies in an area of 4 ha. of coconut garden belonging to ten farm families of Kodavalam village (Pullur – Periye), Baradka (Badiadka) and Puluvinchi (Kuttikkol). The average yield of coconut increased from 52 nuts to 61 nuts per palm after three years. Number of colonies has been increased from 20 to 66 and honey yield was on an average 7.1 kg per hive.

Prophylactic method for control of bud rot disease in coconut: Front line demonstration programme on prophylactic method for the control of bud rot disease was conducted in coconut gardens of seven farmers with five ha area at Manjeswar and West Eleri panchayaths of Kasaragod district.

Dolomite for Acidity management in paddy: Demonstration on acidity management in paddy using Dolomite was done in 10 acres of paddy field with average acidity level 5.6 belonging to 10 farmers at Koyankara, Thrikaripur panchayath (Fig. 88).

Fig. 88. Demonstration of acidity management in paddy

Management of basal stem rot (*Ganoderma* wilt) disease in coconut: Basal stem rot (*Ganoderma* wilt) disease management was taken up in farmers fields of Kodakkad, Pilicode and Kanhangad. Technology demonstrated in fields include basal application of five kg neem cake enriched with *Trichoderma* along with balanced doze of fertilizer application and proper irrigation to all palms in the fields.

Mechanisation in paddy- setting a new trend in Kasaragod: This was carried out to reduce cost of cultivation at Kodla Mogaru and Kodiyamme in Manjeswar block. In this programme, land preparation with rotavator, seeding with drum seeder, transplanting with riding type paddy transplanter (Fig. 89) and demonstration of weeding with cono weeder were conducted.

Fig. 89. Demonstration of drum seeder of paddy

Demonstration of technologies to prevent crop damage due to wild life intrusion: Wild boar olfactory repellant powder and reflecting ribbons (source: KAU) to ward off wild animals and birds respectively from cropped areas was demonstrated in 10 FLD units in which the crop damage was reduced significantly.

Value addition: Processing of jackfruit and its utilization was promoted by a refined low cost indigenous technology of brining with 1400 kg of raw jackfruit processed by the trained groups. Value addition of banana by vermicelli, osmotic dehydration of fruits and production of cookies were also demonstrated (Fig. 90).

Fig. 90. Training programme on jackfruit value addition

Other demonstrations: Organic measures for management of aphids in cowpea (Fig. 91), sucking pests in bhindi, blast disease in paddy, HYV of ginger Varada, green gram CoGG-8, coastal sandy soil management, fresh water pearl culture, scientific cultivation of cocoa in arecanut gardens and micronutrient mixture 'Ayar' for banana also were demonstrated.

Fig. 91. Demonstration of aphid management in cowpea

Training programmes

KVK organized 120 training programmes comprising vocational and sponsored for farmers, farm women and rural youth in which 1590 male and 2095 female persons benefited (Fig. 92). Two training programmes of twenty and ten days on 'EDP on Food Processing' sponsored by District Industries Center, Kasaragod was organized at KVK, Kasaragod. Five programmes on 'Value added products from Nutrimix' were conducted

Fig. 92. Dr. P. Chowdappa, Director handing over climbing device to participant of "Friends of Coconut" training programme

Fig. 93. Dr. K.B. Hebbar, Head, PB & PHT imparting training on Nutrimix to women

for Kudumbasree units from Palghat, Malappuram, Kollam, Idukki, Kottayam and Ernakulam. Training on cocoa production and post harvest technologies for cocoa, sponsored by Directorate of Cashewnut and Cocoa Development (DCCD), Kochi was conducted at Adoor village with participation of 50 farmers (Fig. 93).

Extension activities

Extension activities comprising of field days, advisory services, agricultural seminars, farmers visit to KVK, diagnostic visits, method demonstration, etc. were organized where in 3571 farmers were benefited. Monthly technology advisory meets were also carried out in collaboration with ATMA and Department of Agriculture.

Banana Harvest Festival: KVK, Kasaragod, conducted a Banana Harvest Festival at Bheemanadi on 29-10-2014 with the collaboration of CTCRI, Thiruvananthapuram, West Eleri Grama Panchayath and Krishi Bhavan. This was organized in connection with a FLD on management of banana pseudostem weevil using cassava bioformulations. A total of 150 farmers attended the programme (Fig. 94).

Fig. 94. Dr. P. Chowdappa, Director addressing beneficiaries of management programme on banana pseudostem weevil using cassava bioformulations

Farmer Scientist interface programmes: Three farmer –scientist interface programmes were conducted on "Crop health management" and "Safe food production and nutritional security" at Miyapadavu of Meenja Panchayath, Bambrana of Kumbla panchayath and Manjeswar on November 20th, 21st and December 8th, 2014 respectively. Two other Farmer-scientist Interface meets on demonstration of use of reflective ribbon tape to manage peacock in cropped areas was conducted at Ambiladka and Manjeswar on 03-12-2014 and 08-12-2014 respectively.

Best Exhibition stall awards: KVK participated in exhibitions during Krishi Mela at CPCRI Vittal on 10-1-2015 and at Brahmavar organized by IIHR Bengaluru and won the best stall awards.

Workshop: Workshop on Banana fibre extraction techniques and value addition was organized on 09-12-2014. Following this, knowledge reinforcement meet for ex-trainees was organized on 16-12-2014. A banana fibre unit at KVK was inaugurated on 08-01-2015 and an ex-trainees' meet was organized at KVK on 05-02-2015. A buy back system of banana fibre was also arranged as a motivation for the former trainees. A total of 75 kg of banana fibre was extracted by the former trainees at their homesteads and which

were bought back by a successful entrepreneur at KVK, Kasaragod @ Rs. 350 kg^{-1}.

SAC Meeting

The 19th Scientific Advisory Committee meeting of Krishi Vigyan Kendra of ICAR – CPCRI, Kasaragod was conducted at CPCRI on 11-03-2015, under the chairmanship of Dr. P. Chowdappa, Director, CPCRI. Dr. C.V. Sairam, Principal Scientist, Zonal Project Directorate, Bengaluru, briefed about the convergence on linking the activities of KVK with agriculture and allied departments of the district. KVK newsletter for the period January to December, 2014 and two other publications were released during the occasion. Further, bottled honey, a product of KVK, branded and labelled as Keramadhu was also launched for sales through KVK outlet.

KVK, ALAPPUZHA

Mandated activities *viz;* On Farm Testing (OFT), Front line demonstrations (FLD, Trainings and Extension activities in addition to the external funded programmes and special programmes were taken up. The details are as follows.

Training programmes

A total of 96 training programmes were conducted comprising 40 on campus, 40 off campus, six sponsored and four vocational programmes on various aspects during April, 14-March, 15, in which 2679 participants benefited.

On Farm Testing

Six OFTs on performance of turmeric varieties as intercrop in coconut gardens, performance of *Verticillium* against sucking pest complex in chillies, suitability and durability of low cost pandal using waste cloth, performance of different fodder crops, performance of Malabari and Kanni goats and effect of coconut tonic on yield improvement are in progress at locations at Budhanoor, Karuvatta, Bharanikav and Chettikulangara.

Frontline Demonstrations

Thirteen FLDs on Foliar nutrition in SSNM of paddy, fungal disease management in cowpea using PGPR, stem bleeding management in coconut using bioagents, integrated crop management in banana, management of banana pseudostem weevil using biopesticides, hybrid brinjal – Neelima with ICM practices, elephant foot yam variety Gajendra as intercrop in coconut gardens, fish silage feeding in homestead poultry and duck rearing, total mixed ration in dairy cows, cultivation of soft rot resistant ginger variety "Karthika" and utilisation in value addition of coconut, fodder cowpea for yield improvement in dairy cattle, open precision farming in solanaceous vegetables and coconut based integrated farming system are in progress at different places in the district.

Revolving fund of KVK

Different inputs were made available through revolving fund to the farmers *viz.,* methyl euginol and cue lure traps, seeds and seedlings, layer chicks, mushroom spawn, mother spawn, banana and vegetable specials (micronutrient formulations), bio-agents, Fish amino acid, azolla, EM solution and worms for composting, processed products etc. The progressive closing balance of revolving fund as on 31-03-2015 is Rs. 8,52,827/-

Extension activities

A seminar cum interface on integrated family farming for nutritional and food security was organized at Sreemoolam Town Hall, Ambalappuzha on 06.02.2015. New inputs for the benefits of farmers like fish amino acid, EM solution and value added virgin coconut oil were released on the occasion. An agricultural exhibition was arranged in which seedlings, bio- agents, traps, micro nutrients, EM solution, virgin coconut oil and various publications were available for sale. About 120 farmers from the district actively participated in the seminar. Smt. Radhamani Amma, Smt. Mini Kunjumon, and Shri. P.A. Thomas, who adopt model integrated farming system shared their farming experiences in the interface programme.

The KVK as a knowledge centre took up the extension activities such as advisory Services through help line / kisan mobile / agroclinic, diagnostic field visits, scientists' visit to farmers field, field day/harvest festival, group discussions, film show, farmers' seminar/workshop, method demonstrations, exposure visits to KVK, plant/soil health/soil test/animal health camps, exhibition, awareness programs, newspaper coverage, radio and TV programmes and publication of popular articles in which about 9000 farmers/ rural youth and about 1400 extension officials were involved.

The laboratory provided the facility for testing soil, plant, and water for farming community of the district. Soil samples collected as part of soil testing campaign and for OFTs / FLDs were also analysed. Estimation of pH, EC, Organic C, Available P and K of 40 soil samples received from farmers were done for giving soil test based fertilizer recommendation for various crops during the year.

Educational programmes

Rural Agricultural Work Experience (RAWE): KVK module of the RAWE programme for nine final year B. Sc. (Agri.) students from College of Horticulture, Vellanikkara was conducted from 5th to 8th May, 2014. They were guided on the working pattern and various activities of KVK including an on campus training on 'scientific mushroom cultivation' and an interactive session with progressive farmers and successful entrepreneurs of the district.

On Job Trainings (OJT): On job trainings were conducted for 178 VHSE students from four schools of Alappuzha district. Trainings with more emphasis on practicals were provided on plant protection, protected cultivation, vermicomposting, coconut climbing, and fruit and vegetable preservation.

KVK-ATMA Linkage

Programme coordinator and subject matter specialists took part in the governing body, management committee, and monthly technology advisory meetings of ATMA; Conducted training programmes, and method demonstrations; and participated in farm schools, Kisan Goshtis organized by ATMA at different parts of the district. The team participated in the ATMA Technology meet conducted from 2nd to 4th March, 2015 at Kalarcode by arranging an exhibition stall and serving as resource persons in technical sessions and research-extension-farmer interface.

Radio and TV programmes

Radio talks/interview given on activities of KVK Alappuzha, nutrient management in coconut, nutritional importance of pineapple and its value added products on AIR Kochi FM and AIR Trivandrum.

KVK conducted live phone in programmes on value addition of coconut and jackfruit, soil nutrients for crop growth on Doordarshan, Thiruvananthapuram. success stories on value addition of oriental pickling melon and value addition unit on turmeric with technical and input support was telecasted in "Noorumeni" programme of Farm Information Bureau of Govt. of Kerala on Dooradarshan. Use of drum seeder as a resource conserving technology in paddy cultivation in Kuttanad demonstrated and popularized by KVK-Alapuzha under NICRA project was telecasted in the "Noorumeni programme" of Dooradarshan.

Special programmes

Following programmes were conducted in different parts of the district

1. World environment day celebration
2. Launching value added products of oriental pickling melon (Kanivellari)
3. Launching virgin coconut oil capsules (Fig. 95).
4. Felicitation of SMART farmers of NICRA project
5. Field day celebrations of FLDs on "integrated crop management in paddy" (Fig. 96) and Vigova super M' broiler ducks in IFS units

Fig. 95. Virgin coconut oil capsules launched with technical support from KVK, Alappuzha

Fig. 96. Demonstration of dolomite application in paddy field

6. Farmer field school on 'scientific and sustainable vegetable production' (Fig. 97)

7. Nine soil testing and 13 soil heath campaigns

Fig. 97. Training on scientific and sustainable vegetable production

Scientific Advisory Committee Meeting

The 13th SAC Meeting was held on 06-08-2014 at the training hall of KVK under the chairmanship of Dr. George V. Thomas, Director, CPCRI, Kasaragod. Three publications of KVK *viz.*, an extension booklet on "value added products from jackfruit", leaflet series on "pests of coconut" and KVK Newsletter (April-June, 2014) were released by the dignitaries in the meeting. Following the presentations by subject matter specialists about the activities, Dr. Srinath Dixit, Zonal Project Director, Zone VIII, Bangalore, in his remarks appreciated the activities and teamwork of the KVK.

External funded programmes

National Initiative on Climate Resilient Agriculture (NICRA): The NICRA project is funded by ICAR and coordinated by CRIDA, Hyderabad in which technology demonstration component is implemented in Alappuzha District by the KVK at Muttar village, Veliyanad block, Kuttanad taluk with funds of Rs. 12.51 lakhs for 2014-15. Large scale technology demonstrations on the climate resilient agricultural technologies such as recycling of organic residues for energy generation and crop production using portable biogas units, large scale composting of aquatic weeds using EM solution and utilization in vegetable production, resource conserving and eco-friendly management practices in paddy, rain shelter cultivation of vegetables in flooded situations, poly bag cultivation of TC banana for overcoming flood during initial growth stages, mushroom and spawn production and vermi-compost from spent straw, integrated duck – fish farming, model dairy units, intensive goat and poultry rearing in raised platform, custom hiring centre and milk and other farm produce marketing are in progress in the village. In addition to these demonstrations, nine training programmes, four exposure visits, and nine method demonstrations and one harvest festival cum field day were conducted (Fig. 98 & 99).

Fig. 98. Dr. P. Chowdappa, Director, inaugurating paddy harvest festival at Muttar

Fig. 99. Farmers field day on cultivation of paddy

Development of pest surveillance based crop advisory for plant health management– under the crop health management project funded by the Dept. of Agriculture, Kerala and coordinated by

Kerala State Planning Board with a budget provision of Rs. 6 lakhs. Seven leaflets on pests and five leaflets on diseases of coconut were prepared for the use of pest scouts and for the awareness creation to coconut farmers and capacity building of extension officials of the district. Four trainings were conducted for 19 pest scouts of the CHM scheme from different blocks of Alappuzha district on pest and disease surveillance of banana, vegetables, and coconut.

Training cum awareness programme on PPV&FR Act: Training-cum-awareness programme on Protection of plant varieties and farmers' rights act was organized in association with ATMA Alappuzha at Sreemoolam Town Hall, Ambalappuzha on 07-02-2015. About 100 selected farmers from different parts of the district attended the programme. Display of farmers' varieties was also arranged in the exhibition on the day.

TECHNOLOGIES ASSESSED AND TRANSFERRED

Coconut varieties and hybrid

Three coconut varieties, *viz*. two dwarf tender nut varieties (Kalpa Jyothi, Kalpa Surya) and a tall, dual purpose copra and tender nut variety (Kalpa Haritha), were released and notified by the Central Sub-Committee on Crop Standards, Notification and Release of Varieties.

Five coconut varieties *viz*. Kalpasree, Kalpa Dhenu, Kalpa Mitra, Kalpa Pratibha and Kalparaksha were registered by PPVFRA under extant variety category. The hybrid Kalpa Sankara was also registered.

Sl. No.	Extant variety/hybrid	Reg. No. and date
1	Kalparaksha (CCS-7)	761 / 11-12-2014
2	Kalpa Sankara (CGD x WCT hybrid)	814 / 23-12-2014
3	Kalpasree (Chowghat Green Dwarf)	818 / 26-12-2014
4	Kalpa Dhenu (IND006S) (CCS-6)	828 / 30-12-2014
5	Kalpa Pratibha (IND0168) (CCS-4)	830 / 30-12-2014
6	Kalpa Mithra (IND022S) (CCS-5)	832 / 30-12-2014

Kalpasree

Early bearing dwarf variety suitable for root (wilt) disease tracts with superior quality oil, sweet water, and sweet kernel. The yield is 90 nuts palm^{-1} year^{-1} with copra yield of 1.54 t ha^{-1} year^{-1}. Tender coconut water content is 240ml with 0.048 mg ml^{-1} total sugar, 22.40 ppm sodium and 2150 ppm potassium.

Kalpa Dhenu

Regular bearer, relatively tolerant to drought having a yield 80 nuts palm^{-1} year^{-1}. Copra content of 244 g nut^{-1}, oil yield 2.23 t ha^{-1} year^{-1}, oil content 65.5%, annual yield of 3.66 t copra ha^{-1} and 2.40 t oil ha^{-1} , tender coconut water is 290ml with total sugar 0.0492 mg ml^{-1}, 24.6 ppm sodium and 2650 ppm potassium.

Kalpa Mitra

This is a high nut, oil yielding and drought tolerant variety. Nut yield of 86 nuts palm^{-1} year^{-1}, oil yield of 2.45 t ha^{-1} year^{-1}, oil content 66.5%, annual yield 3.36 t copra ha^{-1} and 2.24 t oil ha^{-1}, tender nut water content is 495ml with total sugar 0.057 mg ml^{-1}, 23.5 ppm sodium and 2150 ppm potassium.

Kalpa Pratibha

High yielding dual purpose variety for copra and tender coconut, average yield of 91 nuts palm^{-1} year^{-1}, copra yield 4.12 t ha^{-1} year^{-1}, oil yield 2.76 t ha^{-1} year^{-1}, oil content 67%, tender coconut water content is 448ml with total sugar 0.055 mg ml^{-1}, 21.7ppm sodium and 2150 ppm potassium.

Kalparaksha

High yielding coconut variety with sweet tender nut water and field resistance to coconut root (wilt) disease, yield of 88 nuts palm^{-1} year^{-1}, copra content 85 g nut^{-1}, oil yield 1.87 t ha^{-1} year^{-1}, oil content 65.5%, tender nut water content is 290ml with total sugar 0.0492mg ml^{-1}, 19.5 ppm sodium and 2100 ppm potassium.

Kalpa Sankara

This coconut hybrid (CGD x WCT) is suitable for cultivation in the root (wilt) disease prevalent tracts with


Kalpa Jyothi


Kalpa Surya


Kalpa Haritha


Kalpasree


Kalpa Dhenu


Kalpa Mitra


Kalpa Pratibha


Kalparaksha


Kalpa Sankara

an yield of 84 nuts palm^{-1} year^{-1} copra content 170 g nut^{-1}, oil yield 1.69 t ha^{-1} year^{-1} and has tolerance to root (wilt) disease. The palms are semi tall in nature, precocious bearing and relatively higher yield in root (wilt) diseased tracts.

Microsatellite markers

Microsatellite markers were successfully used for hybrid authentication of three D x T coconut crosses.

SCAR markers

A Sequence Characterized Amplified Region (SCAR) marker, capable of distinguishing tall/dwarf trait in arecanut, was developed and validated in HD x Tall hybrids.

Coconut sap chiller

The present invention relates to a 'coco sap chiller'- a device specially designed for the collection of fresh, hygienic and unfermented palm sap to maintain palatability. Coconut sap chiller is used for tapping and collecting fresh, hygienic and non-alcoholic Neera from coconut palms. It should be ensured that Neera is tapped free from dust, pollen and other contaminants. The chill temperature is retained for long duration and is light in weight and can be easily hanged in the tree crown using the handles provided. Filled container can be easily removed from box. The waterproof material used to cover the box prevents any water / weather damage on the box.


Coconut sap chiller

Neera bottling technology

CPCRI has developed a technology for collecting coconut inflorescence sap by using a device. The sap thus collected hygienically is called Kalparasa. Kalparasa can be preserved up to 45 days under cold condition (in refrigerator) without adding any preservatives and additives with the bottling technology, the Institute aims at introducing Kalparasa as a natural health drink for commercial sales. The Kalparasa is pasteurized before bottling for a longer shelf-life.

Coconut de-shelling machine

A power operated coconut de-shelling machine was designed and developed. Capacity of coconut shell remover is 120 nuts h^{-1} and saves requirement of labor and time. It is easy and quick to replace the cutting blade. Heavy duty construction and geared motor drives the desheller. It can be used for any size of coconuts.

Bottled Kalparasa

Education and Training

HUMAN RESOURCES DEVELOPMENT

The following personnel have undergone human resources development programmes during the period.

Name and Designation	Title of training course	Place and Duration
Dr. P. Chowdappa, Director, CPCRI	Executive Development Programme on leadership development	NAARM, Hyderabad 19-01-2015 to 23-01-2015
Dr.Murali Gopal Principal Scientist (Microbiology)	Agricultural Genomics Symposium	TNAU, Coimbatore 16-02-2015
Dr. V. Niral, Principal Scientist	Training workshop of all the ICAR institutes HRD nodal officers	ICAR-NAARM, Hyderabad 26-02-2015
Dr. T.S. Manojkumar, Programme Coordinator and Dr. S. Leena, CTO, KVK, Kasaragod	Organic Certification and Internal Control System Management	CTI, KAU, Vellanikkara 11-10-2014 to 18-10-2014
Dr. S. Elain Apshara, Senior Scientist (Hort.)	Workshop on Developing Winning Research Proposal	NAARM, Hyderabad 09-09-2014 to 11-09-2014
	Genomics and Proteomics in plant and microbes towards translational research	IISR, Calicut 21-01-2015 to 01-02-2015
Dr. D. Jaganathan, Scientist (Ag. Extn.)	CAFT training on 'Futuristic Agricultural extension approaches and tools'	IARI, New Delhi 03-09-2014 to 23-09-2014
Dr. Nagaraja, N. R. Scientist (Plant Breeding)	National Seminar on Cocoa	Jawaharlal Nehru National Institute of Engineering and Technology, Shimoga 30-01-2015 to 31-01-2015
Dr. Leichombam Singhajit Singh, Scientist (Hort.)	ICAR Short course on Advances in production of quality planting materials in plantation crops	ICAR-CPCRI, Regional Station, Kayamkulam 18-11-2014 to 27-11-2014
Smt. Lekha G., SMS (Plant Pathology), KVK, Alleppey	IPM in important crops of Puducherry, Tamil Nadu and Kerala	PKKVK, Puducherry 10-09-2014 to12-09-2014
	Production protocol for bioagents and biopesticides	NIPHM, Hyderabad 23-05-2015 to 02-06-2014
Ms. Jissy George SMS (HS), KVK, Alleppey	Frontier Home Science Technologies and economic empowerment	UAS, Dharwad 28-10-2014 to 30-10-2014
Shri Rajeev M.S. SMS (Agronomy) , KVK, Alleppey	Integrated Farming	Central Training Institute, Mannuthy 28-10-2014 to 29-10-2014
Dr. G. Rajeev, Asst. Chief Technical Officer and Shri. K.M.Ansary, Technical Assistant -T4	'Gahan Hindi Karyasala'	Central Hindi Training Institute, New Delhi 25-08-2014 to 29-08-2014
Shri K. Manikantan Programme Assistant, KVK, Kasaragod Shri.Ansary K.M Programme Assistant (Computer), KVK, Alleppey	Data base management for KVKs(Online Reporting System-OLRS)	KVK, Mysore 16-12-2014 to 17-12-2014

Dr. S. Ravi SMS (Animal Husbandry), KVK, Alleppey	Orientation Programme on Mandated activities of the Krishi Vigyan Kendras	KVK, Thrissur 19-11-2014 to 22-11-2014
Shri M.S. Rajeev and Dr. S Ravi, Assistant Chief Technical Officers, KVK, Alleppey	Capacity building programme on Technology demonstrations for climate resilience and value -added agro - met advisories	CRIDA, Hyderabad 27-01-2015 to 28-01-2015
Dr. K. Sajnanath SMS (Soil Science), KVK, Alleppey	Orientation Programme on Mandated activities of the Krishi Vigyan Kendras	KVK, Vijayapura 03-10-2014 to 06-10-2014

Deputation Abroad

Dr. S. Elain Apshara, Senior Scientist (Hort.) was deputed to attend the meeting of 'Asia-Pacific Cocoa Breeders Working Group', held at the University of Reading, UK during 16th to 18th June, 2014.

Asia - Pacific Cocoa Breeding Group - Dr. Elain Apshara along with participants from Indonesia, Malaysia, Philippines, Papua New Guinea and Vietnam

Dr. Chandrika Mohan, Principal Scientist (Agrl. Entomology) was deputed as Focal point expert from India in the Regional Expert consultation workshop on mite management of coconut in SAARC member countries held at Dhaka, Bangladesh during 10-11 August 2014. The workshop was organized by SAARC Agriculture Centre (SAC), Bangladesh.

Dr. Regi J. Thomas, Sr. Scientist and Dr. K. Nihad, Scientist have attended the 29th International Horticultural Congress 2014 during 17th to 22nd August 2014 in Brisbane, Australia.

Dr. Jayasekhar, S., Scientist (Sr. Scale) was deputed to participate in the 17th the International Institute of Fisheries Economics and trade (IIFET) 2014 conference held at Brisbane, Australia during 07th to 11th July 2014. He received the Best Research Paper award for his paper "Restructuring the value chain governance: The impact of food safety regime on fishery sector of Kerala, India" during the conference.

Shri Jayasekhar S. receiving the certificate of honour from Dr. Ann Shriver, Executive Director, IIFET, USA

Dr. G. C. Acharya, Sr. Scientist (Hort.) was deputed on a DST sponsored exposure visit to China as a part of the "National programme for training of scientists and technologists working in Govt. sector" during 18th to 22nd August 2014.

PG Studies

Dr. S. Elain Apshara, Senior Scientist (Hort.) was awarded Post Graduate Diploma in Technology Management in Agriculture (PGDTMA) with distinction, jointly offered by NAARM & University of Hyderabad on 15-07-2014.

International HRD collaboration

Under the International HRD collaboration on *"Research training fellowship for developing country scientists"*, Mr. M'boKacou Antoine Alban, a post graduate student from Côte d'Ivoire underwent training at CPCRI, RS, Vittal under the guidance of Dr. K. S. Ananda for a period of six months from 31-03-2014 to 30-09-2014.

Awards and Recognition

Dr. H.P. Maheswarappa, Project Coordinator (Palms) was honoured with "Fellow of Indian Society for Plantation Crops" during the General Body Meeting of ISPC held on 10th December, 2014 at Calicut.

Dr. H.P. Maheswarappa receiving ISPC Fellow citation from Dr. M. Anandaraj, Director, IISR, Kozhikode

Dr. Anitha Karun, Head, Crop Improvement, CPCRI, Kasaragod and Dr. G.C. Acharya, Sr. Scientist, RC, Kahikuchi were adjudged as the Best arecanut scientists for the biennium 2013-2014 by ISPC for their outstanding contributionrs in the field of arecanut research & development.

The Best Poster Award was conferred to Josephrajkumar, A., Chandrika Mohan, Sunny Thomas, Namboothiri, C.G.N. and Shanavas, M for the paper entitled "Subduing red palm weevil attack on coconut through fine-tuned management approaches" during the National Conference on Sustainability of coconut, arecanut and cocao farming- Technological Advances and Way forward, held at CPCRI, Kasaragod during 22-23August, 2014.

Dr. Anithakumari P. received the Best Poster Award for the paper 'Impact study on area wide extension approach for biomanagement of Rhinoceros beetle in farmers' fields' in PLACROSYM XXI during 10-12, December, 2014 at Kozhikode.

Dr. Nagaraja, N. R., Scientist (Plant Breeding) received the award for the Best Oral Presentation for the research paper entitled 'Molecular marker analysis and tagging of gene for stem rust resistance in wheat',

The paper on "Detection of mature miRNAs in the mitochondrial genome of *Phytophthora* ssp." by Rahul C.U. and Rajesh M.K. was awarded the second Best Poster Award and Dr. Elain Apshara, Senior Scientist received the best Oral Presentation Award for the paper entitled "Cocoa stress gene database (CocoaSTRESSdb): Comprehensive resource for cocoa stress response genes and associated SSR markers to facilitate marker assisted selection" at the National Seminar on "New Horizons and Challenges in Biotechnology and Bioinformatics", organized during 9-10 October 2014 at ICAR-CPCRI, Kasaragod.

The best oral presentation award for the paper 'Efficacy of entomopathogenic nematode in combination with imidacloprid against root grub (*Leucopholis burmesteri*) in arecanut' by Rajkumar, Jagadeesh Patil and K. Subaharan was conferred during the International conference on 'Changing scenario of pest problems in Agri-Horti ecosystem and their management', held at MPUA&T, Udaipur, Rajasthan during 27-29 November, 2014.

Oral presentation entitled "Disrupting insect luminal enzymes for pest management" authored by Josephrajkumar, A. and Chandrika Mohan was adjudged as a best oral presentation in recognition of its research thrust and technical contents in the National Symposium on Entomology as a Science and IPM as a technology-the way forward held at College of Horticulture and Forestry, Central Agricultural University, Pasighat, Arunachal Pradesh during November 13-15, 2014.

Vice chancellor MPUA&T, Udaipur conferring the award to Dr. Rajkumar

The oral presentation entitled "Surveillance note on invasive pests of coconut and strategies on incursion management" authored by Josephrajkumar, A., Chandrika Mohan, Jerald, B.A. and Krishnakumar, V. was conferred the *best oral presentation* award in the International Conference on Innovative Insect Management Approaches for Sustainable Agro Eco System (IIMASAE) held at Agriculture College and Research Institute, Madurai during 27-30 January 2015.

On the occasion of 86th ICAR foundation day held at New Delhi on 29th July,2014 the ICAR award for the year 2013 in the field of Social Sciences was conferred to Dr. Saritha Hegde for the doctoral research work entitled "Evaluation of genetically diversified red rice as functional food with special reference to lactational performance".

Shri Radha Mohan Singh , Hon'ble Union Minister for Agriculture and Dr. Sanjeev Kumar Balyan, Minister of State for Agriculture handing over the award to Dr. Saritha Hegde

Linkages and Collaborations

INTERNATIONAL

APCC, Jakarta, Indonesia	Coconut promotion and cooperation between coconut growing countries in the Asia – Pacific region.
Bioversity International	Coconut genetic resources and International Coconut Gene Bank for South Asia and Collaboration for cocoa germplasm
Coconut Research Institute, Sri Lanka	Resistance breeding programme against coconut Weligama Wilt Disease in Sri Lanka.

NATIONAL

ICAR Institutes

ICAR-CIAE, Bhopal	Development of labour saving machineries and gadgets
ICAR-CIARI, Port Blair	Coconut genetic resources and breeding
ICAR-CIFT, Kochi	IP management and commercialisation of technologies
ICAR-CRIDA, Hyderabad	Climate change network and NICRA
ICAR-CTCRI, Thiruvanthapuram	Cassava and coconut based value added products, intercropping of tuber crops in coconut gardens
ICAR-DCR, Puttur	Research activities in plantation crops
ICAR-IIHR, Bangalore	Phytoplasma disease related studies, agricultural tools & machinery and horticultural IP related activities
ICAR-IISR, Kozhikode	Cropping system studies, phytopthora diseases in plantation crops
ICAR-NBAII, Bangalore	Biological control programmes
ICAR-NBAIM, Mau	Microbial research network
ICAR-NBPGR, New Delhi	Germplasm registration and exchange of PGR
ICAR-NRCOP, Pedavegi	Phytoplasma disease related studies and other common activities under Plantation Crops Sector. Tissue culture and biotechnological investigations.
ICAR-NRC for Orchids, Pakyong	Technology Mission for the development of North Eastern states
ICAR-SBI, Coimbatore	CPCRI is a constituent of the Regional Committee VIII (convened by the SBI)

Agricultural and traditional universities

Kannur University	HRD of personnel and other academic/ research activities
KAU, Thrissur	Plant genetic resources, breeding investigations and region specific agricultural extension activities
Mangalore University	HRD of personnel and other academic/ research activities
TNAU, Coimbatore	BPD under NAIP/ academic/ research activities
UAS, Bangalore	HRD of personnel and other academic/ research activities
UHS, Bagalkot	HRD of personnel and other academic/ research activities

Others

CDB, Kochi	Research and development in coconut
C-DAC	Development of acoustic detection for red palm weevil
DASD, Kozhikode	Research and development in arecanut
DBT, New Delhi	Advancements in Biotechnology and Bioinformatics
DCCD, Kochi	Research and development in cocoa
DIT, New Delhi	Bioinformatics programmes
DST, New Delhi	Molecular biology research and women empowerment programmes
JNSCASR, Bangalore	Development of nanomaterials as carriers of pesticides/ fungicides/ pheromones
NABARD	Developing/ demonstrating model coconut clusters in root (wilt) affected areas
KSCSTE, Thiruvananthapuram	Research in biotechnology, conservation of natural resources
PPV & FRA, New Delhi	DUS Centre on coconut
State Hort. Depts. Krishi Vigyan Kendras	Transfer of technology of mandate crops Demonstration / Technology evaluation trials

All India Coordinated Research Project (AICRP) on Palms

The All India Coordinated Research Project on Palms was commenced from 1972 with the objective of conducting location specific research in mandate crops. During the XII plan period, Arecanut crop has been included and at present the project included Coconut, Oil Palm, Arecanut and Palmyrah as mandate crops.

Major mandates of the AICRP on palms are as follows:

- To identify, conserve and utilize elite genetic resources for useful traits in palms from different agro-climatic regions and to evaluate performance of varieties/hybrids under different locations and to facilitate release of varieties/hybrids.
- To improve input use efficiency and develop location-specific palm based integrated farming systems to enhance the productivity per unit area, and organic cultivation packages for palms and palm based farming system.
- To evaluate bio-intensive insect - pest and disease management strategies, modeling and forecasting of disease incidence and documentation of insects pest dynamics in changing scenario of palm ecosystem.
- Development of post-harvest technologies in palmyrah and to demonstrate and Transfer of technologies to the farmers.

At present, the project is implemented in 28 centers with its headquarters at Kasaragod and, 15centers are conducting research on coconut, seven on oil palm, four on arecanut and two on palmyrah. The coordinating centers are located in 13 states and one union territory covering 13 SAU's, one Central Agricultural University and four ICAR institutes. Coconut centres are located at Aliyarnagar, Veppankulam (Tamil Nadu); Arsikere (Karnataka), Kasaragod and Pilicode (Kerala); Ambajipeta (Andhra Pradesh), Kahikuchi (Assam); Bhubaneshwar (Odisha); Navsari (Gujarat), Jagdalpur (Chhattisgarh); Ratnagiri (Maharashtra), Mondouri (West Bengal); Sabour (Bihar);Goa and Andaman and Nicobar island. Oil palm centres are located at Gangavathi (Karnataka), Mulde (Maharashtra), Vijayarai (Andhra Pradesh), Pattukottai (Tamil Nadu), Madhopur (Bihar), Pasighat (Arunachal Pradesh) and Pedavegi (Andhra Pradesh). Palmyrah centres are located at Pandirimamidi (Andhra Pradesh) and Killikulam (Tamil Nadu). Arecanut centres located in Shivamogga (Karnataka), Wakavalli (Maharashtra); Goa and Andaman and Nicobar Island. The detail profile of centers is mentioned below.

The budget for the year 2014-15 was ₹ 390 lakhs and the scheme is implemented through the respective state Agricultural/Horticultural Universities on 75:25

Sl. No.	Name of the Centre	Location of the centre	University/ICAR Institute
Coconut			
1.	Aliyarnagar	Coconut Research Station, Aliyarnagar - 642 101, Coimbatore District, Tamil Nadu	TNAU, Coimbatore, Tamil Nadu
2.	Ambajipeta	Horticultural Research Station, Ambajipeta -533 214, East Godavari District, Andhra Pradesh	Dr. YSRHU, Venkataramannagudem, Andhra Pradesh
3.	Andaman and Nicobar	Central Island Agricultural Research Institute, Port Blair- 744 101	CIARI, ICAR
4.	Arsikere	Horticultural Research Station, Arsikere - 573 103, Hassan District, Karnataka	UHS, Bagalkot, Karnataka

5.	Bhubaneshwar	Department of Horticulture, Bhubaneswar – 751 003, Odisha	OUAT, Bhubaneshwar, Odisha
6.	Goa	ICAR Research Complex for Goa, Ela, Old Goa, Distt. Goa-403402	ICAR
7.	Jagdalpur	Saheed Gundadhoor College of Agriculture & Research Station, Kumharawand Farm, Jagadalpur - 494 005, Chhattisgarh	IGKV, Raipur, Chhattisgarh
8.	Kahikuchi	Horticultural Research Station, Kahikuchi, Guwahati 781 017, Kamrup District	AAU, Jorhat, Assam
9.	Kasaragod	Central Plantation Crops Research Institute, Kasaragod 671 124.	CPCRI, ICAR
10.	Mondouri	Directorate of Research, P.O. Kalyani – 741 235, Nadia District, West Bengal	BCKV, Mohanpur, West Bengal
11.	Navsari	ASPEE College of Horticulture & Forestry, Navsari Agricultural University, Navsari – 396 450, Gujarat	NAU, Navsari, Gujarat
12.	Pilicode	Regional Agricultural Research Station, Pilicode P.O., Kasaragod – 670 353, Kerala	KAU, Thrissur, Kerala
13.	Ratnagiri	Regional Coconut Research Station, Bhatye - 421 612, Ratnagiri District, Maharashtra	Dr.BSKKV, Dapoli, Maharashtra
14	Sabour	Bihar Agricultural College, Sabour, Bhagalpur District – 813 210, Bihar	BAU, Sabour, Bihar
15	Veppankulam	Coconut Research Station, Veppankulam -614 906, Thanjavur District, Tamil Nadu	TNAU, Coimbatore, Tamil Nadu
Oil Palm			
16.	Gangavathi	Agricultural Research Station, Gangavathi-583 227, Koppal District, Karanataka	UHS, Bagalkot, Karnataka
17.	Madhopur	Regional Research Station, P.O. Madhopur – 845 454, Majhaulia Via., West Champaran Dist., Bihar	RAU, Pusa Samastipur, Bihar
18.	Mulde	Agricultural Research Station, Mulde - 416 520, Kudal Taluk, Sindhudurg District, Mharashtra	Dr. BSKKV, Dapoli, Maharashtra
19.	Pasighat	College of Horticulture & Forestry, Pasighat – 791 102, Arunachal Pradesh	CAU, Imphal
20.	Pattukkottai	Agricultural Research Station- Pattukkotai- 614 602, Thanjavur District, Tamil Nadu	TNAU, Coimbatore, Tamil Nadu
21.	Pedavagi	Indian Institute of Oil Palm Research. Near Jawahar Navodaya Vidyalaya, Pedavegi – 534	IIOPR, ICAR
22	Vijayarai	Horticultural Research Station, Vijayarai - 534 475, West Godavari District, Andhra Pradesh	Dr. YSRHU, Venkataramannagudem, Andhra Pradesh

Palmyrah			
23.	Killikulam	Agricultural College & Research Institute, Killikulam 628 252, Vallanad, Tuticorin Dist., Tamil Nadu	TNAU, Coimbatore, Tamil Nadu
24	Pandirimamidi	Horticultural Research Station, Pandirimamidi, Ramapachodavaram PO 533 288, East Godavari Dist., Andhra Pradesh.	Dr. YSRHU, Venkataramannagudem, Andhra Pradesh
Arecanut			
25	Andaman and Nicobar	Central Island Agricultural Research Institute, Port Blair- 744 101	CIARI, ICAR
26	Goa	ICAR Research Complex for Goa, Ela, Old Goa, Distt. Goa-403402	ICAR
27	Shivamogga	University of Agricultural & Horticultural Sciences, Navile, Shivamooga 577 225	UAHS, Shivamogga
28	Wakawali	Arecanut Research Station, Shriwardhan, Raigad Dt	Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli - 415 712, Ratnagiri District

basis, with 75% ICAR share and with 100% ICAR funding in the case of Central Agricultural University and ICAR Institutes.

RESEARCH ACHIEVEMENTS

COCONUT

Crop Improvement

Among the Tall x Tall hybrids evaluated under AICRP on Palms at Veppankulam centre, the hybrid LCT x CCNT was identified as superior for higher nut yield (161 nuts palm^{-1}year^{-1}), copra out turn (23.44 kg palm^{-1} year^{-1}) and vigorous growth habit. The identified hybrid gives more nut yield (28.47 %) when compared with the VHC- 2.

Crop Production

An experiment to identify the most suitable flower crop as intercrop in adult coconut garden was conducted at CRS, Aliyarnagar from 2011 to 2014. Five flower crops *viz.*, Chrysanthemum (*Dendranthema grandiflora*), Tuberose (*Polianthes tuberosa*), Marigold (*Tagetes erecta*), Zinnia (*Zinnia* sp.) and Gomphrena (*Gompherena globosa*) were grown as intercrops. Coconut + Marigold (*Tagetes erecta*) recorded a flower yield of 6,053 kg ha^{-1} and a net income of

A superior coconut hybrid - LCT x CCNT from Veppankulam

Rs.2,78,350/- ha^{-1} and B:C ratio of 2.77 followed by Coconut + Gomphrena (*Gomphrena globosa*) with a net income of Rs. 2,30,975/- ha^{-1} and B:C ratio of 2.53 with a flower yield of 5206 kg ha^{-1}. Considering the results of consecutive years it can be concluded that Marigold and Gomphrena can be grown as remunerative flower crops in adult coconut gardens as intercrops.

Gomphrena (*Gomphrena globosa*) as intercrop under coconut

In coconut based cropping system at Ratnagiri centre, maximum (126) nuts/palm were recorded in treatment T_2 (50%RDF + recycling biomass + bio fertilizer application + *in situ* green manuaring + vermiwash) which was at par with T_1 (75% RDF + recycling of biomass) i.e. 120 nuts palm^{-1}. Economic of the cropping system revealed that highest B: C ratio (5.08) was recorded in treatment T_1 following T_2 (3.90).

VTLCH – 2 cocoa clones

Intercropping of flowering crops in coconut revealed that the highest net return of Rs. 501,880/- ha^{-1} and benefit cost ratio of 5.07 was obtained in coconut + gerbera followed by coconut + tuberose (Rs. 363,790/- ha^{-1} and B: C= 4.10) in Kahikuchi (Assam).

Under screening of cocoa clones for their performance as a mixed crop in coconut gardens, six cocoa clones *viz* VTLCC – I, VTLCH – I, VTLCH – 2, VTLCH – 3, VTLCH – 4 and VTLC – 1 were evaluated. Among them, the clones *viz* VTLCH – 2 followed by VTLCH-4 were found to be better with 48 pods and 42 pods per tree, respectively. However, the crop is in bearing stage and yet to attain maturity stage.

Crop protection

Coconut slug caterpillar

During the roving surveys, low to medium incidence of coconut slug caterpillar *Macroplectra nararia* was observed in Polamuru, Nowduru, Marteru villages in West Godavari and in Vedireswaram village in East Godavari district in March 2015. A new larval parasitoid parasitising the slug caterpillar larva was collected from the coconut gardens and was identified as *Pediobius* sp. Good natural parsitisation by this parasitoid on the coconut slug caterpillar was observed in the coconut gardens.

Pediobius sp

Under *in vitro* screening of new fungicides, Tebuconazole and Hexaconazole showed complete inhibition of growth of *Ganoderma* species and *Thielaviopsis paradoxa* .Copper oxychloride, Mancozeb, Pyroclostrobin + Metiram, Metalaxyl + Mancozeb, Fenamidone + Mancozeb showed complete inhibition of growth of *Phytophthora palmivora*.

OIL PALM

In the evaluation of 10 new cross combinations of oil palm (NRCOP-1 to NRCOP-10) planted during 2007, the yield data at Gangavathi centre (Karnataka) during 2014-15 indicated that, the hybrid NRCOP- 4 recorded the significantly higher mean FFB yield (14.58 t ha^{-1}) over NRCOP-3 (10.55 t ha^{-1}) and NRCOP-8 (12.95 t ha^{-1}) and it was on par with remaining hybrids. In Vijayarai centre (Andhra Pradesh), NRCOP-4 recorded higher number of bunches per palm (12) with average bunch weight of 13.8 kg with an yield of 165.6 kg per palm per year (23.7 t ha^{-1}), followed by NRCOP-5 which recorded an yield of 19.7 t ha^{-1} with an average yield of 137.5 kg $palm^{-1}$ $year^{-1}$ during 2014-15.

Performance of NRCOP- 4 hybrid at Gangavathi

PALMYRAH

Germplasm collection

Germplasm survey conducted at Puri and Khurdha districts of Odisha by AICRP, Killikulam and Pandirimamidi centres, and a total of six accessions with distinct characters were collected for conservation.

Post harvest technology in Palmyrah

Inflorescence sap collected from palmyrah palms using CPCRI methodology (developed for coconut) and used for preparing RTS beverage, stored in glass bottles and PET bottles. It was observed that pH, TSS, total sugars and reducing sugars decreased during storage but under refrigerated condition there was no significant change without any preservative up to 10 hours. These beverages remained in acceptable condition for one day, but under freezing condition the sap could be stored up to 6 months.

Performance of Acc. OR – 14 – 03 in Odisha

23rd Annual Group meeting of AICRP on Palms held at DOR, Hyderabad from 25th to 28th July 2014

The 23rd Annual group meeting of All India Coordinated Research Project on Palms was organized from 25-28th July 2014 atI CAR-IIOR, Hyderabad. The meeting was inaugurated by Dr. N. K. Krishna Kumar, Deputy Director General (Horticulture Science), ICAR. The inaugural function was presided by Dr. B. M. C. Reddy, Vice Chancellor, Dr. YSRHU, Andhra Pradesh. Dr. P. Reithinam, Former Exec. Dir., APCC, Jakarta, Dr. K. U. K. Nampoothiri, Dr. MSRF, Regional Station, Jeypore, Odisha, Dr. Janakiram, ADG (Horticulture Science-I), Dr. K. S. Varaprasad, Project Directorate of DOR, Hyderabad graced the occasion. Besides, Dr. George V. Thomas, Director, CPCRI, Dr. Arualraj, Director DOPT, Dr. Prakash Patil, Project Coordinator (Fruits) (In-charge), Dr. Nirmal Babu, Project Coordinator of Spices, Head of the divisions of CPCRI, Scientists from different centers of AICRP and scientist from different ICAR institutes and personnel from more than 3 value added products of coconut industries were participated in the programme. A guest lecture on Date palm cultivation and *Trichoderma* as Bio-pesticide for management of soil borne fungal pathogens was also organized. There were seven technical sessions

Dr. N.K. Krishna Kumar, DDG (H.S.), ICAR, New Delhi inaugurating the AICRP (Palms) workshop at ICAR-IIOR, Hyderabad

organized during the group meeting, in which the respective programme leaders of the technical sessions of crop improvement, production, protection and post harvest programmes have presented the progress made during 2013-14.

Dr. N.K. Krishna Kumar, DDG, (Horticulture Science), ICAR, in his presidential address highlighted the emerging problems in plantation crops such as declined crop productivity and soil health management, lack of control measures for disease and pest, declining trend in innovative projects which address the bottlenecks in value addition in palms. He stressed specifically on exploitation of value added products in palms especially in the context of increase in demand of tender coconut water. The production of quality planting material of plantation crops particularly in coconut, areca nut and oil palm has to be taken up on large scale. Dr. BMC Reddy, Vice Chancellor, Dr. YSR Horticultural University, Andhra Pradesh, chief guest of the programme stressed upon popularizing value added products of coconut and palmyrah, and providing technology for introducing cocoa as intercrop in coconut and oil palm. Dr. H. P. Maheshwarappa, Project Coordinator (Palms) lucidly highlighted research findings of AICRP on Palms for 2013-14 and thrust areas of the project. Dr. P. Rethinam, Former Executive Director, APCC, Jakarta emphasized the need of developing short statured oil palm varieties for easy harvesting and mechanization of harvesting process. Dr. T. Janakiram, Assistant Director General, (Horticulture Science-I), ICAR, Dr. K. U. K. Nampoothiri, Director, Dr. MSSFR, Jeypore, Odisha and Dr. K. S. Varaprasad, Project Director, DOR, Hyderabad have participated in the discussions.

Release of publication during the AICRP (Palms) workshop at ICAR-IIOR, Hyderabad

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Training Manual

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Ongoing Projects 2014-15

Institute projects

Sl. No.	Proj. No.	Title of Project	Project Leader	Associate (s)
1	1000761028	Genetic resources management in coconut, arecanut and cocoa	V. Niral	K.S. Ananda, S. Elain Apshara, B. Augustine Jerard, K. Samsudeen, G.C. Acharya, A. K. Sit, N. R. Nagaraja, K.B. Hebbar, M. Senthil Amudhan, M. Chaithra, C. Thamban, Scientist from CARI, Andamans
2	1000761029	Genetical investigations and breeding in coconut, arecanut and cocoa	B. Augustine Jerard	K.S. Ananda, S. Elain Apshara, Regi Jacob Thomas, V. Niral, K. Samsudeen, M. Shareefa, G. C. Acharya, A. K. Sit, N. R. Nagaraj, Merin Babu, A. Josephrajkumar, S. Sendur Kumaran, CARI, Andamans
3	1000761031	Development of robust tissue culture techniques in coconut	Anitha Karun	M.K. Rajesh, KK Sajini
4	1000761030	Biotechnological applications in palms and cocoa	M.K.Rajesh	Anitha Karun, K.S. Ananda, K.Devakumar, Alpana Das, N. R. Nagaraja, Regi Jacob Thomas, M. Shareefa, S. Elain Aphsara, K.K. Sajini
5	1000763057	Cropping/farming approaches for improving soil health and system productivity in coconut, arecanut and cocoa	P. Subramanian	Ravi Bhat, V. Krishnakumar, H. P. Maheswarappa, Surekha, V. Selvamani, Alka Gupta, S. Sujatha, Jeena Mathew, K. Nihad, Murali Gopal, B. A. Jerard, A.C. Mathew, A.K. Sit
6	1000763058	Enhancing nutrient and water use efficiency for sustained productivity in coconut, arecanut and cocoa	Ravi Bhat	P. Subramanian, V. Krishnakumar, K. Nihad, V. Selvamani, Jeena Mathew, Sureka, Sujatha, Priya U.K., Alka Gupta, Merin Babu, Joseph Rajkumar, P. Anithakumari, A.K. Sit, G.C. Acharya, Alpana Das
7	1000763055	Bioresources management in coconut, arecanut and cocoa	Alka Gupta	Ravi Bhat, Murali Gopal, S. Sujatha, P. Subramanian, Priya U.K., Selvamani, Surekha

8	1000765039	Integrated approaches for management of fungal diseases of palms and cocoa	Vinayaka Hegde	M. Chaitra, V. H. Prathibha, Alpana Das
9	1000765040	Diagnostics and management of root (wilt) disease (RWD) in coconut and yellow leaf disease (YLD) in arecanut	Vinayaka Hegde	K.B. Hebbar, A. Joseph Rajkumar, V.K. Chaturvedi, Murali Gopal, Merin Babu, M. Chaithra, M. Alagar
10	1000765041	Integrated pest management in coconut, arecanut and cocoa	Chandrika Mohan	K. Subaharan, A. Joseph Rajkumar, P.S. Prathibha, Rajkumar, Alagar, G.C. Acharya, A.K. Sit, M. Chaithra, Elain Apshara, Sujithra
11	1000266014	Phenotyping for climate resilient adaptation and mitigation strategies	K.B. Hebbar	Arivalagan, V.K. Chaturvedi, Senthil Amudhan, Niral V., Sugatha P., Hareesh G.S., AICRP Scientists
12	1000767018	Mechanization of farm operations, post harvest processing for value addition and product diversification	M. R. Manikantan	K.B. Hebbar, M. Arivalagan, A.C. Mathew
13	1000767017	Developing machineries and gadgets for gender mainstreaming in palms and cocoa	A. C. Mathew	M. R. Manikantan
14	1000767016	Development of pilot level process and technology for the production of health foods from coconut milk residue and VCO cake	M.R. Manikantan	A. C. Mathew, M. Arivalagan
15	1000769019	Development of statistical and computational techniques for improving research methodology	C.T. Jose	K. Muralidharan, K.P. Chandran, D. Jaganathan, S. Jayasekhar, M.K. Rajesh
16	1000769020	Technology transfer and co-learning action research approaches	C. Thamban	K. Muralidharan, S. Kalavathi, P. Anithakumari, K.P. Chandran, C. T. Jose, S. Jayasekhar, D. Jaganathan, M. Alagar, Rajkumar, V.H. Pratibha, P. Subramanian, V. Selvamani, K. Nihad, P. Muralidharan
17	1000769013	Socio-economic dimensions and value chain dynamics in policy perspective	Jayasekhar S	K.P. Chandran, C.T. Jose, K. Muralidharan, C. Thamban

Externally funded projects

Sl. No.	Proj. No.:	Title of Project	Project Leader	Associate (s)
1	2010760004	Seed production in coconut, arecanut, cocoa	K. Samsudeen	K. S. Ananda, V. Niral, B. Augustine Jerard, S. Elain Apshara, Regi Jacob Thomas, M. Shareefa, Merin Babu, V. Hegde
2	1050761086	DUS centre for coconut	George V. Thomas	V. Niral, K. Samsudeen
3	1050231012	Development of a database for plantation crops for biologists (DBT)	George V. Thomas	Anitha Karun, M.K. Rajesh, K. Devakumar
4	1050761091	Molecular docking and 3-D QSAR studies to evaluate the mechanism of antimicrobial action of fatty acids from virgin coconut oil and monolaurin	M.K. Rajesh	
5	1050761087	Generation and analysis of Expressed sequence tags (ESTs) with reference to root (wilt) disease of coconut	M. Shareefa	Regi Jacob Thomas, M.K. Rajesh
6	1050231019	Horticulture mission for North-East and Himalayan States	G. C. Acharya	
7	2010760009	Outreach project on *Phytophthora, Fusarium* and *Ralstonia* diseases of horticultural and field crops (*Phytophthora* diseases of coconut and cocoa)	Vinayaka Hegde	
8	1050761089	Phytoplasma diseases of coconut and arecanut: development of molecular diagnostics	Vinayaka Hegde	M. K. Rajesh
9	1050761088	Refinement of production technology of green muscardine fungus and participatory field validation of integrated biocontrol technology against rhinoceros beetle of coconut	Chandrika Mohan	P. Anithakumari

10	1050761084	Studies on Development and Management of Water Conservation Measures to Augment Water Availability of Surangams -a Unique and Traditional Method of Harnessing Ground Water in Rural Areas of North Kerala and South Karnataka	A. C. Mathew	C. Thamban
11	1050761093	Area Wide Community Approach for integrated management of RPW of coconut using GPS as decision support and evaluation tools	P. Anithakumari	Joseph Rajkumar, Chandran K.P., Merin Babu
12	1050761092	Community based bio-resource management for sustaining production and livelihood security under coconut based farming systems	S. Kalavathi	Merin Babu, Jeena Mathew
13	1050233003	Farmers' Participatory Research cum Demonstration Plots on Arecanut Based Cropping System	D. Jaganathan	C. T. Jose, Nagaraja, N. R., M. Alagar, Rajkumar
14	2010761091	Business Planning and Development Unit, CPCRI, Kasaragod	K. Muralidharan	A.C. Mathew, S. Jayasekhar

Consultancy, Patents, Commercialisation of Technology

Consultancy services

Various consultancy services and contract research projects were taken up as part of the Professional Service Functions of the institute during 2014-15 as per the following details.

Patent filed

A Patent application titled "Coco Sap Chiller" by Dr. K.B. Hebbar, Head, Division of PB&PHT was filed on 21-08-2014 vide: 4077/CHE/2014. This device helps for fresh and hygienic collection of neera from coconut palm in unfermented condition.

Sl.No.	Consultancy service	Client	Amount (₹)
1	Micronutrient analysis of soil samples	Asst. Director of Agriculture, Kasaragod	3,125.00
2	Nutrient analysis of rock phosphate fertilizer	Kerala State Co-op Marketing Federation Ltd., P.B.No. 2024, Gandhi Nagar, Cochin – 682 020	2,500.00
3	Nutrient analysis of soil sample	Jacob D. Mathew, Danavunkal House, P.O. Padre, Via. Perla, Kasaragod	2,500.00
4	Nutrient analysis of Vermicompost	Vincent Sequeira, St. Joseph's Seminary , Kankanady P.O, Jeppu, Mangalore – 575002	10,000.00
5	Nutrient analysis of fish meal	Star Agro Industries, Palli Road, Cherkala	1,250.00
6	Nutrient analysis of fish meal & neem cake	Kairali Biotreat, Mogral Puttur, Kasaragod	2,500.00
7	Analysis of fatty acid and minerals	Prof.M.Rajashekar, P.I., BRNS Research Project Mangalore University Manasagangothri	22,500.00
8	Nutrient analysis of organic manure	Arman Organic manure and Fisharies, Anandapuram, Kannur, Kumbla	1,250.00
9	Nutrient analysis of organic manure	Thejaswini coconut producers organization, Kannur	1,250.00
10	Nutrient analysis of organic manure	Malabar Agro Inustries, Seethangoli, Kasaragod	1,250.00
11	Nutrient analysis of neem cake and organic manure	Agricultural Officer, Krishi Bhavan, Enmakaje, Perla	2,500.00
12	Nutrient analysis of Soil sample	Anitha Narayan, Kalappamayam, Panathoor P O, Rajapuram	1,250.00
13	Consultancy visit for pest and disease advisory service in arecanut(Dr. D. Jaganathan & Dr. Nagaraja, N. R.)	Kalasa Estate, Kalasa, Chickamagalore Dt., Karnataka on 08-08-2014	3,000.00

14	Consultancy visit for pest and disease advisory service in arecanut (Dr. Nagaraja, N. R.)	ABC Group of Estate (Theerthagundi, Halsur, Devadarshini, Elephant & Kundregundi Estates), Koppa (Tk.) and Mudigere, Chickamagalore (Dt.), Karnataka during 1st – 2nd October, 2014	3,000.00
		TOTAL	**57,875.00**

Contract research

Sl.No.	Consultancy service	Client	Amount (₹)
1.	Evaluation of Integrated Water Management Programme	State Level Nodal Agency (IWMP), Rural Development Department, Thiruvananthapuram	2,29,454.00
2	Evaluation of watershed works under IWMP	Kerala State Rural Development Department	1,83,160.00
		Total	**4,12,614.00**

Sale of planting materials and other technology products

During the year, planting materials and other items were sold through ATIC as per the following details.

Sl.No.	Item	Qty/No	Amt (₹)
1	Books	419	18,036
2	CD ROMs	14	3,060
3	Earthworms	18800	14,891
4	Mushroom (kg)	6.150	271
5	Mushroom spawn (kg)	5.75	407
6	Vermicopost (kg)	10541	69,890
7	Vermiwash (Bottle)	1	110
8	Coconuts	46966	7,51,712
9	Areca seed nuts	104	572
10	Arecanut seedlings	22902	2,25,828
11	Coconut seed nuts	1570	44,540
12	Coconut seedlings (Cultivars)	23202	9,30,813
13	Coconut Seedlings (Hybrids)	12185	10,08,930
14	Coconut Seedlings (Dwarfs)	14252	7,34,394
15	Coconut seednuts (Dwarf)	753	15,060
16	OP/Variety polybag seedlings	807	41,272
17	Dwarf polybag seedlings	285	17,864
18	Hybrid polybag seedlings	32	2,641

19	Kera Probio	91	2,499
20	Cocoa Probio	7	193
21	Black pepper cuttings	1535	12,280
22	Bey Leaf air layer + Leaf	4331	1,13,620
23	Cinnamon air layer	229	3,435
		TOTAL	**40,12,318**

Technology commercialization

During the period, nine technologies were commercialized through non-exclusive technology transfer agreement.

Exchange of MoA on technology licensing of machinery

Exchange of MoA on technology licensing of production of virgin coconut oil

Sl. No.	Technology transferred	Licensee	Technology Transfer Fee (₹)
1	Virgin coconut oil (VCO) by hot process	Smt. ShanthiSivashanmugam, Kaniyur Village, Sulur Taluk, Tamil Nadu	25,000
		Vaiga virgin oil company, Shri Balakrishnan, Ullodi House, Ullodi P.O, Kumbla, Kerala	25,000
		Secretary, Vadakara Taluk Primary Cooperative Society, Kakkatil, Vadakara	25,000
		Palm Planet Private Limited, Flat no 101, H no 7-62-362 and 363, Prasanthi Hills Colony, Khajaguda, Hyderabad. 500008	25,000
2	Virgin Coconut Oil (VCO) by fermentation	KCK Agro Products, Malappuram	25,000

3	Collection of fresh and hygienic neera and production of natural coconut sugar	Shri M. Dhanabal, 8/1F, Sethumadai Road, AnaimalaiPost,Pollachi Taluk, Coimbatore district,Tamil Nadu – 642104.	10,000
		Shri K. Mohandas, DakshinaKannada	10,000
		President,Nemom Block Federation of Coconut Producers Societies, Oottyyarathal, Thalayal, Aralummoodu P.O. Thiruvananthapuram, Kerala	10,000
		Thejaswiri coconut farmer producer company. Kannur	10,000
		Ashok Kumar, Chamarajanagar, Kamataka	10,000
		Managing Director, Kerala State Coconut Development Corporation, Elathur, Kozhikode	10,000
		Deejay Farms, St. Patrick's Complex, Brigade Road, Bangalore	10,000
		President, Kunnamangalam federation of coconut producing society	10,000
		KeraJyothiCoconut Fedaration	10,000
		KathiparaCoconut Industry	10,000
		Senthil Seeds Private Ltd, 73, Karur Main Road, Kolathupalayam .P.O, Dharapuram Taluk, Tirupur, Pin – 638661	10,000
		Palm Planet Private Limited, Flat no 101, H no 7-62-362 and 363, Prasanthi Hills Colony, Khajaguda, Hyderabad. 500008	10,000
4	Coconut zygotic embryo culture	DeeJay Consultancy Services, Salauli Village, Sanguem (Taluka), GOA	70,000
5	Arecanut tissue culture	M/s Sunglow Biotech, Perur P.O. Coimbatore	25,000
6	Desiccated coconut powder	Shri M.A. Harris, Mulleria house, Mulleria P.O., Kasaragod-671543	2,000
7	Coconut chips	M/S Malikdinar exports	10,000
		Palm Planet Private Limited, Flat no 101, H no 7-62-362 and 363, Prasanthi Hills Colony, Khajaguda, Hyderabad. 500008	10,000
8	Shell fired copra dryer design	Shri V. Appu, Palakkad	5,000
9	Tender coconut punch and cutter design	Shri M.S.Ganesh Kumar, 50-184-D, Arora Nagar, B-Camp, Kurnool town, Andhra Pradesh – 518002	2,000
		Total	**3,69,000**

RAC, IRC, IMC with Significant Decisions

Research Advisory Committee meeting

The 17th meeting of Research Advisory Committee was held at CPCRI, Kasaragod on 11th February 2015 and the following were present:

Dr. S. Edison,	Chairman
Dr. Brahma Singh	Member
Dr. V.S. Korikantimath	Member
Dr. S. Arulraj	Member
Dr. Subhash Narayanan	Member
Dr. P. Chowdappa	Member
Dr. Anitha Karun	Member Secretary

Release of extension folder during RAC meeting

An interactive meeting with Head of the Divisions and Heads of regional stations and members of the RAC was held in the committee room at 10.00 AM to address the target oriented issues and to sensitize the concerned scientists involved in implementation. This was followed by the RAC meeting at 11.45 AM. RAC suggested to update the ATR every three months and communicate to the Chairman and the Members. It was suggested to include all the stakeholders to finalize any policy document pertaining to mandate crops so that the strategies are acceptable to all States. The Chairman, RAC and members have complimented the Director and the Scientists of the Institute for the significant contributions made in different research programmes and the quality of publications in high impact factor Journals.

Institute Research Committee meeting

The 43rd Annual Institute Research Committee Meeting of the ICAR- Central Plantation Crops Research Institute was held at CPCRI Kasaragod from 23rd to 26th February, 2015. The progress of research programmes and achievements under the ongoing projects were presented by the respective Principal Investigators. During the meeting, all the ongoing research projects (including externally funded projects) grouped under eight research programmes were discussed in detail and the technical programme for the year 2015-16 was finalized.

Dr. P. Chowdappa, Director, ICAR-CPCRI addressing the plenary session of IRC meeting

Institute Management Committee Meeting

Institute Management Committee (IMC) meetings were held twice on 16-01-2015 and 27-03-2015 at CPCRI, Kasaragod. Dr. P. Chowdappa, Director, CPCRI chaired both the meetings, in which important decisions on research and development of the Institute were taken.

Participation of Scientists in Conferences, Meetings, Workshops, Symposia etc. in India and Abroad

Abroad

Chandrika Mohan, Principal Scientist (Ag. Entomology), CPCRI, RS, Kayamkulam participated in the Regional Expert Consultation Workshop on mite management of coconut in SAARC countries at Dhaka, Bangladesh during 10-11 August 2014.

Regi Jacob Thomas, Sr. Scientist (Hort.) and Nihad K., Scientist (Hort.), CPCRI, RS, Kayamkulam participated in the *International Horticulture Congress*, Brisbane, Australia 17-22nd August, 2014.

P. Subramanian, Principal Scientist (Agronomy) participated in the International symposium on organic coconut farming on 28th November, 2014, held at Coconut Research Institute, Lunuvila, Sri Lanka.

Within India

Name & Designation	Title of the programme	Place & Duration
Dr. P. Chowdappa, Director	Asian Solanaceous Round Table Conference	IIHR, Bangalore 09-09-2014 to 10-09-2014
	22nd Group Meeting of AICRP MAP & BV	Bangalore 19-09-2014 to 20-09-2014
Dr. George V. Thomas, Director, Dr. K.S. Ananda and Dr. Ravi Bhat, Heads, Dr. G.C. Acharya, Sr. Scientist , Dr. D. Jaganathan, Scientist	National Seminar on 'Plant Protection and Intercropping in arecanut'	Shimoga 09-05-2014 to 10-05-2014
Dr. Anitha Karun, Dr. Vinayaka Hedge, Dr. Ravi Bhat, Dr.V.Krishnakumar, Heads, Dr. Maheswarappa H.P., Project Coordinator (Palms), Dr. P. Anithakumari, Dr. V. Niral, Dr. B.A. Jerard, Dr. C. Thamban, Dr. P. Subramanian, Dr. A.C. Mathew, Principal Scientists, Dr. M. R. Manikantan, Dr. M.K. Rajesh, Dr. K.P. Chandran, Senior Scientists, Shri S. Jayasekhar, Dr. V.H. Pratibha, Dr. V. Selvamani, Shri M. Arivalagan, Scientists and Shri P. Raveendran, Technical Officer	PLACROSYM XXI - International Symposium on Plantation Crops	Kozhikode 10-12-2014 to 12-12-2014
K. B. Hebbar, Dr. Anitha Karun, Dr. Ravi Bhat, Dr. Vinayaka Hegde, Heads, Dr. K. Muralidharan, Dr. V. Niral, Dr. B.A. Jerard, Dr. K. Samsudeen, Principal Scientists, Dr. M.K. Rajesh, Dr. K.P. Chandran, Dr. Alpana Das, Sr. Scientist, M. Arivalagan, Dr. Nagaraja, N. R., Scientists, Dr. Neema Mohammed and Dr. K.K. Sajini, CTO and Dr. K.S. Muralikrishna, Technical Asst.	National Seminar on 'New Horizons and Challenges in Biotechnology & Bioinformatics'	Kasaragod 09-10-2014 to 10-10-2014

Dr. Maheswarappa H.P., Project Coordinator (Palms)	National Symposium on "Agricultural Diversification for Sustainable Livelihood and Environmental Security	PAU Ludhiana 18-11-2014 to 19-11-2014
Dr. V. Krishnakumar, Head and Dr. Regi Jacob Thomas, Senior Scientist	National Workshop on "Planting material production in coconut- Issues and Strategies"	ICAR-CPCRI, Kasaragod on 10-02-2015
Dr. Chandrika Mohan, Principal Scientist Dr. A. Joseph Rajkumar, Sr. Scientist	International conference - Innovative Insect Management Approaches for Sustainable Agro Eco System (IIMASAE)	Agricultural College & Research Institute, (TNAU), Madurai during January 27-30, 2015
Dr. Chandrika Mohan, Principal Scientist	National Conference on "Advances in Entomological Research *ADVENTOR 2015*" and delivered an invited paper on "*Invasive pests and biosecurity threats in Indian Agriculture*".	University of Calicut, March 20, 2015
Dr. Chandrika Mohan Principal Scientist	23rd Annual Group meeting of AICRP on Biological Control of Crop Pests	OUAT, Bhubaneswar 27-06-2014 to 28-06-2014
Dr. S. Kalavathi, Principal Scientist	State level seminar on "Watershed management for sustainability organized by Kerala State Land Use Board	Alappuzha 19-09-2014
Dr. P. Anithakumari, Principal Scientist	National Workshop on Wireless sensors and robotics for Agriculture and Rural Development	State Planning Board, Trivandrum during March 17-18, 2015
Dr. P. Anithakumari Principal Scientist	Workshop on Women empowerment against sexual harassment at workplaces	Kaloor, Kochi 23-04-2014
Dr. P. Anithakumari, Principal Scientist and Dr. D. Jaganathan, Scientist	7th National Extension Education Congress (NEEC) – 2014	ICAR research complex for NEH region, Barapani, Meghalaya 08-11-2014 to 12-11-2014
Dr. A.C. Mathew, Principal Scientist and Shri H. Muralikrishna, ACTO (TIO)	Agr-IP 2014	IIHR, Bangalore 10-10-2014 to 11-10-2014
M. R. Manikantan, Senior Scientist	International conference on Agribusiness Management- Opportunities and challenges	Mangalore 09-10-2014 to 11-10-2014

Dr. T.S. Manojkumar, Programme Coordinator, KVK and Dr. S. Leena, SMS, KVK, Kasaragod	International conference on Organic Livelihoods, which is part of the event, BIOFACH India together with India Organic 2014	Angamaly, Cochin 06-11-2014 to 07-11-2014
Dr. A.K. Sit, Sr. Scientist	International Conference on Horticulture for Nutritional, Livelihood and Environment Security in Hills: Opportunity and Challenges	UBKV, Kalimpong 22-05-2014 to 24-05-2014
Shri R. Sanalkumar, SMS, KVK, Kasaragod	Workshop on Organic farming in Kerala – Lessons from Organic Kasaragod	KAU, Thrissur 27-11-2014

Workshop, Seminar, Summer Institute, Farmers Day organized at the Institute

Seminar on 'Sustainability of Coconut, Arecanut and Cocoa farming-Technological advances and way forward'

A National Seminar on 'Sustainability of Coconut, Arecanut and Cocoa farming - Technological Advances and way forward' was held during 22-23 August 2014 at CPCRI, Kasaragod. Mr. T.K Jose IAS, Chairman of Coconut Development Board, Kochi, in his inaugural address appreciated the former Directors of CPCRI for playing pivotal role in shaping agricultural scenario in the sector. He opined that sustainability of agricultural crops depends on a large extent on technological advances and the new talent pool entering into agricultural research system. Dr. K. V. Ahmed Bavappa, formerly Director, CPCRI in his presidential address highlighted the importance of transition to organic farming and expressed his concern on fluctuation in prices of coconut and arecanut. Guests of Honour Dr. K.V. Peter, formerly Vice Chancellor of Kerala Agricultural University, Dr. P. Rethinam, formerly Executive Director of APCC, Jakarta, Dr. K.U.K. Nampoothiri, formerly Director, CPCRI also felicitated. The programme witnessed release of nine publications from the Institute. A Biofertilizer formulation – 'KerAM' enriched with arbuscularmycorrhizae was also released during the occasion. This was followed by a key note address by Dr. N. M. Nair, formerly Director, CPCRI wherein he focused on the technological advancements in mandate crops. Dr. George V. Thomas, Director, CPCRI delivered a special lecture and was felicitated by the scientists in view of his superannuation from ICAR service on 31-08-2014. There were six technical sessions during the conference *viz.*, Plant genetic resources and biotechnological approaches, Production system management, Climate resilience, Plant health management, Value addition, product diversification and mechanisation and Technology dissemination, development and marketing. During each session there were plenary lectures by experts followed by panel discussion. During the two day seminar, more than 40 research papers were presented by scientists from ICAR institutes and Agricultural / Horticultural Universities on various topics. On 23rd August, the plenary session was held in which awards for best posters were distributed.

Brainstorming session on somatic embryogenesis and use of bioreactors

A brainstorming on the "somatic embryogenesis and use of bioreactors" was organized at CPCRI, Kasaragod on 02-08-2014. Dr. T. Janakiram, ADG (Hort. Science- I), in his inaugural address lauded the efforts made by the Institute for developing coconut embryo culture technique, which has received international acclaim from Bioversity International. In his presidential address, Dr. George V. Thomas, Director, CPCRI, stressed the role of Biotechnology as a solution to tackle the limitations of conventional methods. Shri Sugata Ghosh, CCDO, CDB, in his felicitations, emphasized that the current multiplication rate of 1:1 ratio (one seed to one palm) in coconut should be modified to at least 1:20 using rapid multiplication protocols without compromising on the quality, to meet the demand of 10 million quality planting materials of coconut per year, of which only

Shri T.K. Jose, IAS, Chairman, CDB inaugurating the seminar on Sustainability of Coconut, Arecanut and Cocoa farming-Technological advances and way forward

3-3.5 million could be met by conventional techniques. There were presentations by biotechnologists from renowned institutions in the sector. Dr. Anitha Karun, CPCRI, briefed the current status of plumule culture in coconut. The following important recommendations were emerged during the Brainstorming:

- An idea of a network project, in collaboration with various Institutes working with *in vitro* recalcitrant species, was mooted.
- Tissue culture protocol to be developed for a single variety in coconut initially and the results could be extrapolated for other cultivars.
- Efforts need to be made in obtaining financial assistance from government agencies apart from ICAR and CDB.

Brainstorming session on "Fine tuning of management package for root (wilt) disease of coconut for plant health and productivity"

Brainstorming on "Fine tuning of management package for root (wilt) disease of coconut for plant health and productivity" was conducted at CPCRI, RS, Kayamkulam on 05-08-2014. In his inaugural address, Dr. George V. Thomas, Director, CPCRI and Chairman highlighted the need to motivate farmers to adopt management strategies for combating root (wilt) disease for improving productivity. He emphasized the need to relook the integrated management of root (wilt) disease taking into account the advancements made in research front and the feedback and suggestions from the extension agencies. He presented an overview of the research highlights made by the Institute in root (wilt) disease management. Scientists from CPCRI, Kerala Agricultural University, officials from State Department of Agriculture and Agricultural Technology Management Agency participated in the programme. A total of 30 participants attended the brainstorming session.

Deliberations were held on the present package of practices recommended by CPCRI and Kerala Agricultural University for the management of root (wilt) disease. Newer technologies developed for the production of healthy coconut seedlings, management of the leaf rot disease as well as other pests and diseases were discussed and it was decided to incorporate such technologies for recommendation.

International Conference on Horticulture

An International Conference on Horticulture for Nutritional, Livelihood and Environment Security in Hills: Opportunity and Challenges was co-organized by CPCRI, RC, Mohitnagar with UBKV from 22-24 May, 2014 at UBKV (Hill Campus), Kalimpong, Darjeeling, West Bengal.

Review of research programmes at RS, Kayamkulam

Dr. S. Edison, RAC chairman, visited CPCRI, RS, Kayamkulam during 3-4 June, 2014 and reviewed the research advancements about root (wilt) disease of coconut. He was impressed by the root (wilt) disease resistant/ tolerant coconut varieties *viz*., Kalparaksha, Kalpasree and Kalpasankara developed at the Station as well as the integrated package evolved for the management of the disease. Indirect DAC ELISA as diagnostic techniques for the detection of RWD using leaf bits was appreciated by him. He complimented the scientists for the IPM technologies developed and farmer-participatory area-wide suppression of key pests of coconut. Dr. George V. Thomas, Director, CPCRI was present during the review meeting.

Dr. George V. Thomas, Director briefing breeding programme to Dr. S. Edison in the Kalparaksha experimental plot at CPCRI Regional Station, Kayamkulam

ICAR Short Course on planting material production

An ICAR sponsored ten days short course on "Advances in production of quality planting materials in plantation crops" was conducted at ICAR-CPCRI, Regional Station, Kayamkulam from 18th to 27th November 2014. The short course was inaugurated by Dr. George V. Thomas, formerly Director, ICAR-CPCRI. Dr. J. Thomas, Director-Research, Indian Cardamom

Dr. P. Chowdappa, Director along with participants of Short Course at CPCRI Regional Station, Kayamkulam

Shri Konkodi Padmanabha, President, CAMPCO inaugurating the Stakeholder's Meeting in presence of Dr. P. Chowdappa, Director, ICAR-CPCRI and Dr. Homey Cheriyan, Director, DASD

Research Institute, Myladumpara delivered the key note address during the valedictory function. The short course was attended by 18 participants from various research institutes (Rubber Research Institute of India, Central Coffee Research Institute, Central Plantation Crops Research Institute), Agricultural Universities and Krishi Vigyan Kendras. A field trip was arranged on 21st November 2014 to different nurseries engaged in production of planting materials of plantation crops. Dr. P. Chowdappa, Director, ICAR-CPCRI, while addressing the participants, highlighted the importance of plant quarantine in production of quality planting material in plantation crops.

Stakeholders meeting on enhancing productivity and value addition in arecanut

A Stakeholders Meeting on 'Enhancing productivity and value addition in arecanut' was organized at ICAR-CPCRI, Regional Station, Vittal, Karnataka on 29-10-2014. More than 200 stakeholders representing farmers, scientists from ICAR-CPCRI, UAHS, Shimoga and KVKs, Officials from Department of Horticulture, CAMPCO, ARDF, Shree Kshetra Dharmasthala GramaabivridhiYojana, Cadbury India Pvt. Ltd., MAMCOs, Shimoga and AGRIMART, Puttur and Media personnel participated to formulate strategies for enhancing the productivity and value addition in arecanut.

Dr. P. Chowdappa, Director, ICAR-CPCRI, Kasaragod presided over the function. During the presidential address he highlighted the importance of fruit rot and yellow leaf disease management and mechanization in arecanut for enhancing the productivity. He also emphasized the need for value added products from arecanut *viz.,* soft drinks, soap, toothpaste etc. Shri Konkodi Padmanabha, President, CAMPCO, Mangalore had inaugurated the Stakeholders Meeting. During his inaugural address, he urged the ICAR-CPCRI scientists to take up research to enhance the effectiveness of Bordeaux mixture for the management of fruit rot disease. He also emphasized the importance of processing and value addition in arecanut to enhance the profitability. Dr. Homey Cheriyan, Director, Directorate of Arecanut and Spices Development, Calicut was the Chief Guest and he emphasised that farmers need to adopt multispecies cropping system to increase productivity and profitability from unit area.

Dr. H. P. Maheswarappa, Project Coordinator (Palms), ICAR-CPCRI, Kasaragod had urged the Department of Horticulture and KVKs to have strong linkage with ICAR-CPCRI and other research institutes for serving the farmers with better technologies. Mr. Manchi Srinivasa Achar, President, All India Arecanut Growers Association, Puttur demanded for more field oriented programmes and appreciated the efforts of ICAR-CPCRI. Mr. P. N. Shashidhara, Director, MAMCOS, Shimoga emphasized the importance of dwarf varieties and hybrids, value addition and mechanization for increasing the productivity. Mr. Shree Padre, Farm Journalist, Adike Patrike, Puttur had pointed out different problems faced by farmers in arecanut cultivation *viz.,* attack of wild animals, fruit rot and yellow leaf disease. He also emphasized the importance of mechanization and value addition in arecanut. Mr. Shankara Bhat, Progressive farmer, had thrown light on different value added products prepared from arecanut. Dr. D. C. Chowta, Progressive farmer, highlighted the importance of cropping system approach to increase the productivity and profitability from unit area.

Stakeholders meeting on Edava Long Fibre Coconut

Stakeholders meeting was held at Edava on 20-11-2014 with regard to registering Edava Long Fibre

Coconut (ELFC) and applying for Genome Saviour Award by the ELFC community. Dr. P.Chowdappa, Director, ICAR-CPCRI, Dr. V. Krishnakumar, Head, ICAR-CPCRI, Mr. Balik, President,Edava Grama Panchayath, Dr. Anitha Karun, Dr. V. Niral, Dr. K. Samsudeen, Dr. P. Anithakumari, Community members, Extension officials participated in the meeting. Dr. P. Chowdappa, Director emphasized the need to popularize this variety for making coir industry more vibrant.

Dr. P. Chowdappa, Director addressing the farmers at Edava

Dream Big – Kalpa 2015

An institute - industry interface meet "DREAM BIG – KALPA2015" was held at CPCRI Kasaragod on 31st January 2015 at 10:30 AM to mark "ICAR Technology Day". Shri M.J. Shetty, President, Kanara Small Industries Association (KSIA), Mangalore inaugurated the programme and told how R&D along with entrepreneurs lead national development. Shri Shetty depicted himself as a witness for success of a farmer as an entrepreneur, the youth in agriculture having plenty of scope in industry as well as tremendous opportunity for employment in agro-industry. Dr. P. Chowdappa, Director, CPCRI in his presidential address expressed the importance of industries to take the technologies to the common man. ShriRammohanPaiMaroor, Vice President, Kanara Chamber of Commerce & Industries Shri Martin Chacko, Asst. Director, MSME, Sri Samuel, Manager, District Industries Centre, Shri Jyotish Jagannath AGM, NABARD offered felicitations.

Technology transfer of machinery for virgin coconut oil production, coconut chips making as well as for collection of fresh and unfermented neera were made

Dr. P. Chowdappa, Director and Shri M.J. Shetty, President, KSIA handing over Coco Sap Chiller to entrepreneur from Kunnamangalam

to the tune of Rs. two lakhs through MoUs. A booklet on "Entrepreneur and Farmer Friendly Technologies" was also released during the programme. Two hundred people took part in the programme. An exhibition on technologies with colour charts and specimen was arranged.

National Workshop on Planting material production in coconut-Issues and Strategies

ICAR-CPCRI organized a National Workshop on 'Planting Material Production in Coconut -Issues and Strategies' on 10th February 2015 at Kasaragod. Dr. P. Rethinam, former Director, APCC chaired the workshop. Delegates from Kerala, Tamil Nadu, Karnataka, Andhra Pradesh, Maharashtra, Gujarat, Odisha, Assam, West Bengal representing various stake holders like research workers, Development agencies, Farmer organizations, NGOs and progressive farmers attended the workshop. Dr. Chowdappa, Director, CPCRI, presided over the plenary session. Dr. Anitha Karun and Dr. Samsudeen K., presented on 'Biotechnological tools for quality planting material' and 'coconut planting material production - national scenario' respectively. The workshop deliberated on issues like improving the availability of quality planting material, decentralized participatory production of planting material, accreditation and certification process for maintaining seedling / seed nut quality and recommended steps to be taken.

Distinguished Visitors

Dr. N.K. Krishna Kumar, DDG (Hort. Sci.), ICAR, visited RC Kahikuchi on 06-04-2014

Dr. S.K. Malhotra, ADG (Hort) ICAR, & Commissioner (Hort), DAC visited RC Kahikuchi on 15-06-2014

Dr. S.K. Chakrabarti, Director, CTCRI, Thiruvananthapuram visited CPCRI Kasaragod on 11th September 2014.

Governor of Kerala visit

Her Excellency Smt. Sheila Dikshit, Governor of Kerala visited Central Plantation Crops Research Institute, Kasaragod on 18-07-2014. She visited the field and laboratories of Institute and was briefed on the latest achievements and innovations made in the Institute. She was impressed by the ongoing activities and appreciated the technologies developed by CPCRI especially, neera collection protocol, snow ball tendernut, coconut chips, virgin coconut oil, varieties and hybrids developed, production technologies, vermicomposting and tissue culture. Dr. George V. Thomas, Director made a presentation on the history, organization, technological advancements of the institute so far.

Smt. Sheila Dikshit, Her Excellency Hon'ble Governor of Kerala is being explained by Dr. George V. Thomas, Director on hygienic neera collection

Nursery Accreditation Committee visits

The team constituted by the National Horticultural Board (NHB) visited the coconut nursery at CPCRI, Kasaragod and Regional Station, Kayamkulam respectively on 27-8-2014 and 30-08-2014 to assess and grade the nursery under the scheme on accreditation of horticultural nurseries.

The team visit to RS, Kayamkulam was headed by Dr. B.K. Karkara, Retired Professor, Y.S. Parmar University of Horticulture & Forestry, Solan, Himachal Pradesh. The team visited the station and inspected the nursery beds, infrastructure facilities and mother palms for the production of quality planting materials in coconut for the root (wilt) endemic areas.

Visit of APCC members

Members of Technical Working Committee of Asia Pacific Coconut Community (APCC) under the leadership of Mr. Uron N. Salum, Executive Director visited ICAR-CPCRI, Kasaragod on 06-02-2015. The team visited various experimental plots and held discussion with scientists on the ongoing research programmes of CPCRI. The team also visited International Coconut Gene Bank (South Asia) maintained at Research Centre, Kidu and held discussion with scope for collaboration for research on coconut germplasm conservation. The visiting team consisted of Dr Wayne Myrie (Jamica), Dr. Alexia Prades (France), Dr. Francis Hackman Kwasi Asiedu (Trinidad & Tobago), Mr. Matias Urrutigoity (Swizerland), Mr. Raymond Fitzgerald Trotz (Guyana), Mr. Anthony George Ho Sang (Jamica), Mr. Tevita Kete (Fiji), Dr. Ponciano A. Batugal (Philippines), Mr. Alan Aku (Papua New Guinea), Mr.Uron N. Salum, Executive Director (Papua New Guinea).

Managerial Personnel

Sl. No.	Name	Designation
1	Dr. George V. Thomas	Director (up to 31-08-2014)
2	Dr. P. Chowdappa	Director (w.e.f. 06-09-2014)
3	Dr. H.P. Maheswarappa	Project Coordinator (Palms)
4	Dr. K. Muralidharan	Head of Division (Social Sciences)
		Acting Head of Division (Social Science w.e.f. 27-05-2014)
5	Dr. K. Balachandra Hebbar	Head of Division (PB & PHT)
6	Dr. Anitha Karun	Head of Division (Crop Improvement)
7	Dr. Vinayaka Hegde	Head of Division (Crop Protection)
8	Dr. Ravi Bhat	Head of Division (Crop Production)
9	Dr. K.S. Ananda	Head, Regional Station, Vittal
10	Dr. V. Krishnakumar	Head, Regional Station, Kayamkulam
11	Shri Suresh Kumar	Chief Administrative Officer
12	Shri T.D.S. Prakash	Finance & Accounts Officer
13	Shri K.M. Jayaram Naik	Administrative Officer
14	Shri B. Sathish	Administrative Officer (w.e.f. 07-04-2014)

Other Information

Agri-incubation Centre inaugurated

An agri-incubation centre was inaugurated by Dr. N.K. Krishna Kumar, Deputy Director General (Hort. Sci.), Indian Council of Agricultural Research, New Delhi on 17th August2014 at CPCRI, Kasaragod. He felt that the concerted efforts are to be made to commercialize the technologies developed by the institute in order to harness the benefits of the technologies at the grass root level. In his presence, MoAs were signed on technologies, "Virgin Coconut Oil (VCO) production by hot process" and" production of desiccated coconut powder" with Shri Balakrishnan, Manya, Kasaragod, and Mr. M.A. Harris, Mulleria, Kasaragod, respectively.

During the programme three other technologies were also transferred to progressive entrepreneurs in agri-business. These include "Collection of fresh and hygienic neera and production of natural coconut sugar" to Mr. Sunny George, Thejaswini Coconut Farmers Producer Company Ltd., Kannur, Kerala, "Transfer of know-how on coconut zygotic embryo culture" to Mr. M. Murali, DeeJay Consultancy Services, Bangalore and "Tissue culture protocol for the multiplication of arecanut" to Mr. T.S. Chellaiah, M/s Sunglow Biotech, Coimbatore, Tamil Nadu.

Dr. George V. Thomas, Director, CPCRI while addressing the gathering had felt that the facilities would graduate good number of entrepreneurs to promote agri-business. Dr. P.L. Saroj, Director, Directorate of Cashew Research Puttur felicitated the programme and mentioned that the allocation to agricultural research is very low compared to the growth in agricultural GDP in the country.

Dr. N.K. Krishna Kumar, DDG (H.S.) handing over MoA on 'arecanut tissue culture' to Shri T.S. Chellaiah, Sunglow Biotech

During the day DDG (H.S.) had also laid foundation stone to a new building wing for KendriyaVidyalaya No. 1, CPCRI, Kasaragod and a Centenary Building for CPCRI, Kasaragod.

Hindi workshop

Hindi workshop was conducted at CPCRI, RS, Kayamkulam on 23-06-2014. Dr. V. Krishna Kumar, Head, presided over the function. Dr. AchyutaPanicker , Farmer Hindi Professor, Bharat Mata College, Trikakkara, Ernakulam, was the chief guest and resource person, who spoke on the usage of simple Hindi for day to day speaking and writing.

Hindi Workshop at Regional Station, Kayamkulam

TOLIC meeting: 26th half yearly meeting of Town Official Language Implementation Committee, Kasaragod was conducted on 07-08-2014 under the Chairmanship of Dr. George V. Thomas Director, CPCRI Kasaragod. Dr. Smt. Sunitha Devi Yadav, Deputy Director (Implementation) Regional Implementation Office, Kochi was present.

Hindi Chetana Maas

Inauguration of the Hindi Chetana Maas was done by Dr. P. Chowdappa, Director, CPCRI on 15-09-2014. He appealed all the staff members to do maximum use of Hindi in official correspondences. Dr. P.V. Samith, Assistant Professor, Pazhassiraja NSS College, Mattannur was the chief guest. During the programme message from the Dr. S. Ayyappan, Hon'ble Director General, ICAR was read.

Hindi Fortnight

Hindi Fortnight was celebrated jointly with TOLIC from 15-09-2014 to 29-09-2014 at RS, Vittal. It

Dr. P. Chowdappa, Director inaugurating Hindi Chetanamaas at CPCRI, Kasaragod

was inaugurated at DCR Puttur on 15-09-2014 by Shri K.T. Ramesh, Lecturer, Junior College Puttur. The Valedictory function was held at CPCRI, Vittal in which Shri KrishnandaBhat, Branch Manager, SBM, Vittal was the chief guest and the programme was presided over by Dr. P.L. Saroj, Director of DCR, Puttur. Various competitions were held for employees and school children.

Hindi week was celebrated from 16th to 22nd September 2014 at RS, Kayamkulam. Various competitions in Hindi were conducted. The valedictory function was held on 22nd September 2014. The chief guest, Dr. R. D. Iyer, former Head of Division, Crop Improvement, CPCRI, Kasaragod, in his speech stressed the importance of learning languages, as it brings people closer. He also gave away the prizes to the winners of various competitions.

Dr. R.D. Iyer, Chief Guest, addressing during the valedictory function of Hindi Fortnight

World Coconut Day

Different programmes were organized in connection with World Coconut Day at the Regional Station. Several coconut-based games such as running with coconut, dehusking, nut-splitting, grating, eating, spoon and button race, one-leg running with nut, nut-hitting, plaiting of leaves, climbing coconut tree, preparation of coconut edibles etc. were conducted for the staff. A farmer's seminar on "Palm health management and value addition in coconut" was also organized. Scientists handled training sessions on good agricultural practices, pest and disease management as well as value addition in coconut. A farmer's quiz programme on coconut was organized and the winners were felicitated.

Three-star status to coconut nursery at Kayamkulam

The National Horticulture Board (NHB) Ministry of Agriculture, Govt. of India has renewed the accreditation of Coconut Nursery at ICAR-CPCRI, Regional Station, Kayamkulam with 3-star rating. This is for the first time a coconut nursery in the root (wilt) disease prevalent tract is getting 3-Star rating. The NHB evaluation team led by Dr. B.K. Karkara, Consultant, and NHB visited ICAR-CPCRI, Regional Station, Kayamkulam on 30th August 2014.

Contingency strategies to manage Hudhud cyclone affected coconut gardens

Coconut growing tracts in the east coast region in states of Andhra Pradesh and Orissa have been hit by the latest 'Hudhud' cyclone. Coconut is the important source of livelihood for the farming community in the affected coastal belt. Livelihood security of the affected farm families can be ensured by implementing following strategies for sustaining coconut based farming in these localities.

1. Removing fully / partially damaged coconut trees and seedlings and disposing the dead logs and organic debris to prevent the emergence of red palm weevil and rhinocerous beetle attack. This can be carried out by opening trenches and burying the organic materials andcovering with soil.

2. Removing the damaged/affected portion in slightly damaged trees, and taking up prophylactic measures such as application of Bordeaux mixture paste / spray.

3. Decomposing debris should be treated with *Metarhizium anisopliae* to avoid Rhinoceros beetle outbreak.

4. Replanting the severely damaged coconut gardens by seedlings of improved varities like Kalpa Pratibha, Kera Chandra, Chandra Kalpa, Chandra Sankara, Kera Sankara, Kera Bastar and Chandra Laksha.

5. To rejuvenate the existing palms, apply 0.5 kg urea, 1 kg super phosphate and 1 kg MOP in the basin area and irrigate, if required, to maintain sufficient moisture. Wherever possible, apply organic manure such as FYM/ vermicompost/ compost at the rate of 25 kg palm^{-1}.

6. Coconut is tolerant to salinity at least for one season. The salinity level becomes normal in the next monsoon season. However, providing irrigation with fresh water, wherever available, can reduce the problems due to enhanced salinity of soil in the affected regions. Soil / sand accumulation in the coconut garden would enhance coconut growth.

7. Though coconut is fairly tolerant to water logging, prolonged water logging needs to be avoided by providing proper drainage.

8. Intercropping of leguminous vegetables may be adopted for livelihood security and increasing fertility of coconut gardens.

Hudhud affected coconut palms at Nimmavanipeta Etcherla, AP

Damaged coconut garden at Kotapalem, AP, caused by Hudhud cyclone

Swacch Bharat Mission & campaign

As part of clean India programme (Swacch Bharat Mission) CPCRI recreation club conducted cleaning programme in the premises of CPCRI nursery school on 28-09-2014. The programme was inaugurated by Dr. P. Chowdappa, Director, CPCRI who emphasized the importance of collective effort in fulfilling the goal of Swacch Bharat Mission at CPCRI. CPCRI Recreation Club donated an amount required for construction of toilet at Koipady village as a part of Swachh Bharat mission in collaboration with Kumbla Grama Panchayat.

During 25th September to 2nd October, 2014, the farm and office premises of the RS, Kayamkulam were made weed-free by a special cleaning drive started on 25th September 2014.

As part of national initiative on *Swachh Bharat* campaign, monthly cleaning drive was undertaken by all staff of the Regional Station, Kayamkulam along the barbed wire fence of the public road as well as on tractor inaccessible zones within the campus in Block II and III on January 21, February 18, and March 18, 2015. In addition a human chain holding placards with the message on cleanliness along the NH-47 in front of the Institute was organized on Jan 1, 2015. The message of cleanliness is thus taken along the length and breadth of the country in general and the State of Kerala in particular. *Swachh Bharat* Mission in the campus has created tremendous impact on all travelers, visitors, farmers and passerby as the tractor inaccessible regions in the experimental plots are free

Dr. P. Chowdappa, Director inaugurating Swachh Bharat Mission at Kasaragod

Dr. P. Chowdappa, Director handing over donation to Kumbla Panchayat towards construction of sanitary unit

of weeds and showcased the beauty of the palms. Bio-management of solid wastes in CPCRI quarters through pipe-composting technology was also initiated.

Online public access library catalogue

CPCRI libraries, at Kasaragod, Vittal and Kayamkulam have got a collection of rare and important publications on coconut, arecanut and cocoa. To increase the visibility of library holdings and to provide better information retrieval/ resource sharing an online union catalogue of library publications, providing web online public access catalogue (OPAC) using KOHA under NAIP scheme. This helps readers to locate the availability of publication by accessing the OPAC online from their desktop either from the library catalogue at institute website (www.cpcri.gov.in/library) or eGranth website (http://egranth.ac.in/). The catalogue data accessible in library OPAC is as per the details given below.

Titles	Kasaragod	Vittal	Kayamkulam
Books	9835	5051	2296
Back volumes	12938	5775	6259
Reprints	1618	1078	650
Others	260	77	-
Total	24651	11981	9205

ICAR- CPCRI won the Overall Championship in ICAR Inter Zonal sports meet

The Director and staff of ICAR- Central Plantation Crops Research Institute felicitated the sports team, the winners of overall championship in the ICAR Inter Zonal sports meet held at NDRI, Karnal during 11 to 14 March, 2015. CPCRI won the championship with 33 points regaining the title after a gap of thirteen years. The team dominated in athletics bagging individual championships as well. Mr. Aneesh and Mrs. Preethi also retained the individual championship for men and women, respectively.

ICAR-CPCRI sports contingent receiving winners trophy from Director, NDRI, Karnal

Annual club day celebrated

The annual club day celebration was held at the Regional Station, Kayamkulam with all pomp and show on 20-03-2015. Dr. P. Chowdappa, Director, ICAR-CPCRI inaugurated the function and complimented the "*we feeling instinct*" of the club members in his inaugural address. Smt. Celin Jose, a noted playback singer engrossed the audience with her melodious voice. The various cultural programmes staged in the open auditorium by the new generation kids was a marvelous show to watch and the sweet voice of *Kalpaswara* orchestra was the star attraction.

Womens' cell activities

Training programme on 'stingless bee culture in coconut based systems for women farmers of Alappuzha district was organized on 24-11-2014 in which 29 farmers attended. The training programme including hands on practical session was handled by Mrs. Thankamoni, Thamarakkulam,master trainer in stingless bee culture.

Coconut plant protection and surveillance women groups (CPPSG) were initiated by ICAR-CPCRI, Regional Station, Kayamkulam in Bharanikkavu panchayath on pilot basis for improving access to technologies and involvement in plant protection operations of coconut palms.

An innovative programme of improving the involvement of women farmers in coconut cultivation was implemented in Bharanikkavu Grama Panchayath during 2014-15. The programme envisages improving skill and knowledge in pest and disease surveillance, plant protection aspects and serving as technology providers for the coconut community

Environmental Day

In collaboration with NSS unit, KVK, Kayamkulam organised the World Environment Day celebrations

on 5th June 2014 at Govt. Higher Secondary School, Budhanoor. The programme was inaugurated by Smt. Rugmini, President, Budhanoor gramapanchayath by planting a neem seedling in the school campus. Smt. Lekha Mohan, Member, Block Panchayath presided over the function. Dr. P. Muralidharan, Programme Coordinator, KVK delivered the key note address by highlighting the relevance of conservation and eco-friendly management of natural resources. The school students conducted a procession in Budhanoor town highlighting the messages of environment conservation. A Quiz competition for the high school and higher secondary students followed by an awareness talk also were conducted.

Inauguration of Environmental day by sapling planting at Budhanoor, Alleppey

Quiz programme at Budhanoor School as part of the Environmental Day

Independence Day

The Institute celebrated 68th Independence Day of our country with tradition and patriotism. Dr. George V. Thomas, Director hoisted the National Flag and delivered Independence Day speech at Kasaragod on 15-08-2014. Independence Day was also celebrated

Independence Day flag hoisting by Director, CPCRI

in the Regional Stations at Kayamkulam, Vittal and Research Centres at Kahikuchi, Kidu, Minicoy and Mohitnagar.

ICAR Foundation day

The 86th Foundation Day of ICAR was celebrated in a befitting manner at CPCRI, Kasaragod, Regional Station, Kayamkulam and Regional Station, Vittal on 16th July 2014. In the inaugural session at RS, Kayamkulam, Dr. V. Krishnakumar, Head and Dr. P. Anithakumari, Principal Scientist, delivered lectures to high school students. Students participated in quiz and essay competitions. Dr. C. Bhaskaran, Retd. Professor, KAU, was the Chief Guest during the valedictory function. He stressed that more youth should take up farming as a career option to meet the increasing demand for food.

Dr. C. Bhaskaran inaugurating ICAR Foundation Day at RS, Kayamkulam

Onam celebrations

Onam was celebrated at CPCRI Kasaragod by Staff Recreation Club CPCRI on 3rd September, 2014. Dr. George V. Thomas (Director, ICAR- CPCRI, retried) was the chief guest of the function. The club members

enthusiastically participated in competitions like pookkalam, tug of war and Uriyadi. A sumptuous onasadhya, cultural programme and various completions heightened the festive mood of all staff members of CPCRI.

Onam celebrations were held with all traditional pomp and fervour at the Regional Station on 4th September 2014 by conducting various programmes which included *Pookalam, Thiruvathira kali, pulikali, vadamvali, Oriyadi* and drawing tail for elephant.

Gandhi Jayanthi

Awareness campaign cum demonstration of EM composting of kitchen wastes and household level bio-resource management was conducted in Kanjikuzhy Block Panchayath campus in connection with Gandhi Jayanthi Celebration and Swachh Bharath Programme on 1st October, 2014. The programme was inaugurated by Adv. D. Priyesh Kumar, President of the Block Panchayath. The training sessions were handled by Dr. S. Kalavathi, Principal Scientist and Dr. Merin Babu, Scientist in which all staff members of the Block Panchayath and farmers participated.

Vigilance Awareness Week

Vigilance awareness week and oath taking were held during 27-10-2014 to 01-11-2014 in headquarters, Regional Stations and Research Centres of ICAR-CPCRI.

Communal Harmony Week

Communal Harmony Week was celebrated during 19-11-2014 to 25-11-2014 in headquarters, Regional Stations and Research Centres of ICAR-CPCRI. Rastriya Ekta Divas was also observed by all the staff on 31-10-2014 .

Republic Day

Republic Day was observed on 26-01-2015 at CPCRI and its regional stations and research centers with tradition and gaity. Dr. P. Chowdappa, Director, CPCRI hoisted the flag and delevered Republic Day speech at Kasaragod.

Food waste management as a part of Swach Bharat campaign at Kanjikuzhy

Dr. P. Chowdappa, Director, CPCRI delivering Republic Day speech at Kasaragod

Library holdings during 2014-15

Station	Current subscription				Books	Back Volumes	Other Publications
	Online Databases	CD-ROM Databases	Foreign Journals	Indian Journals			
Kasaragod	1	-	16	22	10,283	13,364	6,535
Kayamkulam	-	-	8	21	3,572	6,256	3,897
Vittal	-	-	3	22	5,195	5,801	3,014
Mohitnagar	-	-	-	14	526	-	11
Kahikuchi	-	-	-	9	122	-	-
Minicoy	-	-	-	-	-	-	-
Kidu	-	-	-	-	-	-	-

SUCCESS STORY

Vegetables and fruits at Minicoy Island

Coconut is the only crop grown extensively in high density in Lakshadweep group of islands. The islanders mainly depend on mainland for their requirements of fruits and vegetable as the cultivation of these crops is very much limited. Intensified efforts taken up by CPCRI has yielded fruits in identifying the most suitable varieties of fruits and vegetables crops for the ecosystem prevailing under island conditions of Minicoy. Large scale production of vegetables and fruits has become one of the main thrusts of the CPCRI Centre at Minicoy Island to cater to the needs of island community. The Institute has successfully demonstrated organic fruits and vegetable production at the Centre with optimum utilization of available resources through organic methods under coconut gardens. A demonstration unit for protected cultivation of vegetables is also functioning at the Centre. A total of 146 and 63 kg of leafy vegetables (amaranth and curry leaf) and 1,131 and 1,447 kg of other vegetables such as brinjal, drumstick, pumpkin, chilli, tomato, bhindi, gourds such as bitter gourd, ridge / sponge gourd, and snake gourd: cool season vegetables such as cabbage and cauliflower were produced during Jan. – Mar. 2014 and Apr. – Jun. 2014, respectively and made available to the Islanders to meet the food and nutritional security.

Protected cultivation of chilli at Minicoy

Cultivation of vegetable as intercrop under coconut at Minicoy

Kalparasa emerging as a health drink overcoming social barriers

Pamdew - Neera retail sale inaugurated

Kalparasa (Neera) is the fresh hygienic and unfermented sap extracted from inflorescence of coconut palms. It is a natural non-alcoholic beverage, high in nutritional value and is an instant thirst quencher. In Kerala, first fresh neera sale is launched in the brand name of Pamdew by Palakkad Coconut Producers Company Limited (PCPCL) at Vyttila Mobility Hub, Ernakulam recently. PCPCL has obtained Kalparasa collection technology, especially the cocosap chiller technology developed by CPCRI.

'Pamdew' stall inaugurated at Vyttila, Ernakulam

Inauguaration of 'Kalparasa' outlet at Palakkad

Honorable former Chief Minister of Kerala Shri V.S. Achutanandan on November 11, 2014 inaugurated

a Neera outlet of Palakkad Coconut Producers Company at Kanjikode in Palakkad district using the technology developed by ICAR-CPCRI. He said that it is the best natural nutraceutical. On this occasion he complimented the company for adopting the latest technology developed by ICAR-CPCRI and making available farm fresh, hygienic and unfermented 'Kalparasa' in different parts of Kerala as a natural drink. He emphasized that it is not only reviving the coconut sector by improving the economy of small and marginal farmers but also create employment opportunity in tapping, marketing and preparation of value added products like coconut honey, coconut sugar and coconut jaggery. Dr. P. Chowdappa, Director ICAR- CPCRI in his address stressed the usage of name 'Kalparasa' instead of Neera which is often confused as an alcoholic drink. As a nutritious health drink it will improve the nutritional security of the society particularly malnutrition of children. He said even if 10% of the total coconut plants are tapped either for the purpose of health drink or making sugar, it would generate an additional revenue to the tune of Rs. 720 crores in addition to the production of nuts.

It is the eighth outlet in Palakkad district by the PCPCL. A large number of farmers, entrepreneurs, media persons participated in the function and also showed keen interest in the promotion of kalparasa.

Shri V.S. Achuthanandan, former Chief Minister of Kerala and Leader of Opposition, Kerala Assembly inaugurating neera outlet

Resource conserving and Eco-friendly technologies offered Climate Resilience and higher profitability of rice production in Kuttanad, Kerala

Kuttanad, the major rice granary of Kerala, India is one of the few regions of the world that produces rice at below mean sea level in about 30,000 ha. It forms a unique ecologically fragile bio-geographical unit that is located mostly in Alappuzha district. The vulnerability of the system is attributed to the problems of water logging and soil acidity along with climatic variations. Crop damage due to summer rains and flood during monsoon in the low lying paddy fields called *padasekharams* are quite common. This uniqueness in bio-geography and associated social factors and institutions has earned it the status of a Globally Important Agricultural Heritage System (GIAHS) by FAO in 2013. The heritage status also strives for ecological restoration and sustainable development of the water-logged system which has come under increasing stress due to the environmental pollution caused by indiscriminate use of high quantity of chemical fertilizers and plant protection chemicals. In addition to this, use of very high quantity of seeds, and high labour charges result in higher cost of cultivation leaving only marginal profit to paddy farmers.

To address these problems and improve the resilience of the system, technology demonstrations were conducted by Krishi Vigyan Kendra - Alappuzha hosted by Central Plantation Crops Research Institute (CPCRI), in Muttar village of Veliyanad block under the National Innovations on Climate Resilient Agriculture (NICRA) for four successive crop seasons (only one crop possible in a year) from 2011-2015. Farmers were facilitated to undertake the package of demonstrations on (i) optimization of seed rate and plant population through the use of drum seeder, (ii) site specific acidity -nutrient management (SSNM) based on soil testing, and (iii) eco-friendly pest and disease management through the use of *Pseudomonas* for seed treatment, soil, and foliar applications, placement of trichocards for the control of major pests - stem borer and leaf roller, light traps for pest monitoring, and use of fish amino acid against rice bugs. A total of 114 farmers partnered in these demonstrations which covered an area of 74.2 ha in 4 years. Through regular field visits, Farmer Field Schools, and interactions the crop situation from sowing to harvesting was monitored continuously by the KVK team in all these years.

The overall achievements of the demonstrations for four years could be summarized as

1. By using paddy seeder (Drum seeder) the seed requirement could be reduced to 30 kg/ha from of 100-120 kg/ha used by farmers for broadcasting, thus reducing the cost on seed to almost 25%.

Since the seeds were sown in lines keeping a spacing of 20x10cm, the plant population was optimum, the number of productive tillers was high and there was enough aeration in the crop stand which resulted in reduced susceptibility to pests and diseases. Further the plants had strong anchorage in the soil which helped them survive lodging in the harvesting stage due to summer showers and wind, while about 20% crop loss was recorded due to lodging in the traditional broadcasted crop. Thus this technology offered climate resilience to the crop. In addition, the time taken for harvest by the combined harvester and thus the cost on harvesting was reduced by 40-50% due to the uniform population and non-lodging feature achieved by drum seeding. All these factors put together reduced the cost of cultivation by about 10-20%.

2. Application of dolomite as liming material based on soil tests not only reduced the soil acidity for improved nutrient availability to crop, but supplied magnesium also. The cost on fertilizers could be reduced by 30% based on soil tests. This could make up the additional cost on dolomite. This site specific nutrient management (SSNM) resulted in a healthy crop which finally reflected in the yield. Moreover, optimum and efficient use of fertilizers could reduce the pollution of the surrounding water bodies.

3. Many farmers could harvest the crop without using any plant protection chemicals. There were no pest and disease incidence in these plots and the farmers were satisfied with the effect of *Pseudomonas* and trichocards. In other cases the use of chemical pesticides and fungicides reduced by 90%. Those farmers who regularly used plant protection chemicals, the amount spent for pesticides and fungicides reduced to 50 % compared to the previous crop. These practices also reduced the cost of cultivation and environmental pollution.

4. Overall, the package of technologies resulted in an average yield increase of 15-20%. While the traditional broadcasted crop yielded an average 5-6 t/ha, by adopting this package of technologies farmers could harvest 6-7 t/ha with reduced input use. The demonstration plots had higher number of productive tillers per m^2, and grains per panicle and heavier grains in all the four years. The higher yield obtained and the reduced cost of cultivation led to an overall higher net profit of minimum Rs.12500 per ha. The partner farmers were very happy and many of them acted as master farmers to spread this package of technologies to progressive farmers of the adjoining villages.

5. During the cropping season in 2014-15, dolomite was applied and *Pseudomonas* treated seeds were sown in about 400 ha paddy fields in the project village and adjoining villages with the support from Dept of Agriculture, which is a clear evidence of the spread in adoption of these technologies, as narrated by the Agricultural Officers in the district level meetings.

These demonstrations could make a significant impact in the paddy farmers of Kuttanad region in terms of reduced use of seeds, fertilizers and plant protection chemicals, leading to reduced green house gas emission and environmental pollution, and enhanced climate resilience in addition to the higher net profit obtained from paddy cultivation.

Wet seeding using the drum seeder in Kuttanad paddy fields to overcome management problems

Demonstration field on the farther side without lodging, while lodging can be seen in broadcasted field

Weather data 2014-15

CPCRI, Kasaragod

Month	Temp.		RH %		Wind velocity (km/h)	Sunshine (h)	Evaporation (mm)	Rainfall (mm)	Rainy days
	Max (°C)	Min (°C)	FN	AN					
April 2014	33.6	26.3	83	63	2.5	6.3	4.2	14.7	1
May	32.9	25.0	88	67	1.9	7.1	3.7	299.7	9
June	31.1	24.8	90	78	3.1	2.8	2.5	598.3	22
July	28.9	24.3	92	85	2.3	1.2	1.5	690.5	28
Aug.	28.1	24.2	95	85	1.5	2.2	1.5	956.3	26
Sept.	29.4	24.5	92	80	1.2	5.0	2.1	456.6	17
Oct.	30.9	24.9	90	72	1.2	5.1	3.0	379.4	14
Nov.	31.9	22.7	83	61	1.2	7.2	2.9	29.4	3
Dec.	31.2	22.0	81	63	1.2	5.9	2.7	23.5	2
Jan. 2015	30.9	20.1	84	57	1.5	8.6	3.0	0.8	1
Feb.	31.8	20.8	83	57	1.9	9.4	3.4	0.0	0
Mar.	32.5	22.7	83	63	2.1	7.7	3.8	34.6	1

CPCRI, Kayamkulam

Month	Temp.		RH(%)		Wind velocity (km/h)	Sun shine (h/ day)	Evaporation (mm)	Rainfall (mm)	Rainy days
	Max (°C)	Min (°C)	FN	AN					
April 2014	34.0	24.8	92	68	1.7	8.1	3.8	129.3	12
May	33.5	25.8	93	70	1.6	7.9	3.7	226.9	8
June	31.3	25.2	93	81	1.4	5.3	3.2	346.3	19
July	30.5	23.8	92	85	1.3	4.5	3.1	488.6	24
August	30.2	23.8	92	85	1.3	5.4	3.3	507.1	14
September	31.0	23.9	93	84	1.6	6.6	3.6	187.9	12
October	31.5	24.1	92	81	1.8	5.3	3.5	337.4	17
November	31.1	23.2	93	86	1.6	4.6	3.3	42.7	8
December	31.7	23.5	92	86	1.5	6.3	3.5	20.0	3
January 2015	32.8	23.3	90	80	2.1	9.4	4.1	1.8	Nil
February	33.2	24.5	90	74	2.5	9.3	4.3	3.7	Nil
March	33.5	26.2	92	70	2.2	9.6	4.4	136.6	4

CPCRI, RS, Vittal

Month	Temp.		RH %		Wind velocity (km/h)	Sunshine (h)	Evaporation (mm)	Rainfall (mm)	Rainy days
	Max (*C)	Min (*C)	FN	AN					
April 2014	35.9	24.1	93.2	55.1	3.2	5.0	4.0	136.6	5
May	33.9	23.3	93.8	64.1	2.7	5.9	2.8	284.8	11
June	31.7	24.0	96.9	75.2	2.9	3.8	2.5	436.8	16
July	28.7	22.9	98.4	88.4	3.2	1.9	1.9	1033.8	28
Aug.	28.9	22.6	97.7	85.1	2.5	2.0	2.1	960.1	27
Sept.	30.7	22.6	97.1	75.1	2.7	4.1	2.4	349.6	17
Oct.	32.5	23.5	95.7	70.5	2.1	5.2	2.9	169.4	11
Nov.	33.3	21.8	96.9	58.3	1.9	6.0	3.1	48.2	2
Dec.	32.5	21.7	94.1	61.0	1.9	5.0	2.8	17.2	2
Jan. 2015	33.1	19.7	96.7	54.9	2.1	6.9	3.4	0	0
Feb.	34.6	20.6	94.6	39.2	2.6	7.7	4.2	0	0
Mar.	35.2	23.2	94.4	50.7	3.0	5.4	4.8	62.8	2

CPCRI Kidu

Month	Temp.		RH %		Wind velocity (km/h)	Sunshine (h)	Evaporation (mm)	Rainfall (mm)	Rainy days
	Max (°C)	Min (°C)	FN	AN					
April 2014	36.1	23.1	92	48	N.A.	6.9	6.1	103.9.	14
May	34.3	23.1	93	54	N.A.	6.5	4.3	188.7	6
June	30.7	22.3	95	77	N.A.	2.7	3.5	488.5	21
July	27.7	21.3	95	89	N.A.	0.5	3.1	2026.1	31
Aug.	26.7	21.2	96	91	N.A.	1.5	3.0	882.8	31
Sept.	30.3	21.0	95	76	N.A.	201	3.5	494.8	26
Oct.	32.4	21.5	94	62	N.A.	3.9	4.2	363.8	24
Nov.	33.4	18.6	91	53	N.A.	6.5	3.7	47.0	4
Dec.	32.9	18.1	91	55	N.A.	5.5	4.2	11.4	3
Jan. 2015	33.9	16.1	91	43	N.A.	7.9	4.3	Nil	-
Feb.	35.3	17.7	91	39	N.A.	9.2	5.5	Nil	-
Mar.	35.9	20.9	93	48	N.A.	7.1	5.9	94.4	6

राजभाषा कार्यान्वयन रिपोर्ट

राजभाषा हिंदी के उत्तरोत्तर प्रगति हेतु इस संस्थान तथा इसके प्रादेशिक केंद्रों एवं अनुसंधान केंद्रों में राजभाषा कार्यान्वयन के सभी पहलुओं पर भरपूर प्रयास किया जा रहा है। भारत सरकार की राजभाषा नीति के अनुपालन के संबंध में राजभाषा विभाग द्वारा निर्धारित वार्षिक कार्यक्रम में उल्लिखित लक्ष्यों की पूर्ति और भारतीय कृषि अनुसंधान परिषद की ओर से जारी किए जा रहे राजभाषा कार्यान्वयन संबंधी दिशानिर्देश के अनुसार राजभाषा हिंदी के प्रयोग की उत्तरोत्तर प्रगति हेतु प्रयास किया जा रहा है।

राजभाषा कार्यान्वयन कार्य :

राजभाषा विभाग एवं भारतीय कृषि अनुसंधान परिषद के निर्देश एवं आदेशों के अनुपालन एवं राजभाषा कार्यान्वयन की प्रगति की समीक्षा हेतु इस संस्थान में निदेशक महोदय की अध्यक्षता में गठित राजभाषा कार्यान्वयन समिति की बैठक नियमित रूप से आयोजित की जा रही है। बैठक में राजभाषा अधिनियम 1963 धारा 3(3) एवं राजभाषा नियम 1976 के अनुपालन की अनिवार्यता पर बल देकर राजभाषा विभाग की ओर से जारी वार्षिक कार्यक्रम में दिए गए लक्ष्यों की पूर्ति का प्रयास किया जा रहा है। बैठक का कार्यवृत्त परिषद को समीक्षा हेतु भेज दी जाती है। निदेशक (राजभाषा) भारतीय कृषि अनुसंधान परिषद द्वारा प्रत्येक बैठक के कार्यवृत्त की समीक्षा की जाती है और रिपोर्ट के अनुसार अगली बैठक में चर्चा कर निदेशक महोदय की अनुमति से बैठक के निर्णयों की पुष्टि की जाती है।

अधीनस्थ स्टेशनों/केंद्रों को समय-समय पर राजभाषा कार्यान्वयन समिति की बैठकों के आयोजन, प्रशिक्षण की अनिवार्यता एवं राजभाषा कार्यान्वयन कार्य की ओर दिशा निर्देश दिया जाता है। और अधीनस्थ केंद्रों से प्राप्त बैठकों के कार्यवृत्तों एवं प्रगति रिपोर्ट की समीक्षा की जाती है। तदनुसार आवश्यक निर्देश एवं लक्ष्यों की पूर्ति हेतु सहयोग दिया जाता है।

मुख्यालय तथा अधीनस्थ स्टेशनों/केंद्रों की ओर से जारी किए जा रहे संविदा एवं निविदा प्रपत्रों, नोट एवं परिपत्रों को द्विभाषीकरण कर राजभाषा अधिनियम 1963 धारा 3(3) के अनुपालन का अधिकाधिक प्रयास किया जाता है और नियम का अनुपालन सुनिश्चित किया जाता है।

राजभाषा नियम 1976 नियम 10(4) के अधीन भारत सरकार के राजपत्र में अधिसूचित इस संस्थान में हिंदी में प्रवीणता प्राप्त तीन अवर श्रेणी लिपिकों को अपना सरकारी काम काज शत प्रतिशत हिंदी में करने के लिए व्यक्तिगत रूप से राजभाषा नियम 1976 नियम 8(4) के अधीन कार्यालय आदेश जारी किया गया है।

हिंदी पत्रों की आवति प्रत्येक रजिस्टर में की जाती है और राजभाषा नियम 1976 नियम 5 का अनुपालन शत प्रतिशत सुनिश्चित किया जाता है। जावक रजिस्टर में हिंदी पत्रों के सामने लाल रंगीन कलम से एच चिह्न लगाया जाता है।

राजभाषा नियम 1976 नियम 11 का अनुपालन हमेशा सुनिश्चित किया जाता है आवश्यक सामग्रियों आवश्यकतानुसार द्विभाषा में तैयार कर समय-समय पर मार्गनिर्देश दिया जाता है। प्रादेशिक केंद्रों/अनुसंधान केंद्रों को इसके अनुपालन पर सख्त आदेश दिया जाता है और आवश्यक सामग्रियों की तैयारी की मदद दी जाती है। संस्थान की ओर से आयोजित समारोह/बैठकों के बैनर, प्रदर्शनी बोर्ड एवं संगोष्ठी का निमंत्रण पत्र समय-समय पर द्विभाषा में तैयार किया जाता है और प्रदर्शित किया जाता है।

हिंदी समारोह

राजभाषा के प्रति जागरूकता पैदा कराने हेतु हिंदी चेतना मास समारोह का आयोजन विभिन्न कार्यक्रमों के साथ किया गया।

उपर्युक्त अवधि में 12 विभिन्न प्रतियोगिताएँ जैसे, हिंदी समाचार वाचन, आमने-सामने, वाद-विवाद, स्मरण परीक्ष, चित्र देखों और लिखे, गीत (व्यक्तिगत) एवं समूह, प्रश्नोत्तरी, निबंधलेखन, अनुवाद, टंकण, कविता पाठ विभिन्न अनुभागों के सहयोग के साथ आयोजित कर हिंदी चेतना मास समारोह सफलतापूर्वक मनायी गई। कुशल सहायक कर्मचारियों के लिए प्रत्येक रूप से प्रतियोगिताएँ आयोजित की गई। विजेताओं को समापन समारोह के दिन मुख्य अतिथि द्वारा पुरस्कार वितरित किए गए।

सरकारी काम काज में हिंदी का अधिकाधिक प्रयोग करने वाले अधिकारियों एवं कर्मचारियों को प्रोत्साहन योजना के अधीन नकद पुरस्कार वितरित किए गए।

द्विभाषिक यांत्रिक सुविधा

राजभाषा नियम के अनुपालन हेतु कार्यालय में उपलब्ध सभी कंप्यूटरों में यूनिकोड की सुविधा प्रदान की गई। यूनिकोड के प्रयोग पर डेस्क टू डेस्क कार्यक्रम के रुप में उसका उपयोग अवगत कराया गया। सभी कंप्यूटरों में द्विभाषिक पत्रशीर्ष अपलोड करवाया और उपयोग सुनिश्चित किया गया। समय समय पर इसका निरीक्षण किया जाता है।

प्रबोध, प्रवीण एवं प्राज्ञ प्रशिक्षण कार्यक्रम

केंद्रीय हिंदी प्रशिक्षण संस्थान, पत्राचार पाठ्यक्रम द्वारा प्रायोजित प्रबोध, प्रवीण एवं प्राज्ञ प्रशिक्षण के लिए इस संस्थान से हिंदी का कार्यसाधक ज्ञान न रखनेवाले एक अधिकारी को प्रबोध और दो अधिकारियों को प्राज्ञ के लिए नामित किया गया। प्रादेशिक केंद्र, लक्षद्वीप से 1, किडु से 5, मोहितनगर से 1, काहिकुची से 1 कर्मचारी को प्राज्ञ प्रशिक्षण के लिए नामित किया गया।

हिंदी टंकण प्रशिक्षण

केंद्रीय हिंदी प्रशिक्षण संस्थान, राजभाषा विभाग की ओर से पत्राचार पाठ्यक्रम द्वारा आयोजित हिंदी टंकण प्रशिक्षण के लिए इस संस्थान से शेष आठ अवर श्रेणी लिपिक को नामित किया गया। इसके अतिरिक्त एक आशुलिपिक को भी हिंदी टंकण प्रशिक्षण के लिए नामित किया गया। काहिकुची से एक अवर श्रेणी लिपिक और अनुसंधान केंद्र, किडु से एक अवर श्रेणी लिपिक को नामित किया गया।

हिंदी कार्यशाला

डॉ. पी.वी. सुमित, सहायक प्रोफसर (हिंदी) पषश्शिराजा कालेज, मट्टन्नूर, कण्णूर ने 15 सितंबर 2014 को राजभाषा के रुप में हिंदी को चुनने के कारण, उसकी महत्व पर विवरण दिया।

श्री एम. रवी, प्रद्यापक (हिंदी), कड़नप्पल्ली हायर सेकेंटरी सरकार स्कूल, पय्यन्नूर ने 1 नवंबर 2014 को राजभाषा एवं राष्ट्रभाषा के महत्व पर प्रकाश डाला।

अक्तूबर-दिसंबर तिमाही की अवधि में सभी प्रशासनिक अधिकारियों के पास डेस्क टू डेस्क जाकर कंप्यूटरों में यूनिकोड कैसे सक्रिय करें, विवरण दिया और संस्थापना की और हिंदी का प्रयोग सुनिश्चित किया गया और द्विभाषी पत्रशीर्ष सभी कंप्यूटरों में डाला गया और इस पर आधारित आवश्यक सूचनाएँ दी गई।

सरकारी काम काज में हिंदी का प्रयोग बढ़ाने एवं हिंदी के प्रयोग का झिझक दूर करने कराने हेतु मुख्यालय में दिनांक 28 जनवरी 2015 को डॉ. पी.आर. पाल, उप निदेशक, मंगलूर रिफाइनरी एवं पेट्रोकेमिकल्स लिमिटेड के मार्गदर्शन में राजभाषा अधिनियम 1963 धारा 3(3) और राजभाषा नियम पर कार्यशाला आयोजित की गई।

नराकास के सदस्य कार्यालयों के लिए संयुक्त रुप से केरल केंद्रीय विश्वविद्यालय की ओर से दिनांक 22 जनवरी 2015 को आलेखन, टिप्पण एवं अनुवाद पर आयोजित हिंदी कार्यशाला में इस संस्थान से दो सहायक, 3 प्रवर श्रेणी लिपिक, 2 निजी सचिव और कनिष्ठ लेखा अधिकारी को भी नामित किया गया।

गहन हिंदी कार्यशाला

केंद्रीय हिंदी प्रशिक्षण संस्थान, राजभाषा विभाग द्वारा आयोजित पाँच दिवसीय गहन हिंदी कार्यशाला केलिए उपर्युक्त अवधि में मुख्यालय से 5, प्रादेशिक केंद्र कायम्कुलम से 11, अनुसंधान केंद्र, काहिकुची, मोहितनगर, किडु से क्रमशः 3, 2, 1 कर्मचारियों/अधिकारियों को नामित किया गया।

राजभाषा नीति के सफल कार्यान्वयन हेतु केंद्रीय हिंदी प्रशिक्षण संस्थान, राजभाषा विभाग, नई दिल्ली द्वारा दिनांक 13.10.2014 से 17.10.2014 तक आयोजित पाँच दिवसीय अभिमुख कार्यक्रम में इस संस्थान के वरिष्ठ तकनीकी अधिकारी (राजभाषा) को नामित किया गया।

क्षेत्रीय कार्यान्वयन कार्यालय, राजभाषा विभाग, गृह मंत्रालय, भारत सरकार की ओर से दिनांक 27.03.2015 को मंगलूर में आयोजित वर्ष 2013-14 का वार्षिक राजभाषा सम्मेलन में इस संस्थान के वरिष्ठ तकनीकी अधिकारी (राजभाषा) एवं सदस्या सचिव (नगर राजभाषा कार्यान्वयन समिति, कासरगोड़) को नामित किया गया।

वेबसाइट का प्रदर्शन : संस्थान वेबसाइट में अंग्रेज़ी में प्रदर्शित विवरणों को हिंदी में अनुवाद कर वेबसाइट द्विभाषा में प्रदर्शित किया जाता है। अद्यतित विवरणों को समय-समय पर हिंदी में भी अद्यतन किया जाता है।

नगर राजभाषा कार्यान्वयन समिति, कासरगोड़

कासरगोड़ नगर में स्थित केंद्रीय सरकार के कार्यालय, उपक्रम, बैंक सहित 38 सदस्य कार्यालय सम्मिलित नगर राजभाषा कार्यान्वयन समिति, कासरगोड़ की छब्बीसवीं अर्धवार्षिक बैठक दिनांक 7 अगस्त 2014 को डॉ. जॉर्ज वी. थॉमस, निदेशक की अध्यक्षता में और डॉ. (श्रीमती) सुनीता देवी यादव, उप निदेशक (कार्यान्वयन) राजभाषा विभाग, कोची की उपस्थिति में आयोजित की गई।

समिति की सत्ताईसवीं अर्धवार्षिक बैठक दिनांक 28 जनवरी 2015 को डॉ. पी. चौड़प्पा, निदेशक की अध्यक्षता में आयोजित की गई। डॉ. पी.आर. पाल, उप निदेशक (राजभाषा), मंगलूर रिफाइनरी एवं पेट्रोकेमिकल्स लिमिटेड ने बैठक के मार्गदर्शक थे।

संयुक्त हिंदी समारोह

नगर राजभाषा कार्यान्वयन समिति के सदस्य कार्यालयों के लिए संयुक्त हिंदी समारोह आयोजित किया गया समारोह के भाग के रुप में विभिन्न स्कूलों के छात्रों के लिए विभिन्न वर्गों में प्रत्येक रुप से विभिन्न प्रतियोगिताएँ जैसे समाचार वाचन और आमने - सामने आयोजित की गई। कासरगोड़ के विभिन्न स्कूलों के छात्रों ने सक्रिय रुप से उपर्युक्त प्रतियोगिताओं में भाग लिया।

नराकास के सदस्य कार्यालयों के अधिकारियों एवं कर्मचारियों के लिए विभिन्न प्रतियोगिताएँ जैसे हिंदी में विज्ञापन, आइए पढिए और बताइए आयोजित की गई। सदस्य कार्यालयों के अधिकारियों एवं कर्मचारियों ने सक्रिय रुप से भाग लिया। विजेताओं को पुरस्कार वितरण किया गया।

संयुक्त हिंदी कार्यशाला

नरकास के सदस्य कार्यालयों के लिए संयुक्त रुप से केरल केंद्रीय विश्वविद्यालय की ओर से दिनांक 22 जनवरी 2015 को आलेखन, टिप्पण एवं अनुवाद पर डॉ. सी.पी.वी. विजयकुमार, प्रमुख (हिंदी विभाग) केरल केंद्रीय विश्वविद्यालय के मार्गदर्शन में हिंदी कार्यशाला आयोजित की गई।

दिनांक 28 जनवरी 2015 को डॉ. पी.आर. पाल, उप निदेशक, मंगलूर रिफाइनरी एवं पेट्रोकेमिकल्स लिमिटेड के मार्गदर्शन में राजभाषा अधिनियम 1963 धारा 3(3) और राजभाषा नियम पर हिंदी कार्यशाला आयोजित की गई।

संस्थान के निम्नलिखित प्रकाशनों का सारांश हिंदी में प्रकाशित किया गया:-

1. केंद्रीय रोपण फसल अनुसंधान संस्थान, वार्षिक रिपोर्ट - सारांश (वर्ष 2013-2014)
2. अखिल भारतीय समन्वित ताड़ अनुसंधान परियोजना, वार्षिक रिपोर्ट - सारांश (वर्ष 2013-2014)

हिंदी प्रकाशन

1. केंद्रीय रोपण फसल अनुसंधान संस्थान, वार्षिक रिपोर्ट (वर्ष 2012-2013)
2. वरजिन नारियल तेल (तकनीकी बुलेटिन)
3. नारियल चिप्स का वाणिज्यिक उत्पादन (तकनीकी बुलेटिन)

भाकृअनुप
ICAR

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