

# वार्षिक प्रतिवेदन ANNUAL REPORT 2016-17



भा.कृ.अनु.प.-केंद्रीय रोपण फसल अनुसंधान संस्थान  
कासरगोड़, केरल  
ICAR - Central Plantation Crops Research Institute  
Kasaragod, Kerala





Shatamangala variety of arecanut

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कासरगोड़ - 671124, केरल, भारत

ICAR-CENTRAL PLANTATION CROPS RESEARCH INSTITUTE  
Kasaragod - 671 124, Kerala, India



Correct citation: ICAR-CPCRI, 2017. Annual Report 2016-17, ICAR-Central Plantation Crops Research Institute, Kasaragod – 671124, Kerala, India, 236 p.

Published by

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#### **Cover Page Photos**

1. Front cover: Two value added products, Kalpa Dark Chocolate and Kalpa Krunch
2. Back cover: Kalpa Shatabdi variety of coconut
3. Inside front cover: Shatamangala variety of arecanut
4. Inside back cover: Nethra Centura variety of cocoa

Printed at

**Niseema Printers**

S. Kalamassery, Kochi, Ph: 2550849

June 2017

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**Coconut gene bank at ICAR-CPCRI, Research Centre, Kudu**



The year 2016 was a momentous year in the annals of ICAR-Central Plantation Crops Research Institute (ICAR-CPCRI) and coconut research in India alike, stamping its indelible footprint in sands of time, on having completed 100 glorious years in service of the nation from its modest beginning as a small coconut research station in the sleepy village of Kudlu in Kasaragod, way back in 1916. We had ceremoniously flagged off the centenary celebrations on 12<sup>th</sup> March 2016 in a unique way with simultaneous planting of 100 coconut seedlings by 100 farmers in a minute in the Centenary Coconut Park, a massive Kisan Mela and a plethora of other programmes spread along the year. The year-long celebrations concluded with the Kisan Mela on 10<sup>th</sup> December 2016, graced by Shri Radha Mohan Singh, Honourable Union Minister of Agriculture and Farmers Welfare, and a host of other dignitaries, followed by the Third International Symposium on Coconut Research and Development (ISOCRAD 3) during 10<sup>th</sup>-12<sup>th</sup> December 2016 and the 22<sup>nd</sup> edition of PLACROSYM closely on its heels. In between, there was a large number of other programmes catering to all sections of the stakeholders - scientific community, farmers, extension personnel, agri-business entrepreneurs and SHGs. Reaching a century of years is indeed a grand landmark in the history of an institution, certainly the joyous time for celebration and equally the right time for serious introspection and strategizing for the future.

Plantation crops are a dynamic element in the world economy in terms of production, exports and consumption. The Indian plantation sector has inherent strength of varied agro-climatic conditions, huge domestic demand, higher productivity, strong research and development network and technology dissemination systems. However, so far, the sector has not effectively utilized the possible linkages between them for increasing the production and marketing efficiencies. Inclusive growth and sustainability of plantation economy could be achieved through integrated development of cultivation and industry coupled with a stable market. The research programmes targeting higher production and better system productivity coupled with optimum input use efficiency and strengthening the technology dissemination programmes with the active participation of beneficiaries along with new 'social engineering' strategies for aggregation of farmers for group activities (like the community based organizations or CBOs and the three-tier neera producer companies) and creating more skilled workers for farming, harvesting and processing operations, with the overall objective of triggering production, processing and value addition, will, hopefully, place our coconut, arecanut and cocoa sectors at forefront in the world.

Apart from these, since food safety standards are becoming more stringent in the world, and to be competitive in the trade, we must give adequate importance to the Good Management Practices (GMP) in the plantation sector. There is an urgent need to realign the production structure of plantation crops in accordance with the international and domestic price signals. Needless to say, the research and developmental agenda of the R&D institutions should invariably be 'proactive' to keep itself abreast of the latest developments in the sector and to address them effectively. And, ICAR-CPCRI has always been a model institution in plantation crops R&D in India and 100 years of its history stands witness to it.

With the opening up of Indian economy by the end of the last century and liberalization of trade regimes in the first decade of the present century with the GATT and free trade agreements in place, the plantation crops sector in India has been increasingly exposed to competition. In the present day global commodity markets, the winner is always the country in possession of better

technologies, that can produce/supply better products at lower prices. Needless to say, there has to be a continuum of innovations, as technologies also get less efficient over time and eventually become obsolete. Evidently, there is a demand and a right ambience for technology development and dissemination with the state-of-the art laboratories, immeasurable wealth of genetic resources and well-trained scientific manpower in our possession.

The Institute has built up, over the years, a rich repository of genetic resources to provide breeders with required genetic stock to tackle present and future challenges. It is a matter of national pride that it maintains the largest collection of germplasm accessions: coconut (455), arecanut (176) and cocoa (405). International Coconut Genebank for South Asia (ICG-SA) was established under a tripartite agreement among ICAR-FAO-ITPGRFA. The Institute also hosts the National Coconut Gene Bank (NCGB) and serves as the National Active Germplasm Site (NAGS) for coconut, arecanut and cocoa. Recently, DUS (distinctiveness, uniqueness and stability) test centres for coconut, arecanut and cocoa have been started with funding from PPV&FRA, New Delhi. The Institute has facilitated development of the DUS guidelines for coconut and arecanut for effecting plant variety protection mechanism.

Over the past hundred glorious years, this Institute has developed/released an impressive array of high yielding varieties, considering that it takes nearly two decades of continuous and strenuous efforts to develop, evaluate and release a variety in a perennial tree crop like coconut and they have percolated far and wide in all coconut growing tracts. The impact of yearly planting materials supplied from ICAR-CPCRI alone would be to the tune of ₹ 1604 lakh year<sup>-1</sup>, considering the long economic life span of coconut. Most befittingly, in this centenary year, we have released three varieties, Kalpa Shatabdi, Shatamangala and Nethra Centura, one each in coconut, arecanut and cocoa respectively. ICAR-CPCRI has been instrumental in developing several technologies and innovations, 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. Besides the “Kalparasa” technology for fresh and hygienic neera production from coconut, coconut sugar based value-added products like “Kalpa Dark Chocolate” and “Kalpa Drinking Chocolate” and a virgin coconut oil residue based extruded product “Kalpa Krunch” have been commercially launched recently.

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 and processing of coconut Kalparasa including spray-drying technologies. This is the most opportune time for us to rededicate ourselves to the cause of plantation crops research and extension, contributing our might to bring smiles to the farming community, to which we are beholden to.

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 2016-17, presented in a thematic mode. I am grateful to Dr. T. Mohapatra, Secretary, DARE and Director General, ICAR for the encouragement and guidance. I place on record my sincere gratitude to the Deputy Director General (Horticulture Science) for his support, guidance in the activities and progress of the institute. I thank the Assistant Director Generals in the Horticulture Science Division, ICAR for the unstinting support received. I thank the Scientists, Officers and all staff members of this institute for the significant contributions made in fulfilling the mandate of the institute.

30-05-2017  
Kasaragod



**(P. Chowdappa)**  
Director

**भा**रत में रोपण क्षेत्र की भूमिका महत्वपूर्ण है कि यह करोड़ों लघु एवं सीमांत किसानों द्वारा प्रबल है जो मुख्य रूप से आर्थिक और पारिस्थितिक रूप से भेद्य क्षेत्र है। नारियल, सुपारी और कोको भारत की मुख्य रोपण फसल हैं जो देश में 20 करोड़ों लोगों की आजीविका की सहायता करके ग्रामीण आर्थिकता पर अधिक प्रभाव के साथ समर्थन करता है। परिवर्तित फसलन तरीका, जलवायु बदलाव, प्राकृतिक संसाधन उपयोग पर महत्व और रोपण फसल परिदृश्य में लाभदायकता में कमी से नवोन्मेषी रणनीतियाँ और चुनौतियों का सामना करने की पहल और क्षेत्र की त्वरित वृद्धि सुधार की आवश्यकता है।

भा कृ अनु प - केंद्रीय रोपण फसल अनुसंधान संस्थान, भारत के राष्ट्रीय कृषि अनुसंधान पद्धति में प्रथम कृषि अनुसंधान संस्थानों में एक है जो भारत में नारियल, सुपारी और कोको में अनुसंधान करने और समन्वित करने में अधिदेशित है। 1916 में प्रारंभित नारियल अनुसंधान स्टेशन का मूल स्थान कुडलु गाँव है (दक्षिण भारत में केरल के कासरगोड़ जिला में) जो बहुत पहले मद्रास महाप्रान्त के दक्षिण कनारा जिला में था।

इसके प्रारंभ से निदर्शनात्मक अनुसंधान से, उचित प्रौद्योगिकियों के उत्पादन से, और कुशल मानव संसाधनों के विकास से विज्ञान और समाज के पक्ष में उत्कृष्टता के साथ सेवा किया जा रहा है। अधिदेशित फसलों से संबंधित आधारित और प्रायोगिक अनुसंधान आयोजित करने में शक्ति प्रदान करने वाली गति का उपयोग जारी किया जा रहा है और वर्ष 2016 - 17 में शोध कार्य की प्रगति 10 विशेष विषयक क्षेत्रों के अधीन रिपोर्ट किया गया है।

### पादप प्रजनन संसाधन प्रबंधन एवं प्रजनन

आनुवंशिक संसाधन, फसल सुधार कार्यक्रम जारी करने का आधार स्तंभ है। और प्रजनकों को वर्तमान संबंधित आवश्यक आनुवंशिक स्टॉक प्रदान करने और भविष्य चुनौतियों के लिए आनुवंशिक संसाधनों का समृद्ध संग्रह संस्थान द्वारा कई वर्षों से स्थापित किया गया है।

यह एक राष्ट्रीय गौरव की बात है कि विश्व की जननद्रव्य प्रजातियों के बड़े संग्रहण, 455 नारियल, 176 सुपारी और 405 कोको का अनुसंधान किया जाता है। राष्ट्रीय नारियल जीन बैंक के अतिरिक्त

त्रिपक्षीय करार भाकृअनुप - एफ ए ओ - आई टी पी जी आर एफ ए के बीच अन्तर्राष्ट्रीय नारियल जीन बैंक-दक्षिण एशिया की स्थापना अनुसंधान केंद्र, किडु में स्थापित किया गया। इसके अतिरिक्त राष्ट्रीय क्रियाशील जननद्रव्य स्थान के स्म में सेवा करता है। नारियल, सुपारी और कोको के लिए परीक्षण केंद्र, डी. यु. एस की स्थापना की गई जिसकी निधि पी. पी. वी और एफ. आर. ए., नई दिल्ली से प्राप्त किया जाता है। वर्ष 2001 का पी. पी. वी एवं एफ. आर अधिनियम के संस्थान ढाँचे के अधीन पादप प्रजाति संरक्षण प्रभावित करने के लिए नारियल और सुपारी के लिए डी. यु. एस मार्गदर्शन के विकास की सुविधा प्रदान की गई है।

सुपारी जननद्रव्य का संग्रहण कुल 12 विविध जननद्रव्यों से अधिक समृद्ध बनाया गया है कि उत्तर बंगाल से छह असम से दो और कर्नाटक से चार संग्रहण किए गए जिसकी गुठली मोटी (145 ग्रा.भार से ज्यादा) पक्का/ताज़ा फल अच्छा अष्टी और और रंगबिरंगा फल। *थियोब्रोमा ग्रान्डिफ्लोरम* (कुपुवास्सु फल) कोको की एक जंगली संगत (टी कोको एल एल) मूलस्टॉक और मुर्झा प्रतिरोध के मूल्यांकन के उपयोग के लिए संग्रहण किया गया। कोको का एक पेन्टागोना प्रकार, सफेद पिंग बीज के साथ विशेष पाँच पार्श्व फली, का संग्रहण किया गया, जिसका उपयोग आन्दोसयानिन अवरोधात्क जीन और गुण सुधार के अध्ययन में उपयोग के लिए संग्रहण किया गया। निचले पहाड़ों और मैदानों में आशाजनक मात्रात्मक और गुणात्मक परीक्षण के लिए केरल के इडुक्की जिला के उच्च पहाड़ी में अड़िमाली और मन्कुवा गाँव से कोको की स्थानीय जातियाँ संग्रहित की गयी (फली इंडेक्स 10 बीज सूचकांक 1.95-2.11 ग्रा 9.52 प्रतिशत शल्क 90.6 प्रतिशत निब उपलब्धि और 52-55 प्रतिशत वसा मात्रा) और मूल्यांकन के लिए भाकृअनुप-कैरोफअसं, प्रादेशिक केंद्रों में संरक्षण किया गया।

संरक्षित नारियल जननद्रव्य का जीन बैंक अनुसंधान, गुणावगुणन और मूल्यांकन कासरगोड़/किडु और दक्षिण एशिया का अन्तर्राष्ट्रीय नारियल जीन बैंक, किडु के राष्ट्रीय जीन बैंक में किया जा रहा है। और उसमें लगभग 20 स्थिर फलित जातियों में उपज और उपज संघटकों की उच्च क्षमता रिकॉर्ड किया गया।

फेडरेटड मलय स्टेट्स लंबी उच्च फूल रस उपज 31.23 लीटर /फूल (पश्चिम तट लंबी में प्रति फल 23.18 लीटर की तुलना

में) खोपड़ा/गुठली के अतिरिक्त रस उत्पादन के लिए कृषि की क्षमता अधिक है। पेसफिक क्षेत्र से जननद्रव्य संग्रहण के बीच उच्च उत्पादन क्षमता नियु बुलावु, सोलोमन लंबी, नियु हाको, तुटियाला लंबी, रेन्नेल लंबी और निकोरे बौनी में उच्च उत्पादन क्षमता पायी गयी। कासरगोड में बौनी जातियों के तुलनात्मक मूल्यांकन में आई एन डी 003 एस में पहले ही फूल निकलते पायी गयी (18 वीं पत्ता नाली में)। छह लंबी जातियों में (पलवान लंबी, गंगापानी लंबी, पनामा लंबी, निकोबार बीक लंबी, अण्डमान आर्डिनरी, फेडरेटड मलय स्टेट्स लंबी) वर्जिन नारियल तेल पर अध्ययन किया गया और पाया गया कि 100 फल से अण्डमान आर्डिनरी में 4.1 लीटर, पलवान लंबी और फेडरेटड मलय स्टेट्स 6.3 लीटर तक तेल उपज में भिन्नताएँ पायी गयी।

अजैविक तनाव जैसे आद्रता कमी, ठंडा और उच्च ताप के विरुद्ध नारियल जननद्रव्य का छनबीन प्रगति पर है। पश्चिम बंगाल से 15 शीत सक्षम नारियल जातियाँ अनुसंधान केंद्र, मोहितनगर में मूल्यांकनाधीन है। इसमें शीत क्षत का कोई लक्षण नहीं पाया गया।

12 जातियों में अंकुरण के लिए लगे गए दिनों पर किए गए अध्ययन में कुलशेखरम हरी बौनी और सानरामन लंबी पूर्व अंकुरित और बुआई के दो हफ्ते में अधिकतम अंकुर के साथ पायी गयी। पेसफिक क्षेत्र से संग्रहित पाँच लंबी जातियों को मिलाकर आठ जातियों में मृदु फल परीक्षण पर अध्ययन किया गया। उच्चतम मृदुफल पानी और उच्च मृदु फल भार नियु इयि लंबी में अंकित किया गया। सानरोमन लंबी में बड़ा फल, पिंग रंगीन मध्यफल भित्ति पायी गयी। मार्कर सहायक चुनाव और प्रजनन कार्यक्रम आनुवंशिक स्टॉक/दोहन आकर्षक पिंग छिलके के साथ नया मृदुफल प्रजाति के लिए उसकी क्षमता उपयोग के लिए आगे अध्ययन किया गया। पालघाट के चिट्टूर नारियल समूह में फल संघटक परीक्षण और केरल के जड़ मुर्झा रोग विख्यात क्षेत्र में पिंग रंगीन छिलका लंबी प्रजाति के लिए स्वस्थाने गुणावगुणन किया गया। आठ लंबी जातियों सहित 10 नारियल जातियों का गुणावगुणन, कायिक, जननीय और फूल गुण प्रगति पर है। अनुसंधान केंद्र, किडु में 13 संरक्षित जातियों में डिस्क्रेटर परीक्षण और डिस्क्रेटर्स का विकास और परीक्षण रिकार्ड किया गया।

मोहितनगर में एकांतर प्रक्षेत्र जीन बैंक में 71 सुपारी जातियों के लिए उपज संघटक रिकार्ड किया गया है। उसमें से वी टी एल 40, वी टी एल 60 वी टी एल 64 वी टी एल 75 में सूखा अष्टी उपज अत्युत्तम प्रदर्शित किया गया। अण्डमान निकोवर द्वीप से संग्रहित मृदु फल प्रक्रमण अध्ययन 14 जातियों में किया गया और वी

टी एल 34, वी टी एल 36 और वी टी एल 37 जातियों से 66 प्रतिशत से अधिक प्रथम गुणी संसाधित मृदुफल प्राप्त किया गया।

11 विमोचित /वर्तमान नारियल प्रजातियों में डी यु एस परीक्षण आंकड़ा उत्पादन जारी किया गया। कोको के लिए स्थापित नया डी यु एस केंद्र के अधीन बीज कोष संग्रहण से कोको की डी यु एस परीक्षण गुणों की लघु सूची बनायी गयी। कुल 20 विशेष संरचनात्मक / मात्रात्मक/गुणात्मक गुण जैसे पादप प्रकृति, आधार का पत्ता पटल आकार, पत्ता शिखर आकार, अन्तोसयानिन वर्णकता से तरुण चमक पत्ता रंग, पुष्पवृन्त में आन्तोसयानिन, पुष्पवृन्त व्यास, बाह्यदल अभिविन्यास, पुंकेसर तंतु में आन्तोसयानिन, फल आकार, आधार संरचना, शिखर रूप, लंबाई/चौड़ाई अनुपात, सतह झुर्रियाँ या वलयन, नंग, छिलका मोटापा, मोटापा, रिज की ऊँचाई, और झुर्री, पल्प (मज्जा) का मीठापन, बीज की संख्या, बीज की लंबाई/चौड़ाई अनुपात, बीजपत्र रंग, वसा मात्रा आदि प्रौढ़ कोको पेड़ से रिकार्ड किया गया।

उच्च उत्पादनक्षमता और कृषकों के लिए समस्य लाभदायकता सुनिश्चित करने के लिए अनेक उच्च उपज प्रदाय प्रजातियों और संकरों का विकास और विमोचन में केंद्रित प्रजनन प्रयास परकाष्ठा पर पहुँचाया गया है। उच्च उपज और खोपड़ा/डाब जैविक और अजैविक तनाव सक्षम के लिए उचित नारियल की 19 उच्च उपज प्रदाय प्रजातियों (13 सेलेक्शन और छह संकर) का विमोचन खेती के लिए किया गया। लगभग सुपारी की 10 सुधारित प्रजातियाँ (8 सेलेक्शन और दो बौनी संकर) उच्च उपज के साथ और कोको में सात उच्च उपज प्रदत्त प्रजातियों (तीन सर्वोत्कृष्ट क्लोन और चार संकर) विभिन्न प्रक्रमण गुण के साथ, विमोचित किया गया। अभी नारियल और सुपारी में बौनी जातियों और बौनी लंबी संकरों और नारियल में द्वय उद्देश्य से इस क्षेत्र में वास्तविकता के प्रशंसा में जातियों के विकास पर बल दिया जा रहा है।

बड़ा फल और उच्च खोपड़ा प्राप्ति 28.65 कि. ग्रा /ताड़ /वर्ष की कल्प शताब्दी (आई एन डी 034 एस का सेलक्शन) केरल, कर्नाटक और तमिलनाडु के नारियल वर्द्धित क्षेत्रों में खेती के लिए सिफारिश किया जाता है। उच्च उपज प्रदाय सेलक्शन वी टी एल 146, गुजरात से संग्रहित जननद्रव्य से, सूखा अष्टीउपज 3.91 कि. ग्रा. प्रति ताड़ मृदु फल उपज 3.26 कि. ग्रा/ताड़/वर्ष शतमंगला के नाम पर विमोचित किय गया। कोको संकर वी. टी. एल. सी. एच-5 संकर वी.टी. एल. सी-64, वी. टी .एल. सी 69 (आई सी 565554 आई सी 565559) नेत्रासैंटुरा के नाम पर विमोचित किया गया। यह प्रजाति साधारण और उच्च घनता रोपाई

के अधीन, सुपारी और नारियल बाग के अधीन (दोनों पौध और क्लॉन्स) माध्यमिक छत्र (1618 वर्ग मीटर) के साथ कालपूर्व, स्थिर, और भारी फलन देने वाली है। और यह पश्चिम घाट पहाड़ और केरल के मैदानों और कर्नाटक और तमिलनाडु और आन्ध्रप्रदेश के सिंचित सुपारी और नारियल बाग के लिए सिफारिश किया गया है।

पीला पत्ता रोग छानबीन परीक्षण में संरचनात्मक परीक्षण और रोग सूचियांकन किया और इन ताड़ों में पीला पत्ता रोग का कोई लक्षण नहीं देखा गया और पीला पत्ता रोग प्रतिरोध/सक्षमता के लिए पितृ ताड़ों के साथ बौने संकरों, (मंगला x हिरेहल्ली बौनी, हिरेहल्ली बौनी x मंगला, सुमंगला x हिरेहल्ली बौनी, हिरेहल्ली बौनी x सुमंगला, मोहितनगर x हिरेहल्ली बौनी और हिरेहल्ली x मोहितनगर) का अनुवीक्षण सम्बाजे में कृषकों के बाग में प्रगति पर है और किसी भी संकरों में पीला पत्ता रोग लक्षण नहीं देखा गया है।

जैविक और अजैविक तनाव के लिए विविध कोको प्रजातियों का छानबीन जारी किया जा रहा है। 19 लाल रंगीन नैजीरियन क्लॉन्स चाय मच्छर बग के सक्षम के लिए मूल्यांकन किया गया। फली क्षत की प्रतिशतता के आधार पर जो 0-65.2 प्रतिशत दर में है एन सी 56, एन सी 25 और एन सी 41 कल्लेन के साथ जो पूरणरूप से चाय मच्छर बग से मुक्त है। मूल्यांकित कोको वासप्ररूप (पौध) के बीच 20 प्रतिशत प्रक्षेत्र क्षमता में हैड्रिक तनाव के लिए, संरचनाकारीय, शरीरक्रिया वैज्ञानिक परीक्षण, गौण मेटाबोलाइट और जैवरासायनिक संघटक के साथ वी टी एलसी पी 26, वीटीएल सी पी 27 वी टी एल सी पी 25 वी टी एल सी एच 4 और वी टी एल सी पी 22 विस्तृत स्वीकार्यता पहचान लिया गया जो निम्न आद्रता तनाव के प्रजनन के लिए उपयोग किया जाएगा।

पेसफिक सागर बौनी के साथ नए परीक्षणी संकरों के उत्पादन विश्व जननद्रव्य संग्रह केंद्र अण्डमान द्वीप में सानरोमन लंबी और कोचिन चैना लंबी (कासरागोड) से पराग के साथ रोपण किया गया और। मलयन पीला बौना x चौघाट हरा बौना संकर, मलयन बौनी x केनिया लंबी, मलयन पीला बौना x पश्चिम तट लंबी, चौघाट नारंगी बौनी x लकाडीवआर्डिनरी लंबी और चौघाट नारंगी बौनी x पश्चिम आफ्रिकन लंबी आदि बहु स्थानीय परीक्षणाधीन है।

उच्च उपज प्रदाय और जड़ मुर्झा रोग मुक्त चौघाट हरा बौना मातृ ताड़ पहचानने के लिए केरल के मुख्य रोग बाधित आलप्पुषा, कोल्लम, कोट्टयम और पतनमतिट्टा जिलों में विस्तार सर्वेक्षण किया गया। सी जी डी/डब्ल्यू सी टी ताड़ों के जी पी एस आधारित डाटाबेस ताड़ पहचानने में और बीज गुठली संग्रहण और विकेंद्रीकृत

संकर पौध उत्पादन के लिए ताड़ उपयोग के लिए सहायक हो जाएगा।

उपज क्षमता और बौनेपन के लिए हिरेहल्ली बौनी सहित आठ संकरों और विमोचित प्रजातियों विट्टल मोहितनगर और काहिकुची में समवर्ती मूल्यांकन के अधीन है। सूखा अष्टी उपज में संकर और पितृ ताड़ों में महत्वपूर्ण भिन्नताएँ पायी गयी। अधिकतम सूखा अष्टी उपज हिरेहल्ली बौनी x मोहितनगर और मोहितनगर x हिरेहल्ली बौनी और हिरेहल्ली बौनी x सुमंगला में क्रमशः 2.49, 2.42, 2.37 कि.ग्रा प्रति ताड़ प्रति वर्ष अंकित किया गया।

कुल 9.339 लाख रोपाई सामग्री एकक में नारियल में 1.31 लाख, सुपारी में 7.04 लाख और कोको में 0.92 लाख उत्पादन किया गया और कृषकों को और अन्य हितधारकों को वितरण किया गया। और गुणी रोपाई सामग्रियों के उत्पादन के उद्देश्य के लिए अनुसंधान संस्थानों पर अधिक आश्रित रहने से कम रहने के लिए कल्प संकरा संकर उत्पादन के लिए विकेंद्रीकृत संकरण संस्थान का नेटवर्क नौ भागीदारी संस्थानों के साथ भाकृअनुप कृषि विज्ञान केंद्र/राष्ट्रीय सरकारी संगठनों को सम्मिलित कर स्थापित किया गया। उच्च उपज प्रदाय, इएलआई एस ए परीक्षित जड़ मुर्झा रोग मुक्त पश्चिम तट लंबी ताड़ों से संग्रहित पराग भण्डार के लिए प्रादेशिक केंद्र, कायम्कुलम में एक पराग प्रशीत परिरक्षित की स्थापना की गई। भण्डार किया गया पराग कल्पसंकरा (सी जी डी x डब्ल्यूसी टी संकर के विकेंद्रीकृत उत्पादन के लिए उपयोग किया गया। नारियल की प्रदर्शनी प्लॉट चार एकड़ क्षेत्रफल के खुला जेल, नेटुकलतेरी (तिरुवनन्तपुरम जिला, केंरल) में 300 कल्प श्री पौध रोपण किया गया और अतिरिक्त दो एकड़ क्षेत्रफल में रोपाई विस्तार करने के लिए कार्य प्रारंभ किया गया।

उत्कृष्ट रोपाई सामग्रियों के संवर्धन के लिए सुपारी प्रजातियों जैसे शतमंगला, नलबारी, मदुरामंगला और मंगला सेलेक्शन स्थापित किया गया।

स्थानीय/विमोचित उच्च उपज प्रदाय प्रजातियों का उपयोग कर संकरों के उत्पादन के लिए हिरेहल्ली बौनी के अतिरिक्त पैतृक ब्लॉक अखिल भारतीय समन्वित ताड़ अनुसंधान परियोजना केंद्र, वाकावाली और शिमोगा में रोपित किया गया।

### जैव प्रौद्योगिकी और जैवसूचनाएँ

विकसित नारियल भ्रूण प्रशीत परिरक्षण नयाचार का प्रमाणीकरण पाँच अधिक जातियों में किया गया। तीन नारियल जातियों फिलिप्पाइन्स आर्डिनरी लंबी, लकाडीव लंबी और मलयन ग्रीन बौनी) और सुपारी (हिरेहल्ली बौनी और सुमंगला) के पराग लघु

निर्जलीकरण नयाचार उपयोग कर लंबी अवधि भण्डारण के लिए तरल नाइट्रोजन में भण्डार किया गया।

मशीन लैनिंग वर्गीकरण अलगोरिथम, सपोर्ट वेक्टर मशीन का उपयोग समजातिय भूणोद्भव जैसे समजातिय भूणोद्भव रिसेप्टर कैनेस (एस इ आर के) पत्तेदार बीजपत्र (एल इ सी) और वुस्चेल (डब्ल्यू यु एस) में संबद्ध प्रोटीन के लिए भविष्यसूचक मॉडल सृजन के लिए किया गया।

तुलनात्मक जिनोम पहल द्वारा नारियल से आर - प्रोटीन्स का परिवारों को पहचान लिया गया और इन प्रोटीनों को विभिन्न जैसे एन बी एस, एन बी एस - एल आर आर, सी सी एन बी एस एल आर आर, टी आइआर - एन बी एस - एल आर आर और के आई एन ए एस ई में समूह बनाया जा सकता है। समजातता मॉडलिंग द्वारा आर प्रोटीन का 3-डी संरचना निर्धारित किया गया।

कोशिकीय, शरीरक्रियात्मक और विकासन प्रक्रियाओं के रक्तबहुलता के विनियम में सूक्ष्म आर एन ए एस फंसा गया। नारियल में कृत्रिम वातावरण में (कांच के अंदर) भूणोद्भव के विनियमन में सूक्ष्म आर एन ए एस की भूमिका अध्ययन का प्रयास किया गया। 15 सूक्ष्म आर एन ए से संबंधित कुल 27 प्रौढ़ सूक्ष्म आर एन ए एस अनुक्रम नारियल भ्रूणोद्भव कैलस से पहचान लिया गया। और पौध विकास में इन सूक्ष्म आर एन ए एस का विशेष योगदान पाया गया।

दो एन जी एस प्लाटफार्म का उपयोग कर नारियल के पूरे जिनोम अनुक्रमण की एक नयी पहल प्रारंभ की गयी। और नारियल जिनोम के लिए संकरण संयोजन के लिए दोनो प्लाटफार्म से प्राप्त रिकार्ड का उपयोग किया जाएगा।

### फसलन और सस्यन पद्धति

जी. ए. टी. टी और एफ. टी. ए. एस पद में जहाँ एकीकृत वैश्विक विपणन के वर्तमान परिदृश्य में, जहाँ देश में उत्पादन में थोड़ा सा विक्षोभ विश्व में अन्यत्र मूल्यश्रृंगला में अप्रत्याशित प्रभाव डाला जा सकता है। यह अधिक विवेकपूर्ण है कि परंपरागत लघु जोत किसान जितना अधिक फसल साध्य हो सकता और कृषि उद्यम निर्बाध एकीकृत किया जा सकता है। नारियल और सुपारी आधारित अंतर/मिश्रित, बहु परतीय बहु जातिय फसलन मॉडल तथा मिश्रित सस्यन पद्धति कुल पद्धति उत्पादनक्षमता और कृषक आय बढ़ाने के लिए विकास किया गया। नारियल आधारित सस्यनपद्धति बहु जातिय फसलन पद्धति नारियल के साथ कालीमिर्च, केला, जातिफल अनानास अदरक हल्दी कसावा से सकल आय 3.7 लाख

प्रति हेक्टर लगभग नारियल इकफसलन (1.4 लाख प्रति हेक्टर) की तुलना में ढेड गुना अधिक पायी गयी।

नारियल आधारित मिश्रित कृषि पद्धति में नारियल, काली मिर्च केला, संकरनश्ल गाय, मुर्खीपालन, बकरी और मत्स्यपालन से 6.1 लाख जो नारियल इकफसलन की तुलना में तीन गुना अधिक है। अनुसंधान केंद्र, मोहितनगर में सुपारी आधारित फसलन पद्धति कोको, केला और काली मिर्च संघटक फसल के रूप में 8.8 लाख रुपए प्रति हेक्टर जो सुपारी इकफसलन से प्राप्त आय (3.80 लाख प्रति हेक्टर) की तुलना में द्वय गुन है।

डेरी - उद्योग, ताजा जल मत्स्यपालन और चारा घास (संकर नेपियर) संघटक के साथ सुपारी आधारित मिश्रित सस्यन पद्धति से 6.6 लाख रुपए प्रति हेक्टर जो सुपारी इकफसलन से प्राप्त आय से एकदम उच्च है। सुपारी और नारियल आधारित औषधीय सस्य, एस्परागस और एलोवेरा की कृषि से पद्धति से प्राप्त उत्पादन क्षमता में सुधार पायी गयी। सुपारी काली मिर्च, नींबू और हल्दी सहित सुपारी आधारित सस्यन पद्धति से उत्पादन क्षमता उच्च ही पायी गयी, काली मिर्च से 55-60 प्रतिशत अंशदान आय प्राप्त किया गया।

यह प्रदर्शित किया जाता है कि नारियल आधारित उच्च घनता बहु जातिय सस्यन पद्धति में उच्च नारियल उत्पादन क्षमता जो समीकृत पोषण प्रबंधन के समतुल्य है नारिल अलवाल में जैवभार (वर्मीकम्पोस्ट) पुनः चक्रमण, हरा खाद डालकर, जैव उर्वरकों का प्रयोग, वर्मीवाश का प्रयोग, छिलका पलवारना, और मल्लिचंग सम्मिलित पूर्ण जैविक उपचार से लगातार किया जा सकता है।

गोबर, वर्मीकंपोस्ट एज़ोस्फिरिल्लम और फोसफोम्राक्टीरिया द्विमासिक अन्तराल मेंप्रयोग करने से नारियल रोपण में संकर नेपियर जाति Co3 चारा अन्तरफसल की कृषि के लिए जैविक पोषण प्रबंधन मानकीकृत किया गया। और 139 टन प्रति हेटर चारा उपज प्राप्त किया गया।

नारियल बाग में स्टैलोसेन्स के साथ संकर बाजरा नेपियर सुगुणा अन्तरफसलन किया गया। जड़ मुर्झा प्रभावित बाग के अधीन नारियल आधारित मिश्रित कृषि पद्धति में हमटा संगत फसल संयुक्त है। परिणाम यह दिखाता है कि शिम्बीधान्य फसल और चारा घास संयुक्त से मृदा पोषण लभ्यता और चारा उपज बढ़ाता है, मुख्य रूप से चारा घास का वर्द्धन एक फसल के रूप में हो जाने से पोषण निः शेषण द्वारा।

विभिन्न कटाई अन्तराल और डाब कटाई और प्रौढ़ गुठली उत्पादन अनुक्रम के प्रभाव निर्धारण के लिए अध्ययन किया गया। यह

निरीक्षण किया गया कि वर्ष भर डाब कटाई करने से उच्च उपज प्राप्त 167 डाब प्रति ताड़ अंकित किया गया और गुठलीभार 2.2 कि. ग्रा प्रति गुठली है। जो अन्य सभी उपचार से महत्वपूर्णता से भिन्न है। आर्थिक विश्लेषण से यह देखा गया कि वर्ष भर डाब कटाई से उच्च कुल आय (264768/रुपए) प्राप्त किया जाता है।

बोरोन की कमी ताड़ों में बोराक्स के रूप में बोरोन का क्रमिक स्तर (0, 6, 12, 18, 24 ग्रा प्रतिताड़) के साथ प्रक्षेत्र परीक्षण किया गया और पाया गया कि चार विभाटित मात्रा में अलवाल में अनुकूलतम मात्रा 160 ग्रा बोराक्स प्रति ताड़ छिलका पलवारने के साथ 20 कि ग्रा प्रति ताड़ वर्मीकम्पोस्ट का प्रयोग नियत किया गया है।

मृदा का बोरोन स्तर 0.87 पी पी एम और पत्ता का 13.87 मि ग्रा प्रति कि ग्रा पाया गया। स्थान विशेष प्रबंधन पद्धति के माध्यम से नारियल आधारित फसलन पद्धति का आर्थिक व्यवहार्यता मूल्यांकन के लिए बहु संस्थानीय सहयोगी परियोजना 2015 में प्रारंभ किया गया था केरल के पाँच कृषि पारिस्थितिक एकक में केरल राज्य योजना बोर्ड वित्तीय सहायता के साथ किसानों के खेत में परीक्षणी जांच एवं प्रदर्शनी इस परियोजना में निहित है।

इस परीक्षण में पाँच उपचार संयुक्त है सोडियम क्लोराइड (नमक), चूर्ण डोलोमाइट और जिप्सम के साथ सभी मुख्य, द्वितीय और सूक्ष्म पोषण और कृषकों का साधारण वृत्ति नियंत्रण रखें। उपचार के बाद पत्तों में बोरोन मात्रा में महत्वपूर्ण वृद्धि पायी गयी। स्वस्थाने ताड़ अवशिष्टों का पुनचक्रमण से सभी स्थानों में मृदा कार्बनिक मात्रा में सुधार पायी गयी। औसत वार्षिक गुठली उपज में पायी गयी वृद्धि उपचार से हुई महत्वपूर्ण सुधार दिखाता है।

### जैव संसाधनों का उपयोग

वर्मीकंपोस्ट ढेर से केंचुओं को निकालने के लिए एक पुश - पुल रणनीति का प्रयोग किया गया जिसमें जैविक सामग्रियों द्वारा विमोचित चुलबुला के समीकृत उपयोग से वर्मीकंपोस्ट ढेर से उसका प्रवासन नियंत्रित करने का परिहार की शक्ति के रूप में पास में डाला ताजा गोबर में स्थानांतरण करते हैं और अंततोगत्वा संग्रहित किया जाता है ऐसे वर्मीकंपोट टैंक से केंचुओं की छंटाई आसान और मज़दूर सौहार्द रूप से है।

उपभोक्ताओं द्वारा डाब फल पार्लर/गली विक्रेता में उसी स्थल में डाब पानी पिया जाता है और छिलका वहीं छोड़ा जाता है जो परिसरों में ढेर बन जाता है। कंपोस्ट बनाने के लिए यह अत्यंत रेशेदार जैव कचड़ा, अप्रौढ़ नारियल छिलका का प्रक्रमण एवं उपचार डायज़ोट्रोफिक सूक्ष्माणुवीय सहायता संघ और मुर्गीपालन खाद के

साथ तीन महीने की अवधि तक किया जाता है। यद्यपि यह टेनिन और लिग्निन समृद्ध सामग्री कम परिवर्ती है और उसका कार्बन रसायन समूक्ष्माणुवीय क्रियाशील के लिए अधिक सुभेद्य नहीं है। प्राथमिक परिणाम से यह देखा गया कि दस कार्बनिक सामग्री में रससमीकरणमिति परिवर्तन प्राप्त किया जा सकता है। कंपोस्ट बनाने के लिए पर्यावरण हितैषी प्रौद्योगिकी के विकासन की ओर परीक्षण किया गया कि सड़ जाने में मशकल प्राकृत लिंगो - सेल्युलोलोसिक सुपारी छिलका, सूक्ष्माणुवीय और गैर सूक्ष्माणुवीय दखल आदि का प्रयास किया जा रहा है।

सार्वजनिक पहुँच में सुलभ गौण आंकड़े से मुख्य नारियल वर्द्धित क्षेत्रों के सूक्ष्मपोषक स्थिति नक्शा का विकास किया गया। भारत में मुख्य नारियल वर्द्धित क्षेत्रों के बीच 47 प्रतिशत क्षेत्रों के अधीन के मृदा में ज़िंक कमी और 25 प्रतिशत क्षेत्रों की मिट्टी में बोरोन की कमी 16 प्रतिशत के अधीन की मृदा में लोहा कमी 10 प्रतिशत क्षेत्रों की मिट्टी में माननीयता की कमी और 9 प्रतिशत क्षेत्रों की मिट्टी में भस्वीय की कमी पायी गयी। उच्च ज़िंक विलेयीकरण क्षमता के साथ पाँच जीवाणु एकलन के बीच, *माइक्रोकोकस ल्यूटियस* सी यु के 5, जीवाणु-समूह में सम दक्षता के साथ ZnO और ZnCO<sub>3</sub> दोनों को विलेय किया जा सकता है।

गमला संवर्द्धन अध्ययन में, मृदा में लभ्य ज़िंक कम (0.31 से 0.70 पी पी एम) ज़िंक विलेय जीवाणु के साथ निवेशन से ज़िंक स्तर में काफी वृद्धि पायी गयी विशेषतः CUK 5 एकलन में।

विभिन्न जैव संसाधनों जैसे *यूड्रिलस* जाति (नारियल पत्ता वर्मीकंपोस्ट बनाने की केंचुएँ) 3,60,000) 'कल्प ओरगानिक गोल्ड' (नारियल पत्ता वर्मीकंपोस्ट, 10 टन) कल्प सॉयल कैय (यूरिया मुक्त कायर गूथा कंपोस्ट, 6 टन) केरा प्रोबियो (पीजीपीआर बायोइनोकुलेंट 120 कि ग्रा) नारियल पत्ता वर्मीवाश, 80 लीटर) मशरूम स्पॉन (70 कि. ग्रा) का उत्पादन किया गया और किसानों को और अन्य अंत उपयोगकर्ताओं को वितरण किया गया।

### फसल नाश कम करना

पारिस्थितिकीय स्थिरता और पर्यावरणीय धारणीयता संवर्द्धन कर ताड़ और कोको में कीट प्रबंधन प्रयास विस्तार रूप से परिष्कृत किया गया। सामुदायिक भागीदारी पद्धति द्वारा समीकृत कीट प्रबंधन अधिक यथार्थ, नवीन, और कृषक केंद्रित बनाने के लिए वनस्पतिक तैयारियों, जैविक धमन और सेमियो रसायन रणनीतियों, अबोधगम्यता से गूँथा गया। निकटवर्तिता में कीट धमकी युद्ध में व्यवहार्य विकल्प के रूप में सस्य - पारिस्थितिक तंत्र आधारित पारिस्थितिक जैव - इंजिनियरी पहुँच पूर्वानुमानित किया गया।

तरुण ताड़ों में राईनोसेरस भृंग का संक्रमण, जो फिलहाल वर्षों में धमकी अनुपात में है विरोध करने के लिए रोगनिरोधी पत्ता नाली प्रयोग के लिए एक वनस्पतिक केक और वनस्पतिक लेप का विकास किया गया है। प्रक्षेत्र वितरण के लिए वनस्पतिक केक खुराक तरीके में आगे परिष्कृत कर पेलेट बनाया गया।

सस्य पारिस्थितिक तंत्र आधारित कीट लक्षणाओं की पुनरावृत्ति होने की रणनीति - पारिस्थितिकीय इंजिनियरी द्वारा रुपांकन किया गया राईनोसेरस भृंग के प्रबंधन के लिए नारियल के साथ मसाला और फल पेड़ों के फसल संयुक्त के साथ, फसल बाहुल्य का मिश्रित-अस्थिर संकेत (रंबूटान, जातिफल, कड़ीपत्ता, केला, हल्दी, चना, पपीता) के अन्योन्यक्रिया शोषण कर, कम क्षति (15.8 प्रतिशत) आंतरिक ताड़ पर पहुँचा (30 प्रतिशत)।

इंच ऑफ लांड और बंच ऑफ क्रोप्स संकल्पना पूरक कर कीट लक्षणाओं की पुनरावृत्ति होने के अतिरिक्त ताड़ों को अधिक रक्षा प्रोत्साहित करने से निरंतर रोजगार और आय उत्पादित किया जाता है।

फेरोमोन वितरण के दो विभिन्न तरीके जैसे केम्टिका (पॉलिमर मेम्बरेन) और भाकृ.अनु.प.-के.रो.फ.अ.सं. (नानोपोरस मेट्रिक्स) का उपयोग कर कीट स्थानिक क्षेत्र 2014-16 (जून-मई) कायमकुलम में किए गए अध्ययन से यह देखा गया कि प्रक्षेत्र में भृंग की अधिक संख्या पकड़ने में नानोपोरस मेट्रिक्स श्रेष्ठ है। लेकिन केरल की घरेलू परिस्थिति के अधीन समीकृत कीट प्रबंधन रणनीति के अधीन मुख्य संघटक के रूप में उपयोग नहीं किया जा सकता है। बड़ा रोपण में क्षेत्र विस्तृत सामुदायिक स्तर पहल अच्छा होगा। पिछले तीन वर्षों के लिए समीकृत कीट प्रबंधन प्रौद्योगिकियों के प्रक्षेत्र विस्तार कार्यान्वयन (2013-2016) तीन स्थानों में केरल के आलप्पुषा जिला में, रोगनिरोधी पत्ता नाली भरना वनस्पतिक केक रेत के साथ मिश्रण कर, मेटाराइज़ियम अनिसोप्लिए और घासपात का संयोजन, क्लियोडेन्ड्रान इनफोर्टुनाटम और ओरिक्टस राईनोसेरस नुडिवाईरस संक्रामित भृंग के विमोचन से भृंग क्षति 81.2 प्रतिशत कम किया जा सकता है।

लाल ताड़ घुन, ताड़ का अधिक विनाशक कीट में अंतर्जिधि पर घना शूक तथा पुरुष का फीमर की उपस्थिति से यौगिक द्विरूपता पर एक नया आकारिकी लक्षण स्थापित किया जा सकता है। और मादा भृंग में पूर्ण रूप से नामौजूद। लाल ताड़ घुन पकड़ने के लिए उपयुक्त प्लास्टिक बाल्टी ट्राप का पुनः रुपांकन छतरी के आकार में पी. वी. सी के साथ टिकारूपन बढ़ाकर, फेरोमोन का अनुकूलतम विसरण और भृंग का अधिक पकड़ सुनिश्चित किया जाता है।

रुगोस स्पैरल्लिंग सफेद मच्छर (*अलेयुरोडिकस रीगियोपेरकुलाटस मार्टिन*) नारियल पर एक अक्रामक कीट पोल्लाची (तमिलनाडु) और पालघाट (केरल) (जुलाई-अगस्त 2016) में रिपोर्ट किया गया और बाद में अगले छह महीने की अवधि में रुगोस स्पैरल्लिंग सफेद मच्छर केरल, तमिलनाडु (पोल्लाची, पाटुकोट्टाई) कर्नाटक (उडुप्पी) और आन्ध्र प्रदेश (कदियमपलंगा) में फैला देखा गया। कीट का फैलाव बराबर नहीं था। अधिक रूप से देशीय और राज्य मार्गपथ में। जलस्रोतों के पास के एकाकी बागों में और मध्य देश क्षेत्रों में सीमित बागों में पायी गयी।

कज्जलित फफूंदी और क्रियाशील अण्डा सर्पिल की व्यापकता और प्रौढ़ सफेद मच्छर आदि संक्रमण का लक्षण के रूप में अंकित किया गया है। कोई तीव्र आर्थिक नाश का कारण नहीं है। रुगोस स्पैरल्लिंग सफेद मच्छर ताड़ के रस चूस लेने से ताड़ से पानी और पोषण नष्ट हो जाने से तनाव का कारण बन जाता है। यद्यपि प्रकाश संश्लेषण क्षमता का नाश कज्जलित फफूंदी के कारण हो जाता है। इसके कारण पेड़ नहीं मर जाता है। नारियल से संग्रहित अलेयुरोडिकस जाति के 1 जीन (माइटोकोन्ड्रियल साइटोक्रोम ऑक्सिडेस) से व्यूहाण्वय गुणावगुणन से फ्लोरिडा, अमेरिका से रिपोर्ट किया गया *ए. रीगियोपेरकुलेंटस* के माइटोकोन्ड्रियल COI अनुक्रम के साथ 100 प्रतिशत समानता पायी गयी। इस प्रकार उसकी वर्गिकीय समूह पहचान पुष्टि की गई। मौसम में मॉड्यूलन (मानसून में 40 प्रतिशत कमी और लगभग ताप में 2 डिग्री सेल्शियस बढ़ाव और मानसून अवधि के बाद अपराह्न 7 प्रतिशत आनुपातिक आद्रता पर कमी 2016 में पायी गयी जो *ए. रीगियोपेरकुलाटस* भड़कने का कारण हो जाएगा। सफेद मच्छर के प्रबंधन के लिए कीटनाश का उपयोग व्यवहार्य नहीं है क्योंकि प्राकृतिक शत्रुओं के निर्माण में कमी का कारण बन जाता है। विशेषतः *इ. गुआडेलोपडिए*, एक समीकृत कीट प्रबंधन प्राकृतिक शत्रुओं की संख्या निर्माण पर लक्षित है, जैविक नियंत्रण या परजीवित प्यूपे का परिचित कराने से लंबी अवधि के लिए रुगोस स्पैरल्लिंग सफेद मच्छर के जैव-धमन की अधिक साध्य और लगातार वैकल्पिक अभिगम है।

दक्षिण कन्नड़ जिला के बन्टवाल तालुक के सुपारी बाग से एक नया कीट अम्ब्रोसिया, क्रोस्सोटारसुस जाति (कुरकुलियोनिडे) रिकार्ड किया गया है। इसका सुस्पष्ट लक्षण यह है कि भृंग के प्रवेश द्वार से पीला चिपचिपा निःस्त्राव रिसता हुआ दिखाई पड़ता है।

कोको फली, चेरिल्लेस, फूल और पत्तों पर संक्रमित प्रभावी, प्रमुख चूर्णी मत्कुण, प्लानोकोकस लिलासिनस कोकरेल्ल है। चूर्णी मत्कुण का मौसमीय लक्षण से यह पहचाना गया कि फरवरी में कीट वृद्धि और चरम सीमा मार्च से मई तक होता है। दो

प्राकृतिक शत्रुओं जैसे एसेरोफोगस पपायिए नोएस एवं स्काउफ और अइनासियस अरिजोनेनसिस (गिराउल्ट) कोको पारिस्थिति तंत्र में प्रमुख पाया गया कि चूर्णी मत्कुण संख्या के प्राकृतिक जैवधमन के लिए है। अभी कर्नाटक में कोको के नए कीटों में एक के रूप में रिपोर्ट किया गया है। वर्ष 2013 में कीट लक्षण धीमी गति पर था। वर्ष 2016 में वह बढ़कर 40 प्रतिशत पहुँच गया है शायद मौसम परिवर्तन से होगा।

केरल के कासरगोड जिला के उदुमा पंचायत में सुपारी बाग में संक्रमित मूल ग्रब से *हेटिरोराबिटिस* इन्डिका का एक नया दबाव रिपोर्ट किया गया है। जिससे पूर्व इन्स्टार ग्रब के 90 प्रतिशत मृत्यु दर प्रवृत्त होता है।

0.0045 प्रतिशत इमिडाक्लोप्रिड और 2 कि. ग्रा नीम केक प्रति ताड़ के साथ ई पी एन, *स्टेरिनेरनेमा कारपोकाप्सेडे* (150 लाख) संयुक्त सुपारी मूल ग्रब जैव - धमन का क्षेत्र विस्तृत प्रदर्शनी कर्नाटक में श्रृंगेरी और सुल्लिया में की गई और दो वर्षों की अवधि में उपचारित ताड़ों में मूलग्रब संख्या में 91.8 प्रतिशत की अधिक कमी पायी गयी और 62.1 प्रतिशत उपज वृद्धि पायी गयी।

सामान्य स्लग डेरोसेरोस जाति, नारियल बाग से संग्रहित स्लग के मल में स्पोरांजिया की उपस्थिति द्वारा नारियल कली सड़न रोग व्याधिजन *फाईटोफ्थोरा पाल्मिवोरा* का प्राशन और अन्तर्गहण का लक्षण के रूप में ताजा स्वास्थ्य मृदुल नारियल पर जल जल भिगोया दरार दिखाई पड़ता है। और निवेशित गुठली से *पी पाल्मिवोरा* का पुनः एकलन में नारियल कली सड़न रोग के फैलाव में स्लग का योगदान की पुष्टि की गई।

रोग पीड़ित सुपारी बाग से संग्रहित स्वयं वर्द्धित कोलोकेशिया नमूने से *फाईटोफ्थोरा* एकलन का संरचनात्मक और व्यूहाण्विय गुणावगुणन किया गया और जो इक फसल के रूप में वर्द्धित है। रोग बंधित सुपारी बाग से एकलित 20 *फाईटोफ्थोरा* में 18 में 100 प्रतिशत पहचान *पी. मिडियाइ*, सुपारी फल सड़न व्याधिजन के साथ दिखाया। अन्य दो एकलन स्वयं वर्द्धित कोलोकेशिया से पुनः प्राप्त किया गया और इकफसल के रूप में वर्द्धित कोलोकेशिया से पाँच 100 प्रतिशत पहचान *पी. कोकोसिए* एकलन के साथ दिखाया। कोलोकेशिया से सुपारीका *पी. मिडियाइ* के संकरण निवेशन फल सड़न रोग लक्षण का प्रारूपिक लक्षण प्रदर्शित किया। सुपारी फल सड़न व्याधिजन *फाईटोफ्थोरा मिडियाइ* के लिए कोलोकेशिया एक सम्पार्शी परपोषी है।

सुपारी फूलों की शीर्षारंभीक्षय पर अनियमित सर्वेक्षण से देखा गया कि कर्नाटक, केरल के मुख्य सुपारी वर्द्धित सभी प्रक्षेत्रों में प्रचलित

है। कर्नाटक के दावंगरे जिला में उच्चतम लक्षण 27.3 और केरल के कासरगोड में 24.7 पाया गया। रोग स्थानिक क्षेत्रों से संग्रहित एकलनों के बीच महत्वपूर्ण संरचनात्मक विभिन्नताएँ पायी गयी। नारियल पत्ता चित्ती पर किए गए सर्वेक्षण से तमिलनाडु के तिरुपुर जिला में उच्चतम रोग लक्षण और कर्नाटक के तुमकुर जिला में 20 प्रतिशत पाया गया।

फाईटोप्लाज्मा विशेष विश्वव्यापी प्राईमर उपयोग कर नारियल पारिस्थितिक तंत्र से विभिन्न औचैनोरेन्चा फॉना में फाईटोप्लाज्मा का सूक्ष्माणु पहचान यह सूचित किया जाता है कि ओरोसियस अलबिसिन्क्टस (दूर) के लिए 1250bp पर अनुकूल प्रवर्धन होता है जो सिसेमम जाति फिललोडी समूह में फाईटोप्लाज्मा के पारेषण में रोगवाहक का योगदान दिखाता है।

जड़ मुर्झा रोग प्रभावित नारियल रोपण में लाक्षणिक घासपात से फाईटोप्लाज्मा का व्यूहाण्विय गुणावगुणन से द्विबीज घासपात (जंगली सिसेमम, और क्लियोम विस्कोसा) में 16SrII समूह की उपस्थिति और एकबीज घासपात में 16SXIV (उरोचोआ डिस्टाच्या सिनोडोन डाक्टिलोन) से यह देखा गया कि ये घासपात जड़ मुर्झा रोग फाईटोप्लाज्मा के लिए परपोषी के रूप में सेवा नहीं करता है।

### जलवायु समुत्थान प्रौद्योगिकियाँ

ऊपर खुला चैम्बर में नारियल पौध की वृद्धि और विकास पर जलवायु परिवर्तन पर प्रभावित करने वाली वस्तुओं जैसे CO<sub>2</sub> और अनावृष्टि के साथ उन्नत ताप के पारस्परिक प्रभाव पर अध्ययन किया गया। [ECO<sub>2</sub>] और [ET] से पुनरुत्पादन अवस्था में नारियल की प्रतिक्रिया से यह देखा गया कि चैम्बर नियंत्रण की तुलना में भूमि के ऊपर पौध वृद्धि 550 पी पी एम में 1.55 मोड़ उच्च है और 700 पी पी एम CO<sub>2</sub> में 2 मोड़ उच्च है। लेकिन उत्तनत CO<sub>2</sub> के साथ वृद्धि महत्वपूर्णता से कम है उन्नत ताप के साथ वृद्धि नाश की क्षतिपूर्ती निश्चित प्रदाकर। तथापि निम्न रंध्री रंध्रीचालन से आंतरिक जल उपयोगक्षमता [ECO<sub>2</sub>] के अधीन वर्द्धित ताड़ों में उच्च है। नारियल में अनावृष्टि का प्रभाव शमन करने के लिए जलवायु परिवर्तन के अधीन लगातार फल उत्पादन के लिए फसल जल उपयोग क्षमता बढ़ाना अधिक प्रधान है। कभी कभी लंबी जीनप्ररुपों के लिए जल उपयोग क्षमता गैर तनाव परिस्थितियों में उच्च है, तनाव परिस्थितियों में अपेक्षाकृत निम्न है। और जल कमी तनाव के अधीन जल उपयोग क्षमता तुलनात्मक रूप से उच्च है, दिखाता है कि सुलभ जल संसाधनों के उपयोग में बौनी प्रजातियों की अपेक्षा लंबी अधिक दक्ष है।

कृत्रिम परिस्थिति में (काच में) पराग अंकुरण के लिए अनुकूलतम आवश्यक ताप 24.55 डिग्री सेल्शियस से 29.31 डिग्री सेल्शियस है लेकिन लंबी और बौनी जीवनप्ररूप उच्चताप की विभिन्न प्रतिक्रिया दिखाते हैं। लंबी जातियाँ सामान्य रूप में अंकुरण का स्वीकार्य स्तर का अनुरक्षण किया जाता है 20 डिग्री से 35 डिग्री लेकिन ताप 40 डिग्री बढ़ जाने से 35 प्रतिशत कम दिखाता है। बौनी जातियों केवल अनुकूलतम ताप के पास 30-32 प्रतिशत अंकुरण दिखाता है। और उच्च ताप या उससे निम्न में अंकुरण महत्वपूर्ण रूप से कम हो जाता है और 40 डिग्री सेल्शियस में अंकुरण 5 प्रतिशत से कम हो जाता है।

### उत्पाद विविधीकरण, मूल्य वर्द्धन और यांत्रिकीकरण

वर्जिन नारियल तेल प्रक्रमण का मुख्य उपोत्पाद जो पूर्ण रूप से उपयोग नहीं किया जाता है नारियल दूध अवशेष है। जो आहारीय फाइबर, प्रोटीन, पॉलिफिनोल और आन्टिऑक्सिडन्ट (प्रतिउपचायक) समृद्ध है। प्रक्रमण से निकलते उपोत्पादों का श्रेष्ठ उपयोग प्रोत्साहन और उच्च आर्थिक आय सुनिश्चित करने की है। और वर्जिन नारियल तेल प्रौद्योगिकी व्यवहार्य के लिए भक्तानुप-कॅरोफास ने नारियल दूध अवशेष से स्वस्थ, प्राकृतिक और कुरकुरा बनाया गया। 'कल्प क्रन्च' एक नारियल दूध अवशेष है जो प्राकृतिक और धनिया, लहसुन, लवंग, दालचीनी, मिर्च, टकसाल और इलायची से आवरण किया गया है जो खाने को तैयार नारियल दूध अवशेष से निकाला स्नॉक है।

फाइबर समृद्ध पास्टा, रस्क(सूखा बिस्कुट या दो बार पका हुआ ब्रेड) और तला हुआ स्नॉक्स आदि खोजा गया है। मृदु नारियल पानी/नारियल फूल रस के साथ नारियल शक्कर, मीठा करने का एजेंट, गुड शक्कर के बदले, से जैली (लसलसा पदार्थ) की तैयारी के लिए प्रयासरत है।

सुपारी छिलका निकालने का एक मशीन का विकास किया गया है और हस्तचालित क्रिया दूर करने के लिए स्वचालित क्रिया उपकरण के साथ सुपारी श्रेणीकरण एकक का विकास किया गया है। संस्थान फार्म में छिलका निकालने का यंत्र का निष्पादन मूल्यांकन से कृषकों ने प्रोत्साहनजनक प्रतिपुष्टि दी गई है छिलका निकालने में हुई मज़दूरी की तुलना में हस्त से छिलका निकालने से खर्च 1/5 अंश कम हो जाता है।

### क्षमता वृद्धि कार्यक्रम

भारत के दक्षिण राज्यों में 120 लाखों से अधिक लोगों की आजीविका प्रदान करने का एक मुख्य रोपण फसल है नारियल। दक्षिण राज्यों

की औसत नारियल उत्पादन क्षमता 11775 गुठली प्रति हेक्टर है जो अनुसंधान स्टेशनों से प्राप्त उपज 30625 गुठली/हेक्टर की तुलना में निम्न है। अभी नारियल क्षेत्र में बार बार मूल्य उतार - चढ़ाव का प्रभाव पड़ा है, कीट एवं रोगों का लक्षण, आद्रता तनाव, मूल्य वर्द्धन आदि। नारियल खेती की उत्पादनक्षमता और लाभदायकता बढ़ाने की नई तरीका प्रौद्योगिकीय नवीनताओं और नई प्रौद्योगिकियों का फैलाव है।

शताब्दी वर्ष में सभी जगह के अधिक संख्या के किसानों की भागीदारी के साथ देश में पूरे वर्द्धित क्षेत्रों को सम्मिलित कर एक श्रेणीबद्ध किसान मेलाएँ आयोजित की गई। विभिन्न हितधारकों को सहयोजित कर अभिमुखी वीडियो सम्मेलन से अनेक अभिमुखी कार्यक्रमों का आयोजन किया गया जिसमें उनके कई प्रश्नों पर विस्तार रूप से चर्चा हुई। मोबाईल टेलिफोन का अधिक उपयोग और भारत में बढ़ती डिजिटल नेटवर्क को विचार करते हुए कृषक समुदाय तक उत्तम स्तर से पहुँचाने के लिए एक दूसरे को प्रभावित करने वाली पढ़ाई और उचित समय आंकड़ा रिकॉर्ड करने की तरीका विकास किया गया। विषय अब बहु भाषाओं में उपलब्ध हैं। इसके अलावा ई प्लान्टेशन सर्वेक्षण प्रयोग का विकास किया गया अनुसंधान परियोजनाओं और विस्तार गतिविधियों के लिए यथार्थ जी पी एस टैग आंकड़ा संग्रहण का विकास किया गया।

कृषि/बागवानी विभाग के सहयोग से लगभग 23 प्रशिक्षण कार्यक्रमों का आयोजन किया गया। आत्मा और अन्य एजेंसियों के मुख्य फसलों की सुधारित प्रौद्योगिकियों पर विभिन्न राज्यों से 600 से अधिक विस्तार कार्मिकों को प्रशिक्षण प्रदान किया गया।

मुख्य फसलों पर संकरण तकनीकी, नर्सरी प्रबंधन, फसल उत्पादन, संरक्षण और मूल्य वर्द्धन आदि अधिक संख्या के किसानों के लिए आयोजित किया गया।

केरल के सात जिलों में नारियल जड़ मुर्झा रोग के समीकृत कीट प्रबंधन पर प्रक्षेत्र प्रदर्शन, कर्नाटक में सुपारी मूल ग्रब के समीकृत प्रबंधन और कासरगोड में नारियल के गैनोडेरमा विल्ट आदि जारी की जा रही है। 70 गाँवों में 'मेरा गाँव मेरा गौरव' कार्यक्रम सफलतापूर्वक कार्यान्वित किया गया। अधिक संख्या के किसानों की प्रतिभागिता के साथ मृदा स्वास्थ्य प्रबंधन कार्यक्रम दिनांक 5 दिसंबर 2016 को विश्व मृदा दिवस आयोजित किया गया। और 120 कृषकों को मृदा स्वास्थ्य कार्ड वितरित किया गया।

### प्रौद्योगिकी वितरण तरीके

केरल में पथियूर पंचायत में पूरे क्षेत्र के (1657 हेक्टर) के कृषक समुदायों को सम्मिलित कर नवंबर 2016 से फर्मस फस्ट परियोजना

का कार्यान्वयन किया गया। छह मॉड्यूल जैसे नारियल आधारित पद्धित, बागवानी आधारित मॉड्यूल, पशुधन/मुर्गीखाना आधारित मॉड्यूल, एन आर एम आधारित मॉड्यूल, मूल्य वर्द्धन/उपज विविधीकरण मॉड्यूल और समीकृत कृषि पद्धित मॉड्यूल के अधीन एक श्रेणीबद्ध गतिविधियों/प्रौद्योगिकीय दखल परिकल्पित किया गया। हल्दी, मसाला, कंद फसल, तिल की उच्च उपज प्रदाय जातियों की प्रौद्योगिकी स्वीकार करना और क्षेत्रफल बढ़ाना, नारियल पादप संरक्षण में सामुदायिक पहुँच, परंपरागत औषधीय और नवरा धान, जड़ मुर्झा के समीकृत प्रबंधन में कृषक भागीदारी, जैव निवेश उत्पादन एकक, दूध उत्पादन और पशुधन के सुधार के लिए कृषक भागीदारी समीकृत प्रबंधन, केला ऊत संवर्द्धन, कृषि और मृदा संरक्षण विधियों पर बल दिया गया।

नबार्ड सहायक (फार्म नवोन्मेषी एवं प्रोन्नत निधि) जैवसंसाधन प्रबंधन आधारित सामुदायिक परियोजना आलप्पुषा जिले में 2014-16 की अवधि में कंजिकुषि में कार्यान्वित किया गया। इस परियोजना का मुख्य लक्ष्य जैवभार पुनःचक्रमण पर कृषकों की क्षमता प्रबल करना और कृषि उत्पादन में बनाए रखने वाला संवृद्धि सुनिश्चित करने के लिए लाभदायक सूक्ष्माणुओं के साथ जैविकों को समृद्ध बनाना है।

जैव-संसाधन प्रबंधन, मृदा और जल संरक्षण तकनीकी और फसल विविधीकरण पर बल देकर समीकृत पोषण प्रबंधन से नारियल आधारित कृषि पद्धति से उत्पादन क्षमता और आय बढ़ाना।

उपयोग किए जाने वाले जैविक निवेश और गुणी जैविक निवेश की लभ्यता पर उचित ज्ञान न होना आदि मुख्य समस्याएँ जैविक कृषि के क्षेत्र में कृषकों द्वारा सामना की जा रही है। इसके अतिरिक्त परियोजना क्षेत्र (कंजिकुषी ब्लॉक) जहाँ तटवर्ती बलुआर मिट्टी, जो निम्न जैविक अंश और कमजल धारण क्षमता है, मृदा उर्वरता स्थिति के साथ अनेक दबाव है। क्षमता विकास के भाग के रूप में चुने गए किसानों को कंपोस्ट बनाने की तकनीकी पर प्रशिक्षण दिया गया, जैविक की सूक्ष्माणुवीय समृद्धन, जैव संसाधन प्रबंधन पर विशेष बल के साथ पोषण प्रयोग आधारित मृदा परीक्षण, अधिक संख्या के कुशल विकास कार्यक्रम पर प्रशिक्षण, जिसके आधार पर किसान - स्थान - विशेष प्रबंधन पद्धतियाँ और पूरे क्षेत्र के कृषकों को आगे बढ़ाया गया।

जागरुकता बढ़ाना और मृदा परीक्षण पर आधारित चूना प्रयोग और अन्य पोषण प्रयोग से नारियल की उपज में 26 प्रतिशत वृद्धि अंतर फसल 142.9 प्रतिशत पशुधन और अन्य उद्यम 30.9 प्रतिशत की वृद्धि से औसत फार्म उपज में 1.17 लाख रुपए से

2.91 लाख रुपए प्रति हेक्टर 149.8 प्रतिशत वृद्धि पायी गयी। कृषक भागीदारी कार्रवाई प्रबंधन, परीक्षणी पढ़ाई और निरंतर प्रक्षेत्र स्तर निर्धारण और परिष्कार के साथ स्वीकृति से कृषकों को खेती एक लाभदायक उद्यम के रूप में अपनाने का आत्मविश्वास पर बल दिया जाता है।

### आर्थिक और सांख्यिकीय विश्लेषण

नारियल क्षेत्र में प्रौद्योगिकियों का प्रक्षेत्र स्तर उपयोग के निर्धारण के भाग के रूप में केरल राज्य में कल्परस का नूतन क्षेत्रीय पद्धति पर विश्लेषण किया गया। पिछले तीन वर्ष की अवधि में कल्परस उत्पादन के लिए 220 लाईसेंस दिए गए। यद्यपि 94 नारियल उत्पादक सोसाईटी उत्पादन कार्रवाईयों शुरू की गई वर्तमान में केवल 57 नारियल उत्पादन फेडरेशन द्वारा कल्परस उत्पादन जारी किया जा रहा है। जो इस क्षेत्र में समस्या महसूस कर रहे हैं। मूल्य श्रृंखला में किसानों का अंशदान उपभोक्ता मूल्य का 17 प्रतिशत है और कल्परस टैपिंग करने वालों का भाग 20 प्रतिशत है। नीति स्तर पर कल्परस उत्पादन के साथ संबंधित मद प्रति दिन टैपिंग करने नारियल ताड़ पर सीमित है, उपज पर बिक्री नियंत्रण, पंजीकरण औपचारिकताओं पर है। उत्पादन क्षेत्र में कुशल टैपिंग करने वालों की कमी, संस्करण में आवश्यक आधारभूत सुविधाओं की कमी आदि मुख्य समस्याएँ हैं। कल्परस का विपणन भी चुनौतियों का सामना कर रहा है कि उपभोक्ताओं का अनुभव और पूर्ण रूप से खरीददार भाग अध्ययन की कमी और कोई संरचनात्मक विपणन अध्ययन के बिना केवल पूर्वानुमान पर आधारित लाभ विश्लेषण है। अन्य उसी प्रकार के उत्पादों के साथ आगे स्पर्धा करने के लिए उसके पोषण मूल्य के लिए विपणन में समुचित रूप से स्थितिकरण दिया जाना है। यह एक विकासन उत्पाद है। उत्पाद एकरूपता की कमी विपणन बेधी की बाधा हो जाए। सर्वोपरि अप्रैल 2017 से व्यापार करार के अनुसार आयात सीमा शुल्क एशियन उत्पाद भारतीय विपणन में आधिक्य हो जाए और उसके बाद सची स्पर्धा स्थापित हो जाएगा।

सामाजिक आर्थिक पहलू का विश्लेषण और नीति बोधात्मक से मूल्य श्रृंखला गति की नीति निर्णय के लिए आलोचनात्मक निवेश प्रदान करने मुख्य गतिविधियों में एक है।

वर्ष 2013 से मूल्य विश्लेषण से यह पाया गया कि नारियल तेल का मूल्य (घरेलू और अन्तर्राष्ट्रीय के बीच) अस्थिर पाया गया और घरेलू नारियल तेल का मूल्य हास के कारण मूल्य संवेदी उपभोक्ता सस्ता तेल की ओर जाएँगे। यह निरीक्षण किया गया कि निम्न मूल्य का ताड़ तेल नीचे की ओर खींचेगे और केवल मूल्य वर्द्धन

की आवश्यकता देश में नारियल मूल्य स्थिर रहा जा सकता। समय के अनुक्रम में नारियल तेल की गति (घरेलू और अन्तर्राष्ट्रीय) पिछले 13 वर्षों से यह देखा गया कि घरेलू नारियल तेल में चढ़ाव है, अन्तर्राष्ट्रीय मूल्य एक घटाव शक्ति देकर मूल्य समीकृत किया। व्यापार उदारीकृत सामाजिक व्यवस्था में प्राथमिक माल का मूल्य एकीकरण पर अन्तर्राष्ट्रीय व्यापार सिद्धांत अधिमान्यकरण करता है।

यह निर्णायक व्याख्या यह है कि नारियल तेल जैसे एकही माल पर आश्रित होने से लगातार लंबी अवधि के लिए आवश्यक सीमा नहीं प्रदान करेंगे।

देशवार व्यापार प्रतिस्पर्धा समझने के लिए नारियल मूल्य वर्द्धित उपजों के अन्तर्राष्ट्रीय व्यापार परिदृश्य विश्लेषण करना अनिवार्य है। लेकिन अन्य मुख्य वैश्विक निर्यातकों के साथ तुलना करने से नारियल उत्पाद निर्यात में भारत का अंश अल्प है। यद्यपि यह एक स्वीकृत तथ्य है कि नारियल क्षेत्र में भारत का एक प्रबल घरेलू विपणन है, यह एक उच्च समय है कि नारियल निर्यातकों के वैश्विक श्रृंखला में हमारा स्थान उन्नत करने से हम एक मुख्य निर्यातक के रूप में उभर सकें।

### कृषिव्यापार उद्यम

आई टी एम यु के अधीन वर्ष 2016-17 की अवधि में प्रौद्योगिकी हस्तांतरण/कैसे जानें पर रिकार्ड संख्या में 52 समझौता ज्ञापन जारी किया गया। और 15,62,000/ रुपए राजस्व प्राप्त किया गया। वर्ष में हस्तांतरित प्रौद्योगिकियों के बीच 45 नारियल संसाधन के लिए नयाचार पर है। दूसरा वाणिज्यिकीकृत उच्च प्रौद्योगिकी फेरोमोन विमोचन के लिए नानोमेट्रिक्स है जिसका विकास संयुक्त रूप से भाकृअनुप - केंरोफअसं और जवाहरलाल नेहरू केंद्र उन्नत वैज्ञानिक अनुसंधान बेंगलूर ने किया है।

### कृषि विज्ञान केंद्र

भारतीय कृषि अनुसंधान परिषद के अधीन स्थापित कृषि विज्ञान केंद्र की ओर से प्रमुख प्रौद्योगिकियों, ज्ञान प्रदान करना, कृषकों को निवेश के लिए मदद आदि प्रदान किया जाता है। कृषि विज्ञान केंद्र कासरगोड द्वारा आयोजित 100 प्रशिक्षण कार्यक्रमों के अतिरिक्त 5 और 8 प्रक्षेत्र संदर्शन से 2985 कृषकों को हितकार्य किया गया। इसके अतिरिक्त विस्तार गतिविधियाँ जैसे फसलोत्तर उत्सव, कैंप, सहायक सेवाएँ, कृषि क्लिनिक, प्रदर्शनियाँ प्रौद्योगिकी बैठक, प्रक्षेत्र दिवस आदि आयोजित किया गया। कृषि विज्ञान केंद्र की ओर से प्रधान मंत्री बीमा फसल योजना पर 28 मई 2016 को जागरूकता

कार्यक्रम आयोजित किया गया। जिससे भारत सरकार के नए प्रारंभ से अधिकतम लाभ उठाने के लिए कृषकों को सहायता करने में पालन किए जाने वाले तौर तरीके क्या हैं। कृषि विज्ञान केंद्र, कासरगोड और आलप्पुषा के तत्वावधान में और नबार्ड की वित्तीय सहायता के साथ कृषकों को उद्यमकर्ताओं के रूप में बदलाने की ओर दो कृषक-उत्पादक कंपनियों को प्रोत्साहन दिया गया।

### शताब्दी समारोह

भाकृअनुप-केंद्रीय रोपण फसल अनुसंधान संस्थान के इतिहास और भारत में नारियल अनुसंधान में वर्ष 2016 एक स्मरणीय वर्ष है कि वर्ष 1916 में एक निंद्रालु गॉव कुडलु में शुरू एक छोटा नारियल अनुसंधान स्टेशन राष्ट्र की सेवा में 100 शानदार वर्ष पूरा किया है।

शताब्दी समारोह उत्सव की तरह 20 मार्च 2016 को अद्वितीय रूप से 100 कृषकों द्वारा एक साथ शताब्दी नारियल पार्क में 100 नारियल पौधों की रोपाई एक मिनिट में कर शुरू किया गया और उसके बाद उसी दिन बहुत बड़े किसान मेला और अन्य कार्यक्रमों का अतिथि सत्कार/प्रचुरता किया गया।

वर्ष की अवधि में हितधारकों के सभी अनुभागों के लिए 100 कार्यक्रमों का प्रबंधन, किसान मेलाओं की श्रेणी और बहु संपर्क कार्यक्रम देश भर में किया गया। कृषकों और विस्तार कार्मिकों के लिए प्रशिक्षण कार्यक्रम, वैज्ञानिक समुदाय के लिए कार्यशालाएँ/संगोष्ठी और प्रमुख सत्र, कृषि व्यापार उद्यमकर्ताओं और स्वयं सहायक समूह की क्षमता सुग्राही बनाने के लिए कृषिव्यापार बैठक आयोजित की गई। वर्ष लंबित किसान मेला 10 दिसंबर 2016 को समाप्त किया गया। कृषि एवं किसान कल्याण मंत्री माननीय राधा मोहन सिंह जी द्वारा उस समारोह का गौरव बढ़ाया गया। उसके बाद नारियल अनुसंधान एवं विकास पर तीसरी अन्तर्राष्ट्रीय संगोष्ठी दिनांक - 10-12 दिसंबर को आयोजित की गई। और उसके बाद लघु तौर पर प्लाक्रासिम भी आयोजित की गई। माननीय मंत्री द्वारा नया शताब्दी भवन और पुनः नूतन किया गया कल्पका अतिथिगृह का उद्घाटन भी किया। कुछ स्मारक प्रकाशन केंरोफअसं 100 वर्ष की वैज्ञानिक उत्कृष्टता, नारियल वर्द्धकों के ज्ञान, भारतीय बागवानी पर एक विशेष पत्रिका, विमोचित किया गया। इसके अलावा नारियल से मूल्य वर्द्धित उपज 'कल्प चॉक्लेट बार' (भाकृअनुप-केंरोफअसं और काम्पको संयुक्त रूप से उत्पादित) का विमोचन किया गया।

शताब्दी वर्ष में लगभग 60 विस्तार प्रकाशन (विस्तार फोल्डर/तकनीकी बुलेटिन) कुछ स्मारक प्रकाशन (सोवनीर) और 10 वैज्ञानिक किताब (इस संस्थान से और बाहर संगठनों के विशेषज्ञों

के एक बड़े समूह के योगदान के साथ केंरोफअसं से वैज्ञानिकों द्वारा विद्वता पूर्ण संपादित) इस वर्ष प्रकाशन किया गया। प्रक्षेत्र का रोग एवं बागवानी फसल, नारियल, रोपण फसनल की कीट एवं विकार, रोपण फसल की जैव प्रौद्योगिकी, रोपण फसल में जैविक कृषि, रोपण फसल में मृदा स्वास्थ्य प्रबंधन, रोपण फसल में यांत्रिकीकरण आदि वैज्ञानिक संगोष्ठी, 'आईसोक्राड' और 'प्लाक्रासिम' में विमोचित किया गया। कृषक समुदायों की सेवा में केंरोफअसं एवं नारियल में समीकृत कीट प्रबंधन पर वीडियो फिल्म अंग्रेज़ी और अन्य क्षेत्रीय भाषाओं में निकाली गयी।

विभिन्न ग्राहक वर्ग तक और संदेश आरपार पहुँचाने के लिए नई पीढ़ी सामाजिक मीडिया प्लेटफार्म के साथ दृश्य और प्रिंट माध्यम

को सोद्देश्य से सचेत होकर नियुक्त किया गया। शताब्दी समारोह के सिलसिले में आयोजित सभी घटनाएँ/कार्यक्रम व्यापक रूप से विवरित और उपलब्धियों अधिक रूप से राष्ट्रीय/जनभाषा में विशिष्टताओं दर्शायी गयी। इसमें कुछ विशेष रूप से केंरोफअसं के शताब्दी और भारत में नारियल अनुसंधान के स्मारक के रूप में प्रकाशित किया गया। दृश्य माध्यम का योगदान भी इसी प्रकार मुख्य रहा और वे उनके नियमित समाचार संप्रेषण के अधीन विवरण दिया। केंरोफअसं और भारत में नारियल अनुसंधान के 100 वर्ष पर स्मारक डाक टिकट निकालने में दिए गए प्रस्ताव का अनुमोदन डाक विभाग द्वारा किया गया और विशेष डाक टिकट उत्सव की तरह इस वर्ष सुविधापूर्ण दिनों में विमोचित करने की प्रत्याशा है।



Coconut planting materials production at ICAR-CPCRI

The plantation sector in India is dominated by millions of small and marginal farmers, mainly confined to the economically and ecologically vulnerable regions. Coconut, arecanut and cocoa are important plantation crops of India with a profound influence on the rural economy by supporting the livelihoods of 20 million people in the country. The changing cropping pattern, climate change concerns and constraints on natural resource use and reduction in profitability in the plantation crops scenario warrant innovative strategies and approaches to address challenges and promote accelerated growth of the sector.

ICAR-Central Plantation Crops Research Institute (ICAR-CPCRI), one of the premier agricultural research institutions in the National Agricultural Research System of India, is presently mandated to conduct and coordinate research on coconut, arecanut and cocoa in India. ICAR-CPCRI had a modest origin with its lineage tracing back to the Coconut Research Station started in 1916 at Kudlu village (of present Kasargod district of Kerala in Southern India) in the South Kanara district of erstwhile Madras presidency. Ever since its inception, it has served the cause of science and society with distinction through exemplary research, generation of appropriate technologies and development of skilled human resources. The Institute has continued its momentum in conducting basic and applied research relevant to the mandate crops and the progress of research work during the year 2016-17 is being reported under distinct thematic areas.

### Plant Genetic Resources Utilization

Genetic resources are the basic building blocks for undertaking crop improvement programmes and the institute has built up, over the years, a rich repository of genetic resources to provide breeders with required genetic stock to address the present concerns and the future challenges. The institute maintains the world's largest collection of germplasm accessions in coconut (455) and arecanut (176), besides a vast assemblage in cocoa (405). The institute hosts the International Coconut Genebank for South Asia (ICG-SA) at its Research centre, Kidu, established under a tripartite agreement among ICAR-FAO-ITPGRFA, besides the National Coconut Gene Bank (NCGB). It also serves as the National Active Germplasm Site (NAGS) for

coconut, arecanut and cocoa. DUS (distinctiveness, uniqueness and stability) test centres for coconut, arecanut and cocoa have been established at the institute with funding from PPV&FRA, New Delhi and it has facilitated development of the DUS guidelines for coconut and arecanut for effecting the plant variety protection under the institutional framework of PPV&FR Act of 2001.

Arecanut germplasm holdings has been further enhanced with the collection of 12 diverse germplasm, six from North Bengal, two from Assam and four from Karnataka, which include types with bold nuts (>145 g wt.), ripe/fresh nuts with free kernel and variegated nuts. *Theobroma grandiflorum* (Cupuassu fruit), a wild relative of cocoa (*T. cacao* L.) was collected for evaluating its utility as rootstock and for wilt resistance. A 'pentagona' type of cocoa with distinct five-ribbed pod with white to pink beans was collected, for utilizing in expression study of anthocyanin inhibitory genes, and possibly in quality improvement. Local cocoa types from Adimaly and Mankuva villages in high range of Idukki district of Kerala (with pod index 10, bean index 1.95 to 2.11 g, 9.52% shell, 90.6% nib recovery and 52-55% fat content) were collected and conserved at its Regional Stations, Vittal and Kayamkulam for evaluating in the lower hills and plains for desirable quantitative and qualitative traits.

Gene bank maintenance, characterization and evaluation of conserved coconut germplasm were undertaken in the national gene banks at Kasaragod/Kidu and the International Coconut Gene Bank for South Asia (ICG-SA) at Kidu. Higher potential for yield and yield component traits was recorded in about 20 accessions in stabilized bearing and among them, Federated Malay States Tall (FMST) with higher inflorescence sap yield of 31.23 litre inflorescence<sup>-1</sup> (as compared to 23.18 l inflorescence<sup>-1</sup> in West Coast Tall) has great potential for cultivation for sap production in addition to copra/nuts. Among the conserved germplasm from the Pacific region, higher yield potential was recorded in Niu Bulavu, Solomon Tall, Niu Hako, Tutiala Tall, Rennell Tall and Nikkore Dwarf. In the comparative evaluation of dwarf accessions at Kasaragod, early inflorescence emergence (in the 18<sup>th</sup> leaf axil) was recorded in IND003S.

Studies on virgin coconut oil (VCO) yield in six tall accessions (Palawan Tall, Gangapani Tall, Panama Tall, Nicobar Beak Tall, Andaman Ordinary Tall and Federated Malay States Tall) indicated variation with oil yield from 100 fruits, ranging from 4.1 litre in Andaman Ordinary Tall to 6.3 litre in Palawan Tall and Federated Malay States Tall. Qualitative differences in oil quality across accessions indicate the scope for identifying accessions with oil characteristics suitable for different end purposes.

Screening of coconut germplasm against abiotic stresses *viz.*, moisture deficit, cold, and high temperature, is in progress. Among the 15 cold tolerant coconut selections from West Bengal under evaluation at its Research Centre, Mohitnagar, no cold injury symptoms were noticed.

Studies on days taken for germination in 12 accessions indicated very early germination in Kulasekharam Green Dwarf and San Ramon Tall, with maximum germination in about two weeks from sowing. Tender nut traits were studied in eight accessions, including five tall accessions from the Pacific region. Higher volume of tender nut water and also higher tender fruit weight was recorded in Niu Ui Tall. A coconut palm bearing large fruits with pink coloured mesocarp was identified in San Ramon Tall population and is being studied further for its potential use in marker assisted selection and to develop it as a genetic stock/exploitation in breeding programme for a new tender coconut variety with attractive pink husk. *In situ* characterization for fruit component traits in Chittoor coconut population of Palakkad and a pink husked tall accession in root (wilt) disease prevalent tract of Kerala was undertaken. Characterization of 10 coconut accessions, including eight tall accessions, for vegetative, reproductive and inflorescence characters is in progress for development of descriptors and descriptor traits were recorded in 13 conserved accessions at its Research Centre, Kidu.

In the alternative field gene bank at Mohitnagar, yield components have been recorded for 71 accessions of arecanut and among them, VTL-40, VTL-60, VTL-64, VTL-75 exhibited superiority for dry kernel yield. Tender nut processing studies was undertaken in 14 collections from Andaman and Nicobar islands and more than 66% first quality processed tender nuts could be recovered from accessions, VTL-34, VTL-36 and VTL-37.

Generation of DUS test data was continued in 11 released/extant coconut varieties. Under the newly established DUS centre for cocoa, DUS testing characters for cocoa have been short-listed from

core collections. A total of 20 distinct morphological/quantitative/qualitative characteristics *viz.*, plant habit, leaf blade shape of base, leaf apex shape, young flush leaf colour through anthocyanin pigmentation, anthocyanin in flower pedicel, pedicel diameter, orientation of sepal, anthocyanin in stamen filament, fruit shape, basal constriction, apex form, length/width ratio, surface rugosity, colour, husk thickness, prominence of ridges and furrows, sweetness of pulp, number of beans, bean length/width ratio, cotyledon colour and fat content were recorded from adult cocoa trees.

The focused breeding efforts have culminated in development and release of several high yielding varieties and hybrids ensuring higher productivity and overall profitability to the farmers. Twenty improved high yielding varieties (14 selections and six hybrids) of coconut with higher yield and suitable for copra/ tender nut/ biotic and abiotic stress tolerance have been released for cultivation. Altogether, 11 improved varieties of arecanut (nine selections and two dwarf hybrids) with higher yield and eight high yielding varieties in cocoa (three elite clones and five hybrids), with varying processing qualities have also been released. Presently, the emphasis is on developing dwarf varieties and D x T hybrids in coconut and arecanut and dual purpose varieties in coconut, in appreciation of the present day realities in this sector.

Kalpa Shatabdi (a selection of IND034S) with large fruits and a high copra out turn of 28.65 kg palm<sup>-1</sup> year<sup>-1</sup> is recommended for cultivation in the coconut growing tracts of Kerala, Karnataka and Tamil Nadu. A high-yielding selection, VTL-146, from a germplasm line collected from Gujarat with dry kernel yield of 3.91 kg palm<sup>-1</sup> year<sup>-1</sup> and tender nut yield of 3.26 kg palm<sup>-1</sup> year<sup>-1</sup> was released as 'Shatamangala'. The cocoa hybrid, VTLCH-5, a hybrid between VTLC-64 x VTLC-69 (IC 565554 x IC 565559) has been released as variety 'Nethra Centura'. This variety is precocious, stable and a heavy bearer with medium canopy (16-18 m<sup>2</sup>) under arecanut and coconut gardens (as both seedlings and clones) under normal and high density plantings. It is recommended for Western Ghats hills and plains of Kerala and Karnataka and irrigated arecanut and coconut gardens of Tamil Nadu and Andhra Pradesh.

Recording of morphological traits and disease indexing were undertaken in the yellow leaf disease (YLD) screening trial and no symptoms of YLD noticed in these palms. Screening of dwarf hybrids (Mangala x HD, HD x Mangala, Sumangala x HD, HD x Sumangala, Mohitnagar x HD and HD x Mohitnagar) along with parents for yellow leaf disease

resistance/tolerance is in progress in farmers' gardens at Sampaje and none of them have so far showed symptoms of yellowing of leaves.

Screening of diverse cocoa accessions for biotic and abiotic stresses has been continued. Nineteen red coloured Nigerian clones were evaluated for tolerance to tea mosquito bug based on percentage of pod damage which ranged from 0-65.2% , with clones NC-56, NC-25, and NC-41 totally free of TMB damage. Among the cocoa genotypes (seedlings) evaluated for hydric deficit stress at 20% field capacity, with morpho-physiological traits, secondary metabolites and biochemical constituents, VTLC-26, VTLC-27, VTLC-25, VTLC-4 and VTLC-22 were identified as having wider adaptability, which will be utilized for breeding for low moisture stress.

Production of new experimental hybrids with the Pacific Ocean dwarfs planted at World Coconut Germplasm Centre, Andaman islands with pollen from San Ramon Tall and Cochin China Tall (from Kasaragod) was continued. Cross combinations such as Malayan Yellow Dwarf x Chowghat Green Dwarf, Malayan Yellow Dwarf x Kenya Tall, Malayan Yellow Dwarf x West Coast Tall, Chowghat Orange Dwarf x Laccadive Ordinary Tall and Chowghat Orange Dwarf x West African Tall are under multi-location testing.

Extensive survey was conducted in the disease 'hotspots' of Alappuzha, Kollam, Kottayam and Pathanamthitta districts of Kerala for locating high yielding and root (wilt) disease-free Chowghat Green dwarf (CGD) mother palms. The GPS based database of CGD/WCT palms will be helpful in locating the palms for seed nut collection and also for using the palms for decentralized hybrid seedling production.

Eight hybrids involving Hirehalli Dwarf (HD) and released varieties are under concurrent evaluation for yield potential and dwarfness at Vittal, Mohitnagar and Kahikuchi. Hybrids and parents showed significant differences for dry kernel yield. Maximum dry kernel yield was recorded in HD x Mohitnagar, Mohitnagar x HD and HD x Sumangala with 2.49, 2.42 and 2.37 kg palm<sup>-1</sup> year<sup>-1</sup>, respectively.

A total of 9.339 lakh planting material units, including 1.31 lakh in coconut, 7.04 lakh in arecanut and 0.92 lakh in cocoa, were produced and distributed to farmers and other stakeholders. For augmenting quality planting material production and reducing the over dependence on research institutions for this purpose, a network of decentralized hybridization units for Kalpa Sankara hybrid production has been established with nine partnering institutions (including ICAR-KVKs/ NGOs). A pollen cryopreservatory was established at its Regional

Station, Kayamkulam for storing pollen collected from high yielding, ELISA tested root (wilt) disease-free West Coast Tall palms for supply of quality pollen for production of hybrids. The demonstration block of coconut, established in a four acre area at Open Prison, Nettukaltheri (Thiruvananthapuram district, Kerala) was planted with 300 Kalpasree seedlings and work has been initiated for extending planting in an additional two acre area.

Compact blocks of released arecanut varieties viz., Shatamangala, Nalbari, Madhuramangala and Mangala selections have been established for augmenting elite planting materials production. Additional parental blocks of Hirehalli Dwarf have been planted at AICRPP centres at Wakawali and Shimoga for production of hybrids utilizing local/ released high yielding varieties.

### Biotechnology and Bioinformatics

Coconut embryo cryopreservation protocol developed was validated in five more accessions. Pollen of three coconut accessions (Philippines Ordinary Tall, Laccadive Tall and Malayan Green Dwarf) and arecanut (Hirehalli Dwarf and Sumangala) was stored in liquid nitrogen for long term storage using simple desiccation protocol. Somatic embryogenesis and plantlet regeneration was achieved in arecanut, with immature inflorescence explants of Hirehalli Dwarf, dwarf hybrids and select YLD-free arecanut palms.

Machine learning classification algorithm, Support Vector Machine (SVM), was used to create predictive models for proteins involved in somatic embryogenesis viz., Somatic Embryogenesis Receptor-like Kinase (SERK), Leafy Cotyledon (LEC) and Wuschel (WUS). Families of R-proteins from coconut were identified through a comparative genomic approach and these proteins could be grouped into different classes such as NBS, NBS-LRR, CC-NBS-LRR, TIR-NBS-LRR and KINASE. 3-D structures of R-proteins were determined by homology modeling.

MicroRNAs (miRNAs) have been implicated in the regulation of a plethora of cellular, physiological and developmental processes. In an attempt to study the role of miRNAs in the regulation of *in vitro* embryogenesis in coconut, a total of 27 mature miRNA sequences, belonging to 15 miRNA families, were identified from the callus transcriptome data of coconut embryogenic calli and these miRNAs were found to possess particular roles in plant development.

A new initiative, whole genome sequencing of coconut, was undertaken utilizing two NGS platforms and the reads obtained from both these platforms will be utilized for hybrid assembly for the coconut genome.

### Cropping and Farming Systems

In the present scenario of integrated global markets in the post GATT and FTAs, where the slightest disturbance in the production front in one country can have unpredictable impact in the value chain elsewhere in the world, it is all the more prudent that a traditional small-holder farmer should go for as many crops and agri-enterprises as can possibly be integrated seamlessly in to the farming system. Coconut and arecanut based inter/mixed, multi-storied multi-species cropping models as well as mixed farming systems have been developed for increasing total system productivity and farmer income. The coconut based cropping system using multi species cropping of coconut with pepper, banana, nutmeg, pineapple, ginger, turmeric and elephant foot yam generated a net income of ₹ 3.7 lakhs ha<sup>-1</sup>, nearly one and a half times higher than that of coconut monocrop (₹1.4 lakhs ha<sup>-1</sup>). A coconut based mixed farming system (CMFS) comprising coconut, pepper, banana, crossbred cows, poultry birds, goat, and pisciculture generated a net return of ₹ 6.1 lakhs, nearly three times higher than that of coconut monocrop, in line with the hon. Prime Minister's vision of doubling farmers income.

Arecanut based cropping system with cocoa, banana and black pepper as component crops generated net returns as high as ₹ 8.8 lakhs ha<sup>-1</sup>, which is more than double compared to that of arecanut monocrop (₹ 3.80 lakhs ha<sup>-1</sup>). Arecanut based mixed farming system (AMFS) with dairying, fresh water aquaculture and fodder grass (Hybrid Napier) components generated net returns up to ₹ 6.6 lakhs ha<sup>-1</sup>, which is quite higher than that of arecanut monocrop. Cultivation of medicinal plants, asparagus and *Aloe vera*, improved system productivity under arecanut and coconut based cropping system at Mohitnagar. Arecanut based cropping system model involving arecanut, black pepper, acid lime and turmeric continued to record higher system productivity with black pepper contributing 55-60%.

It was demonstrated that in coconut based high density multi species cropping system higher coconut productivity, on par with integrated nutrient management, can be sustained through fully organic treatments including recycling of biomass (vermicompost), green manuring, application of biofertilizers, vermiwash application, husk burial and mulching in coconut basin. Organic nutrient management was standardized for cultivation of Hybrid Napier var. CO3 fodder intercrop in coconut plantations, with application of cow dung slurry, vermicompost, *Azospirillum* and *Phosphobacteria* at

bimonthly interval resulting in high fodder yield of 139 t ha<sup>-1</sup>.

Hybrid Bajra Napier *cv.* Suguna, intercropped in coconut garden along with *Stylosanthes cv.* Hamata, is a compatible crop combination in coconut based mixed farming system under root (wilt) affected gardens. The results indicate that the combination of fodder grass and leguminous crops can help in the enhancement of soil nutrient availability and fodder yield mainly by combating the nutrient exhaustion by the fodder grass when grown as a pure crop.

Studies were undertaken to assess the impact of different harvesting intervals and sequence of harvesting on tender nut and mature nut production. It was observed that harvesting of tender nut throughout the year recorded higher yield (167 tender nuts palm<sup>-1</sup>) and nut weight (2.2 kg nut<sup>-1</sup>) which is significantly different from all other treatments. Economic analysis shows that the harvesting of tender nut throughout the year has realized nearly four times higher net returns (₹ 2,64,768/-) as compared to harvesting of matured nuts (₹ 66,178).

From the field experiment conducted with graded levels of boron (0, 6, 12, 18, 24 g of boron palm<sup>-1</sup>) as borax in boron deficient palms, the optimum dose has been fixed as 160 g borax palm<sup>-1</sup> to be applied in four split doses along with husk burial in the basin and vermicompost application @ 20 kg palm<sup>-1</sup>. Critical boron level was estimated as 0.87 ppm for soil and 13.87 mg kg<sup>-1</sup> for leaf.

A multi-institutional collaborative project for evaluating the economic viability of coconut based cropping system through site-specific management practices was initiated during 2015 in five Agro Ecological Units of Kerala with the financial assistance from the Kerala State Planning Board. The project consists of experimental trials and demonstration in farmer's plots. The experiment consists of five treatment combinations including application of all the major, secondary and micronutrients along with sodium chloride, lime, dolomite and gypsum and farmers' practice kept as control. Boron content in the leaf showed significant increase after the application of treatments. *In situ* recycling of palm residues showed improvement in soil organic matter content in all the sites. Average annual nut yield also showed significant improvement with the treatments.

### Bioresource Utilization

A 'push-pull' strategy was employed to harvest earthworms from vermicompost heaps through an integrated use of volatiles released by biological materials as forces of avoidance and attraction to

manipulate their migration from the vermicomposted heap to the adjacently laid fresh cow dung from where they were eventually collected, thus, making sorting of earthworms from vermicomposting tanks easy and labour-friendly.

In tender nut parlours/street vendors, mostly the tender nut water is consumed on the spot by the consumers, leaving the husk refuse which accumulate in heaps in the premises. For composting this extremely fibrous bio-waste, the immature coconut husks were processed and treated with diazotrophic microbial consortium and poultry manure over a three months period. Though this tannin and lignin rich material is less labile and its carbon chemistry does not allow much vulnerability to microbial action, preliminary results revealed that stoichiometrical changes could be achieved in this organic material. Towards developing an eco-friendly technology for composting the recalcitrant natured lingo-cellulosic areca husk, microbial and non-microbial interventions are being attempted.

Micronutrient status map of major coconut growing areas was developed from secondary data available in the public domain. Among the major coconut growing area in India, 47 per cent of the area falls under soil available zinc deficient zone 25 per cent area under boron deficiency, 16 per cent under iron deficient zone, around 10 per cent with manganese deficiency and 9 per cent of the area coming under Cu deficient zone. Among the five bacterial isolates with high zinc solubilization potential, the isolate *Micrococcus luteus* CUK5 could solubilize both ZnO and ZnCO<sub>3</sub> with equal efficiency (up to 400 %) in cultures. In pot culture studies, soils low in available zinc (0.31 to 0.70 ppm), when inoculated with zinc solubilizing bacteria, showed appreciable increase in Zn levels, with CUK5 isolate found most promising.

Different bioresources viz., *Eudrilus* sp. (coconut leaf vermicomposting earthworms; 3,60,000 Nos.), Kalpa Organic Gold (coconut leaf vermicompost; 16 tonnes), Kalpa Soil Care (urea-free coir-pith compost; 6 tonnes), Kera Probio (PGPR bioinoculant; 120 kg), coconut leaf vermiwash (80 l) and mushroom spawn (70 kg) were produced and supplied to farmers and other end users.

### Reducing Crop Losses

Pest management interventions in palms and cocoa have been vastly refined, augmenting ecological stability and environmental sustainability. Botanical preparations, biological suppression and semio-chemical strategies are inexplicably intertwined to

make IPM more realistic, innovative and farmer-centric through a community participatory mode. In recent times, agro-ecosystem based ecological bio-engineering approaches have been projected as a viable option in combating the pest menace.

To counter the infestation of rhinoceros beetle on juvenile palms which is acquiring menacing proportions in recent years, a botanical cake and a botanical paste have been developed for prophylactic leaf axil placement/application. Botanical cake in tablet mode has been further refined to pellets for effective field delivery. An agro-ecosystem based pest regression strategy through ecological bio-engineering was designed for managing rhinoceros beetle with the crop combination of coconut with spices and fruit trees, exploiting the interplay of mixed-volatile cues of crop plurality (rambutan, nutmeg, curry leaf, banana, turmeric, red gram, papaya), with lesser damage (15.8%) inflicted on the palms in the inner lines compared to those in the outer lines (30%). In addition to pest regression, continuous employment and income is generated fostering closer care to palms, complementing the concept of an “inch of land and a bunch of crops”.

Studies conducted at Kayamkulam, a pest endemic region during 2014-2016 (June-May) using two different modes of pheromone dispensation viz., ‘Chemtica’ (polymer membrane) and ICAR-CPCRI (nanoporous matrix), established the superiority of nanoporous matrix in trapping more number of beetles in the field. However, it should not be used as a sole component in IPM strategy under homestead conditions of Kerala; rather, an area-wide community level approach in a large plantation would be the better option. Area-wide (1400 ha) implementation of IPM technologies for the past three years (2013-2016) in three locations at Alappuzha district of Kerala involving prophylactic leaf axil filling of botanical cakes admixed with sand, incorporation of *Metarhizium anisopliae* and the weed, *Clerodendron infortunatum* and release of *Oryctes rhinoceros* nudivirus inoculated beetle could reduce beetle damage by 81.2%.

A new morphological feature on sexual dimorphism in red palm weevil, the most destructive pest of palms, could be established with the presence of thick setae on tibia as well as femur of male and the same totally absent in the female weevils. The plastic bucket trap used in the trapping of red palm weevil was re-designed with a PVC one with an umbrella mode ensuring enhanced durability, optimum dissipation of the pheromone and higher catch of weevils.

Rugose Spiralling Whitefly (RSW) (*Aleurodicus rugioperculatus* Martin), an invasive pest on coconut was reported from Pollachi (Tamil Nadu) and Palakkad (Kerala) during July-August 2016 and subsequently in a period of next seven months, spread of RSW was observed in all districts of Kerala, Tamil Nadu (Pollachi, Pattukottai), Karnataka (Udupi) and Andhra Pradesh (Kadiyampalanka). The distribution of the pest is uneven, mostly along the National and State Highways, isolated gardens near water bodies and restricted gardens in midland regions. Presence of sooty mould and the prevalence of active egg spirals and adult whiteflies are the marked symptoms of infestation. Though it has not caused any severe economic losses, extensive desapping of RSW could induce stress on the palms due to removal of water and nutrients. Even though there was loss of photosynthetic efficiency due to the formation of sooty mold fungus (*Capnodium* sp.), mortality of palms has not been observed. Molecular characterization of mitochondrial cytochrome oxidase 1 gene (*COI*) of *Aleurodicus* sp. collected from coconut indicated 100 % similarity with that of mitochondrial *COI* sequence of *A. rugioperculatus* reported from Florida, USA, thus confirming its taxonomic identity. Modulations in weather factors (with over 40% deficit in monsoon and at least 2°C increase in temperature and a reduction of afternoon relative humidity to the tune of 7% during the post-monsoon period) experienced during 2016 could have been the reasons for the flare-up of *A. rugioperculatus*. Since use of insecticides is not a viable option for the management of whitefly as it causes a reduction in the build of natural enemies, especially *E. guadeloupae*, an integrated pest management aimed at population build-up of natural enemies, either through biological control or introduction of parasitized pupae, would be a more feasible and sustainable alternative approach at this point of time for the long-term bio-suppression of RSW.

A new pest, ambrosia beetle, *Crossotarsus* sp. (Curculionidae) was recorded from an arecanut garden in Bantwal taluk of Dakshina Kannada district, with oozing of yellowish gummy exudates from the point of entry of beetle as the most conspicuous symptom. *Planococcus lilacinus* Cockerell is the predominant mealy bug species infesting cocoa pods, cherelles, flower cushions and leaves. Seasonal incidence of mealy bugs on cherelles and pods indicated pest build-up during February with peak incidence during March to May. Two natural enemies viz., *Acerophagus papayae* Noyes & Schauff and *Aenasius arizonensis* (Girault) were found dominant in cocoa ecosystem for natural bio-suppression of mealy bug

population. Recently, *Conogethes punctiferalis* has been reported as one of the emerging insect pests of cocoa in Karnataka. The pest incidence which was very low (2.07%) during 2013 has now increased to as high as 40% during 2016, probably due to change in weather factors.

A new strain of *Heterorhabditis indica* has been reported from the root grub infested arecanut gardens in Udma panchayat, Kasaragod district of Kerala that induced 90% mortality of early instar grubs. The area-wide demonstration of arecanut root grub bio-suppression with the EPN, *Steinernema carpocapsae* (1.5 billion IJs ha<sup>-1</sup>), in combination with 0.0045% imidacloprid and 2 kg neem cake palm<sup>-1</sup> was carried out in Sringeri and Sullia in Karnataka and has given convincing results with drastic reduction of root grub population by 91.8% and yield enhancement by 62.1% in treated palms over a period of two years.

The feeding and ingestion of *Phytophthora palmivora*, the coconut bud rot pathogen, by the common slug *Deroceras* sp., the presence of sporangia in the faecal matter of the slugs collected from coconut garden, induction of symptoms of water soaked lesions on the fresh healthy tender coconut on inoculation with faecal matter and the re-isolation of *P. palmivora* from the inoculated nuts confirmed role of slugs in the spread of coconut bud rot disease.

Morphological and molecular characterization of *Phytophthora* isolates recovered from self-grown colocasia samples collected from diseased arecanut gardens and those grown as a monocrop has given interesting results. Eighteen out of the twenty *Phytophthora* isolates from the diseased arecanut gardens showed 100% identity with *P. meadii*, the arecanut fruit rot pathogen, in terms of its morphology and ITS sequences. The other two isolates recovered from self-grown colocasia and five from colocasia grown as monocrop exhibited 100% identity with *P. colocasiae* isolates. Cross inoculation of *P. meadii* isolates from colocasia to arecanut exhibited typical symptoms of fruit rot disease symptoms, adding credence to the theory that colocasia is a collateral host for the arecanut fruit rot pathogen, *Phytophthora meadii*.

Random survey on arecanut inflorescence dieback revealed that this disease is prevalent in all the major arecanut growing areas of Karnataka and Kerala, with higher incidence in Davanagere district of Karnataka (27.3) followed by Kasaragod district (24.7) of Kerala. Significant morphological variability has been observed among the isolates collected from the disease endemic areas. Survey on coconut leaf blight disease indicated highest leaf blight disease

incidence (80%) in Tirupur district of Tamil Nadu, followed by Tumkur district (20%) of Karnataka.

Molecular detection of phytoplasma in different achenorrhyncha fauna collected from coconut ecosystem using phytoplasma-specific universal primers (P1/P6-R16F2n/R16R2) indicated positive amplification at 1250 bp for *Orosius albicinctus* (Distant) alone, indicating its vectoral role in transmission of phytoplasma disease especially in *Sesamum* sp. phyllody group. Molecular characterization of phytoplasma from symptomatic weeds in RWD affected coconut plantations showed the presence of 16Sr II group in dicot weeds (wild *Sesamum* sp. and *Cleome viscosa*) and 16 Sr XIV group in monocot weeds (*Urochloa distachya* and *Cynodon dactylon*) indicating that these weeds do not serve as the hosts for RWD phytoplasma.

### Climate Resilient Technologies

The interaction effect of climate change variables *viz.*, CO<sub>2</sub> and elevated temperature (ET) with moisture deficit, on growth and development of coconut seedlings was studied in an Open Top Chamber (OTC). Response of coconut to ECO<sub>2</sub> and ET at reproductive phase show that above-ground plant growth was almost 1.5 fold higher at 550 ppm, and two fold higher at 700 ppm CO<sub>2</sub> compared to chamber control, whereas growth was significantly low with [ET]. Elevated CO<sub>2</sub> compensated the growth loss with [ET] to a certain extent. However, the intrinsic WUE was high in plants grown under ECO<sub>2</sub> due to lower stomatal conductance. For mitigating the effect of drought in coconut, an imminent threat under climate change, improving crop water use efficiency (WUE) is most important for sustained nut production. While WUE for tall genotypes was high under non-stress conditions, it was relatively low under stress condition. On the other hand, dwarf cultivars showed low WUE under non-stress condition and showed comparatively high WUE under water deficit stress, indicating that tallers are more efficient than dwarfs in utilizing available water resources.

The optimum temperature required for *in vitro* pollen germination ranged from 24.55°C to 29.31°C, with the tall and dwarf genotypes showing differential response to high temperature. Tall cultivars, in general, maintained an acceptable level of germination from 20°C to 35°C, but showed a decline of about 35% when the temperature rose to 40°C. Dwarfs, on the other hand, showed a germination percentage of 30-32% only at near-optimum temperatures, and at temperatures higher or lower than that, germination was significantly reduced and at 40°C, germination was lower than 5%.

### Product Diversification, Value Addition and Mechanization

Coconut milk residue (CMR) is the main underutilized by-product of virgin coconut oil processing, which is rich in dietary fibre, protein, polyphenols and antioxidants. Towards encouraging optimum utilization of by-products generated in the process and ensuring higher economic returns and viability of the VCO technology, efforts were made to develop healthy, natural and crispy extrudates from coconut milk residue. *Kalpa Krunch* is a coconut milk residue enriched ready-to-eat extruded snack, coated with natural and healthy flavours like coriander, garlic, clove, cinnamon, chilli, mint and cardamom. The feasibility of using coconut milk residue (CMR) for the preparation of fibre enriched pasta, rusk (a hard, dry biscuit or twice-baked bread) and fried snacks are also being explored. A new initiative for preparation of jelly from tender coconut water/coconut inflorescence sap with coconut sugar as sweetening agent, instead of cane sugar, is also currently underway.

The institute has developed a beating type arecanut de-husking machine and an arecanut grading unit with an automatic feeding device to avoid manual feeding. Performance evaluation of the de-husking machine conducted in the institute farm and by farmers has given encouraging feedback, with the labour cost of de-husking reduced to one fifth of the cost of manual de-husking.

### Capacity Building Programmes

Coconut is one of the important plantation crops mainly grown in the southern states of India providing livelihood security to more than 12 million people. Average productivity of coconut from southern states (11775 nuts ha<sup>-1</sup>) is much lower in comparison to research station yield of 30625 nuts ha<sup>-1</sup>. In recent times, coconut sector has suffered from frequent price fluctuations, incidence of pests and diseases, moisture stress, lack of value addition etc. Hence, technological innovations and diffusion of new technologies are the key drivers to enhance the productivity and profitability of coconut farming.

A series of Kisan Melas (five) were organized at Kasaragod, Kayamkulam, Kahikuchi and Mohitnagar during the centenary year covering the entire growing tracts in the country with the participation of a large number of farmers. Several interface programmes through interactive video conferencing were organized connecting various stakeholders in the loop, addressing a wide range of issues close to their heart. Considering the high density of mobile telephones and the ever increasing reach of the digital network in India, an android based mobile application 'e- kalpa'

enabling technology delivery, interactive learning and real time data recording was developed for better reaching out to farming communities. The contents are now available in multi-language formats. Besides this, an e-Plantation Survey App was also developed for accurate GPS tagged data collection for research projects and extension activities.

About 23 capacity building programmes were organized in collaboration with Department of Agriculture/Horticulture, ATMA and other agencies, imparting training on improved technologies for the mandate crops to over 600 extension personnel from various states. Over a 100 training programmes, covering hybridization techniques, nursery management, crop production, protection and value addition on mandate crops were conducted for the benefit of a large number of farmers. Frontline demonstrations (FLDs) established in 35 ha of farmers' gardens (5 ha in a select panchayath in each district) on integrated management of coconut root (wilt) disease in seven districts of Kerala, integrated management of arecanut root grub in Sullia in Karnataka and Ganoderma wilt of coconut in Kasaragod, are being continued. Besides, 50 demonstration plots (comprising of one ha each) on cocoa technologies were maintained in five districts *viz.*, West Godavari, East Godavari, Krishna, Vishakapatnam and Vizianagaram in Andhra Pradesh and the techno-socio-economic feasibility of the technologies is being assessed on a participatory mode.

*Mera Gaon Mera Gaurav* programme is being implemented successfully in 70 villages across Assam, West Bengal, Kerala and Karnataka. 'World Soil Day' was celebrated on 5<sup>th</sup> December 2016, with an Interface programme on 'Soil Health Management' with the participation of a large number of farmers and soil health cards were distributed to 120 farmers.

### Technology Delivery Models

The FARMERS' FIRST project is being implemented at Pathiyoor panchayath in Kerala involving the farming communities of the entire area (1657 ha) since November, 2016. A series of activities/technological interventions are envisaged under six modules *viz.*, coconut based systems, horticulture based module, livestock/poultry based modules, NRM based modules, value addition/product diversification module and Integrated Farming System module. During the year, emphasis was on enhancing area and technology adoption of high yielding varieties of turmeric, spices, tuber crops, sesamum, community approaches in coconut plant protection, promoting medicinal and traditional 'Navara' paddy, farmer

participatory integrated management of root (wilt) disease, bio input production units, mastitis elimination campaign for improving milk production and health of livestock, tissue culture banana cultivation and soil moisture conservation measures.

NABARD supported (Farm Innovation and Promotion Fund) Project on community based bio-resource management was implemented in Kanjikuzhy Block of Alappuzha District during 2014-16. The major objectives of the project were (a) to strengthen the capacities of farmers on biomass recycling and enrichment of organics with beneficial microbes to ensure sustainability in agricultural production and (b) to increase the productivity and income from coconut based farming system through integrated nutrient management with emphasis on bio-resource management, soil and water conservation techniques and crop diversification.

The major problems faced by farmers practicing organic farming in the area were lack of proper knowledge on the organic inputs to be used and availability of quality organic inputs. Apart from this, the project area (Kanjikuzhy block) having littoral sandy soil characterized by low organic matter content and poor water holding capacity, was found to have several constraints with regard to soil fertility status. As part of capacity development, the selected farmers were trained on composting techniques, microbial enrichment of organics and soil test based nutrient application with special emphasis on bioresource management and imparted large number of skill development programmes, based on which the farmers could adopt site-specific management practices and further replicate to farmers of the entire block area. Awareness creation and application of lime and other nutrients based on regular soil testing resulted in gradual improvement in the yield of coconut (26%), intercrops by 142.9% and livestock and other enterprises to the tune of 30.9%, contributing to an increase in the average farm income from ₹ 1.17 to 2.91 lakhs ha<sup>-1</sup> (149.8%) over the project period. Farmer participatory action management, involving experiential learning and adoption coupled with continuous field level assessment and refinement, was found to strengthen the confidence of the farmers to accept farming as a profitable enterprise.

### Economic Analysis and Policy Perspectives

As part of the assessment of field level utilisation of technologies in coconut sector, an analysis was done on the evolving sectoral innovation system of Kalparasa in the state of Kerala. In a span of last three years, a total of 220 licenses have been granted

for Kalparasa production and though 94 Coconut Producer Societies (CPSs) initiated the production activities, only 57 Coconut Producer Federations (CPFs) are continuing the Kalparasa production at present, which point towards the already experienced commodity problematique in the sector. The farmer share in the value chain is just 17% of the consumer price and the tapper's share is 20%. Issues concerned with Kalparasa production at policy level include the ceiling for the number of coconut palms to be tapped per day, the selling controls on the product, the registration formalities etc. On the production front, scarcity of skilled tappers and lack of adequate infrastructure for processing are the major problems. Marketing of Kalparasa also poses challenges as consumer perception and buyer segment studies are completely lacking and profit analyses are based only on projections without any structured marketing studies. Further to compete with other similar products, it has to be appropriately positioned in the market for its nutritional edge. Since it is an evolving product, lack of product uniformity may hamper the market penetration. Above all, from April 2017 onwards ASEAN products may flood the Indian market with the phasing out of customs import duty as per the trade agreement, and the real competition will be set in motion then onwards.

Analysis of socio-economic dimensions and value chain dynamics from a policy perspective is one of the important activities providing critical inputs for policy decisions. Price analysis revealed that the price wedge of coconut oil (between domestic and international) from the year 2013 onwards led to price instability and price crash of the domestic coconut oil as the price sensitive consumers switched to cheaper oils. It was observed that low palm oil prices act as a downward anchor, and only a demand pulled price rise can sustain the coconut prices in the country. The time series price movement of coconut oil (domestic as well as international) for the last 13 years (from the year 2004 onwards) revealed that whenever there is rise in domestic coconut oil price, the international prices exerted a pull-down-force to make the prices integrated. This aspect very well validates the international trade theory on price integration of primary commodities in the trade liberalized regime. The crucial interpretation is that dependency on single commodity like coconut oil will never provide the adequate margin to sustain for a longer period.

It is also imperative to analyze the international trade scenario of coconut value added products to understand the country-wise trade competency. While comparing with other major global exporters,

the share of India in coconut product exports is meagre. Though it is an accepted fact that India holds a robust domestic market in the coconut sector, it is high time that we emerge as a major export player by upgrading our position in the global value chain of coconut exports.

The cost of production of arecanut (chali) was worked out following the standard cultivation practices in a well-maintained garden as ₹ 200/-per kilogram of chali and adding 25 percent profit margin to the cost of production, ₹ 250 per kilogram of chali was recommended as MSP. Policy brief on Minimum Support Price for arecanut was also presented in the stakeholder's meeting and the proceedings were sent to the Ministry of Commerce. The cost of production for fixation of MSP was suggested as ₹ 76 kg<sup>-1</sup> of copra and a policy note on raw coconut procurement was prepared and submitted to the CACP, New Delhi. In view of the efficient raw coconut procurement, it was suggested to establish panchayat level hubs with forward and backward integration under the supervision of CPS networks.

### **Agri-business Ventures**

Under the aegis of ITMU, a record number of 52 MoAs on transfer of technology/ know-how were executed during 2016-17 realizing a revenue of ₹ 15,62,000. Among the technologies transferred in the year, 45 were on protocols for coconut processing. Another higher-end technology commercialized in the year was the nanomatrix for pheromone delivery (priced at ₹ 3 lakhs) which was jointly developed by ICAR-CPCRI and Jawaharlal Nehru Centre for Advanced Scientific Research, Bengaluru.

### **Krishi Vigyan Kendras**

Krishi Vigyan Kendras (KVKs), established under the Indian Council of Agricultural Research (ICAR) in all rural districts, are disseminating frontline technologies, imparting knowledge and critical input support to the famers. KVK Kasaragod undertook five OFTs and 18 FLDs, besides 100 training programme benefitting 2985 farmers. KVK Alappuzha organized seven OFTs, 14 FLDs and 89 training programmes benefitting 2467 farmers. In addition, extension activities like harvest festivals, campaigns, helpline services, agro clinics, exhibitions, technology meets, field days were conducted. Krishi Vigyan Kendra has organized an Awareness Programme on the Pradhan Mantri Fasal Bima Yojana on 28<sup>th</sup> May, 2016 at Kasaragod, highlighting the potential benefits and modalities to be followed, enabling the farmers for deriving maximum benefit from this new initiative of the Government of India. Towards transforming farmers to entrepreneurs, two Farmers-Producer

Companies have been promoted under the aegis of the two KVKs, one each in Kasaragod and Alappuzha districts, with financial support from the NABARD.

### Centenary Celebrations

The year 2016 was a memorable one in the history of ICAR-Central Plantation Crops Research Institute (ICAR-CPCRI) and coconut research in India, on completing 100 glorious years in service of the nation from its modest beginning as a small coconut research station in the sleepy village of Kudlu way back in 1916.

The centenary celebrations were ceremoniously flagged off on 12<sup>th</sup> March 2016 in a unique way with simultaneous planting of 100 coconut seedlings by 100 farmers in a minute in the Centenary Coconut Park, a massive Kisan Mela and a host/ plethora of other programmes later in the day. During the year, over a hundred programmes catering to all sections of the stakeholders - a series of Kisan Melas and mass contact programmes in all over the country, training programmes for farmers and extension personnel, workshops/seminars and brain-storming sessions for the scientific community, agri-business meets for sensitizing the potential agri-business entrepreneurs and SHGs were organized. The year-long celebrations were concluded with the Kisan Mela on 10<sup>th</sup> December 2016, graced by the hon. Union Minister of Agriculture and Farmer's Welfare, Shri. Radha Mohan Singh Ji and a host of other dignitaries, followed by the third edition of the International Symposium on Coconut Research and Development (ISOCRAD-III) during 10<sup>th</sup>-12<sup>th</sup> December, 2016 and PLACROSYM shortly thereafter. The Hon'ble Minister also inaugurated the new Centenary Building and the renovated Kalpaka Guest House, released a few commemorative publications, ('CPCRI:100 Years of Scientific Excellence', 'Harvesting Wisdom of Coconut Growers', and a special issue of 'Indian Horticulture' Journal) besides launching the value-added product from coconut, 'Kalpa Chocolate Bar' (jointly developed by ICAR-CPCRI and CAMPCO) on the occasion.

During the centenary year, about 60 extension publications (extension folders/technical bulletins), a few commemorative publications (souvenirs) and ten scientific books (scholarly volumes edited by scientists from CPCRI with contributions from a large pool of experts from within and outside the organization) were also brought out during the year in arrangement with reputed publishers in India. The titles include "Diseases of Field and Horticultural Crops", "Diseases, Pests and Disorders of Plantation Crops", "Biotechnology of Plantation Crops", "Coconut", "Planting Material Production in Coconut", "Impact of Climate Change on Plantation Crops", "Organic Farming in Plantation Crops", "Soil Health Management in Plantation Crops" and "Mechanization in Plantation Crops", released during the ISOCRAD 3 and PLACROSYM 22. Video films on 'CPCRI in the service of farming community' and 'Integrated pest management in coconut' were produced in English and regional languages.

Conscious efforts were made to meaningfully engage the visual and print media, along with the new-age social media platforms to reach out to the varied clientele and put the message across them. All the events/programmes conducted in connection with the centenary celebrations were widely covered and the achievements greatly highlighted in the national/vernacular dailies, with some of them bringing out exclusive supplements commemorating the centenary of ICAR-CPCRI and coconut research in India. The visual media was also equally appreciative of the efforts and they covered the programmes under their regular news broadcasts as well as airing special programmes commemorating the event. The proposal for releasing a commemorative postage stamp on 100 years of ICAR-CPCRI and coconut research in India has been approved by the Department of Posts and the special stamp is expected to be ceremoniously released on a convenient date later this year.

## IV.

# VISION, MISSION AND MANDATE

### **Vision**

To develop ICAR-CPCRI as a technology generation and repository centre, wherein the Institute strives to showcase, demonstrate and compare world-wide technologies in the commodity chains of coconut, arecanut and cocoa to make India the global leader.

### **Mission**

To develop technologies that enhance resource use efficiency, profitability and livelihood security of people who depend on plantation crops.

### **Mandate**

- Basic, strategic and applied research to enhance sustainable productivity, quality and utilization of coconut, arecanut and cocoa,
- Repository of plantation crops genetic resources and scientific information,
- Transfer of technology, capacity building and impact assessment of technologies,
- Coordinate research and validation of technologies on plantation crops through AICRP on Palms.



**I**CAR-Central Plantation Crops Research Institute (ICAR-CPCRI), the premier research institution in the National Agricultural Research System of India, is presently mandated to conduct research in plantation crops (coconut, arecanut and cocoa). It had a modest origin with its lineage tracing back to the Coconut Research Station started in 1916 at Kudlu village (of present Kasaragod district of Kerala in Southern India) in the South Kanara district of erstwhile Madras Presidency. Ever since its inception, it has served the cause of science and society with distinction through exemplary research, generation of appropriate technologies and development of skilled human resource.

## Historical perspective

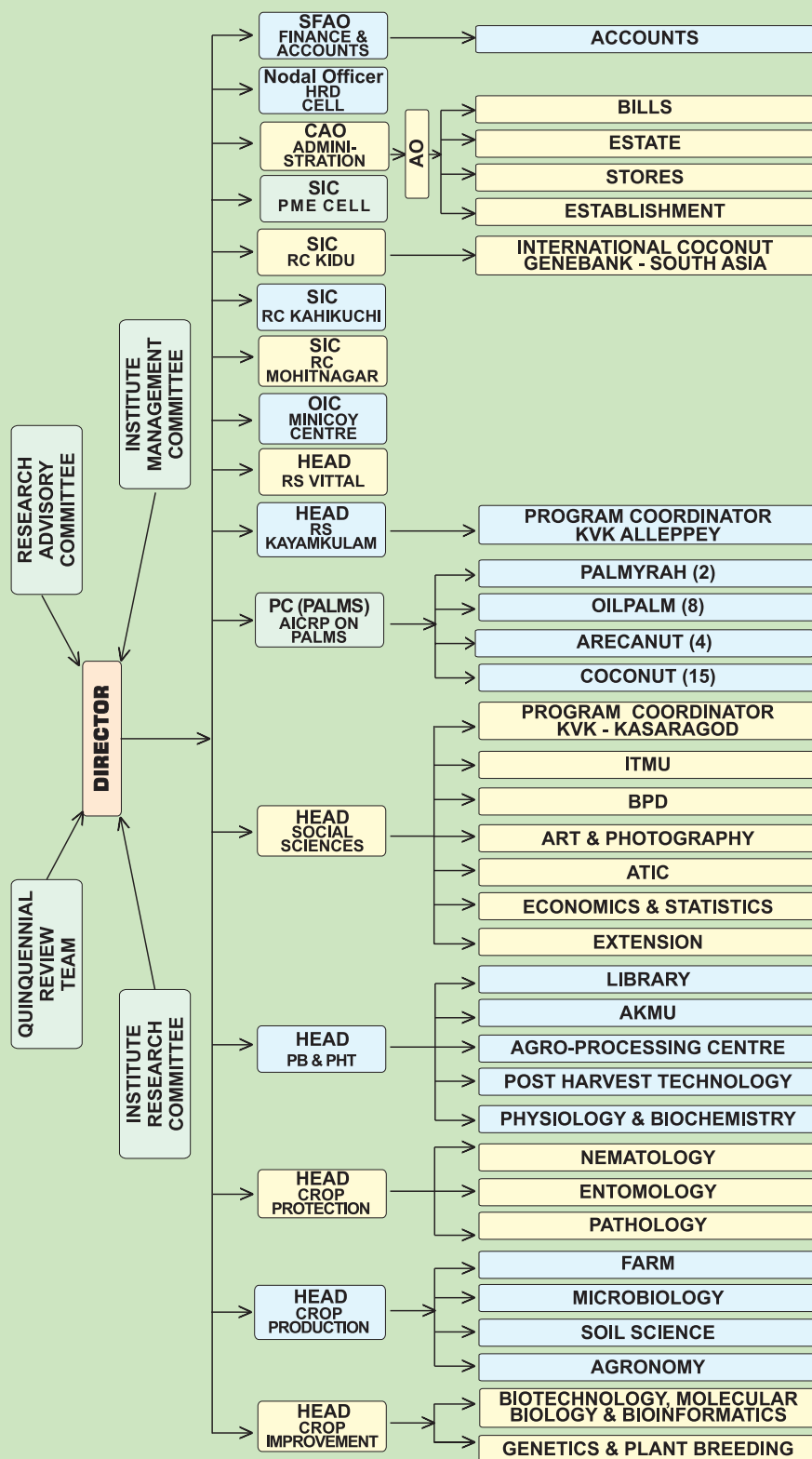
The Coconut Research Station at Kudlu (Kasaragod) was subsequently taken over by the Indian Central Coconut Committee and established the Central Coconut Research Station (CCRS), Kasaragod in 1947 and a little later in 1949, the Central Coconut Research Station (CCRS) at Kayamkulam was also established exclusively for tackling diseases in coconut. Coconut research became an integral part of the national agricultural research system in 1966 when the Indian Central Coconut Committee was abolished and the coconut research was taken over directly by the Indian Council of Agricultural Research. In 1970, the Central Plantation Crops Research Institute was established with headquarters at Kasaragod, by merging the Central Coconut Research Stations at Kasaragod and Kayamkulam and the Central Arecanut Research Station at Vittal along with its five substations at Kannara, Mohitnagar, Kahikuchi, Hirehalli and Palode.

Since 1986, crops like spices, cashew, and oil palm were taken out of the ambit of the institute with the formation of dedicated research institutions like Indian Institute of Spices Research, Kozhikode, Directorate of Cashew Research, Puttur, Indian Institute of Oil Palm Research, Pedavegi and Central Coastal Agricultural Research Institute, Goa. Some of the erstwhile Research Centres at Hirehalli, Palode, Appangala, Kannara, Port Blair and Minicoy were either handed over to sister ICAR institutions or phased out. At present, the mandated crops are limited to coconut, arecanut and cocoa and the research and frontline extension aspects of these crops are undertaken under five divisions *viz.*, Crop Improvement, Crop Production, Crop Protection, Physiology, Biochemistry and Post Harvest Technology and Social Sciences at the institute. The Regional Station at Kayamkulam (Kerala) is mandated to work on pests and disease problems in coconut, while the Regional Station at Vittal (Karnataka) caters to research and extension in arecanut and cocoa. The Research Centres at Kahikuchi (Assam) and Mohitnagar (West Bengal) undertake location-specific research in these crops, while the Research Centre at Kidu (Karnataka) hosts the National/ International Coconut Gene Bank for South-Asia (ICG-SA) and also caters to the large-scale production of quality planting materials in the mandate crops. Besides, there are two KVKs (at Kasaragod and Kayamkulam) functioning under the Institute.

All India Co-ordinated Coconut and Arecanut Improvement Project (AICCAIP) started functioning from 1972 at CPCRI, Kasaragod and was later renamed as All India Coordinated Research Project (AICRP) on Palms in 1986. The AICRPP has 15 centres working on coconut, four on arecanut, eight on oil palm and two on palmyrah.



# Organogram



## Achievements at a Glance

### Plant Genetic Resources

ICAR-CPCRI maintains the world's largest repository in coconut with 455 accessions (323 indigenous and 132 exotic genotypes) from 28 countries, 176 germplasm collections in arecanut of which 23 are exotic and 141 indigenous and 405 cocoa germplasm collections. International Coconut Genebank for South Asia (ICG-SA) was established under a tripartite agreement among ICAR-FAO-ITPGRFA. The Institute also hosts the national coconut genebank (NCGB) and serves as the National Active Germplasm Site (NAGS) for coconut, arecanut and cocoa.

Through intensive breeding and evaluation, 20 improved coconut varieties including six hybrids involving tall and dwarf as parents have been released for commercial cultivation. The high yielding varieties are capable of yielding 3.12 to 6.28 tonnes of copra ha<sup>-1</sup> annually, as compared to 2.96 t copra ha<sup>-1</sup> in West Coast Tall local. Eleven improved varieties of arecanut, including nine selections and two dwarf hybrids, have been released. The improved varieties with annual average yield of 2.54 to 4.15 kg dry kernel palm<sup>-1</sup> yr<sup>-1</sup> and higher dry kernel recovery, in comparison to South Kanara Local (2 kg dry kernel palm<sup>-1</sup> yr<sup>-1</sup>), have significantly improved arecanut productivity in the country. In cocoa, eight high yielding varieties have been released from the institute, which include three elite clones and five hybrids, which yield up to 3.0 kg dry bean tree<sup>-1</sup> yr<sup>-1</sup> with varying processing qualities, as compared to 1.0 kg dry bean tree<sup>-1</sup> yr<sup>-1</sup> in existing cocoa plantations.

The institute has been producing quality planting materials in coconut, arecanut and cocoa for distribution to farmers and other stakeholders. Seed gardens of improved varieties have been established in the Institute as well as in farmer's garden to augment planting material production. ICAR-CPCRI nurseries at Kasaragod, Kidu, Kayamkulam and Vittal were graded with 'four-star' status in the five star scale by National Horticultural Board. Quality planting materials are produced to an extent of 1.3 lakh coconut seedlings including 59,000 hybrids, 7.0 lakh arecanut planting materials including 1.4 lakh seedlings and 86,000 cocoa seedlings/graft annually.

### Biotechnology and Bioinformatics

Achievements under biotechnology include standardization of embryo culture protocol for germplasm exchange, standardization of regeneration protocol for inflorescence tissues of arecanut and cryopreservation of coconut embryo and pollen. In arecanut, the protocol developed for

somatic embryogenesis and plantlet regeneration from immature inflorescence explants has been commercialized. A simple and easy vitrification protocol has been developed for cryopreservation of coconut zygotic embryos from both tall and dwarf accessions. The protocol developed for cryopreservation of coconut pollen for the first time by ICAR-CPCRI, has been commercialized; this would be instrumental in enhancing hybrid seed production as it facilitates year round availability of coconut pollen for all stakeholders across the coconut growing states of India. The safe movement of coconut germplasm through embryo cultures, instead of seed nuts, is recommended by FAO/ IPGRI.

Sequence characterized amplified regions (SCAR) markers have been developed for confirming the hybridity at seedling level in both coconut and arecanut. A panel of SSR markers has been identified for confirming the hybridity of D x T hybrids (CGD x WCT) which will ensure supply of genuine hybrid material to farmers. Transcriptome analysis of response of coconut to root (wilt) disease and somatic embryogenesis have been undertaken using RNA-Seq and transcripts up/ down-regulated have been identified. Many of transcripts down-regulated in root (wilt) diseased palms were primarily involved in defense responses, signaling pathways, cellular transport and other metabolic processes. Transcriptome analysis of coconut embryogenic calli, derived from plumular explants of West Coast Tall, resulted in the identification of 14 genes with important roles in somatic embryogenesis. Work on deciphering the genome sequence of Chowghat Green Dwarf has been initiated.

ICAR-CPCRI hosts Distributed Information Sub Centre (Sub-DIC) under the Biotechnology Information System Network (BTISnet), the Bioinformatics Centre and Agri-Bioinformatics Promotion Centre (ABPC). Various tools and databases have been developed under these centre's which include MAPS (Microsatellite Analysis and Prediction Software), stand alone EST-SSR analysis pipeline (SEMAT), prediction tools for resistant gene analogues and enzymes in gibberellic acid biosynthesis using machine learning algorithms, prediction of miRNAs in date palm, coconut and *Phytophthora* spp. and transcriptome based reconstruction of carotenoid biosynthetic pathway in cocoa and gibberellic acid biosynthetic pathway in coconut.

### Cropping and farming systems

Coconut or arecanut based inter/mixed, multi-storied multi-species cropping as well as mixed farming systems have been developed by integrating

livestock to increase total productivity. The coconut based cropping system using multi-species cropping of coconut with black pepper, banana, nutmeg, pineapple, ginger, turmeric and elephant foot yam generated a net income of ₹ 3.7 lakhs ha<sup>-1</sup>, which is 164% higher than that of coconut monocrop (₹ 1.4 lakhs), while the coconut based mixed farming system (CMFS) comprising coconut, black pepper, banana, cross bred cows, poultry birds, goat, and pisciculture generated a net return of ₹ 5.5 lakhs ha<sup>-1</sup>, reflecting 293% higher than coconut monocrop.

Arecanut based cropping system with cocoa, banana and black pepper as component crops generated net returns as high as ₹ 8.8 lakhs ha<sup>-1</sup>, which is 132% higher than that of arecanut monocrop (₹ 3.80 lakhs). On the other hand, cropping systems like arecanut + vanilla, arecanut + medicinal and aromatic plants, and arecanut + cocoa have generated 68%, 53%, and 26% higher net returns respectively over arecanut monocrop. Arecanut based mixed farming system with dairying, freshwater aquaculture and fodder grass (Hybrid Napier) components generated net returns up to ₹ 6.6 lakhs ha<sup>-1</sup>, which is 74% higher than that of arecanut monocrop. In addition to the economic benefits, the systems ensure food and nutritional security coupled with sustainability and environmental services.

Drip irrigation in arecanut, coconut and cocoa has reduced the use of water to the extent of 35-40 per cent, with increase in yield by 30-40 per cent. Drip fertigation in these crops has reduced the use of chemical fertilizer from 50 to 75 per cent, with increase in yield by 35-40 per cent. *In situ* soil and water conservation techniques such as, half-moon bund reinforced with pineapple planting, trench filled with coconut husk and bund reinforced with pineapple planting and providing catch pits helps in augmenting the soil moisture availability in coconut plantations having mild slope and could enhance coconut yield up to 60%. This could reduce soil erosion from 2.73 t ha<sup>-1</sup> to 0.02 t ha<sup>-1</sup> and consequent reduction of nutrient loss due to soil erosion (N from 7.98 to 0.36 kg ha<sup>-1</sup>, P from 12.52 to 0.9 kg ha<sup>-1</sup> and K from 28.5 to 1.1 kg ha<sup>-1</sup>).

The productivity of coconut in coastal sandy soil, which is made of 99 % sand, is very low (30 nuts palm<sup>-1</sup> yr<sup>-1</sup>) due to the porous nature and low fertility. Incorporation of coconut husk in the interspaces of the coconut garden and growing various intercrops like vegetables, flowers, grasses and pineapple and fertigation along with mulching to coconut has increased the yield of coconut to 140 nuts palm<sup>-1</sup> yr<sup>-1</sup>. The intercrops generated an additional income of ₹ 2.5 to 3.5 lakh ha<sup>-1</sup> of coconut garden.

## Bioresources utilization

Recycling crop wastes in coconut, arecanut and cocoa through vermicomposting and mushroom production helps in disposing of wastes, improving soil fertility, reduction in use of chemical fertilizers and sustaining the yield besides enhancing nutritional security. Coconut gardens of one hectare area can generate up to eight tonnes of leaf biomass residues every year. Technology has been developed to utilize these wastes for production of vermicompost, vermiwash, compost and mushrooms. From about eight tonnes of leaf residues, 3-4 tonnes of vermicompost could be produced annually using the local isolate of *Eudrilus* sp. or 1,660 kg of fresh mushroom can be generated that adds more than ₹ 50,000 year<sup>-1</sup> to the farmer's income. The coconut leaf vermicompost can also meet 50% of the nitrogen requirement of coconut palms grown in one hectare area saving expenditure on inorganic fertilizer. After coconut leaves are vermicomposted, earthworms are to be separated for which a 'push-pull' strategy was successfully adopted to harvest earthworms from vermicompost heaps through the use of behaviour-modifying stimuli. This will make sorting of earthworms easy and labour-friendly and reduce labour requirement of the farmers who have taken up vermicomposting technology. Vermiwash, produced from coconut waste vermicomposting unit, is a good liquid fertilizer for organic farming. On farm coir pith composting technology has been developed to produce organic input to the plantation as well as use as soil-less medium for production of quality planting material. Efforts are on to standardize composting of immature coconut husk, which otherwise accumulates in heaps outside tender nut parlours along the roadside.

Arecanut and cocoa gardens generate biomass of 4-5 and 0.7-0.8 million tonnes ha<sup>-1</sup> respectively and these wastes could be effectively utilized for production of oyster mushroom and livestock feed, in addition to vermicompost. Recyclable biomass in arecanut supplies approximately 95 g N, 10 g P<sub>2</sub>O<sub>5</sub> and 110 g K<sub>2</sub>O palm<sup>-1</sup> yr<sup>-1</sup> that has the potential to meet nitrogen and phosphorus requirements of arecanut, which can save the cultivation cost to the extent of ₹ 5,200 ha<sup>-1</sup>. The yield of arecanut can be sustained at 26 q ha<sup>-1</sup> by recycling waste as vermicompost. A net income of about ₹ 30,000 could be generated from vermicompost production from wastes of one hectare arecanut garden, while arecanut leaf sheath and bunch waste can result in production of 643 kg fresh mushroom with a net income of about ₹ 30,000.

In the area of microbial bioresources, plant growth promoting rhizobacteria (PGPR) based bioinoculant products, 'Kera Probio' containing *Bacillus megaterium*

and 'Cocoa Probio' containing *Pseudomonas putida* have been released for production of healthy and vigorous coconut and cocoa seedlings. The genes involved in the plant growth promoting properties and other important metabolic functions of three PGPRs, one each from coconut, arecanut and cocoa, have been identified through whole genome sequencing. An efficient zinc solubilizer has been identified from alkaline soil which could not only increase availability of soluble zinc in soil, but also its electrical conductivity. This bioresource could prove to be useful in regions where zinc availability is a problem.

### Reducing crop losses

Bud rot, stem bleeding, basal stem rot and root (wilt) of coconut; fruit rot, inflorescence die back and yellow leaf disease of arecanut and black pod and stem canker in cocoa are the major diseases that cause substantial crop losses. Integrated disease management strategies developed for the major diseases over the years has resulted in saving of thousands of coconut and arecanut palms and reduced the loss due to black pod diseases in cocoa. Most importantly, the disease management strategies are being continuously refined based on the change in pathogen population, soil and climatic factors and screening of new and native bioagents or fungicides or host plant resistance.

Random survey conducted in coconut gardens in Kasaragod district of Kerala has shown about 0.9 % bud rot incidence during the year 2016. The role of slug *Deroceros* sp. in spreading of bud rot has been confirmed by observing the presence of sporangia of *P. palmivora* in faecal matter of the slugs collected from bud rot affected garden and proving its pathogenicity on coconut. Prophylactic treatments of Bordeaux mixture (1%) or placement of two perforated sachets containing mancozeb (5 g) or *Trichoderma* coir pith cake in the innermost leaf axil of coconut with the onset of monsoon (first week of June) can prevent the appearance of bud rot in disease endemic areas.

Survey of arecanut gardens in Dakshina Kannada, Udupi and Uttara Kannada districts of Karnataka and Kasaragod district of Kerala during the monsoon season (July-August, 2016) indicated less than 5 % fruit rot incidence. Self-grown colocasia (*Colocasia esculenta*) in the arecanut gardens was confirmed as a collateral host of *Phytophthora meadii*, the causal organism of fruit rot of arecanut based on PCR-based identification and cross inoculation studies. Out of the 12 fungicides screened for management of fruit rot, spraying of Bordeaux mixture (1 %) or mandipropamid (0.5 %)

was found to be significantly effective in reducing the fruit rot incidence compared to ten other fungicides tested. Among the arecanut accessions screened, only two wild species viz., *Areca triandra* and *Areca concinna* were found resistant to fruit rot. Basal stem rot disease caused by *Ganoderma lucidum* is another major disease of coconut and soil application of *Trichoderma* enriched neem cake (5 kg palm<sup>-1</sup>) at quarterly interval was found very effective in reducing the disease incidence.

Among the foliar fungal diseases, inflorescence die back of arecanut caused by *Colletotrichum* spp. and leaf blight of coconut caused by *Lasiodiplodia* spp. were the major diseases observed. Random survey conducted indicated up to 27 % incidence of inflorescence die back in arecanut. Survey conducted in coconut growing areas of Karnataka and Tamil Nadu revealed highest leaf blight disease incidence (80 %) in Tirupur district of Tamil Nadu followed by Tumkur district of Karnataka (20 %). A total of 20 *Lasiodiplodia* isolates were obtained from coconut leaf blight samples collected from Tamil Nadu and Karnataka and identified as *L. theobromae*.

Root (wilt) disease of coconut caused by phytoplasma is another major disease and efforts have been made to improve the PCR-based diagnostic techniques for reliable early detection of phytoplasma. The phytoplasma causing phyllody in wild *Sesamum* sp. and *Cleome viscosa*, a common weed in coconut plantations, was identified as "*Candidatus Phytoplasma australasiae*" - related strain belonging to subgroup 16SrII and these weeds do not act as hosts for coconut root (wilt) phytoplasma belonging to 16 SrXI-B group. Integrated disease management strategies involving farm and palm hygiene, application of soil test based nutrients NPK (N: 500 g, P: 300 g K: 1250 g palm<sup>-1</sup> yr<sup>-1</sup> in two splits in May-June and August-September), 250 g MgSO<sub>4</sub> palm<sup>-1</sup> yr<sup>-1</sup>, irrigating the palms (250 L water palm<sup>-1</sup> week<sup>-1</sup>) during summer months, basin management with green manure crops like cowpea and control of leaf rot by application of hexaconazole 5 EC @ 2ml in 300 ml water, which have been developed for root (wilt) and leaf rot affected coconut gardens, could increase the yield by 25-83% depending on severity of the disease.

Phytoplasmal etiology of YLD has been established and management of the affected gardens with soil test based application of NPK (N:100g, P:40g, K:140g per palm<sup>-1</sup> yr<sup>-1</sup> application of FYM @ 12 kg per palm<sup>-1</sup> yr<sup>-1</sup> with summer irrigation (20 L water palm<sup>-1</sup> day<sup>-1</sup>) and improving drainage during rainy season has been advocated.

Clean and green innovative pest management technologies have been developed and field validated for the bio-suppression of rhinoceros beetle, red palm weevil, leaf eating caterpillar and eriophyid mite infesting coconut. IPM module for the management of rhinoceros beetle through integration of biocontrol agents *viz.*, *Oryctes rhinoceros* nudivirus (OrNV), Green Muscardine Fungus (GMF), *Metarhizium anisopliae*, botanicals (leaf axil filling with neem/marotti/pongamia cake @ 250 g mixed with equal volume of sand) and aggregation pheromone embedded nanomatrix trap @ one trap ha<sup>-1</sup> has been developed. Area-wide (1575 ha) farmer-participatory experiments undertaken at Krishnapuram (Kerala), Semanampathy (Tamil Nadu), Voodimudi (Andhra Pradesh) and Doddenhally (Karnataka) significantly reduced the spear leaf and inflorescence damage to an extent of 81.2%. Recently, an agro-ecosystem based pest regression strategy through ecological bio-engineering has been designed for managing rhinoceros beetle, exploiting the interplay of mixed-volatile cues of crop plurality of coconut with spices and fruit trees.

Integrated management technologies involving complete destruction of infested palm, close monitoring and sustained surveillance for early diagnosis, leaf axil filling of chlorantraniliprole sachet, curative management with imidacloprid (0.02%) and pheromone trap @1 trap ha<sup>-1</sup> were found effective in the management of red palm weevil. Community level technology convergence and large-area adoption of IPM technologies conducted in 2150 ha in Bharanikavu (Kerala), Palladam (Tamil Nadu), Ambajipet, (Andhra Pradesh) and Bidramamandi (Karnataka) could reduce the pest incidence to 56.8%.

For the bio-suppression of leaf eating caterpillar, augmentative release of stage-specific parasitoids *viz.*, *Goniozus nephantidis* and *Bracon brevicornis* @ 20 parasitoids per palm, removal of heavily damaged outer three leaves and improving soil and palm health of infested palms reduced the leaf damage to 95.3% in a period of 12-15 months. Area-wide field validation and demonstration experiments conducted at Vechoor and Kasaragod (Kerala), Sethumada (Tamil Nadu), Matlapalem (Andhra Pradesh) and Arsikere (Karnataka) in an area of 550 ha recorded a minimal pest incidence of 2.4% from an initial damage level of about 73.4% indicating the success of the technology.

IPM technologies for the suppression of eriophyid mite developed by ICAR-CPCRI involving 2% neem oil-garlic emulsion spray, root feeding of azadirachtin 10000 ppm @ 10 ml + 10 ml water and soil and palm health management practices reduced pest incidence to the tune of 71.4%. From an initial pest incidence

of 58.6% observed in Krishnapuram (Kerala), Kottur (Tamil Nadu), Ambajipet, (Andhra Pradesh) and Boranakoppalu (Karnataka), the pest incidence was reduced to 16.3% in a period of two years indicating the success of the technology at national level.

Integrated pest management strategies involving soil application of neem cake (2 kg palm<sup>-1</sup>), drenching the root zone with chlorpyrifos 20EC @ 2.5 ml L<sup>-1</sup> or imidacloprid 17.8 SL @ 675 ml ha<sup>-1</sup> or bifenthrin 10 EC @ 20 litre ha<sup>-1</sup> and entomopathogenic nematodes (EPN), *Steinernema carpocapsae* @ 1.5 IJ ha<sup>-1</sup> during May-June and September- October reduced the arecanut white grub population significantly. Placement of the neonicotinoid, thiamethoxam (2 g) in perforated poly sachets on the innermost two leaf axils of areca palms during April-May safeguarded arecanut palms from spindle bug damage. IPM strategies, developed for phytophagous mites and pentatomid bugs, involves the spraying of neem oil emulsion (0.5%) has been found effective in controlling these sporadic pests on arecanut.

### Climate resilient technologies

Coconut, arecanut and cocoa are highly sensitive to climate change variables like high temperature and water deficit stress. The impact, adaptive strategies and the mitigation potential of the above crops were studied to develop climate resilient technologies. The impact of climate change variables, elevated carbon dioxide [ECO<sub>2</sub>] and elevated temperature [ET], on coconut seedlings was studied in an open top chamber. The study indicated that the present level of biomass could be produced in future climate with less expense of water due to high water use efficiency observed under [ECO<sub>2</sub>]; however, at high temperature biomass production would be less. As an adaptive strategy, coconut genotypes were phenotyped for water deficit and high temperature stress. At 100% Field capacity (FC) tall genotypes exhibited high WUE (3.5 g biomass L<sup>-1</sup> water), while at 25% FC dwarf genotypes had high WUE (3.8). Tall genotypes had highly sensitive stomata while, dwarfs exhibited better root growth under stress. Furthermore, studies on leaf epicuticular wax content revealed that tall cultivars (Kalpa Pratibha and Kalpatharu) showed relatively high wax content than dwarf varieties.

At the reproductive phase, pollen germination was found to be very sensitive to high temperature. It was 63% at 30°C and got drastically reduced to 14% at 45°C. Across all the temperatures, WCT (58%) had high pollen germination while it was least in MYD (37%). A clear contrast was observed between tall and dwarfs in terms of pollen germination at high temperatures, which can be an important selection

criteria in evolving varieties with tolerance to high temperature. As a climate change mitigation strategy, areca based HDMSCS in North East significantly sequestered the carbon into the soil and SOC increased to 52.796 t ha<sup>-1</sup> as against 44.541 t ha<sup>-1</sup> of fallow lands. Similar sequestration was also seen in coconut based cropping systems.

As a measure of water conservation, institute has developed hydraulically efficient, environmentally compatible and cost effective filtration systems and structures for roof water harvesting, run-off collection, storage and percolation tanks. Low-cost water harvesting structures like check dam, sub surface dam, vented cross bars, storage structures using ferro-cement technology could augment surface/ sub surface water resources.

### **Product diversification, value addition and mechanization**

Value addition and product diversification can ensure the sustainable livelihood of plantation farmers and entrepreneurs. In this context, the recently developed 'coco-sap chiller' technology for collecting fresh, hygienic and unfermented coconut inflorescence sap (Kalparasa) is very promising. Other value added products like virgin coconut oil, coconut chips could improve the profitability and employment generation in coconut sector. In an effort towards product diversification and value addition, coconut milk residue based extrudate ('Kalpa Krunch'), pasta, rusk and fried snacks have been developed. Similarly, 'Kalpa Bar' (coconut sugar based dark chocolate) and 'Kalpa Drinking Chocolate' have been developed in collaboration with CAMPCO Limited, Puttur. For effective utilization of by-products, the process of vinegar production from mature coconut water and fermented neera, jelly and squash production from mature and tender coconut water, muffins cake production from virgin coconut oil cake, and low fat desiccated coconut flour production from coconut milk residue have been standardized.

Farm mechanization and various processing machineries developed at the institute could contribute substantially in reducing the production cost, increased labour efficiency and enhanced product output and quality. The safety attachment incorporated by ICAR-CPCRI to Chamberi Joseph model of climbing device has become an effective solution since it could be operated even by women with proper training. This gives much required confidence to the climbers, especially the beginners. Apart from this, machineries and gadgets developed for labour saving and gender main streaming viz., power operated coconut and arecanut husking machines,

coconut de-shelling and shell removing machines for copra making and wet processing respectively, tender coconut punch and cutter, copra and coconut chips dryers of varying capacities and using different fuel sources, testa remover, manual and power operated coconut slicing machines, coconut milk expellers of various capacities, VCO cookers, VCO fermentation tank and copra moisture meter are the other major contributions from the institute. A recent addition to this impressive array of gadgets is the gender-friendly self loading arecanut dehusking device (with dust control) along with the arecanut grading attachment. During the year, 10 post harvest technologies developed by the institute have been successfully transferred to 49 entrepreneurs, which generated a revenue of ₹ 9,49,500.

### **Capacity building programmes**

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 have been conducted. Besides, the institute has participated in exhibitions, radio talks, television interviews, phone-in programme and press meets. Commemorating the centenary year, Mega Expo and Kisan Mela were organized in addition to release of various publications and documentation farmers' experiences and felicitation of the innovative farmers across the country.

Applications of ICT tools like videoconferencing to develop linkages with various stakeholders were implemented. Statistical databases have been created and technical bulletins, extension pamphlets and information brochures have been published. Krishi Vigyan Kendras under the institute catered to the 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 utilized for facilitating the Research-Extension-Farmer interface. The Institute website (<http://www.cpcri.gov.in>) is being updated regularly with 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.

### Socio-economic studies and policy interventions

The impact of changing trade policy environment (domestic/international) on mandate crops in terms of prices (cointegration also) and demand-supply equations was studied and continuously monitored. Consultancy briefs (yearly basis) on production and trade aspects of the coconut sector were submitted to CACP as inputs to facilitate the fixation of Minimum Support Prices of copra. Policy brief on Minimum Support Price for arecanut was also prepared, suggestions of which were incorporated in price fixation of arecanut for the year 2016-17. Policy note on raw coconut procurement was prepared and submitted to the CACP. In view of the efficient raw coconut procurement, it was suggested to establish village level/panchayath level hubs with forward and backward integration along with unit level collection centers under the supervision of CPS networks.

The theoretical concept of Sectoral System of Innovation approach was empirically adopted in the coconut sector of India and a restructured sectoral innovation system has been put forth for a vibrant and sustainable coconut economy. Innovation system analysis of neera was also carried out.

### Statistical models to improve field experiments

Analysis of covariance technique in field experiments has been made more robust/flexible by taking the relationship between the response variable and covariate as non-parametric instead of linear. Semi-parametric additive regression model has been proposed to estimate/eliminate the positional effect in field experiments, when the number of experimental units is comparatively small. Crop production model in arecanut was developed based on semiparametric regression technique. A data driven technique was

developed to estimate the trend and relative growth rate of time series data. The method was extended for handling sudden shifts or changes in the trend or growth rate functions by adding dummy variables for the jumps. It has been applied to estimate trend and growth rate of area, production and yield of major crops in India. Robust spatial smoothing technique was developed to estimate the spatial effect of a field in the presence of outliers or extreme observations. It is based on fitting M-type robust nonparametric spatial regression following iterative kernel weighted local regression surface technique. Yield prediction in cocoa was done using biometrical/partial harvest data. Besides, weather based crop yield modelling was carried out in mandate crops. Pest and disease incidence and severity were regularly assessed employing appropriate sampling strategies in Kerala and Karnataka. Customized programmes have been developed in SAS, R and MATLAB for specific data analytic requirements.

### Impact of ICAR-CPCRI technologies

In the case of coconut, studies on rate of adoption of the selected technologies showed that about 12 per cent of farmers in Kerala adopted coconut hybrids and improved varieties. Around 13.6 per cent of total area in Karnataka is presently under released arecanut varieties. The economic impact of released arecanut varieties in monetary terms was estimated to be ₹ 421 million yr<sup>-1</sup>. The impact assessment of arecanut based cropping systems in coastal region of Karnataka revealed that total economic impact in monetary terms due to adoption of cropping systems in the region was around ₹ 1022 million yr<sup>-1</sup>. There would be an economic impact to the tune of ₹ 1604 lakhs yr<sup>-1</sup> from the planting materials supplied from the institute, considering the fairly long economic life span of coconut palms.



**Arecanut Plantation**



## VI. RESEARCH ACHIEVEMENTS

### GENETIC RESOURCES

#### 1.1. Coconut

##### 1.1.1. Germplasm enrichment

Conservation of 10 accessions, including five new germplasm from Andaman and Nicobar Islands viz., Kodiaghat Tall, Prothopur Tall, Chitrakud Tall, Chitrakud Semi Tall, Andaman Green Dwarf and five Pacific germplasm, namely, Solomon Island Tall, Fijian Tall Wanigata, Niu Leka Dwarf II, Tahitian Tall and Muwa Tall, was undertaken at Research Centre, Mohitnagar. Seed nuts of a regular bearing coconut genotype from South Andaman Island were collected and sown in the nursery for raising seedlings for conservation. For regeneration safety duplication, seed nut/seedling production was undertaken in 15 coconut accessions having low population size.

##### 1.1.2. Germplasm characterization and evaluation

Characterization and evaluation of conserved coconut germplasm in the national gene banks at Kasaragod/Kidu and the International Coconut Gene Bank for South Asia (ICG-SA) at Kidu are being continued. Higher potential for yield and yield component traits in conserved germplasm in stabilized bearing phase was recorded in Federated Malay States Tall, Kenya Tall, San Ramon Tall, Palawan Tall, Fiji Tall, Laguna Tall, Philippines Lono Tall, Kappadam Tall, New Guinea Tall, Niu

Leka Dwarf, Guam Tall II, Jamaica Tall, Surinam Tall, Kongthieyong Tall, Nigerian Green Dwarf, Zanzibar Tall, Jamaican San Blas Tall, Cameroon Red Dwarf and Laccadive Orange Dwarf. Among the conserved germplasm from the Pacific region, higher yield potential was recorded in Niu Bulavu Tall, Solomon Tall, Niu Hake Tall, Kavieng Tall, Tutiala Tall, Rennell Tall and Nikkore Dwarf. Among the 11 accessions planted in 1991, with West Coast Tall (WCT) as local control, highest copra yield of 28.65 kg palm<sup>-1</sup> year<sup>-1</sup> was recorded in the accession Philippines Lono Tall, followed by San Ramon Tall, Palawan Tall and Federated Malay States Tall, with 27.72, 27.58 and 26.28 kg palm<sup>-1</sup> year<sup>-1</sup>, respectively. Among these, Federated Malay States Tall (FMST) was observed to give higher inflorescence sap yield as compared to West Coast Tall (WCT), with sap yield of 31.23 l inflorescence<sup>-1</sup> in FMST as compared to 23.18 l inflorescence<sup>-1</sup> in WCT, during the month of December, and has potential for sap production in addition to production of copra/nuts.

Among the germplasm collections from Odisha in the pre-stabilized phase, highest yield was recorded in the accession Goja (91 nuts palm<sup>-1</sup> year<sup>-1</sup>), while the accessions Gole (72 nuts palm<sup>-1</sup> year<sup>-1</sup>), Narangi (70 nuts palm<sup>-1</sup> year<sup>-1</sup>) and Dhanei (64 nuts palm<sup>-1</sup> year<sup>-1</sup>) also recorded higher yield than WCT (52 nuts palm<sup>-1</sup> year<sup>-1</sup>). Among the inflorescence characters,

**Table 1. Evaluation of Odisha germplasm for reproductive traits**

Accession	Length of inflorescence (cm)	Length spikelet bearing portion (cm)	Girth of inflorescence stalk (cm)	Length of spikelet (cm)	Spikelets/ inflorescence	Female flowers/ inflorescence	Years to flowering
Dhanei	101.8	32.3	9.0	49.0	29	35	6
Goja	99.6	34.2	9.4	42.4	32	18	7
Gole	95.6	31.0	8.8	45.3	29	13	8
Jahaji	94.0	34.0	9.5	39.0	30	19	9
Narangi	87.5	30.5	8.0	42.8	26	17	8
Orissa Giant	115.5	37.0	9.5	50.0	31	19	9
Sakhigopal	92.5	28.0	8.8	37.0	29	9	6
WCT	102.1	36.6	8.6	40.1	29	18	8
CD 0.05	ns	5.37	ns	ns	ns	ns	1.49

significant differences were recorded for length of the spikelet bearing portion. Significant differences were observed for time taken to flowering, with earliest flowering recorded in the accession Dhanei and late flowering in the accessions Jahaji and Orissa Giant Tall. Higher number of female flowers per inflorescence was observed in Dhanei Tall, while fruit yield was higher in the Goja (Table 1).

Among the five Pacific germplasm planted during 1997, with WCT as local control, significant variations were observed among the accessions for annual bunch and nut production. The time taken for flowering also varied among the accessions, with very late flowering (>10 years) recorded in Samoan Tall and Niu Tavkave Tall (Table 2). Significantly higher yield was recorded in Niu Hake Tall (97 nuts palm<sup>-1</sup> year<sup>-1</sup>).

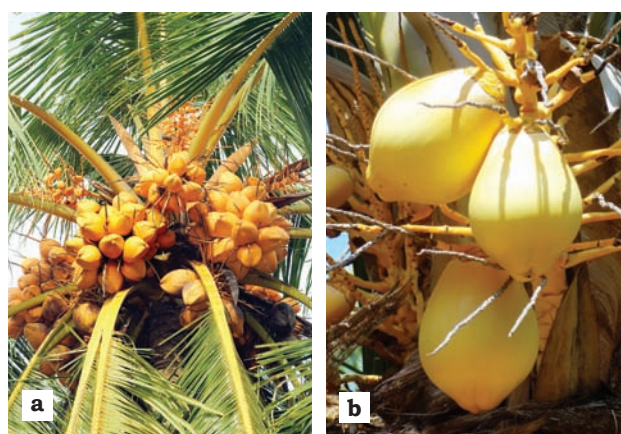
**Table 2. Evaluation of Pacific Ocean germplasm for yield**

Accession	No. of bunches (palm yr <sup>-1</sup> )	Nut yield (palm yr <sup>-1</sup> )	Months to flowering
Niu Bulavu Tall	13.2 <sup>a</sup>	81 <sup>ab</sup>	80
Niu Hake Tall	13.0 <sup>ab</sup>	97 <sup>a</sup>	78
Niu Ui Tall	8.5 <sup>b</sup>	44 <sup>ab</sup>	76
Samoan Tall	10.2 <sup>ab</sup>	44 <sup>ab</sup>	134
Niu Tavkave Tall	7.0 <sup>b</sup>	33 <sup>b</sup>	150
WCT	10.2 <sup>ab</sup>	78 <sup>ab</sup>	89
CD 0.05	2.26	36.4	

Wide variation for growth characters were recorded in juvenile germplasm conserved at the field gene bank. In the comparative evaluation of 33 dwarf accessions at Kasaragod, early inflorescence emergence (in 18<sup>th</sup> leaf axil) was recorded in a palm of IND003S. Majority of the dwarfs *viz.*, IND134S, IND133S, IND089S, IND449, IND432, IND395, IND433, IND394, IND068S, IND414, INGR13062, IND007S, IND049S, IND048S, IND058, IND047S, IND112S and IND052S have flowered after a period ranging from 24-48 months after planting, while IND003S and IND116S exhibited early flowering, within 24 months after planting. Distinct variation in inflorescence characters were recorded, with inflorescence length ranging from 35-117 cm. Higher number of female flowers per inflorescence was recorded in IND116S and IND089S (>23 female flowers inflorescence<sup>-1</sup>).

Among the accessions conserved in ICG-SA and national gene bank at Kidu, much higher annual nut

yield (> 53 nuts palm<sup>-1</sup>), than the population mean of 18 nuts palm<sup>-1</sup>, was recorded in Arasampatti Tall, Laccadive Micro Tall, Tiptur Tall, Federated Malay States Tall, Kenya Tall, San Ramon Tall, Andaman Ordinary Tall, Laccadive Ordinary Tall, West Coast Tall, Benaullim Tall, Sakthigopal Tall, Lifou Tall, West African Tall, Philippines Ordinary Tall, British Solomon Islands Tall, Rotuma Tall, East Coast Tall, Straits Settlement Apricot Tall, Panama Tall, Borneo Tall, Car Nicobar Tall, Sri Lankan Tall, Spicata Tall, Guam Tall, Kappadam Tall, Standard Kudat Tall, Java Tall, Straits Settlement Green Tall, Philippines Lono Tall, Jamaican Tall, Niu Hake Tall, Adirampatam Tall, Kenya Tall, Zanzibar Tall, Niu Guinea Tall, Andaman Ranguchan Tall, Chandan Nagar Tall, Sendagan Tall, Tinisera Tall, Cochin China Tall and Fiji Tall among Talls and Kulashekaram Orange and Yellow Dwarfs, Chowghat Orange Dwarf, Pattukottai Green Dwarf, Chowghat Green Dwarf, Malayan Green Dwarf, Malayan Yellow Dwarf, Laccadive Orange Dwarf, King Coconut and Cameroon Red Dwarf among dwarfs (Fig. 1). Higher potential for fruit yield was observed in Sambava Green Tall, Kadedhdhoo Small Round Tall, Kadedhdhoo Oblong Tall, King Kumbra Tall, Comoros Moheli Tall, Sambava Tall, Coco Bleu Tall, Comoros Tall and Pemba Red Dwarf among Indian Ocean accessions; Uzirpur Tall, Kayemkola Tall, Rupadia Tall, BARI Narikel Tall and Khairthala Tall, among Bangladesh accessions and Sri Lankan Green Dwarf, Sri Lankan Yellow Dwarf and Sri Lankan Orange Dwarf among Sri Lankan accessions.



**Fig. 1. Promising accessions with respect to nut yield (a) Cameroon Red Dwarf and (b) Straits Settlement Apricot Tall**

In the indigenous germplasm in pre-stabilized phase, at Kidu, higher nut yield (above the population mean of 12 nuts palm<sup>-1</sup> year<sup>-1</sup>) was recorded in Pazhuvil Tall,

Laccadive Micro Tall, Kurmadera Tall, Burmanella Tall, Aliyarnagar Tall, Mayipadi Tall, Achamthuruty Tall, Kothavade Tall, Carbin Brown Tall, Engandiyoor Tall, Malaca Tall, Barajaguli Tall, Chappadam Tall, Pinarai Tall, Mullasery Tall, Pallisery Tall, Champin Micro Tall, Kodiaghat Big Round Tall, Katchal Micro Tall, Bionliten Green Tall, Manjery Tall and Nicobar Beak Tall.

Among the 15 coconut genotypes under evaluation at Kahikuchi, higher plant height (412 cm) were recorded in WCT and more number of leaves were recorded in Chandra Laksha (28). In case of dwarfs, number of leaves (28) as well as nut production was higher in Malayan Orange Dwarf (54 nuts palm<sup>-1</sup> year<sup>-1</sup>) compared to check (Chowghat Orange Dwarf) with 26 leaves and 46 nuts palm<sup>-1</sup> year<sup>-1</sup>. Among the 13 local accessions, higher plant height (442 cm) in KKHC 1 while higher number of leaves (24) and nuts (36.67 nuts palm<sup>-1</sup> year<sup>-1</sup>) in KKHC- 4 were recorded. Fifteen accessions were studied for floral characters at different intervals at Kahikuchi. Among dwarf varieties, Malayan Orange Dwarf produced larger inflorescence, with higher length of inflorescence (77.70 cm), length of spikelet (33.28 cm), with more number of spikelets (38), more number of female flowers per inflorescence (25) and more number of male flowers per spikelet (212). Among the tall and hybrids, Laksha Ganga recorded larger inflorescence (87.22 cm) with more female flowers per inflorescence (41) followed by Chandra Sankara (87.10 cm length and 34 female flowers inflorescence<sup>-1</sup>).

At Mohitnagar, higher yield was recorded in IND 172 (105 nuts palm<sup>-1</sup> year<sup>-1</sup>) followed by IND175 and IND 045S (85 nuts palm<sup>-1</sup> year<sup>-1</sup>), as compared to check (WCT-29 nuts). Among the five dwarfs under evaluation, Chowghat Green Dwarf recorded significantly lower nut yield (32) than the other four dwarfs viz., Malayan Orange Dwarf (42), Malayan Green Dwarf (45), Malayan Yellow Dwarf (42) and Chowghat Orange Dwarf (43). The performance of hybrids viz., Laksha Ganga, Kera Ganga, Chandra Laksha, Kera Sankara and Chandra Sankara, was poor with nut yield ranging from 28 nuts palm<sup>-1</sup> year<sup>-1</sup> in Chandra Sankara to 38 nuts palm<sup>-1</sup> year<sup>-1</sup> in Laksha Ganga. Juvenile growth characters viz., plant height, girth and number of leaves, recorded in 14 germplasm collected from North East India, indicated variation in plant height and girth. Among the 21 coconut accessions planted during 2016 at Mohitnagar, West Bengal with local check Mohitnagar-III, plant height was observed to be higher in Kalpatharu (208.8 cm). No variation was observed in leaf production among these accessions.

### 1.1.2.1. Sweet kernel nuts

Among the 22 seed propagated progenies of *Mohachao Narel*, from Ratnagiri region of Maharashtra, nine palms were found to produce fruits with sweet endosperm, with percentage of sweet kernel fruits in a palm varying from 4.6 to 60 percent (Fig. 2). It was further observed that among the families, NSD4 showed higher number of progenies (3) with sweet kernel fruits, with one palm recording highest percentage (60%) of sweet kernel fruits. Only one sweet kernel producing progeny was recorded in NSD1, NSD6, NSD10, NSD15, NSD27 and NSD28.

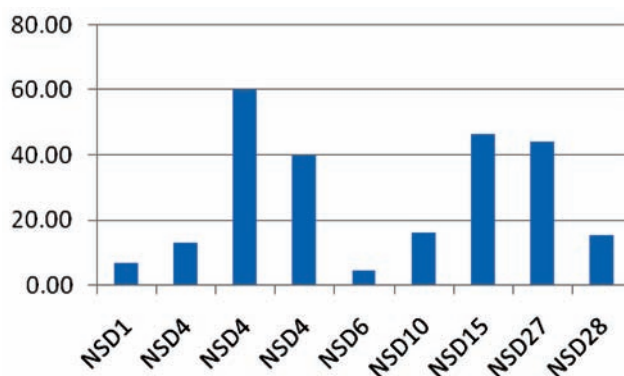


Fig. 2. Per cent of nuts with sweet kernel in different palms

### 1.1.2.2. Tolerance to moisture deficiency and low temperature

West Coast Tall, Tiptur Tall, Malayan Yellow Dwarf, Chowghat Green Dwarf, Cochin China Tall and Laccadive Ordinary Tall exhibited differential response to moisture deficit stress at Kasaragod, Kerala. In the evaluation trial for low moisture stress tolerance planted in farmer's garden in Sivaganga District, Tamil Nadu, better leaf production was realized in Federated Malay States Tall, Philippines Ordinary Tall and Cochin China Tall among the 10 coconut accessions. Among the 15 cold tolerant lines identified from Sub Himalayan Terai region and under evaluation at Mohitnagar, no cold injury symptoms were observed. However, significant variations in plant height and girth were observed with highest plant height in Mohitnagar III and Lataguri II (464.3 and 420.3 cm, respectively) as compared to the check, West Coast Tall (329.7 cm).

### 1.1.2.3. Virgin coconut oil

Studies on yield of virgin coconut oil (VCO) in six tall accessions viz., Palawan Tall, Gangapani Tall, Panama Tall, Nicobar Beak Tall, Andaman Ordinary Tall and Federated Malay States Tall, indicated variation in oil yield from 100 nuts, ranging from

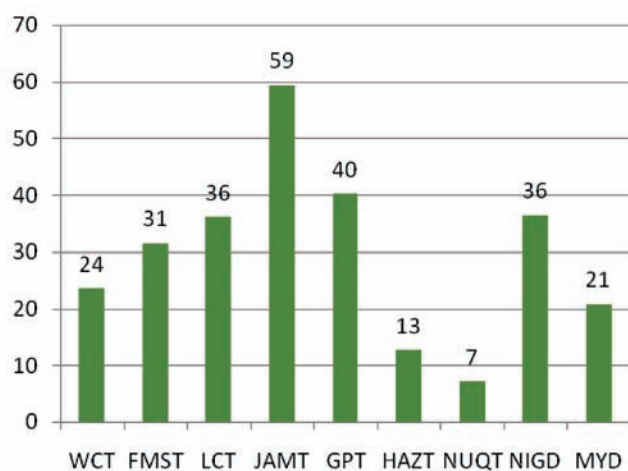
4.1 in Andaman Ordinary Tall to 6.3 in Palawan Tall and Federated Malay States Tall. Variation in VCO viscosity was observed, ranging from 1.36 in Gangapani Tall to 1.40 in VCO obtained from nuts of Palawan Tall and Federated Malay States Tall (Table 3), indicating qualitative differences in oil quality and the scope for identifying accessions with premium oil characteristics.

**Table 3. Evaluation of VCO yield and quality in selected accessions**

Accession	VCO yield (l per 100 fruits)	Oil viscosity (sec 120 ml <sup>-1</sup> )
Palawan Tall	6.32	1.40
Gangapani Tall	4.85	1.36
Panama Tall	5.59	1.39
Nicobar Beak Tall	5.50	1.38
Andaman Ordinary Tall	4.09	1.38
Federated Malay States Tall	6.28	1.40

#### 1.1.2.4. Inflorescence sap yield

Inflorescence sap yield was determined during the month of December in nine accessions namely West Coast Tall, Federated Malay States Tall, Jamaica Tall, Gangapani Tall, Hazari Tall, Niu Quewen Tall, Nigerian Green Dwarf, Laccadive Ordinary Tall and Malayan Yellow Dwarf. Variation in sap yield was recorded among the genotypes studied. Higher sap yield (31-59 l inflorescence<sup>-1</sup>) was observed in Jamaica Tall, Gangapani Tall, Federated Malay States Tall, Nigerian Green Dwarf and Laccadive Ordinary Tall as compared to West Coast Tall (24 l inflorescence<sup>-1</sup>). Low sap yield (7 and 13 l inflorescence<sup>-1</sup>, respectively) was observed in Hazari Tall and Niu Quewen Tall (Fig. 3).



**Fig. 3. Sap yield (litre inflorescence<sup>-1</sup>) in coconut accessions**

#### 1.1.2.5. Germination rate

The number of days taken for germination were examined in 12 tall accessions *viz.*, Guam III Tall, Guam II Tall, Gudanjali Dwarf, Kenya Tall, Kulasekharam Green Dwarf, Markham Tall, Niu Leka Dwarf, Philippines Laguna Tall, San Ramon Tall, Strait Settlement Green, Tiptur Tall and Zanzibar Tall. Kulasekharam Green Dwarf and San Ramon Tall seed nuts germinated early (14 days after sowing) while Tiptur Tall was the slowest to germinate (after two months of sowing). The early germinating Kulasekharam Green Dwarf and San Ramon Tall also recorded higher seedling height and girth, with more number of leaves. Studies on time taken to germination in 12 accessions collected from the Andaman and Nicobar Islands indicated a mean germination time, ranging from about one month in tall accessions from Kodiaghat (JA2, JA4 and JA5), to about three months in Chitrakud Tall and Chitrakud Semi Tall. Chitrakud Dwarf, with mean germination period of 52 days, showed highest number of leaves (12) as compared to the rest of the accessions (9-10 leaves). Spatial differences in germination time were also observed within this collection, with accessions collected from Kodiaghat being comparatively early germinating than collections from Chitrakud. Days to germination was negatively correlated with seedling height and seedling growth parameters of one year old seedlings were strongly correlated with growth characters two years after sowing, indicating the importance of robust seedling selection in nursery.

#### 1.1.2.6. Fruit component traits

Fruit component traits were also recorded in 12 accessions collected from Andaman and Nicobar Islands, five tall accessions from the Pacific region and two accessions from Odisha. Higher volume of tender nut water (850 ml nut<sup>-1</sup>) and also higher tender fruit weight (4125 g) was recorded in Niu Ui Tall, while Jahaji Tall recorded lesser tender nut water content (270 ml), among the accessions studied. Fruit weight in coconut germplasm from Andaman and Nicobar islands, varied from 545 g in Kodiaghat Tall to 1660g in Chitrakud Semi Tall and copra content from 141g (Chitrakud Dwarf) to 334 g (Chitrakud Semi Tall). Chitrakud Dwarf recorded lesser endosperm and shell thickness (0.8 cm and 0.23 cm, respectively).

#### 1.1.2.7. Generation of planting materials

A total of 4633 female flowers in 16 accessions were pollinated for seed production. About 2000 seed nuts in 15 accessions were sown for producing seedlings for conservation, gap filling and evaluation. A total of 458 seed nuts of 22 accessions, including 19 Pacific germplasm were received from ICAR-CIARI,

Port Blair and sown for conservation and evaluation. Pollen of WCGC Acc. 5 was received for production of experimental crosses, while pollen of Cochin China Tall and San Ramon Tall were sent to ICAR-CIARI for production of experimental crosses. Planting materials of dwarf tender nut varieties, Kalpa Surya, Kalpa Jyothi and Chowghat Orange Dwarf, were provided to All India Coordinated Research Project on Palms (AICRPP), Horticulture Research Station, Arsikere, Karnataka, while seedlings of Kalpatharu was provided to AICRPP Coconut Research Station, Aliyarnagar, Tamil Nadu for establishment of seed garden. Planting materials of germplasm/released varieties *viz.*, San Ramon Tall, Tiptur Tall, Niu Leka Dwarf and Kalpa Haritha were provided to ICAR-CPCRI Regional Station, Kayankulam for evaluation against root (wilt) disease; Straits Settlement Apricot Tall to AICRPP Centre, Aliyarnagar; Laguna Tall, East African Tall 32, Kalpa Haritha, Kalparaksha and Markham Tall to AICRPP Centre, Arsikere for conservation/evaluation; physiological screening for moisture deficit tolerance (Malayan Yellow Dwarf, Chowghat Green Dwarf, Tiptur Tall, Cochin China Tall, Laccadive Ordinary Tall and West Coast Tall), climate change (Malayan Yellow Dwarf, Chowghat Green Dwarf and Malayan Orange Dwarf) and hydroponic studies (Malayan Yellow Dwarf, Chowghat Green Dwarf, Federated Malay States Tall and Kalpa Haritha) at Kasaragod. Technology evaluation trials on identified, registered / released

varieties (INGR13065, INGR13060, INGR13061, IND058 x EAT 32, IND0925 x IND0295, Kalpa Surya, Kalpa Jyothi, Kalpa Samrudhi and Chowghat Orange Dwarf have been established in farmers' fields in the states of Kerala, Andhra Pradesh and Tamil Nadu and are being monitored for farmers participatory performance evaluation.

#### 1.1.2.8. Potential markers for marker assisted selection

A coconut palm bearing large fruits with pink coloured mesocarp was identified in San Ramon Tall population and studied for exploitation in breeding programme to develop genetic stocks and new tender coconut varieties. The flowers and fruits from all bunches of the palm exhibit pink colour below the tepals, slightly extending outwards. The husk fibres of tender fruits also exhibit the colour ranging from intense to light pink from outer to inner side. A significant observation was made on the male flowers of this palm which has potential for use in marker assisted selection and in the development of tender nut varieties with attractive pink husk. Two types of male flowers, one with dark pink and another with yellow colour anther filaments, were documented. This is the first report of differential colour of male flowers in a single inflorescence. Although no morphological difference could be seen on size of male flowers and anthers, the flowers with pink filaments could be easily identified even at unopened stage as the pink tinge is present in the bottom of tepals.



**Fig. 4. Pink coloured coconut showing distinct pink flowers and mesocarp**

**Table 4. Biochemical estimation in normal and pink husk coconut**

Sample	Tissue	Phenolics (mg g <sup>-1</sup> )	Flavonoids (mg g <sup>-1</sup> )	Anthocyanin (mg g <sup>-1</sup> )
Pink husked	Husk	22.22	172.05	13.89
	Leaf	49.67	196.76	23.50
Normal husked	Husk	19.56	145.14	2.50
	Leaf	38.75	144.70	12.69

Higher phenolic, flavonoid and anthocyanin content were recorded in husk tissues of the palm with pink mesocarp, as compared to palms with normal husk colour (Table 4). The palm has been selected for further studies on the pollination behaviour and use of pollen from the pink flowers for pollination and studies on segregation.

#### 1.1.2.9. *In situ* characterization of ecotypes

*In situ* characterization for fruit component traits were undertaken in Chittur coconut population of Palakkad district of Kerala. Two percent palms in the population showed fruits less than 1 kg in weight. Thirty nine percent palms in the population showed fresh fruit weight ranging from 1 to 1.5 kg. Thirty five percent palms in the population showed fresh fruit weight ranging from 1.5 to 2.0 kg and 23 percent palms in the population showed fresh fruit weight ranging from 2.0 to 2.5 kg. Palms with more than 2.5 kg of fruits were only about 2.5 percentage in the population. Husk thickness varied from 2.0 to 5.1 cm with 80 percent palms showing husk thickness between 3.1 and 3.5 cm. Nut (husked fruit) weight varied from 186 g to 928 g with 80 percent palms showing nut weight between 360 and 540 g. Copra weight varied from 102 g to 254 g with 80 percent palms showing copra weight between 135 and 220 g. Chittur Tall coconut population could be grouped into two clusters based on fruit component traits.

*In situ* characterization of a pink husked tall accession in root (wilt) disease prevalent tract was also undertaken. Biochemical analysis showed that

the nut water of the pink husked coconut selection possesses total protein (38.75 µg ml<sup>-1</sup>), amino acid (29.75 µl ml<sup>-1</sup>) and total phenol (23.79 µg ml<sup>-1</sup>). The tender nut water has antioxidant scavenging activity against DPPH radical (IC<sub>50</sub>=19.5 µl ml<sup>-1</sup> ascorbic acid). A total of 25 SCoT and 16 RAPD primers were screened for molecular analysis and among these four primers (SCoT 2, SCoT 18, SCoT 21 and SCoT 22) could differentiate pink husked coconut selection from normal West Coast Tall palms.

#### 1.1.2.10. Release of Kalpa Shatabdi

Kalpa Shatabdi (a selection of IND034S) has been developed through selection and *inter se* mating between the selected palms from the ICAR-CPCRI accession IND034, originally introduced from the Philippines during 1955. This variety, with large fruits, gives a high copra out turn of 28.65 kg palm<sup>-1</sup> year<sup>-1</sup>, which is 61.40 % higher than the copra yield of local control, WCT (17.80 kg palm<sup>-1</sup> year<sup>-1</sup>), at Kasaragod (Fig 6). It has tender nut water in large quantity (612 ml) with TSS of 6.12° Brix. Considering the high copra out turn and tender nut quality, the variety Kalpa Shatabdi has been recommended for cultivation in the coconut growing tracts of Kerala, Karnataka and Tamil Nadu. The proposal for release of coconut variety Kalpa Shatabdi (based on the performance at ICAR-CPCRI and AICRPP Centre, Aliyarnagar) was approved and recommended by the XXV AICRPP Group Meeting 2016 for submission to Central Sub-committee on Crop Standards, Development and Release of Varieties of Horticultural crops for release and notification.

**Fig. 5. Difference in fruit shape among palms of Chittur Tall population**



**Fig. 6. Kalpa Shatabdi**

#### 1.1.2.11. DUS Centre for coconut

Generation of DUS test data was continued in 10 released/extant coconut varieties *viz.*, Chowghat Orange Dwarf, West Coast Tall, Kalpa Pratibha, Kalpa Dhenu, Kalpa Mitra, Chandra Kalpa, Kera Chandra, Kalparaksha, Chandra Sankara and Chandra Laksha and Kera Sankara, which were planted in 2013 in two different spacings (4 m x 4 m and 6 m x 6 m). Flower initiation was observed in almost all the varieties, except West Coast Tall and Kalpa Dhenu. Early flowering (25 months after planting) was recorded in Chowghat Orange Dwarf and Chandra Sankara, while flower initiation in other varieties (Kalpa Pratibha, Kalpa Mitra, Chandra Kalpa, Kera Chandra, Chandra Laksha and Kera Sankara) ranged from 36-39 months after planting. Significant variations for juvenile growth characters were observed between the varieties. The plant height, girth, annual leaf production, length of the leaf and breadth of leaflet, recorded significant variations between the two spacings adopted, with leaf length and plant height being higher in closer



**Fig. 7. View of coconut DUS plot**

spacing of 4 m x 4 m, while leaf breadth, annual leaf production and leaflet breadth were higher in the 6m x 6 m spacing.

### 1.2. Arecanut

#### 1.2.1. Enrichment of germplasm

Germplasm holdings in the main field gene bank has been enhanced to 176 with the collection of 12 diverse germplasm from North Bengal (6), Assam (2) and Karnataka (4), which include types with bold nuts (>145 g wt.), nuts with free kernel and variegated nuts. Muchulpukuri, a promising accession with individual fresh nut weight >145 g, was collected from Coch Behar, North Bengal (Fig. 8). Seventeen germplasm collected from Konkan, Andaman and Nicobar Islands and Karnataka have been planted in the field during August 2016 for assessing the yield and its economic traits.

#### 1.2.2. Germplasm evaluation

A total of 176 accessions are under evaluation for yield and other economic traits. Accessions Sirsi, Kodinar,

**Table 5. Juvenile growth characters of coconut palm grown under different spacings**

Trait	4 m x 4 m spacing	6 m x 6 m spacing	CD 0.05
Palm height (cm)	708.89	686.93	14.61
No. of leaves produced per year	12.36	13.43	0.46
Petiole length (cm)	152.44	142.83	4.19
Leaf bearing portion (cm)	356.17	341.21	15.15
Total length of leaf (cm)	543.56	522.18	10.68
Leaflet breadth (cm)	4.50	5.03	0.16



**Fig. 8. Muchulpukuri**



**Fig. 9. Ripe arecanut with free kernel**



**Fig. 10. Variegated and normal arecanuts**

Nalbari and Chare-I showed high yielding tendency, with dry kernel yield of 3.90, 3.68, 3.64, and 3.57 kg palm<sup>-1</sup> year<sup>-1</sup>, respectively. In the alternate field gene bank at Mohitnagar, yield components have been recorded for 71 accessions planted in different batches. Among the accessions, VTL-40, VTL-60, VTL-64, VTL-75 exhibited higher dry kernel yield.

Morphological and inflorescence traits have been recorded in 18 accessions from North East region. Borehat recorded the maximum plant height (3.16 m) followed by Nalbari (2.95 m). Maximum circumference and more number of leaves were recorded in Birubari (36.70 cm) and Kahikuchi (10.72), respectively. Maximum number of palms producing inflorescence was recorded in accession Sarugoan-1. Based on morphological, yield and fruit components, 13 Gujarat and Karnataka collections have been described. Tender nut processing studies was undertaken in 14 collections from Andaman and Nicobar Islands and more than 66% first quality processed tender nuts could be recovered from accessions, VTL-34, VTL-36 and VTL-37.

#### **1.2.2.1. Generation of *inter se* materials in germplasm**

A total of 6000 female flowers were pollinated in 13 accessions for generating *inter se* material for replanting as well as screening against YLD.

#### **1.2.2.2. Release of Shatamangala**

A high-yielding selection VTL-146, from a germplasm line collected from Gujarat, with dry kernel yield of 3.91 kg palm<sup>-1</sup> year<sup>-1</sup> and tender nut yield of 3.26 kg palm<sup>-1</sup> year<sup>-1</sup> was released as 'Shatamangala' (Fig. 11). The palms of the variety are regular bearing with good kernel quality suitable for tender nut processing. The variety has exhibited better performance for yield over the released varieties *viz.*, Mangala (34.24%), Sumangala (20.73%), Sreemangala (24.53%), and South Kanara Local (47.76%), with high recovery of first quality processed tender nut (68.4%).

Shatamangala variety is semi tall in habit and characterized by medium thick stem, shorter internodes, partially drooping crown, regular bearing, medium maturity and bearing by 4<sup>th</sup> year,



**Fig. 11. Crown of arecanut variety Shatamangala**

synchronized maturity of nuts, high yield, well placed bunches, round, orange colour fruits, higher content of polysaccharides and polyphenols and high recovery (26.80%) of dry kernel from fresh nut. The variety is suitable for production of dry kernel and processed tender nut, and is recommended for cultivation in the states of Karnataka, West Bengal and Gujarat.

### 1.3. Cocoa

#### 1.3.1. Germplasm enhancement

*Theobroma grandiflorum* (Cupuassu fruit) was collected for evaluating its utility as rootstock, wilt resistance and product diversification (Fig.12). *Pentagona* type of cocoa with distinct five-ribbed pod with white to pink beans (Fig.13) was collected, for utilizing in expression study of anthocyanin inhibitory genes, the sterility mechanism and quality improvement. Local cocoa types from Adimaly and Mankuva villages in high hills of Idukki district of Kerala (with pod index 10, bean index 1.95 to 2.11 g, 9.52% shell, 90.6% nib recovery and 52-55% fat content) (Fig.14) were collected and conserved at Regional Station at Vittal and Kayamkulam for evaluating in the lower hills and plains for quantitative and qualitative parameters.

#### 1.3.2. Germplasm conservation and regeneration

A total of 405 cocoa accessions are being conserved in field gene banks of Vittal under arecanut. An alternate cocoa gene bank, involving 61 genotypes, was established at Kidu and 25 genotypes, regenerated as clones, were planted at Kayamkulam.

#### 1.3.3. Characterization and evaluation

##### 1.3.3.1. DUS centre for cocoa

DUS descriptor characters such as morphological, floral, pod and bean traits have been short-listed from 50 core collections. A total of 20 distinct morphological/quantitative/qualitative characteristics such as plant habit, shape of base of leaf blade, leaf apex shape, young flush leaf colour through anthocyanin pigmentation (Fig.15), anthocyanin in flower pedicel, pedicel diameter (Fig. 16), orientation of sepal, anthocyanin in stamen filament, fruit shape, basal constriction, apex form (Fig. 17.), length/ width ratio, surface rugosity, colour, husk thickness, prominence of ridges and furrows (Fig. 18), sweetness of pulp, number of beans, bean length/ width ratio, cotyledon colour and fat content were recorded from adult cocoa



*T. cacao*

*T. grandiflorum*



Pubescent leaves in  
*T. grandiflorum*



*T. grandiflorum*  
fruit

Fig. 12. *Theobroma grandiflorum*



Pentagona tree



Pentagonal pod

Fig. 13. *Pentagona* type cocoa



Mankuva tree



Mankuva pods



Mankuva beans

Fig. 14. Mankuva cocoa from Idukki

trees. Five pod and bean characters were identified as useful grouping characteristics. Explanations to

each distinctive character along with illustrations have also been prepared.

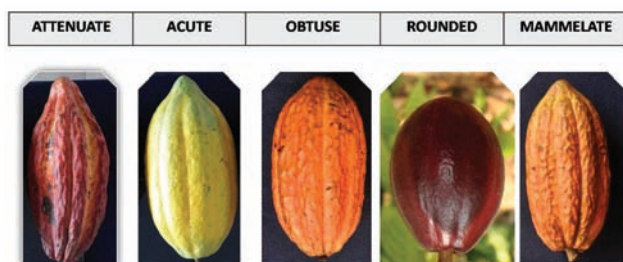


Fig. 15. Anthocyanin pigmentation in leaf flush

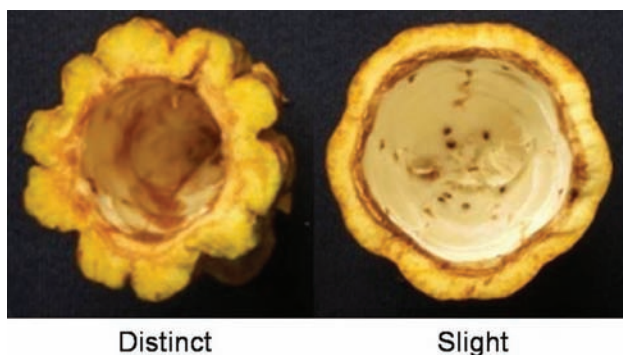




**Fig. 16. Pedicle diameter**



**Fig. 17. Fruit apex form**



**Fig. 18. Prominence of ridges/ furrows**

#### 1.3.3.2. Morphological characterization

Clones with higher annual dry bean yield *viz.*, NC-26 (3.15 kg), NC-49 (2.68 kg), NC-50 (2.64 kg), NC-23 (2.53 kg), NC-27 (2.58 kg), NC-30 (2.57 kg), NC-3 (2.40 kg), NC-43 (2.40 kg), NC-57 (2.26 kg) and NC-51 (2.20 kg), in comparison to check NC 45 (1.14 kg) and having desirable traits and processing value have been identified for further studies. Evaluation of new cocoa collections of Central and South America over nine years identified SCZ-1 and SCZ-20 as precocious and high bearers (2012-2016, 5<sup>th</sup> to 9<sup>th</sup> year of planting). Trait-specific evaluation of 15 years old exotic collections resulted in identification of 33 clones with 1.1 to 1.50 g single dry bean weights and 50-55% fat contents.

#### 1.3.3.3. Identification of clones for different agro-climatic conditions

The following cocoa clones performed well in different agro-climatic conditions:

- Kahikuchi (Assam) - VTLC-5, VTLC-19 (under arecanut)

- Mohitnagar (West Bengal) - VTLC-1 (under arecanut), VTLC-5 (under coconut)
- Kasaragod (Kerala) - VTLC-1, VTLC-5 (under coconut)
- Ratnagiri (Maharashtra) - VTLC-17, VTLC-1 (under coconut)
- Ambajipeta (Andhra Pradesh) - VTLC-2 (under coconut)
- Vijayarai (Andhra Pradesh) - VTLC-4 (under oil palm)
- Pollachi (Tamil Nadu) - VTLC-3 (under coconut)
- Navsari (Gujarat) - VTLC-1 (under coconut)

#### 1.3.3.4. Compatibility mechanism in cocoa trees

Compatibility mechanism, based on the frequency of flower retention after manual protected pollination, was studied in 10 accessions (one tree accession<sup>-1</sup>). Trees with flower retention of 10% or less at 15 days after pollination were classified as self-incompatible, whereas trees with 30% or more flowers after the same span of time were considered as self-compatible. About 16 to 51 flowers were self pollinated in each accession, depending on the availability of flowers, to determine their compatibility reaction. Higher



**Fig. 19. Selection of flower bud**



**Fig. 20. Cocoa flower bud covered with polythene tube with one end covered with muslin cloth and the other end fastened to the trunk by wood putty**



**Fig. 22. Pollinated flowers covered with polythene tubes**

flower retention was observed in VTLC-156 (6.6%), followed by VTLC-153 (6.4 %), while VTLC-151 exhibited flower retention percentage of 2.9 % and the remaining seven accessions (VTLC-144, VTLC-146, VTLC-148, VTLC-149, VTLC-155, VTLC-168 and VTLC-191) recorded no flower retention. Therefore, all the 10 trees belonging to 10 different accessions studied in the present investigation exhibited self incompatibility reaction (Fig. 19-22).

#### 1.3.3.5. Screening for biotic and abiotic stress

Twenty six Upper Amazon Forastero/Refractario cocoa clones were screened against black pod rot disease resistance under laboratory condition through detached pod technique. Highly virulent *Phytophthora palmivora* isolate (KL/CA-216), grown in carrot agar medium, was used for inoculation. All the accessions exhibited susceptible reaction to black pod rot.



**Fig. 21. Artificial pollination**

Nineteen red coloured Nigerian clones were evaluated for tolerance to tea mosquito bug based on percentage of pod damage which ranged from 0-65.2%. Severity index based on grades of damage ranged from 0 to 1.17. Pods free of tea mosquito bug damage was observed in clones NC-56, NC-25, and NC-41. Among 37 Upper Amazon Forastero / Refractario cocoa clones, the severity index ranged from 0 to 1.91. VTLC-173 and VTLC-176 were free of tea mosquito bug damage.

Cocoa genotypes (seedlings) were evaluated for hydric deficit stress at 20% field capacity with morpho-physiological traits, secondary metabolites and biochemical constituents. Based on these studies, VTLC-26, VTLC-27, VTLC-25, VTLC-4 and VTLC-22 have been identified with wider adaptability which will be utilized for breeding for low moisture stress.

## 1.4. Coconut

### 1.4.1. Hybrids for release

The two coconut hybrids recommended for release, Chowghat Orange Dwarf x West African Tall (COD x WAT) and Chowghat Orange Dwarf x Laccadive Ordinary Tall (COD x LCT), showed superiority in yield with more than 150 nuts palm<sup>-1</sup> year<sup>-1</sup> (Fig. 23) compared to control (West Coast Tall; 149 nuts palm<sup>-1</sup> year<sup>-1</sup>). The hybrids have brownish green oval shaped fruits and are good for copra (4.83-5.71 t ha<sup>-1</sup> year<sup>-1</sup>) as well as tender nut purpose (Table 6). Seed nuts of these hybrids have been produced for establishment of multi location evaluation trials. These hybrids also yield higher inflorescence sap in comparison to Chandra Laksha (Laccadive Ordinary Tall x Chowghat Orange Dwarf) and West Coast Tall (Fig. 24).



**Fig. 23. High yielding hybrids (a) COD x LCT and (b) COD x WAT**

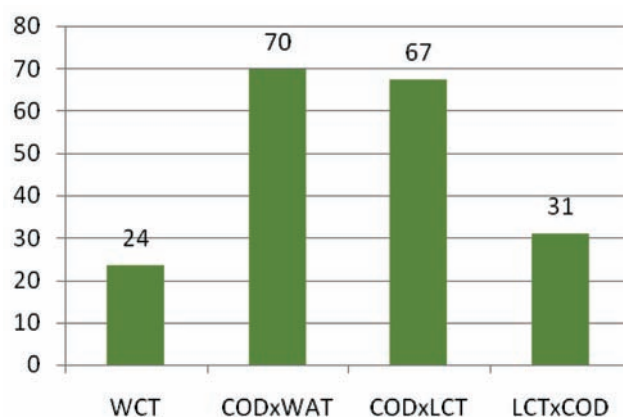
**Table 6. Tender nut traits of identified hybrids**

Trait	COD x WAT	COD x LCT
Tender fruit weight (g)	2.058	2.252
Volume of tender nut water (ml)	490	341
TSS ( $^{\circ}$ Brix)	5.8	6.1
Taste of tender nut water	Good	Very Good
Husk thickness (cm)	2.33	2.58

#### 1.4.2. Hybrid evaluation trials

In the new hybrid evaluation trial initiated during 2013 and 2014 at Kasaragod and Kidu, comprising of 28 D x T hybrid combinations, early flowering, within three years, was observed in a few Chowghat Green Dwarf x Cochin China Tall and Gangabondam Green Dwarf x Cochin China Tall hybrids. In the Dwarf x Dwarf trial laid out at Kidu, Chowghat Orange Dwarf x Chowghat Green Dwarf, Chowghat Orange Dwarf x Gangabondam Green Dwarf, Malayan Yellow Dwarf x Malayan Orange Dwarf, Malayan Yellow Dwarf x Niu Leka Green Dwarf, Malayan Yellow Dwarf x Chowghat Green Dwarf, Malayan Yellow Dwarf x Gangabondam Green Dwarf, Malayan Yellow Dwarf x Cameroon Red Dwarf and Chowghat Green Dwarf x Malayan Orange Dwarf were observed to be better for bunch production and nut yield. Significant variations were observed for juvenile growth characters among the Dwarf x Dwarf hybrids planted at Kasaragod during 2016.

Pollen of San Ramon Tall and Cochin China Tall collected from Kasaragod was used for production of new hybrid combinations using three Pacific Ocean Dwarfs, planted at WCGC, Port Blair, as female parents. Hybrid seedlings of Malayan Yellow Dwarf



**Fig. 24. Inflorescence sap yield (litres/inflorescence)**

x Chowghat Green Dwarf, Malayan Yellow Dwarf x Kenya Tall, Malayan Yellow Dwarf x West Coast Tall, Chowghat Orange Dwarf x Laccadive Ordinary Tall and Chowghat Orange Dwarf x West African Tall were produced for establishment of multi-location trials.

#### 1.4.3. Developing coconut inbreds

In the trial involving selfed progenies planted at Kidu, early flowering (flowering within 39 months from field planting) was recorded in dwarfs. Growth characters of field planted S3 progenies produced by selfing of S2 palms at RARS, Pilicode along with Chowghat Orange Dwarf, West Coast Tall and Laccadive Micro Tall, indicated that there were significant differences with regard to seedling characters like seedling height, petiole length, leaflet length and leaflet width (Table 7). Seedling height ranged from 232.6 cm (in OP seedlings of WCT S2) to 300.32 cm (in selfed seedlings of S2 family 2/S2). Petiole length ranged from 76.1 cm (in OP seedlings of WCT S2) to 111.25cm (in WCT S1). Leaflet length ranged from 57.25 cm (in WCT S1)

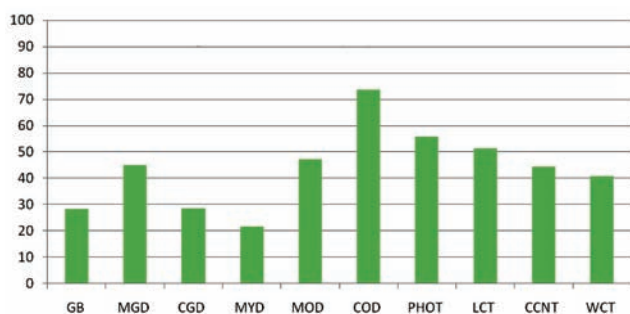
to 82.95cm (in selfed seedlings of S2 family 2/S2). Leaflet width ranged from 3.01cm (in OP seedlings of WCT S2) to 4.3cm (in selfed seedlings of S2 family 2/S2).

**Table 7. Seedling characters of self pollinated WCT families**

Family	Seedling height (cm)	Petiole length (cm)	Leaflet length (cm)	Leaflet width (cm)
1A/S2 self	282.87	91.30	76.48	4.22
1B/S2 self	291.00	96.76	75.88	4.23
2/S2 self	300.32	110.53	82.95	4.30
3/S2 self	290.26	93.26	73.52	4.20
4/S2 self	234.82	78.73	61.18	3.52
5/S2 self	251.81	86.00	62.69	3.56
WCT self (S1)	294.00	111.25	57.25	3.48
S2 WCT (OP)	232.60	76.10	65.80	3.01

#### 1.4.4. Genetical investigations

Germination of pollen in nectar as a test of compatibility between coconut cultivars was studied in selected genotypes. The nectar was diluted to 1:50 with distilled water and used for pollen germination. Pollen from Malayan Orange Dwarf, Malayan Yellow Dwarf, Malayan Green Dwarf, Gangabondam Green Dwarf, Chowghat Orange Dwarf, Philippines Ordinary Tall, Cochin China Tall, Laccadive Ordinary Tall and West Coast Tall was tested for germination using nectar collected from Malayan Orange Dwarf, Malayan Yellow Dwarf, Gangabondam Green Dwarf, Laccadive Ordinary Tall and Cochin China Tall. Initial results suggest that there exists differential germination of pollen in nectar of different cultivars (Fig. 25)



**Fig. 25. Pollen germination (%) in GBGD nectar**

#### 1.4.5. Coconut root (wilt) disease

##### 1.4.5.1. Survey and characterization

Extensive survey was conducted in the root (wilt) disease 'hotspots' of Alappuzha, Kollam, Kottayam and Pathanamthitta districts of Kerala for locating

high yielding and root (wilt) disease-free Chowghat Green dwarf (CGD) mother palms. About 500 CGD palms were selected based on visual observation and a Geographical Positioning System (GPS) based database of 350 CGD palms has been developed. The GPS based database of CGD palms will be helpful in locating the palms for seed nut collection and also for using the palms for decentralized hybrid seedling production. In addition, a GPS based database of 100 West Coast Tall (WCT) palms, being used as pollen parent in the hybridization programme for production of Kalpa Sankara (CGD x WCT) hybrid, has been developed.

A total of 350 CGD palms were subjected to serological testing and 210 palms have so far been found to be healthy based on ELISA test. Altogether 240 palms are currently under pollination, including the recently ELISA tested 210 healthy palms and 30 CGD which already was being used for seed nut collection

##### 1.4.5.2. Crossing programme for production of Kalpa Sankara hybrids

The crossing programme was carried out in 240 visually disease-free and serologically negative CGD mother palms located in 'hot spots' of Alappuzha, Kollam, Kottayam and Pathanamthitta, as well as the institute farm, for production of Kalpa Sankara hybrid (CGD x WCT). A total of 787 inflorescences with 24,951 buttons (31.70 buttons per inflorescence) have been pollinated. Utmost care was taken to ensure maximum fruit setting in all CGD palms under pollination. The previous year's pollination recorded an average fruit setting of 18-20 %. A total of 1050 pollinated (CGD x WCT) seed nuts have been sown in nursery for producing hybrid seedlings of Kalpa Sankara.

##### 1.4.5.3. Establishing decentralized hybridization units

Nine institutions including ICAR-KVKs/NGOs have been contacted for initiating decentralized hybridization programme and skilled pollinators have been trained in pollination techniques. The decentralized hybrid seedling production programme are being carried out in association with agencies such as Sreyas, Neendakara (Kollam); ICAR-KVK, Kottayam; Kottayam Social Service Society, Thellakom (Kottayam) and Pazhakulam Social Service Society, Adoor (Pathanamthitta).

##### 1.4.5.4. Production of Kalpasree seedlings

A total of 17,942 seed nuts of Kalpasree have been collected and sown in nursery for raising seedlings for distribution among farmers in the root (wilt) disease prevalent tract.

#### 1.4.5.5. Evaluation of existing trials

Observations recorded 48 months after planting revealed that 20% of the *inter se* mated second generation progenies of West Coast Tall have started flowering compared to 16% flowering in selfed second generation progenies of WCT. The juvenile growth characters of *inter se* mated and selfed progenies were on par.

The initial nut yield (for a period of 10 months), recorded three years after planting (year of planting: 2013), from the evaluation trial involving six green dwarfs revealed that Gudanjali Green Dwarf (80.8 nuts palm<sup>-1</sup>) was significantly superior compared to other dwarf *viz.*, Malayan Green Dwarf (MGD, 37.8 nuts palm<sup>-1</sup>), Gangabondam Green Dwarf (36.2 nuts palm<sup>-1</sup>) and Chowghat Green Dwarf (CGD, 34.5 nuts palm<sup>-1</sup>).

In the evaluation trial involving different dwarfs and its hybrids planted during 2009, CGD x WCT (13.3%) and CGD x MGD (15.6%) recorded lesser root (wilt) disease incidence. These hybrids also recorded higher nut yield (45-50 nuts palm<sup>-1</sup>) and showed heterosis for morphological and nut characters. Performance of CGD x MGD is promising in terms of less root (wilt) disease incidence and increasing trend in annual nut yield. However, the copra weight recorded from CGD x MGD was only 120 grams nut<sup>-1</sup> as compared to other hybrid combinations with copra content of 153-168 grams nut<sup>-1</sup>.

In the evaluation trial initiated during 2014 involving 13 promising Talls including the recently released Tall varieties, flowering was observed in one Kalpa Haritha palm 25 months after planting. Flaccidity, the initial symptom of root (wilt) disease, was observed in five tall accessions *viz.*, Federated Malay States Tall, St. Vincent Tall, Cochin China Tall, Andaman Giant Tall and Philippines Laguna Tall.



**Fig. 26. Screening of tall accessions for root (wilt) disease resistance**

#### 1.4.6. Floral visitors

The season wise variation in floral visitors was recorded from Malayan Green Dwarf, Malayan Orange Dwarf, Malayan Yellow Dwarf and Chowghat Green Dwarf. The diversity and density of floral visitors (including different bees, ants, flies, wasps and weevils) was higher in MGD compared to MYD, MOD and CGD. Small carpenter bee (*Ceratina* sp.) was occasionally observed in CGD and MGD and very rarely from MYD. The diversity of floral visitors on coconut inflorescence was more during June-July. However, the density of different floral visitors was more during the period October-April.



**Fig. 27. Foraging insects on coconut inflorescence**

#### 1.4.7. Coconut pollen bank

A pollen cryopreservatory was established at ICAR-CPCRI, Regional Station, Kayamkulam for storing pollen collected from high yielding, ELISA tested root (wilt) disease-free West Coast Tall palms. Coconut pollen is collected and transferred to 2 ml polypropylene vials and stored in liquid nitrogen storage vessel (with capacity to store 6000 vials) maintained at -196°C. In addition, coconut pollen is also being stored in deep-freezer maintained at -40°C. The stored pollen is used for decentralized production of Kalpa Sankara (CGD X WCT) hybrid.

### 1.5. Arecanut

#### 1.5.1. Hybrid evaluation

Eight hybrids involving Hirehalli Dwarf (HD) and released varieties have been under evaluation for yield

potential and dwarfness at Vittal, Mohitnagar and Kahikuchi. Hybrids and parents showed significant differences for dry kernel yield. Higher yield was recorded in the hybrids, HD × Mohitnagar, Mohitnagar × HD and HD × Sumangala with dry kernel yield of 2.49, 2.42 and 2.37 kg palm<sup>-1</sup> year<sup>-1</sup>, respectively. At Kahikuchi, Sumangala × HD recorded maximum dry kernel yield while Sreemangala × HD showed maximum values for nut traits. Among the dwarf hybrids, maximum number of nuts was recorded in Mohitnagar × HD and tall parent Mohitnagar produced maximum number of nuts under North Bengal conditions. Among the tall hybrids, Mangala × Mohitnagar combination recorded highest dry kernel yield of 3.82 kg palm<sup>-1</sup> year<sup>-1</sup> followed by the hybrid Shriwardhan × Sumangala (Fig. 28) with 3.69 kg dry kernel palm<sup>-1</sup> year<sup>-1</sup>.



**Fig. 28. Shriwardhan × Sumangala, a high yielding tall hybrid**

#### 1.5.1.1. Yellow leaf disease

Screening of six dwarf hybrids along with parents for yellow leaf disease resistance/tolerance is in progress in farmers' garden at Sampaje, Karnataka. Morphological characters such as plant height, stem height, stem girth, production of nodes and leaves are being recorded. Dwarf hybrids showed lower values for growth parameters compared to tall parents. None of the hybrids have so far showed symptoms of yellowing of leaves (Fig. 29). Growth traits and disease index were recorded from tissue-cultured palms in two farmers' gardens at YLD endemic area. There were no symptoms of YLD and normal growth was observed in the tissue cultured palms (Fig. 30).

Recording of morphological traits and disease indexing were undertaken in the yellow leaf disease

(YLD) screening trial comprising of *Areca triandra*, *Areca concinna*, *Areca microcalyx* and *Actinorhytis calapparia* and no symptoms of YLD were noticed in these palms.



**Fig. 29. Dwarf hybrids in YLD endemic areas**



**Fig. 30. Tissue cultured plantlets in YLD endemic areas**

#### 1.5.1.2. New arecanut hybrid combinations

A total of 6333 hybrid nuts have been produced in 16 new combinations involving Hirehalli Dwarf (HD) and released high-yielding varieties. Production of new hybrids involving HD and recently released varieties has been initiated and a total of 10392 female flowers have been pollinated, involving four hybrid combinations.

Inter-specific crossing between *Areca concinna* and *Areca triandra* and high yielding arecanut

varieties (*Areca catechu*) has been initiated for screening against YLD and fruit rot and a total of 954 female flowers were pollinated. A total of 849 *inter se* seedlings of released arecanut varieties viz., Shatamangala, Nalbari, Madhuramangala and Mangala selections have been planted and compact blocks established for elite planting materials production. In addition, parental blocks of Hirehalli Dwarf have been established at AICRPP Centres at Wakawali (Maharashtra) and Shimoga (Karnataka) with 50 seedlings each for production of hybrids utilizing high yielding local/released varieties.

## 1.6. Cocoa

### 1.6.1. Release of Nethra Centura

The cocoa hybrid, VTLCH-5 (IC 622884), was released as variety 'Nethra Centura' in the XXV AICRPP workshop. It is a hybrid between VTLC-64 x VTLC-69 (IC 565554 x IC 565559). This variety is precocious, stable and a heavy bearer with medium canopy (16-18 m<sup>2</sup>) under arecanut and coconut gardens (as both seedlings and clones) under normal (2.7 m x 5.4 m under arecanut) and high density plantings (2.7 m x 2.7 m under arecanut and 2.5 m x 2.5 m under coconut). With an average of 66 pods tree<sup>-1</sup> year<sup>-1</sup>, 43 beans pod<sup>-1</sup>, single bean dry weight of 1.11 g, it recorded the highest dry bean yield of 3.2 kg tree<sup>-1</sup> year<sup>-1</sup> and the yield per hectare is 1800 kg (600 trees). With 11% shelling percentage, 88% nib recovery and 52% fat content, this variety is highly suitable for chocolate industry. Further, the



**Fig. 31. Nethra Centura**

yield of VTLCH-5 was much higher than the check varieties VTLCH-1 (1.4 kg tree<sup>-1</sup> in hybrid trial) and VTLCC-1 (1-1.3 kg tree<sup>-1</sup> in clonal trial). It is recommended for cultivation in Western Ghats, hills and plains of Kerala and Karnataka and irrigated arecanut and coconut gardens of Tamil Nadu and Andhra Pradesh.

## 1.7. Planting material production

### 1.7.1. Kasaragod

A total of 47498 hybrid seed nuts were produced and sown in the nursery from the flowers pollinated last year (Fig. 32). Over 1,11,662 female flowers from 650 WCT palms were pollinated during the current year. About 27358 seed nuts of coconut varieties were produced and sown in the nursery for seedling production. Pollen germination was observed daily to determine the viability and pollen with more than 30% germination used for pollination. Breeding behaviour of selected palms in terms of male and female phase, days to female flower receptivity were observed. The database, developed for monitoring and planning artificial pollination program in coconut, has been used during the year. The database has been useful in recording all the pollination details as well as for analysis of data.

The blocks of mother palms planted in farmer's field at Mooladkam seed garden were continuously monitored for developing seed gardens in a participatory mode. Three varieties (Chowghat Orange Dwarf, Kalpa Jyothi and Kalpa Haritha) out of seven varieties planted in this garden flowered within 30 months of planting.

Observations were recorded on the seedling characters for developing a soilless media for coconut planting material production. Seedlings sown in bags with media containing vermicompost showed better germination and growth (Table 8).

Pollination in the rainy season, for increasing production of hybrids, was continued on an experimental basis. Different types of bags were tested for bagging bunches and pollination: 23 bunches (682 female flowers) in five palms for plastic bag, 34 bunches (1036 female flowers) in seven palms for denim cloth and 488 bunches (1151 female flowers) in 115 palms for *kora* cloth. Fruit setting was better (12.8% in COD and 15.8% in WCT) when denim cloth bags were used (Table 9).

### 1.7.2. Kidu

In coconut, 10524 hybrid seed nuts were produced and sown in the nursery from the flowers pollinated last year. During the year, 43,529 female flowers from 508 WCT were pollinated and assisted pollination

**Table 8. Germination and seedling characters in different media**

Treatments	Days to germination from sowing	Height (cm)	Girth (cm)	No. of leaves
Soil	104.90	45.23	6.86	5.02
Shredded coconut leaf	100.07	47.37	6.87	5.20
Shredded coconut leaf + vermicompost	94.41	62.21	7.86	5.75
Coirpith	103.95	52.84	7.13	5.23
Coirpith + vermicompost	92.32	69.81	8.00	5.83
Shredded husk + soil	100.39	52.56	7.07	5.46
Shredded husk	106.95	49.99	7.18	5.20
Shredded husk + vermicompost	95.93	62.43	7.71	5.93
Coirpith compost	99.10	65.74	7.98	5.71

**Table 9. Rainy season pollination using different types of bags**

Treatment	Flowers pollinated	Nuts harvested	Fruit set (%)
<b>COD</b>	<b>4778</b>	<b>536</b>	11.2
Cloth bag	4112	461	11.2
Denim bag	376	48	12.8
Poly bag	290	27	9.3
<b>WCT</b>	<b>10353</b>	<b>1431</b>	13.8
Cloth bag	9463	1316	13.9
Denim bag	549	87	15.8
Poly bag	341	28	8.2
<b>Overall</b>	<b>15131</b>	<b>1967</b>	13

was carried out in 674 COD palms. In all, 30954 seed nuts of different varieties were produced.

In arecanut, about 4,56,460 seed nuts and 72,076 seedlings were produced. In cocoa, 212 seed pods and 713 seedlings were produced.

#### 1.7.3. Vittal

About 1,00,000 seed nuts of arecanut were produced and 71897 seedlings were distributed during the period. In cocoa, 2192 seed pods and 85,381 seedlings/440 grafts were produced and sold.

#### 1.7.4. Kayamkulam

About 14431 seed nuts including 1089 hybrid nuts were produced in participatory mode and sown in the nursery at Kayamkulam.

Overall, at the institute, about 9,196,96 units of planting materials were produced in the mandate crops (Table 10), with revenue realization to the tune of Rs 1.71 crores (Table 11).

**Table 11. Revenue from planting material production (in lakh rupees)**

Centre	Coconut	Arecanut	Cocoa	Total
Kasaragod	74.92	-	-	74.92
Vittal	-	22.01	3.60	25.61
Kayamkulam	13.00	-	-	13.00
Kidu	24.44	33.03	0.11	57.58
Total	112.36	55.04	3.71	171.11

#### 1.8. Pollinating device

A simple, cost-effective and labour-saving device for pollinating coconut palms from ground-level (consisting of a pollination bag, pollen delivery tube and pollen pump) has been developed and tested. This is ideal for large-scale commercial production of coconut hybrids and can even be handled by

**Table 10. Seed production in coconut, arecanut and cocoa**

Centre	Coconut			Arecanut			Cocoa			Total
	Varieties	Hybrids	Total	Seednuts	Seedlings	Total	Pods	Seedlings/grafts	Total	
Kasaragod	27358	47498	<b>74856</b>	-	-	-	-	-	-	<b>74856</b>
Vittal	-	-	-	100000	71897	<b>171897</b>	2192	85381	<b>87573</b>	<b>259470</b>
Kayamkulam	13342	1089	<b>14431</b>	-	-	-	-	-	-	<b>14431</b>
Kidu	30954	10524	<b>41478</b>	456460	72076	<b>528536</b>	212	713	<b>925</b>	<b>570939</b>
<b>Total</b>	71654	59111	<b>130765</b>	556460	143973	<b>700433</b>	2404	86094	<b>88498</b>	<b>919696</b>



**Fig. 32. Coconut nursery at Kasaragod**

farmers themselves. Using this device, the climber bags the emasculated inflorescence and attaches a pollen tube to inflorescence and suspends it to the ground. This first visit to the crown is followed by another climbing to ascertain the maturity of the female flowers. Thereafter, there is no need to climb the palm for pollination and bag removal (saving 4-5 climbings per inflorescence). Pollen dusting

can be undertaken from ground-level itself using the pollen delivery tube and pollen pump. After the pollination, the bag can also be pulled down effortlessly from ground. The pollination device reduces the drudgery of pollination work and can also be adapted for hybrid seed production in other commercially valuable palms such as oil palm, date palm, arecanut and palmyrah.

# BIOTECHNOLOGY AND BIOINFORMATICS



## 2.1. Coconut tissue culture

### 2.1.1. Medium optimization for efficient somatic embryogenesis and plantlet regeneration from shoot meristem explants of coconut zygotic embryo

Various combinations of growth regulators/supplements and gelling agents were experimented to optimize media for efficient somatic embryogenesis and plantlet regeneration from shoot meristem explants of coconut zygotic embryos. Different concentrations of zeatin riboside *viz.*, 1, 2, 3, 4 and 5 mg l<sup>-1</sup> along with picloram (24.2 mg l<sup>-1</sup>) and TDZ (one mg l<sup>-1</sup>) were supplemented in Y3 media for testing the potential of these growth regulators in enhancing somatic embryogenesis from shoot meristem explants of coconut zygotic embryos of West Coast Tall (WCT) variety. Zeatin riboside at one mg l<sup>-1</sup> was found to be good for formation of embryogenic calli (Fig. 33).

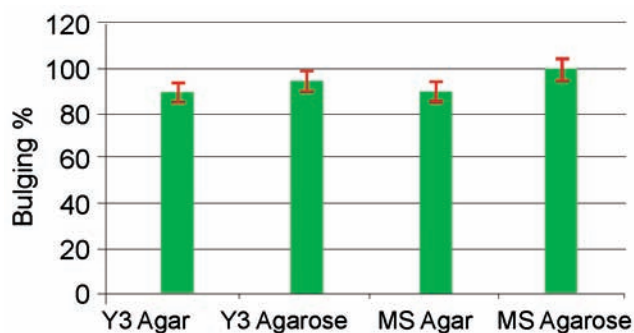
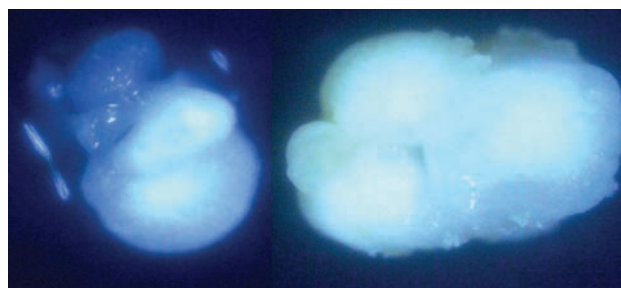


**Fig. 33. Effect of zeatin riboside on embryonic shoot meristem culture**

The effect of different culture environments such as Phyta jars (67×78mm), corning glass Petri dish (200mm × 20mm), Petri plate (100mm × 20mm) and

'Planton' plant tissue culture container (100 × 75 mm) were studied for its efficiency for callus induction from shoot meristem explants of coconut zygotic embryos of WCT variety. The explants were cultured in these vessels in Y3 medium supplemented with picloram (24.2 mg l<sup>-1</sup>) and TDZ (one mg l<sup>-1</sup>). No evident differences were observed in these cultures.

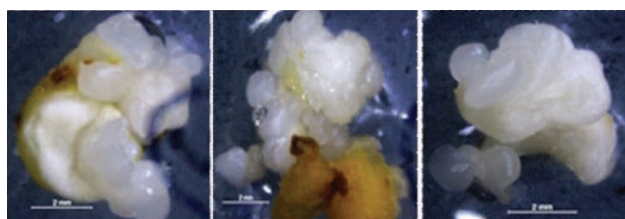
Agar or agarose was used as gelling agent in Y3 or MS medium supplemented with 2,4-D (16.5 mg l<sup>-1</sup>) and TDZ (one mg l<sup>-1</sup>) for culturing embryonic meristem and thin layers of shoot apical portion from WCT and Chowghat Green Dwarf (CGD) varieties. Irrespective of basal medium or cultivars, enlargement of explants was observed in media supplemented with agarose in comparison with media supplemented with agar (Fig. 34). However marked differences were not observed between the two treatments for callus induction.



**Fig. 34. Response of explants in agar and agarose medium**

BAP or TDZ at various concentrations (5, 10, 15 and 20 mg l<sup>-1</sup>) were tested for their potential to induce multiple shoots from embryonic shoot meristem in WCT. The explants regenerated in to a single shoot in

all the treatments. Effect of TIBA (1, 2, 3 and 4 mg l<sup>-1</sup>), an auxin inhibitor, was studied on embryonic shoot meristem of WCT for callus induction; however, callus initiation was not noticed in the cultures. In another experiment, embryonic shoot meristem explants from WCT were cultured in Y3 medium with a combination of auxins *viz.*, 2,4-D (5.5 mg l<sup>-1</sup>) + picloram (6.1 mg l<sup>-1</sup>), 2,4-D (5.5 mg l<sup>-1</sup>) + dicamba (5.5 mg l<sup>-1</sup>), dicamba (5.5 mg l<sup>-1</sup>) + picloram (6.1 mg l<sup>-1</sup>), along with TDZ (one mg l<sup>-1</sup>), to study the synergistic effect of auxins, if any, on callus induction. Combination of auxins did not alter the frequency of induction of calli or nature of calli (Fig. 35).



2, 4-D + picloram 2, 4-D + dicamba dicamba + picloram  
**Fig. 35. Callus initiation from embryonic shoot meristem in various combination of auxins**

### 2.1.2. Response of various explants (other than plumular explants) for callus induction and somatic embryogenesis

#### 2.1.2.1. Immature inflorescence culture

Immature inflorescences of 2-12 cm sizes were collected from WCT palms and after surface sterilization, the rachilla were sliced into 1-1.5 mm bits and cultured on four media combinations. The cultures were incubated in dark condition. Maximum callusing (92%) and minimum browning (1%) was observed in Y3 medium supplemented with 2,4-D (1 ppm) followed by Medium 72 with picloram (10 ppm) + putrescine (10 ppm) + TDZ (1 ppm) (87%). The cultures were subcultured into Y3 medium with three different hormone combinations 2,4-D and picloram. Shoot-like out growth was more in Y3 medium supplemented with 1 ppm each of 2,4-D and picloram (66%). After eight months of incubation in dark, the cultures were transferred ½ MS supplemented with 1 ppm each of NAA and BAP for induction of shoots. Shoots which developed from the floral primordia were transferred to rooting media containing Y3 with NAA and IBA. The stage of maturity of inflorescence was a very critical factor in the conversion of floral buds to vegetative shoots and it was found that inflorescence of sizes ranging 4 -7.5 cm were the best for the reversion. Twenty five SCOT markers were employed to validate the clonal fidelity of *in vitro* raised plantlets and the results revealed that no variability was detected among the plantlets. The

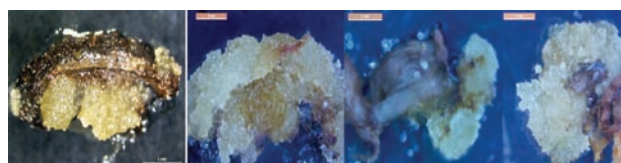
study indicated the feasibility of developing an *in vitro* plant regeneration protocol with the use of immature inflorescence of coconut as the explants (Fig. 36).



**Fig. 36. Plantlet regeneration from immature inflorescence**

#### 2.1.2.2. Meristem culture

Meristem base obtained from a 40-year old WCT palm was chopped and inoculated in modified MS medium with 2,4-D (5 mg l<sup>-1</sup>), TDZ (one mg l<sup>-1</sup>) and glutamine (500 mg l<sup>-1</sup>) as additional supplements and incubated for three months. Subsequent transfer of these cultures in to modified MS medium supplemented with 2, 4-D (one mg l<sup>-1</sup>), TDZ (one mg l<sup>-1</sup>) and glutamine (500 mg l<sup>-1</sup>) resulted in callus formation. However, the rate of multiplication and callus growth was observed to be very slow (Fig. 37).



**Fig. 37. Callus formed from shoot meristem of adult palm**

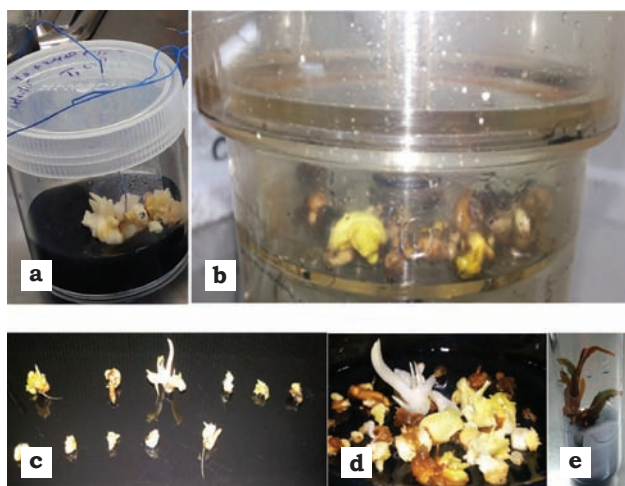
### 2.1.3. Response of different stress conditions for induction of somatic embryogenesis and subsequent regeneration from shoot meristem explants of coconut zygotic embryo

#### 2.1.3.1. Effect of electric stimulus

Explants such as whole zygotic embryos, germinating zygotic embryos, embryonic shoot meristem-derived calli and meristemoids in Y3 medium, supplemented with picloram (24.2 mg l<sup>-1</sup>) and TDZ (one mg l<sup>-1</sup>) and cultured in Phyta jars, were subjected to 1 and 2 µA current, either continuously or at the rate of 1 hour day<sup>-1</sup> (Fig. 38). Volume of the calli was found to be more under the influence of electric current stimulus.

#### 2.1.3.2. Establishment and maintenance of cell suspension cultures

Embryogenic callus was inoculated in different media combinations containing different concentrations of 2,4-D (1, 2.5 and 5 mg l<sup>-1</sup>) with myo-inositol (300 mg l<sup>-1</sup>), ascorbic acid (100 mg l<sup>-1</sup>) and malt extract (300 mg l<sup>-1</sup>). Medium supplemented with 2,4-D (2.5 mg l<sup>-1</sup>) promoted cell multiplication (Fig. 39). However, the cell suspension did not proliferate on transfer to solid medium.

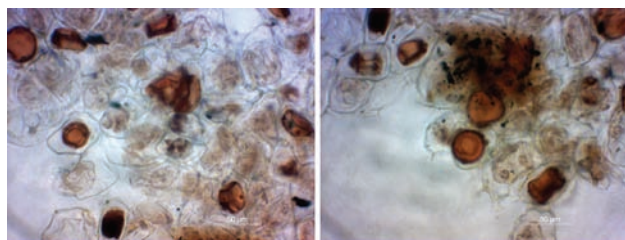


**Fig. 38. Use of electric current on coconut explants. Electric current induced to the explant (a), produced callus in temporary immersion system (b), meristemoids developed (c & d) and plantlet development (e).**

## 2.2. Arecanut tissue culture

### 2.2.1. Immature inflorescence culture

The cultures initiated during previous year (VTLAH-1 and VTLAH-2 hybrids, Hirehalli Dwarf (HD) and YLD disease-free palms) are at different stages of development. About 100 plantlets of HD and dwarf hybrids have been obtained (Fig. 40). The embryogenic cultures from dwarfs and dwarf hybrids are being multiplied and maintained in low auxin medium. The response of inflorescence cultures initiated from four YLD disease-free palms was very slow with respect to induction of calli. Callus initiation was noticed only in three palms at a low frequency (40%).



**Fig. 39. Microscopic view of cells in suspension culture**

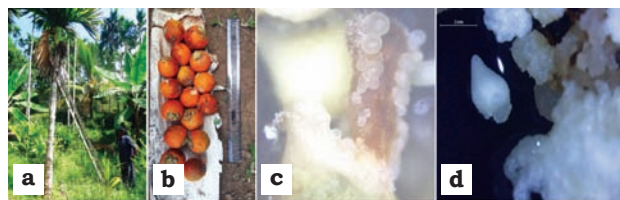
Immature inflorescences were sampled from YLD disease-free arecanut palms of Kottiyoor in Kannur district, Kerala. The response of shoot meristem from zygotic embryos of dwarf hybrids was also studied for callus induction and somatic embryogenesis. Callus initiation was faster which led to more number of somatic embryos.



**Fig. 40. Regenerated plantlets of arecanut in liquid medium and in pot**

### 2.2.2. Shoot meristem and immature leaf culture

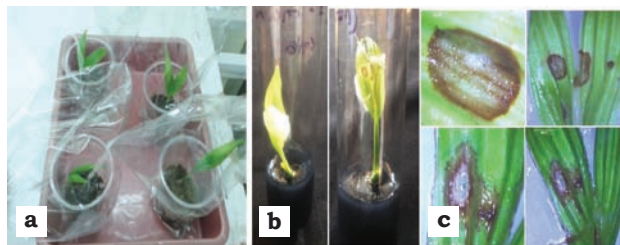
Shoot meristem and immature leaf from three seedlings of Andaman Dwarf (Fig. 41 a, b) were inoculated on to Y3 medium combinations supplemented with auxins viz., 2,4-D, picloram and dicamba (200  $\mu$ M each). Explants were sub-cultured in to medium with lower concentrations of auxin. Callusing (~75%) was observed in shoot meristem and leaf cultures in media supplemented with picloram (Fig. 41c). Both friable (10%) and compact type (65%) of calli were observed. The frequency of somatic embryogenesis ranged from 5-10% (Fig. 41 d). Somatic embryos were transferred into hormone-free Y3 medium.



**Fig. 41. Andaman Dwarf arecanut palm (a), nuts (b), initiation of callus (c) and somatic embryos (d) from immature leaves.**

### 2.2.3. Embryo rescue in *Areca* spp.

Plantlets obtained from immature embryos of *Areca triandra* and *Areca concinna* were hardened *ex vitro* (Fig. 42a). The *in vitro* plantlets (six months after germination) were utilized as a viable system to screen for resistance against *Phytophthora meadii*. Challenge inoculation was performed on adaxial leaf surface of the embryo cultured plantlets by pricking (four



**Fig. 42. *Ex vitro* hardening of embryo cultured plantlets of wild species of arecanut (a) and use of embryo derived plantlets for *in vitro* screening against *Phytophthora meadii* (b and c)**

under cryogenic condition for its effective utilization for hybrid seed production. A two-step drying process followed by cryogenic storage resulted in 37 to 74 % germination in West Coast Tall (WCT) and 22 to 30 % in Chowghat Orange Dwarf (COD). The same pollen from WCT utilized for pollination with COD resulted in 8% nut set using desiccated pollen whereas it was 9.5% with cryopreserved pollen after four months (Fig. 44).

### 2.3.1. Validation of coconut embryo cryopreservation protocol

### 2.3.3. Maintenance of arecanut embryogenic calli

**a**

**b**

### 2.3.2. Long term conservation of coconut pollen and its viability and fecundity studies

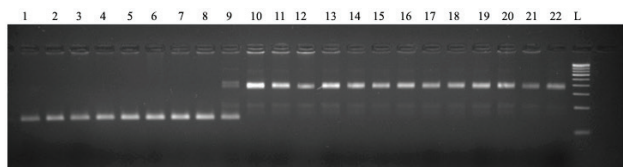
## 2.4. Genome sequencing of coconut

Whole genome sequencing of a Chowghat Green Dwarf (CGD) palm was undertaken utilizing two NGS platforms. Combination of short reads with different insert sizes and mate pair libraries, using Illumina sequencing technology, resulted in the generation of ~320 GB data with an average depth of 135X. Also, ~79.8 GB data of PacBio long reads has been generated using Blue Pipin library protocol and PacBio RS II sequencing technology, with a total coverage of 30X. The reads obtained from both these platforms will be utilized for hybrid assembly for the coconut genome.

## 2.5. Molecular markers

### 2.5.1. Development of variety-specific markers in coconut

From the data obtained from double digest restriction-site associated DNA sequencing (ddRADseq) of six each of West Coast Tall (WCT) and Chowghat Green Dwarf (CGD) palms, unique primers were designed which could differentiate these two varieties. These primers were validated in individual palms of these varieties and also their hybrid, with hybrid displaying the banding pattern of both the parents (Fig. 46).



**Fig. 46. Amplification of WCT (lanes 1-9), CGD palms (lanes 10-22) and CGD x WCT hybrid (lane 9) using primers designed from ddRAD sequence data. L: 100 bp ladder**

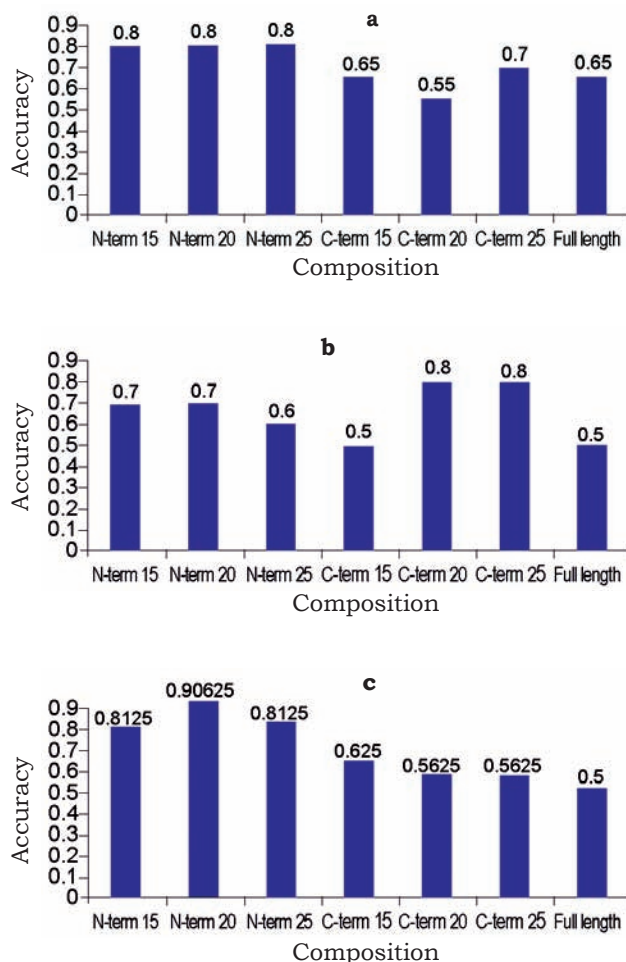
## 2.6. Bioinformatics

### 2.6.1. Development of gene prediction algorithms for genes involved in somatic embryogenesis

Machine learning classification algorithm, Support Vector Machine (SVM), was used to create predictive models for proteins involved in somatic embryogenesis viz., Somatic Embryogenesis Receptor-like Kinase (SERK), Leafy Cotyledon (LEC) and Wuschel (WUS). In order to obtain different features based on amino acids, the frequency of occurrence of the 20 amino acids and their composition were considered. Different standard window size were created among all the selected sequences i.e. N-Terminal composition and C-terminal composition with 15, 20, 30 window size in both cases. Performance evaluation was carried out using standard prediction methods (sensitivity, specificity, precision, accuracy and F-measure). Independent data set and cross validation set were used to evaluate the performance of the predictive model and the best models were selected (Fig. 47).

### 2.6.2. Structure based computational study of coconut WRINKLED (WRI1) transcriptional factor

WRINKLED1 (WRI1) is a member of the APETALA2/ethylene-responsive element binding proteins (AP2/EREBP), which is an important regulator of oil accumulation. Computational study of WRI1 protein from coconut was carried out. The protein contained two domains. The predicted amino acid length of



**Fig. 47. Performance chart of accuracy for different composition methods for linear kernel for the independent and cross validation data set test for SERK (a), LEC (b) and WUS (c) proteins.**

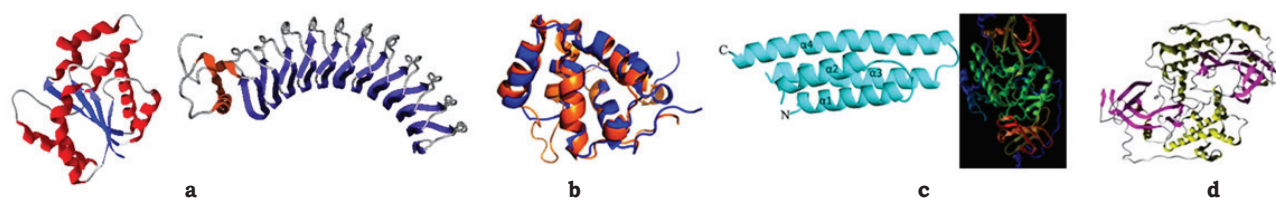
the DNA-binding domain was 67. The predicted 3-D structure contained three helices, four strands and eight turns (Fig. 48).



**Fig. 48. 3-D structure of coconut WRINKLED (WRI1) protein**

### 2.6.3. Structure based computational studies of coconut resistance (R) proteins

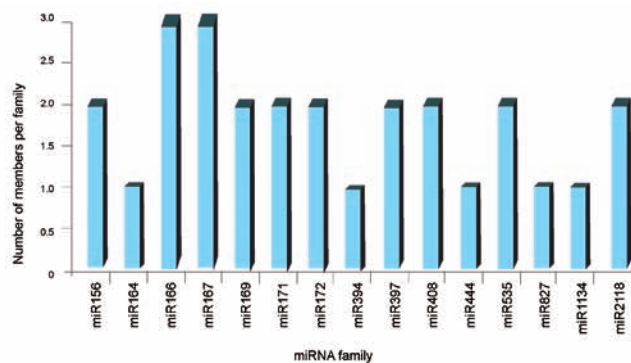
Families of R-proteins from coconut were identified through a comparative genomic approach and these proteins could be grouped into different classes such as NBS, NBS-LRR, CC-NBS-LRR, TIR-NBS-LRR and STK. Full length ORFs of a few of these genes were isolated and computational analyses of these TIR, NBS, CC and KINASE class proteins revealed features about their physicochemical properties like molecular weight, isoelectric point, grand average of hydropathy, instability and aliphatic index. 3-D structures of R-proteins were determined by homology modeling (Fig. 49). Docking studies were also undertaken to identify the interaction network of R proteins with ligands.



**Fig. 49. 3-D structure of coconut RGAs (a) NBS-LRR (b) TIR-NBS-LRR (c) CC-NBS-LRR (d) STK**

### 2.6.4. Prediction of miRNAs involved in somatic embryogenesis

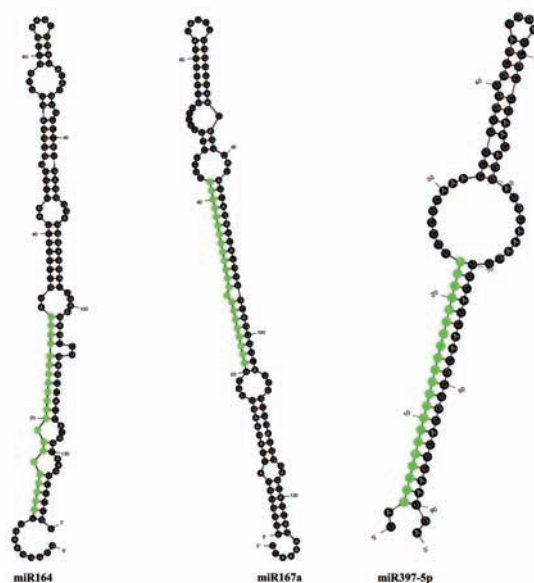
MicroRNAs (miRNAs) have been implicated in the regulation of a plethora of cellular, physiological and developmental processes which include developmental regulation, hormone response and adaptation to stresses. In an attempt to study the role of miRNAs in the regulation of *in vitro* embryogenesis in coconut, miRNA and their targets were predicted from callus transcriptome data of coconut embryogenic calli generated in an Illumina Hi-Seq platform (SRX 472157). A total of



**Fig. 50 a. Distribution of coconut miRNAs in different miRNA families**

1,17,790 unigenes from coconut embryogenic calli were compared against monocot mature miRNA sequences. A total of 27 mature miRNA sequences, belonging to 15 miRNA families, were identified (Fig. 50 a, b). Target prediction of these miRNAs was carried out using psRNATarget tool. All the 27 miRNAs were found to possess particular roles in plant development. Predicted targets could be mainly classified into transcription factors, comprising of auxin response factor, nuclear transcription factor Y subunit (miR167), transcription factor bHLH113-like (miR156), E2F transcription factor-like E2FE and transcription factor RAX3-like (miR172). Some of the miRNAs were observed to possess tendencies to regulate kinases such as a calcium-dependent

protein kinase (miR166), mitogen-activated protein kinase (miR164) and leucine-rich repeat receptor-like serine/threonine/tyrosine-protein kinase SOBIR1 (miR2118). Multiple targets were found for all the predicted miRNAs.



**Fig. 50 b. Stem-loop secondary structures of a few miRNAs. Mature miRNA sequence shaded in green colour**

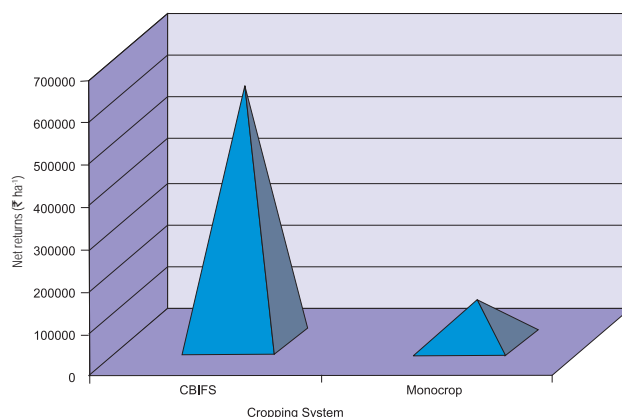
# CROP PRODUCTION



## 3.1. Cropping and Farming Systems

### 3.1.1. Coconut based integrated farming systems (CBIFS) for enhancing farmer's income

The sustainability and profitability of the coconut based integrated farming system comprising coconut, pepper (trailed on the coconut trunk), banana (in the border of the plots), fodder grass-Hybrid Bajra Napier cv. Co5 (in the interspaces of coconut), dairy unit (seven cows of Holstein Friesian and one Jersey cross breed), poultry (100 broiler birds), goatery (20 does and two bucks) and aquaculture (1000 fingerlings) was assessed. From one ha of coconut based integrated farming system, 22,750 coconuts, 13,275 litres of cow's milk, 315 kg live weight of goat, 189 kg live weight of broiler birds, 2,535 kg banana, 525 kg pepper and 112 kg fish were obtained. The highest net returns of ₹ 6,10,503/- was realized in the CBIFS which received combined application of 50 per cent organics (25 kg palm<sup>-1</sup> FYM/poultry/goat manure and cow dung slurry) produced from the system and 50 per cent inorganics (250:160:600 g of N,P,K palm<sup>-1</sup>) with a B:C of 1.89. The same manurial practice resulted in fodder yield of 144 tons ha<sup>-1</sup> year<sup>-1</sup> which was comparable to fully organic treatments viz., FYM/poultry/goat manure (15 t ha<sup>-1</sup>) + cow dung slurry (fodder yield of 133 t ha<sup>-1</sup> year<sup>-1</sup>) and significantly higher than the chemical fertilizers viz., NPK@ 45:30:24 kg ha<sup>-1</sup> alone (96 t ha<sup>-1</sup> year<sup>-1</sup>). In coconut palms maintained under CBIFS receiving integrated nutrient management practices i.e. organic recycling and 50% of the recommended chemical fertilizers, an increase in yield (130 nuts palm<sup>-1</sup>) by 10 percent compared to monocropping (118 nuts palm<sup>-1</sup>) was recorded. Adoption of coconut based integrated farming resulted in net income of ₹ 6,10,503/- as compared to monocrop of coconut (Fig. 51). Thus, coconut farmers can increase their income by four times with the adoption of a integrated farming system. Besides, soil organic carbon (0.6%) and total N (0.081%) are also higher in this system with recycling of organic biomass generated in the system over monocropping (0.46% and 0.07% respectively).



**Fig. 51. Net returns (₹ ha<sup>-1</sup>) obtained from the coconut based integrated farming system**

### 3.1.2. Coconut based fodder inter cropping in root (wilt) affected sites

Experiment was conducted on fodder grass cultivation in root (wilt) disease affected coconut gardens at Regional Station Kayamkulam exclusively under organic management (Fig. 52). It was observed that Hybrid Napier cv. Co3, grown as intercrop in one hectare coconut garden (60% area) to which cow dung slurry (3750 l) + vermicompost (2,000 kg) + *Azospirillum* (3.5 kg) were applied after every cutting at 45 days intervals (i.e. six times a year), recorded an average fodder yield of 139 t ha<sup>-1</sup> (six harvests) which was self sufficient for rearing of four milch cows. The recorded BCR of the Intergrated Farming Unit was about 1.35. Before initiation of



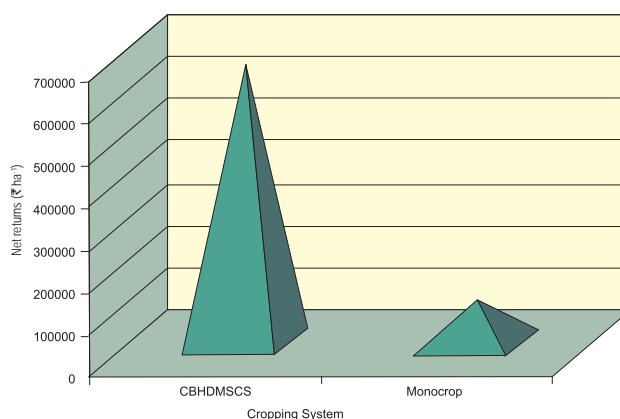
**Fig. 52. Hybrid Napier cv. Co3 cultivation through organic nutrition**

the experiment, the palms in the experimental site were categorized into 'healthy' (28%), 'disease early' (25%), 'disease middle' (22%) and 'disease advanced' (20%), based on disease indexing. After three years of experiment, 13% palms in the 'disease middle' stage recorded a reduction in yellowing and flaccidity, shifting to 'disease early' category where as only 5% palms shifted from 'disease advanced' to 'disease middle' stage. No progression in disease was noticed in 'disease early' or 'healthy' palms. After three years of experiment, the nut yield from 'healthy', 'disease early' and 'disease middle' palms increased from 50 to 66, 36 to 42 and 13 to 18 and the percentage of fallen nuts reduced from 52 to 51, 62 to 54 and 81 to 72 respectively. There was an improvement in the soil health of the system in terms of nutrients, soil organic carbon (0.32% to 0.68%), available P (83.7 ppm to 122 ppm) and available Ca (120 ppm to 248 ppm) and population of function-specific and general microorganisms *viz.*, nitrogen fixers ( $32 \times 10^4$  to  $58 \times 10^4$ ), actinomycetes ( $39 \times 10^4$  to  $76 \times 10^4$ ) and fluorescent pseudomonads ( $0$  to  $2.5 \times 10^2$ ). The net return from the coconut + grass system was ₹ 2,52,084/-, which was almost more than 6 times higher than coconut monocropping. This phenomenal increase is due to the fact that the lower yield of coconut (33 nuts palm<sup>-1</sup>) in root (wilt) affected palms was increased to 42 nuts palm<sup>-1</sup> (average of all the disease categories) after cultivation of fodder grass and the net income from fodder grass also greatly contributed to increased net income from the system.

### 3.1.3. Coconut based high density multi species cropping system

Observations were recorded on coconut based high density multi species cropping system (initiated in 2007) involving coconut, pepper (trailed on the coconut trunk), banana *cv.* Kadali and Robusta (inter row space of palms), cinnamon (inter row space of palm) and nutmeg (center of four coconut palms). The palms were maintained under organic (vermicompost, biofertilizers, vermiwash and green manure) and integrated nutrient (organic + inorganic) management. The observations indicated that yield of intercrops such as black pepper (4.5-5.1 kg vine<sup>-1</sup>), cinnamon (220-256 kg ha<sup>-1</sup>) and banana *cv.* Kadali (8-9 kg bunch<sup>-1</sup>) and Robusta (12-16 kg bunch<sup>-1</sup>) did not differ significantly among the treatments. Coconut yield also did not differ significantly among the treatments *viz.*, palms with fully organic, palms with 1/3<sup>rd</sup> recommended chemical fertilizers (NPK @ 167:107:400 g plant<sup>-1</sup>) and recycling of biomass (vermicompost @ 30 kg palm<sup>-1</sup>) + biofertilizer (200 g plant<sup>-1</sup>) + green manuring + vermiwash

(10 l palm<sup>-1</sup>) and palms with 2/3<sup>rd</sup> (NPK @ 333:213:800 g plant<sup>-1</sup>) recommended chemical fertilizer and recycling of biomass (vermicompost @ 30 kg palm<sup>-1</sup>). The net returns from the coconut based HDMSCS was to the tune of ₹ 6,59,082/- ha<sup>-1</sup> year<sup>-1</sup> which is seven times more than coconut monocrop (₹ 98,148/-) indicating advantage of adoption of HDMSCS in coconut for increasing the income of farmers (Fig. 53).



**Fig. 53. Net returns (₹ ha<sup>-1</sup>) obtained from coconut based high density multi species cropping system**

### 3.1.4. Coconut based papaya intercropping

A field trial was taken up with papaya as intercrop in one year old dwarf juvenile palms in a factorial RBD design with three varieties (Red Lady, Co8 and Arka Prabhat) (Fig. 54) and four nutrient combinations [T1 : 40: 40: 80 g NPK; T2: 2 kg vermicompost + 200 g rock phosphate + 100 g Sulphate of Potash (SOP); T3: 1.25 kg vermicompost + 600 g poultry manure + 100 g SOP and T4: 1.25 kg vermicompost + 500 g neem cake + green manure cow pea @ 10 kg fresh biomass plant<sup>-1</sup>). In general, plant height (205.7 cm) and total number of leaves (85) were recorded to be higher in papaya plants supplied with vermicompost, rock phosphate and sulphate of potash in all the three varieties. First fruiting (152 days after planting) was observed in plants supplied with poultry litter but the fruits were of smaller size (930.3 g). The plants supplied with vermicompost, rock phosphate and sulphate of potash produced bigger fruits (1326 g fruit plant<sup>-1</sup>) with the highest TSS content (10.22° Brix). The study indicated that papaya can be grown in juvenile coconut plantations (40% area) of 2-4 years with vermicompost (2 kg plant<sup>-1</sup>), rock phosphate (200 g plant<sup>-1</sup>) and sulphate of potash (100 g plant<sup>-1</sup>) at bimonthly intervals. The net income from papaya was ₹ 2,16,720/-, with a benefit cost ratio of 2.72.



Red Lady



Co8



Arka Prabhat

**Fig. 54. Papaya cultivars intercropped in a juvenile coconut garden**

### 3.1.5. Coconut based fodder - legume intercropping

Field experiment was laid out to study the impact of growing fodder and leguminous crops on the soil quality and yield of root (wilt) affected coconut palms, with six treatments *viz.*, fodder grass (Hybrid Bajra Napier cv. Suguna), (Fig. 55) *Stylosanthes* (cv. Hamata) and cowpea (EC 4216) as pure crop followed by the combination of fodder grass and *Stylosanthes*, fodder grass and cowpea (Fig. 56) and fodder, *Stylosanthes* and cowpea under organic management. The highest green fodder yield of 132 t ha<sup>-1</sup> year<sup>-1</sup> was recorded in the combination of fodder grass and *Stylosanthes*, followed by the combination of fodder grass and cowpea (126.3 t ha<sup>-1</sup>). The available nutrient status in the plots having the sole crop of fodder grass was 23.75 ppm K, 211.68 ppm Ca and 35.54 ppm Mg. Treatment with the combination of fodder grass and *Stylosanthes* recorded 27.5 ppm K, 303.05 ppm Ca and 55.09 ppm Mg. Treatment with combination of fodder grass and cowpea recorded 22.63 ppm K, 226.57 ppm Ca and 40.64 ppm Mg. The results reveal that the combination of fodder grass and leguminous crops can help in the enhancement of soil nutrient availability and fodder yield mainly by combating the

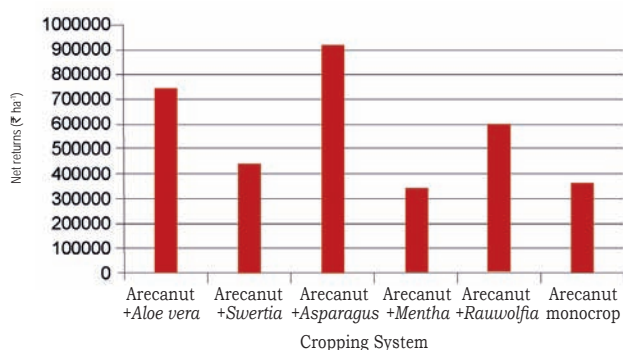
nutrient exhaustion by the fodder grass when grown as a pure crop, which was indicated by improvement in soil organic carbon (0.539% from 0.215%) and calcium (303 ppm from 202.5 ppm) content in soil. Hybrid Bajra Napier cv. Suguna, intercropped in coconut gardens along with *Stylosanthes* cv. Hamata, (Fig. 57) is a compatible crop combination in coconut based integrated farming system under root (wilt) affected gardens. The average annual net returns from the coconut + fodder grass - legume cropping

**Fig. 56. Cowpea and Hybrid Bajra Napier cv. Suguna as components of the system****Fig. 55. Hybrid Bajra Napier cv. Suguna as a component of the system****Fig. 57. *Stylosanthes* as a component of the system**

system was ₹ 2,06,000/- ha<sup>-1</sup> whereas under mono cropping system, the net income was ₹ 44,720/- ha<sup>-1</sup>, indicating the possibility of increasing the farmers income by four times with this technology.

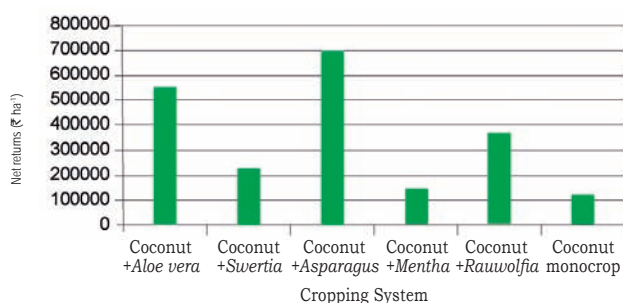
### 3.1.6. Palm based cropping system for sub-Himalayan Terai region

Medicinal plants *viz.*, *Asparagus*, *Aloe vera*, *Mentha*, *Swertia* and *Rauwolfia* were evaluated as intercrop in arecanut and coconut plantation to increase the system productivity. In arecanut based system, maximum system productivity (8.77 t chali ha<sup>-1</sup>) was recorded in arecanut and *Asparagus* combination followed by arecanut and *Aloe vera* (7.22 t chali ha<sup>-1</sup>) and arecanut and *Rauwolfia* combination (6.22 t chali ha<sup>-1</sup>) over arecanut as monocrop (3.82 t chali ha<sup>-1</sup>). All the cropping systems except arecanut + mentha increased the net returns by 1.2 to 2.5 times over arecanut monocrop (Fig. 58).



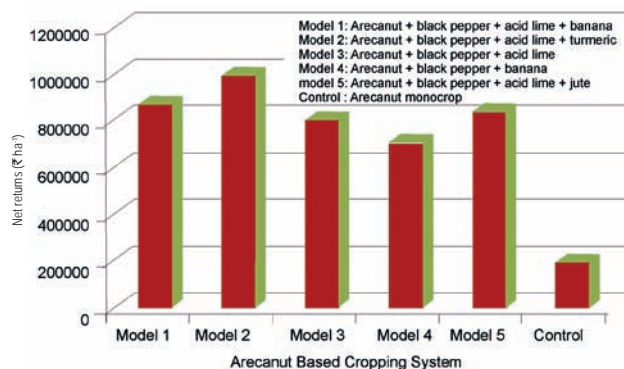
**Fig. 58. Net returns (₹ ha<sup>-1</sup>) from arecanut based cropping systems involving medicinal plants**

In coconut based system, the maximum system productivity (8.62 t copra ha<sup>-1</sup>) was recorded in coconut and *Asparagus* system followed by coconut + *Aloe vera* and coconut + *Rauwolfia* over coconut as monocrop (2.8 t copra ha<sup>-1</sup>). All the cropping systems except coconut + *Mentha* increased the net returns by 1.8 to 5.5 times over coconut monocrop (Fig. 59).



**Fig. 59. Net returns (₹ ha<sup>-1</sup>) from coconut based cropping systems involving medicinal plants**

The sustainability and profitability of the arecanut based High Density Multi Species Cropping System (HDMSCS) comprising arecanut, black pepper, acid lime, banana, turmeric and jute were assessed in different combinations to find out the total system productivity and net returns and also find out the percent contributions of different crops on total system productivity. It was found that arecanut + black pepper + acid lime + turmeric (Model 2) had maximum total system productivity (10361 kg ha<sup>-1</sup> of arecanut chali) and net returns of ₹ 10,01,618/- followed by arecanut + black pepper + acid lime + banana (Model 1) with a total system productivity of 9355 kg ha<sup>-1</sup> arecanut chali and net returns of ₹ 8,73,895/-. Among the different inter/mixed crops, black pepper contributed maximum (55-60%) to the total system productivity whereas the main crop arecanut contributed only 29-36%. The results of these experiment revealed that the cultivation of inter/mixed crops in arecanut system is highly profitable with 224-334% increase in total system productivity. Thus, with the adoption of cropping system in arecanut garden, farmers can increase the income by 3.6 to 5.1 times (Fig. 60).



**Fig. 60. Net returns (₹ ha<sup>-1</sup>) in different arecanut based cropping systems in comparison to monocrop**

### 3.1.7. Coconut based tuber cropping system

Tuber crops *viz.*, greater yam (*var.* Sree Keerti), lesser yam (*var.* Sree Latha), dwarf white yam (*var.* Sree Dhanya) and tapioca (*vars.* Vellayani Hraswa, Sree Vijaya and H165) were grown as intercrops in coconut with different nutrient management practices *viz.*, T1: traditional (farmers practice) (FYM @ 15 t ha<sup>-1</sup> and ash @ 1.5 t ha<sup>-1</sup>), T2: conventional (FYM @ 10 t ha<sup>-1</sup> and NPK @ 80:60:80 kg ha<sup>-1</sup>), T3: integrated (FYM @ 10 t ha<sup>-1</sup> and NPK @ 60:30:60 kg ha<sup>-1</sup> + *Azospirillum* + P solubilizer + K solubilizer @ 3 kg ha<sup>-1</sup> each) and T4: organic (FYM @ 15 t ha<sup>-1</sup>, green manure @ 20 t ha<sup>-1</sup>, neem cake @ 1 t ha<sup>-1</sup>, ash @ 1.5 t ha<sup>-1</sup>). Yield recorded under different treatments for greater

yam was 8.1, 9.2, 8.6 and 10.8 t ha<sup>-1</sup>, for lesser yam 5.9, 4.7, 6.5 and 5.3 t ha<sup>-1</sup> and for dwarf white yam 4.7, 5.2, 4.7 and 3.2 t ha<sup>-1</sup> for T1, T2, T3 and T4 respectively. Yield of tapioca var. Sree Vijaya was 8.0, 10.1, 8.1 and 7.0 t ha<sup>-1</sup>, 11.4, 9.6, 9.5 and 8.4 t ha<sup>-1</sup> for Vellayani Hraswa and 10.6, 12.0, 8.7 and 9.3 t ha<sup>-1</sup> for H165 under treatments T1, T2, T3 and T4 respectively.

### 3.1.8. Impact of harvesting tender nut on the sustained productivity of coconut

Studies were undertaken to assess the impact of different harvesting intervals and sequence of harvesting on tender nut and mature nut production. It was observed that harvesting of tender nuts throughout the year (at 25 days intervals) recorded significantly higher yield (167 tender nuts palm<sup>-1</sup>) and nut weight (2.2 kg nut<sup>-1</sup>). Harvesting of mature nut throughout the year (at 35-40 days intervals) recorded lowest nut yield (106 mature nuts palm<sup>-1</sup>). The economic analysis showed that harvesting of tender nuts throughout the year recorded higher net returns (₹ 2,64,768/-) compared with harvesting mature nuts (₹ 66,178/-). Quality parameters of tender nut water were analysed from May 2015 to April 2016 to assess the effect of harvesting stage. Results reveal that there is no significant difference among the treatments with the volume of water ranging from 290-366 ml nut<sup>-1</sup>, TSS from 4.8-5.6° Brix and pH from 5.1-5.2.

## 3.2. Nutrient and water management in palms

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

Nutritional requirement of dwarf varieties of coconut (Kalparaksha, Chowghat Orange Dwarf and Kalpasree) were tested with different nutrient

combinations. There was no significant differences in leaf production rate with an average of 17 leaves year<sup>-1</sup>. Among the treatments, 100% soil test based nutrient management + green manure + vermicompost + neem cake recorded the highest nut yield (47 nuts palm<sup>-1</sup> year<sup>-1</sup>) with an average tender nut weight of 1.87 kg nut<sup>-1</sup>. The tender nut water quantity, TSS of endosperm and water under this treatment were 365 ml nut<sup>-1</sup>, 5.9° Brix and 7.1° Brix respectively. The disease indices were recorded using standard procedures. In Kaparaksha, 18 palms showed disease incidence, whereas three palms each of COD and Kalpasree were diseased. At the end of eight years of experiment, root (wilt) disease was recorded in 5.2, 3.1, 1.6 percent of palms in Kalparaksha, COD and Kalpasree varieties, respectively. The lowest disease incidence (5.6%) was recorded with the treatment, 100% soil test based nutrient management + green manure + vermicompost + neem cake. The early growth of palms and initial disease incidence and yield indicated that 100% soil test based nutrient management + green manure + vermicompost + neem cake application helps in preventing the disease incidence in the early years of establishment of dwarf coconut types (Fig. 61).

### 3.2.2. Boron nutrition in coconut

A field experiment was conducted with graded levels of boron (0, 6, 12, 18, 24 g of boron palm<sup>-1</sup>) as borax in boron deficient palms. From the quadratic response plot with different levels of borax and that of the absolute yield level, the optimum dose was fixed as 16 g boron palm<sup>-1</sup> (160 g borax palm<sup>-1</sup>) to be applied in four split doses along with husk burial in the basin and vermicompost application @ 20 kg palm<sup>-1</sup>. Critical boron level was estimated as 0.87 mg kg<sup>-1</sup> for soil and 13.87 mg kg<sup>-1</sup> for leaf.



Kalparaksha

COD

Kalpasree

**Fig. 61. Palms supplied with 100 percent nutrients based on soil test + vermicompost (15 kg) + neemcake (5 kg)**

### 3.2.3. Integrated nutrient management of arecanut under sub-Himalayan terai region

Integrated nutrient management in arecanut was studied with five treatments *viz.*, no fertilizer, recommended inorganic fertilizer (100:40:140 NPK g palm<sup>-1</sup>) and 100% N substitution, 50% N substitution and 75% N substitution by vermicompost. Number of nuts palm<sup>-1</sup> and chali yield palm<sup>-1</sup> year<sup>-1</sup> was maximum in the treatment of 100% N substitution by vermicompost in all the varieties. Maximum nuts/palm (383) and chali yield palm<sup>-1</sup> year<sup>-1</sup> (4.025 kg) was recorded in Mohitnagar followed by Mangala (361 nuts and 3.177 kg chali palm<sup>-1</sup> year<sup>-1</sup>) at 100% N substitution by vermicompost. However, analysis of cumulative yield for the previous seven years revealed that different varieties responded well in terms of yield at different levels of fertilizer combinations. The economic analysis indicated that among the varieties, performance of Mohitnagar was the best with a net income of ₹ 4,04,632/- year<sup>-1</sup>. Similarly, among the fertilizer treatments, application of recommended dose of fertilizer (100:40:140 NPK g palm<sup>-1</sup>) resulted in highest net income of ₹ 3,78,311/-. Thus, for sub-Himalayan terai region, Mohitnagar can be recommended to be grown with 100:40:140 NPK g palm<sup>-1</sup>.

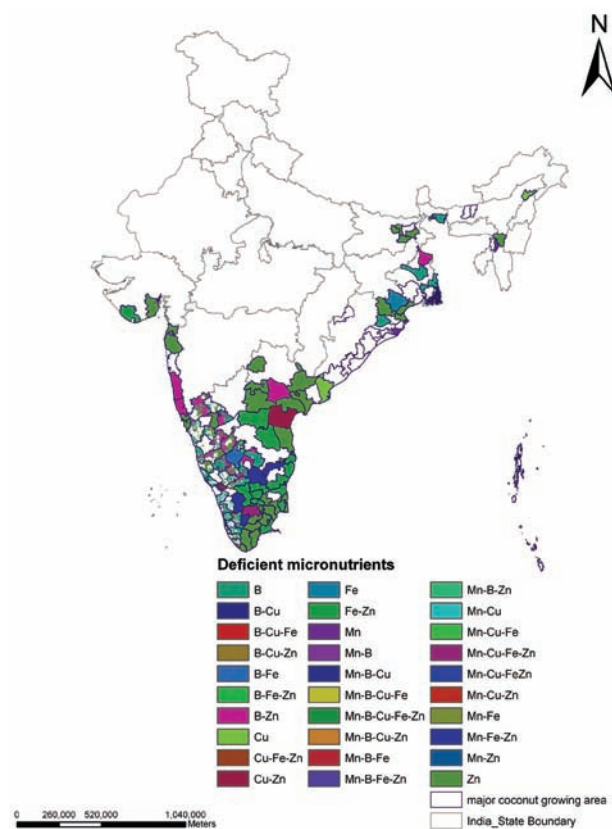
### 3.2.4. Micronutrient management for enhancing yield and quality

#### 3.2.4.1. Micronutrient mapping of coconut growing areas

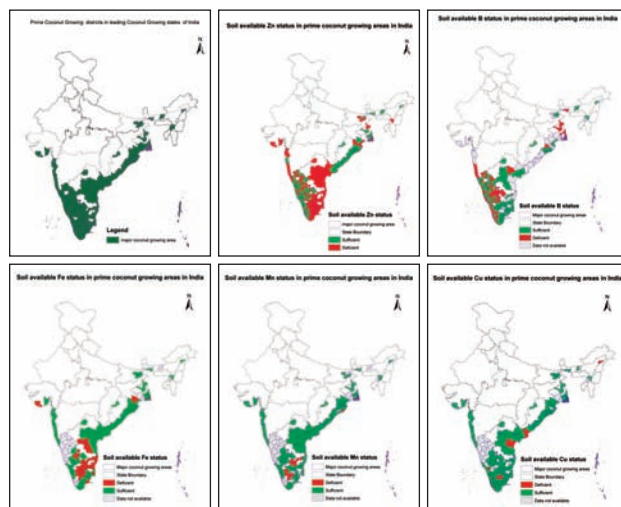
Micronutrient status map of the major coconut growing areas was developed from secondary data available in the public domain (Fig. 62 and 63). Among the major coconut growing area in India, 47 per cent of the area fell under soil available zinc deficient zone, observed mainly in Tamil Nadu, Andhra Pradesh and Gujarat and parts of Karnataka and Maharashtra. Co-limitation of zinc and iron deficiency was seen to occur in these states. Iron deficiency was seen to exist in 16 per cent of the coconut growing area and boron deficiency in around 25 per cent area, mainly in parts of Kerala, Karnataka and West Bengal. Around 10 per cent area was found to be deficient in manganese and 9 per cent area, deficient in copper.

#### 3.2.4.2. Improving coconut productivity in Kerala

A multi-institutional collaborative project for evaluating the economic viability of coconut based cropping system through site-specific management practices was initiated during 2015 in five agro-ecological units of Kerala (No.1, 3, 9, 10 and 11) with the financial assistance from the Kerala State Planning Board. The project consists of experimental trials and



**Fig. 62. Map of micronutrient deficiency zonation in major coconut growing areas**



**Fig. 63. Prime coconut growing areas and the micronutrient deficiency status**

demonstration in farmer's plots. Demonstration is being carried out in 10 plots (each consisting of 30-40 palms) in each agro-ecological unit. The experiment consists of five treatment combinations in four replications including application of all the major, secondary and micronutrients along with sodium chloride, lime, dolomite and gypsum and farmers' practice kept as control. Boron content in the leaf

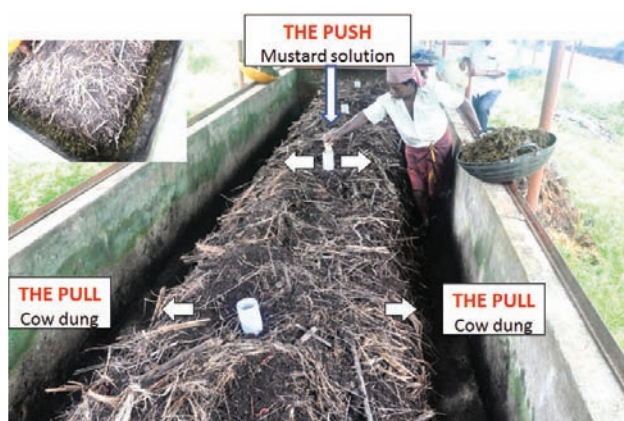
showed significant increase after the application of treatments. *In situ* recycling of palm residues showed improvement in soil organic matter content (50 to 75% increase) over control in all the sites. After one year of treatment imposition, the average annual nut yield increased by 25% in the project area.

### 3.3. Bioresource management

#### 3.3.1. 'Push-pull' strategy for harvesting earthworms from vermicomposting tanks

'Push-pull' concept, a business management strategy, was adopted by Rothamsted Research, UK for insect management based on chemical ecology principle. This push-pull strategy was followed at ICAR-CPCRI to harvest earthworms from vermicompost heaps by employing an integrated use of volatiles released by biological materials as forces of avoidance and attraction. In the ready-to-harvest coconut leaf vermicomposting tanks, the strategy was adopted through the use of behaviour-modifying stimuli to earthworms to manipulate their migration from the vermicomposted heap to the adjacently laid fresh cowdung from where they were eventually collected, thus, making sorting of earthworms from vermicomposting tanks easy and labour-friendly.

To achieve this, in the vermicomposting tanks, a thin strip of cow dung was spread on the periphery of vermicomposting heap after the composting process was over. At the same time, PVC pipes were inserted into the vermicomposted substrate and mustard solution was poured through these pipes. Mustard repelled earthworms from the vermicomposted substrate which was the 'push' component. The fresh cowdung, being a preferred food for the earthworms, attracted earthworms from the vermicomposted substrate which was the 'pull' component (Fig. 64).



**Fig. 64. 'Push-pull' system of harvesting earthworms from vermicomposting tanks. Close up of cow dung at the periphery of vermicomposting coconut leaves heap (inset)**

Allyl isothiocyanate present in mustard seeds was responsible for 'pushing' the earthworms from the compost heaps and cowdung, a known attractant, was used for 'pulling' the earthworms.

#### 3.3.2. Composting of tender coconut husk

In ICAR-CPCRI tender nut parlour, mostly tender nut water is consumed on the spot by the consumers, leaving the husk refuse which accumulates in heaps (Fig. 65). This extremely fibrous tender nut refuse (alternatively called as immature or green coconut husk) was used for making compost. The immature coconut husks were processed (Fig. 66) and treated with diazotrophic microbial consortium (Fig. 67) and poultry manure, etc. over a three months period. Though this tannin and lignin rich material is less labile and its carbon chemistry does not allow much vulnerability to microbial action, preliminary results revealed that stoichiometrical changes could be achieved in this organic material. Tender nut wastes were composted to a reasonable extent (Fig. 68). The composted material had an alkaline pH with a significant narrowing down of C/N ratio. However, further efforts and some procedural modifications are required for its quality up gradation.



**Fig. 65. Tender nut husks piled outside tender nut parlour**



**Fig. 66. Tender nut husks prior to treatment**



**Fig. 67. Diazotrophs used for composting**



**Fig. 68. Treated tender nut husks after three months**

### 3.3.3. Areca husk composting

Towards developing an eco-friendly technology for composting the recalcitrant natured ligno-cellulosic areca husk, attempts were made using microbial and non-microbial interventions. Areca husk pretreatment was undertaken to increase the porosity of the biomass, to improve site access for depolymerising microbial organisms and their enzymes. Pretreatment helped to enhance the water holding capacity of the husk to the tune of 4.47 times and also helped in the reduction of about 22.09 per cent of the total husk tannin. Total microflora associated with raw and pre-treated areca husk was enumerated and the associated predominant microorganisms were assayed for their ligno-cellulolytic potential and four ligno-cellulolytic fungi and six bacteria were isolated.

### 3.3.4. Microbial community in the rhizosphere and endophytic matrix of healthy and root (wilt) affected coconut palms

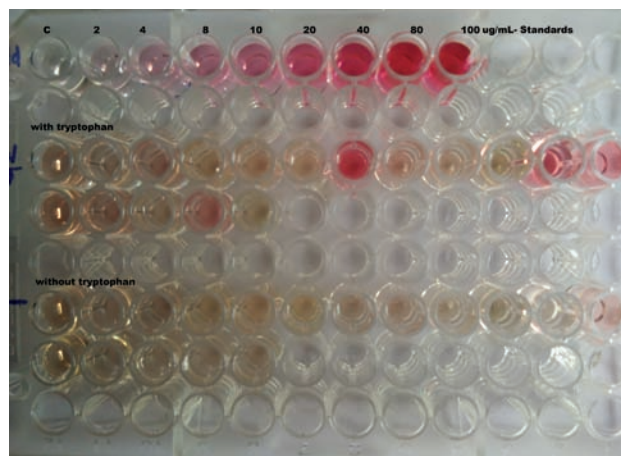
Rhizosphere samples collected from diseased and healthy palms from farmers' field of Kulasekharapuram panchayat, Kollam district in

Kerala during the pre-monsoon season (April-May) were subjected to microbial analysis. Soil type in this region was Onattukara sandy loam with pH ranging from 5.75 to 6.6 and organic matter ranging from 0.6% to 0.8%. No significant difference was observed in microbial population among the healthy and diseased categories. Forty bacterial isolates from healthy palms were subjected to preliminary screening for PGPR activities and the five potent rhizobacterial isolates possessing the PGP traits such as ability to solubilize mineral (P, Zn and Si), antagonistic activity against pathogens and growth hormone production (IAA) were selected for further studies

Rhizosphere samples were also collected from healthy (mother palms) and diseased palms of root (wilt) disease hotspot areas of Kottayam and Pathanamthitta districts for microbial analysis. No significant difference was noted in general and functions specific microbial population between healthy and diseased palms, except for P solubilizing bacteria. About 120 bacterial isolates including fluorescent *Pseudomonas*, phosphate solubilizers and *Azospirillum* from the healthy mother palms are being maintained for screening studies (Fig. 69). Among the 15 isolates initially screened, five isolates were positive for IAA secretion (Fig. 70) and nine isolates



**Fig. 69. *Azospirillum* and other bacterial isolates from rhizosphere of healthy coconut mother palms**



**Fig. 70. Screening bacteria for IAA production using microplate method**

solubilized tricalcium phosphate and magnesium trisilicate.

### 3.3.5. Physico-chemical and biological studies of YLD affected areas

Rhizosphere soil samples were collected from traditional elevated terrains and low land paddy converted arecanut gardens of both healthy and YLD infected palms during pre-monsoon, monsoon and post monsoon seasons. Rhizosphere microflora were enumerated and no significant differences in bacteria, fungi and actinomycetes population was noticed. The root endophytic microflora (22 nos.) and the rhizosphere microflora (15 nos.) associated with both the healthy and YLD affected palms were isolated and screened for ACC deaminase (11 nos.) and mineral Zn solubilization potential (15 nos.) qualitatively. The available macro and micronutrient dynamics revealed that K, Mg and Zn are the key limiting nutrients in arecanut yellow leaf disease complex areas of Sullia, Karnataka.

### 3.3.6. Quantitative zinc metal solubilization in liquid medium

Zinc solubilization potential of five bacterial isolates, which gave highest zone of solubilization in solid medium, was studied quantitatively in liquid medium with ZnO as insoluble zinc source. Among them, two isolates AHR1 and CUK5 (Fig. 71) solubilized highest quantities of zinc ( $494 \text{ mg L}^{-1}$  to  $548 \text{ mg L}^{-1}$ ), after three weeks of incubation. During the solubilization



**Fig. 71. Single colonies of isolate CUK5 (left) and AHR1 (right)**



**Fig. 72. ZnO amended culture broths of solubilizing bacteria**

studies, bacterial proliferation occurred over a period of 30 days, (Fig. 72) concurrently with a drop in the pH of the zinc oxide-supplemented culture broths, eventually reaching a final value of pH 2.95 from the initial pH of 6.9.

### 3.3.7. Solubilization of different insoluble Zn sources

On comparison of different insoluble Zn sources, it was found that most of the isolates solubilized more Zn when  $\text{ZnCO}_3$  was used as insoluble source of Zn in solid minimal medium. However, the isolate CUK5 could solubilize both ZnO and  $\text{ZnCO}_3$  with equal efficiency (upto 400%) (Fig. 73).



**Fig. 73. Zn solubilization by *Micrococcus luteus* CUK5**

### 3.3.8. Identification of efficient zinc solubilizer

The microorganism was found to be a Gram positive bacterium with round, pinhead type colonies raised in the centre (Fig. 74), belonging to Micrococcaceae family. To establish taxonomic identity of the prominent isolate,

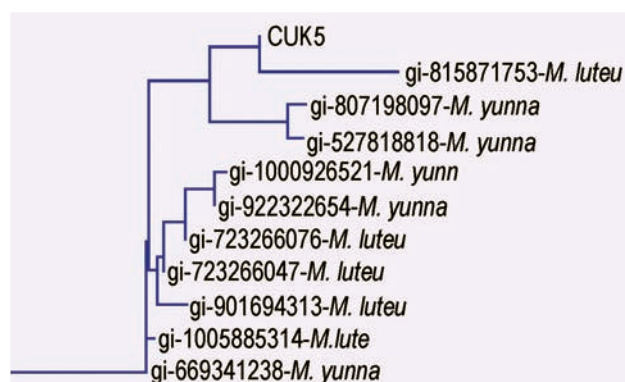


**Fig. 74. Pin head type colonies formed by *Micrococcus luteus* CUK5**

16SrRNA region was amplified and sequenced (Fig. 75); sequence analysis revealed it to be *Micrococcus luteus*. Partial 16S rRNA gene sequence of ~1.3 kb was obtained and deposited in NCBI Genbank database with Accession number KX532238. Based on maximum identity score, first few sequences were selected and aligned using multiple sequence alignment software ClustalW2 and a dendrogram was constructed (Fig. 76).



**Fig. 75. Amplification of 16S rRNA of CUK5**



**Fig. 76. Phylogram showing relationship of CUK5 with *Micrococcus* spp.**

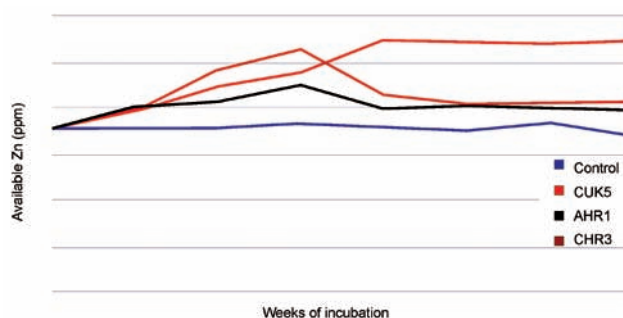
### 3.3.9. Zinc solubilization studies in soil medium

A study was conducted in which soils low in available zinc (0.31 to 0.70 ppm) were inoculated with selected zinc solubilizing microorganisms in an effort to see whether these microorganisms could help in solubilizing complexed zinc available in this soil (Fig. 77). The soil was clay loamy black and alkaline in nature (pH 8.0-8.5). Sub-soil samples were collected at weekly intervals after inoculation with zinc solubilizers and analysed for soluble zinc

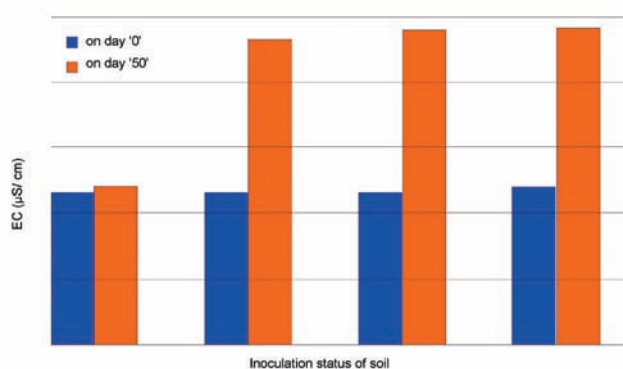
by AAS. Available zinc levels in soils inoculated with all three zinc solubilizing bacteria showed increase with *Micrococcus luteus* CUK5 inoculation recording highest levels. In uninoculated control treatment, available zinc level showed no change throughout the experimental period of seven weeks (Fig. 78). Additionally, the electrical conductivity levels in soils inoculated with zinc solubilizers showed increase in comparison to uninoculated soils, as measured at the end of the experiment (50<sup>th</sup> day). However, there was no change in the pH status of all the treatment soils throughout the 7 weeks experimental period (Fig. 79).



**Fig. 77. Soil experiment with zn solubilizers**



**Fig. 78. Zn availability in soils on inoculation with efficient Zn solubilizers**



**Fig. 79. pH and EC status of bacterized soils**

**3.3.10. Citizen/Client's charter service**

Different bioresources were produced for use as organic amendments/bioinoculants and supplied to farmers and other end users as detailed below (Table 12).

**Table 12. Production and distribution of bio-resources**

Bioresource	Produced	Sold
<i>Eudrilus</i> sp. (Coconut leaf vermicomposting earthworms)	3,60,000 nos.	10,550 nos.
<i>Kalpa Organic Gold</i> (Coconut leaf vermicompost)	16 tonnes	7.05 tonnes
<i>Kalpa Soil Care</i> (Urea-free coir-pith compost)	1.5 tonnes	434 kg
<i>Kera Probio</i> (PGPR bioinoculant)	671 packets	593 packets
Coconut leaf vermiwash	80 litres	4 litres
<i>Pleurotus</i> sp. spawn (Mushroom spawn)	70 kg	41 kg
Fresh <i>Pleurotus</i> mushrooms	1 kg	1 kg



## INTEGRATED MANAGEMENT OF DISEASES

### 4.1. *Phytophthora* diseases

#### 4.1.1. Bud rot of coconut

##### 4.1.1.1. Survey and collection of isolates

Random survey of coconut gardens in nine grama panchayats of Kasaragod district of Kerala during October 2016 indicated 0.2 to 2.7 per cent bud rot incidence. Out of 7950 coconut palms in 19 randomly selected coconut gardens in these nine panchayats, 79 coconut palms (0.9 %) were observed to be affected with bud rot. Prophylactic treatment for management of bud rot was not taken up by the farmers in all the 19 gardens. Two fresh isolates of *P. palmivora* were obtained from the bud rot affected samples during the year 2016 and were added to the culture collections.

##### 4.1.1.2. Epidemiology

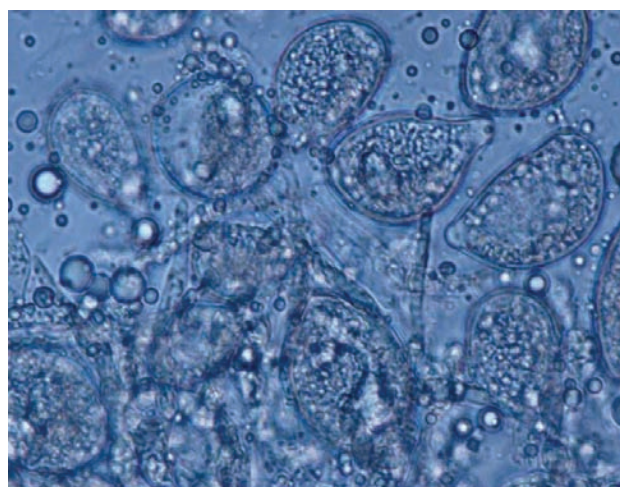
Previous studies have indicated the involvement of slug *Deroceros* sp. in the spread of bud rot disease of coconut. The feeding and ingestion of coconut bud rot pathogen *P. palmivora*, by the slug was further confirmed by observing sporangia in the faecal matter of the slugs collected from coconut gardens from Dakshina Kannada district of Karnataka. The common slugs were collected from bud rot disease affected coconut gardens of Kasaragod during June-August 2016 and starved for two days. Starved slugs were found feeding voraciously on the *P. palmivora* culture but not on *Trichoderma harzianum* culture when released under a bell jar in the laboratory (Fig. 80). Microscopic examination of faecal matter of the slugs, fed on *P. palmivora* cultures and collected at 24 hours interval, revealed the presence of *Phytophthora* propagules (Fig. 81). The faecal matter (about one g) containing the *Phytophthora* propagules, when inoculated on seven months old nuts of West Coast Tall cultivar, induced typical water soaked lesions five days after inoculation (Fig. 82). The pathogen could be reisolated from the inoculated nuts after eight days. This study further confirms the role of slugs in spread of coconut bud rot disease.

##### 4.1.1.3. Disease management

Field trial on management of coconut bud rot disease was conducted in Konnakkad of Balal panchayath of



**Fig. 80. Starved slugs feeding on the *Phytophthora palmivora* culture**



**Fig. 81. *Phytophthora* sporangia in faecal matter of slugs**

Kasaragod district, Kerala using nine treatments *viz.* copper oxychloride 50WG, copper hydroxide 77% WP, chlorothalonil 78.12%WP, iprovalicarb 5.5 + propineb 61.25 % WP, dimethomorph (9 %) + mancozeb (60 %), fosetyl-Al 80 WP + propineb 61.25%WP, metiram 50 + pyraclostrobin 50%WG, 1% Bordeaux mixture and *Trichoderma* coir pith cake. Prophylactic treatments were imposed by placing two perforated sachets containing 3 g fungicide in innermost leaf axil during first week of June 2016. In the treatment,



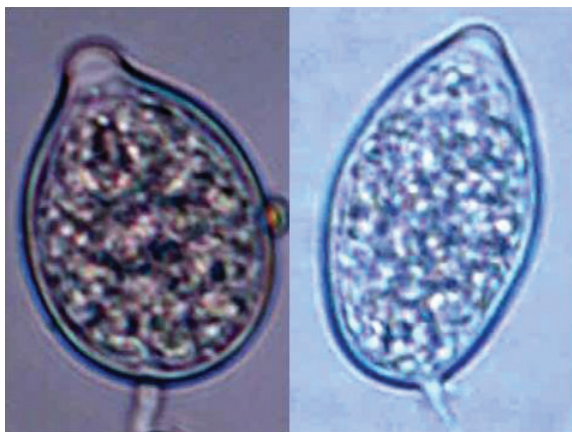
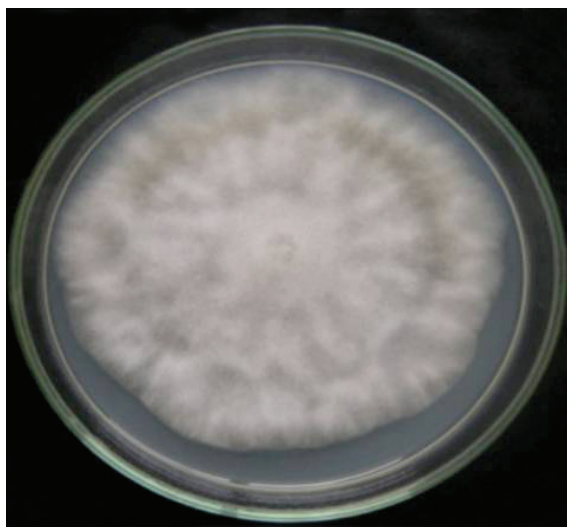
**Fig. 82. Water soaked lesion on immature coconut**

*Trichoderma* coir pith cake, two cakes were placed in the inner most leaf axil. In case of Bordeaux mixture, 300 ml of the freshly prepared 1 % Bordeaux mixture was poured in the innermost leaf axil. Fresh bud rot incidence was not noticed in all the treatments except the treatments *viz.*, copper oxychloride 50%WP and *Trichoderma* coir pith cake treated palms in which 6.6 % and 10 % fresh bud rot incidence respectively was recorded from July – December 2016.

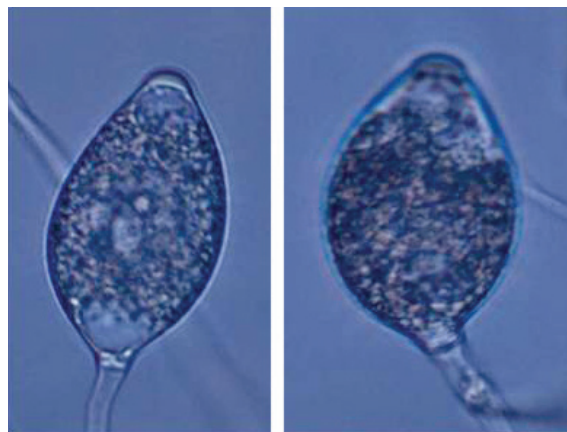
#### **4.1.2. Fruit rot of arecanut**

##### **4.1.2.1. Survey and collection of pathogen isolates**

In surveys of arecanut gardens in Dakshina Kannada, Udupi and Uttara Kannada districts of Karnataka and Kasaragod district of Kerala during July 2016 for fruit rot, self-grown colocasia plants in arecanut gardens affected with *Phytophthora* leaf blight were observed in many of the gardens. A total of 20 *Phytophthora* isolates were recovered from diseased colocasia samples collected during the survey.



*P. meadii*

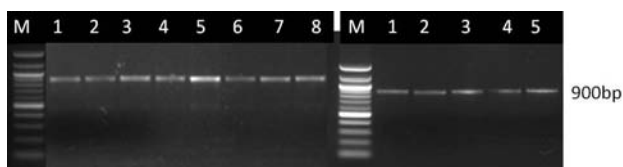


*P. colocasiae*

**Fig. 83. Culture and sporangia of *P. meadii* and *P. colocasiae***

#### 4.1.2.2. Characterization of the pathogen

Eighteen out of 20 *Phytophthora* isolates isolated from leaf blight affected colocasia in arecanut gardens, exhibited stellate to slight rosaceous type pattern with significant variation in colony growth rate and produced caducous, ovoid to ellipsoidal sporangia with conspicuous papilla. PCR amplification and nucleotide sequences of ITS region of all the 18 isolates showed 100% identity with *P. meadii*. Two isolates recovered from self-grown colocasia exhibited stellate to cottony type pattern with significant variation in colony growth rate and produced caducous, ovoid to ellipsoidal sporangia with conspicuous papilla and basal plug (Fig. 83). PCR amplification and nucleotide sequencing of ITS region of the two isolates showed 100% identity with *P. colocasiae* isolates. Five isolates of *Phytophthora* obtained from leaf blight affected colocasia grown as monocrop in Thiruvananthapuram, Kerala showed 100% identity with *P. colocasiae* (Fig. 84). When *P. meadii* isolates from colocasia were cross inoculated on arecanut, typical symptoms of fruit rot disease were exhibited, adding credence to the theory.



**Fig. 84.** PCR amplification of ITS region of *Phytophthora meadii* isolates from self grown colocasia in arecanut gardens (A - lanes 1 to 8) and *Phytophthora colocasiae* isolates from colocasia monocrop (B - lanes 1 to 5) using ITS1 and ITS4 primers

#### 4.1.2.3. Disease management

##### Screening of fungicides

Field trial on management of fruit rot disease of arecanut was conducted at Kidu and Vittal, Karnataka using 12 treatments involving fungicides viz., Famoxadone 16.6 % + Cymoxanil 22.1% SC, Kresoxim methyl 44.3% SC, Fosetyl-Al 80 WP + Propineb 61.25% WP, Mandipropamid 23.3 %, Dimethomorph 50 WP + Mancozeb 80 WP, Ametoctradin 30% + Dimethomorph 22.5% SC, Cymoxanil 8% + Mancozeb 64 % WP, Iprovalicarb 5.5% + Propineb 61.25 % WP, Metiram 50% + Pyraclostrobin 5%WG, Copper hydroxide 77%WP, Metalaxyl 8% + Mancozeb 64%WP and Bordeaux mixture (1 %). The fruit rot disease incidence was initiated in second week of July 2016 at Kidu. When compared to different treatments, fruit rot disease incidence was significantly less in 1% Bordeaux mixture sprayed plot (13.0 %) followed by

Mandipropamid 23.3% SC (15.3 %) at Kidu. No fruit rot disease incidence was noticed at Vittal during 2016 (June- September).

##### Persistence of mandipropamid 23.3% SC on arecanut

Mandipropamid 23.3% SC fungicide was found effective in the management of fruit rot disease of arecanut and hence the analysis of mandipropamid persistence in arecanut is very much important. Analysis of mandipropamid 23.3% SC fungicide residue in treated arecanuts revealed that the fungicide residue could be detected both in arecanut outer peel (3.6 ppm) and kernel (0.6 ppm). The persistence could be observed up to 60 days after application.

##### Screening of potassium phosphonate against *P. meadii*

Potassium phosphonate preparation developed from ICAR-CPCRI was tested against *Phytophthora meadii* at various concentrations (0.05 to 0.8 %) and recorded 100% mycelial growth inhibition at 0.5% (Fig. 85).



**Fig. 85.** *In vitro* screening of potassium phosphonate against *P. meadii* causing fruit rot of arecanut

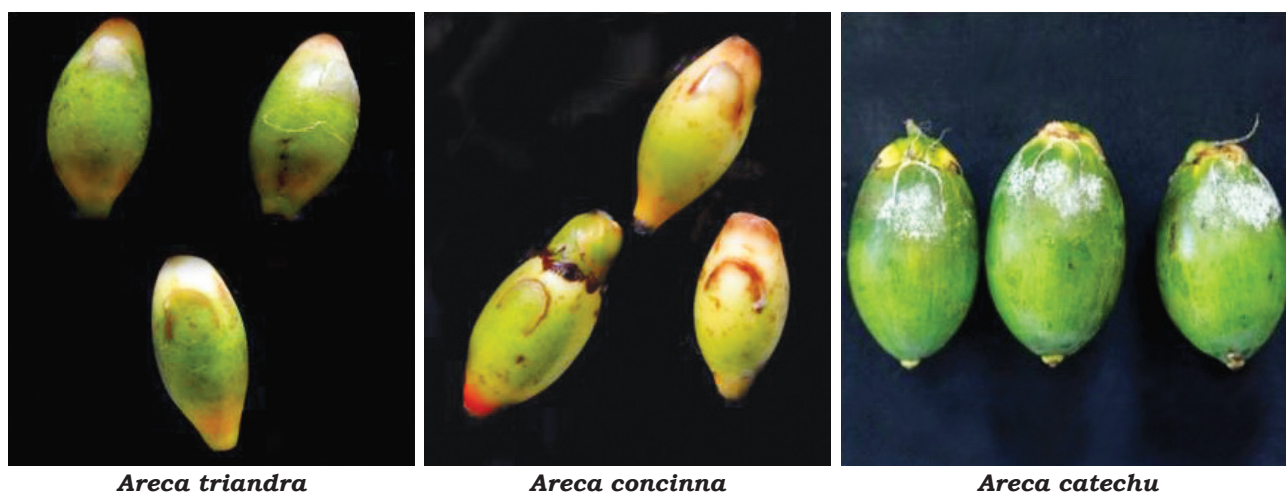
##### Identification of resistant sources against fruit rot disease of arecanut

Among the 20 arecanut accessions, seven varieties, Hirehalli Dwarf and two wild *Areca* spp. screened against virulent isolate of *P. meadii* (P19), only the two wild species viz., *Areca triandra* and *Areca concinna* were found resistant (Fig. 86).

#### 4.2. Ganoderma diseases

##### 4.2.1. Basal stem rot or Ganoderma wilt of coconut

Field trial on management of *Ganoderma* wilt disease was conducted with five treatments viz., root feeding with Hexaconazole 5EC @ 1%, drenching with Hexaconazole 5EC @ 0.01%, root feeding with Hexaconazole 5EC @ 1% + application of *Trichoderma* (*T. harzianum* CPTD 28) enriched neem cake @ 5 kg palm<sup>-1</sup>, application of *Trichoderma* enriched neem cake @ 5 kg palm<sup>-1</sup> (three rounds year<sup>-1</sup>) and application



**Fig. 86. Resistance of wild arecanut species to *Phytophthora meadii***

of *Trichoderma* enriched neem cake @ 5 kg palm<sup>-1</sup> (four times year<sup>-1</sup>) at Arzal, Maniat and Alakode areas of Kasaragod and Kannur districts of Kerala after recording pretreatment *Ganoderma* disease index. Out of five treatments, application of *Trichoderma* enriched neem cake @ 5 kg palm<sup>-1</sup> at three and four rounds per year was found very effective in reducing the disease index compare to other treatments.

### 4.3. *Colletotrichum* diseases

#### 4.3.1. Inflorescence dieback in arecanut

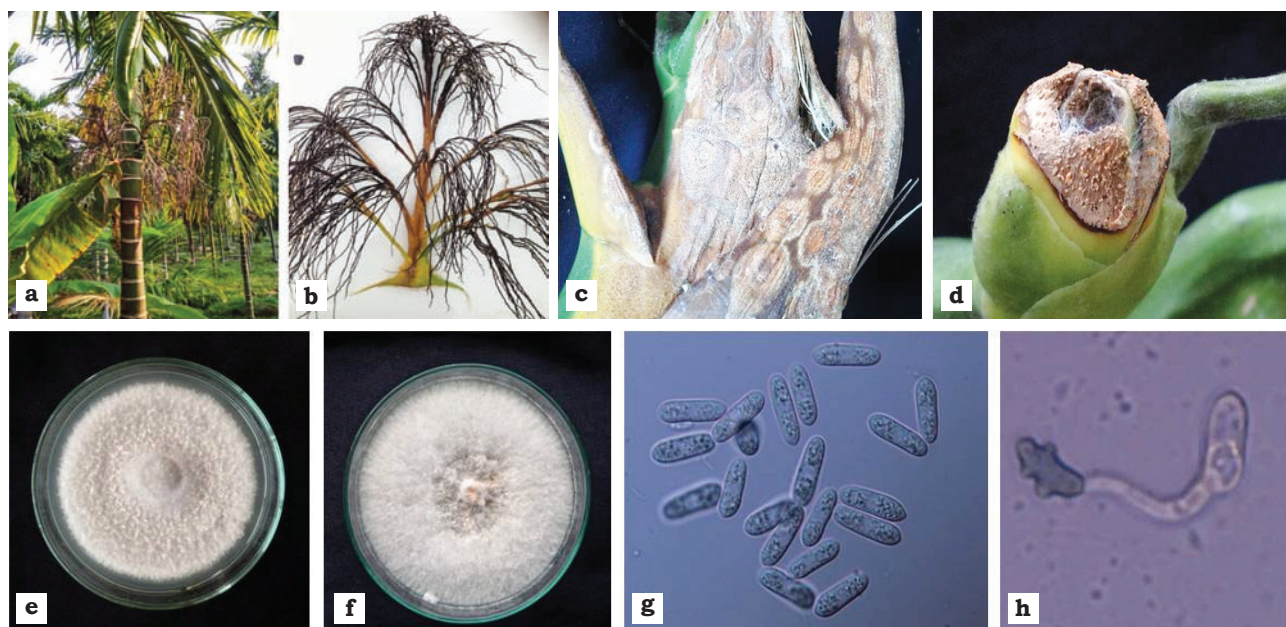
##### 4.3.1.1. Survey and collection of pathogen isolates

Random surveys conducted in all the major arecanut growing areas of Karnataka and Kerala

during November–December 2016 revealed that inflorescence dieback disease caused by *Colletotrichum gloeosporioides* was prevalent in all the areas but the incidence was more in Davanagere district of Karnataka (27.3%) followed by Kasaragod district of Kerala (24.7%). Symptoms of brownish patches on rachille, drying of inflorescence from the tip and shedding of small buttons were the main symptoms observed (Fig. 87).

##### 4.3.1.2. Characterization of the pathogen

A total of 62 *Colletotrichum* isolates were recovered from inflorescence dieback disease affected arecanut samples collected and morphological characterization was carried out for all the isolates (Table 13). PCR assay



**Fig. 87. Symptoms of arecanut inflorescence dieback (a-d), colony (e,f) and conidia (g,h) of *Colletotrichum* sp. isolated from the inflorescence dieback samples**

**Table 13. Morphological characterization of *Colletotrichum* spp. associated with inflorescence dieback disease of arecanut**

Fungal pathogen	Colony morphology		Conidial morphology			Pathogenicity lesion size (mm)	Appressoria morphology		
	Colony Color	Colony Growth rate (mm/day)	Shape	Length (μm)	Width (μm)		Shape	Length (μm)	Width (μm)
<i>Colletotrichum gloeosporioides</i>	White, grey and whitish grey color colony and slight fluffy with or without conidial ooze in the center	11.0 ± 0.3	Conidia were cylindrical with both apices rounded or with one end rounded and the other end pointed	11.3 - 16.0	5.0 - 7.3	16 - 25	Clavate and lobed	6.0-11.5	4.2-6.4
<i>Colletotrichum</i> spp.	Whitish grey color with more fluffy type colony	11.0 ± 0.4	Conidia were cylindrical with constriction and one apex rounded and the other end pointed	10 - 13.2	4.5 - 7.0	14- 26	Clavate and lobed	6.2-11.3	4.5-7.0

with the *C. gloeosporioides* species-specific primers (CgINT with ITS4) yielded a single band of 450 bp (Fig. 88). Nucleotide sequences of amplified DNA of 60 *Colletotrichum* isolates showed 100% identity with *C. gloeosporioides* and two isolates to *Colletotrichum* spp. Further multilocus gene phylogeny is in progress for accurate identification of the species.

#### 4.3.1.3. Studies on cross infectivity

Cross infectivity study indicated that *Colletotrichum gloeosporioides* of arecanut was pathogenic to other hosts like coconut, cocoa and pepper.



**Fig. 88. PCR based identification of *Colletotrichum gloeosporioides* using species specific primers, CgINT with ITS4 (lane 1 to 14 *C. gloeosporioides* isolates)**

#### 4.3.1.4. *In vitro* screening of fungicides

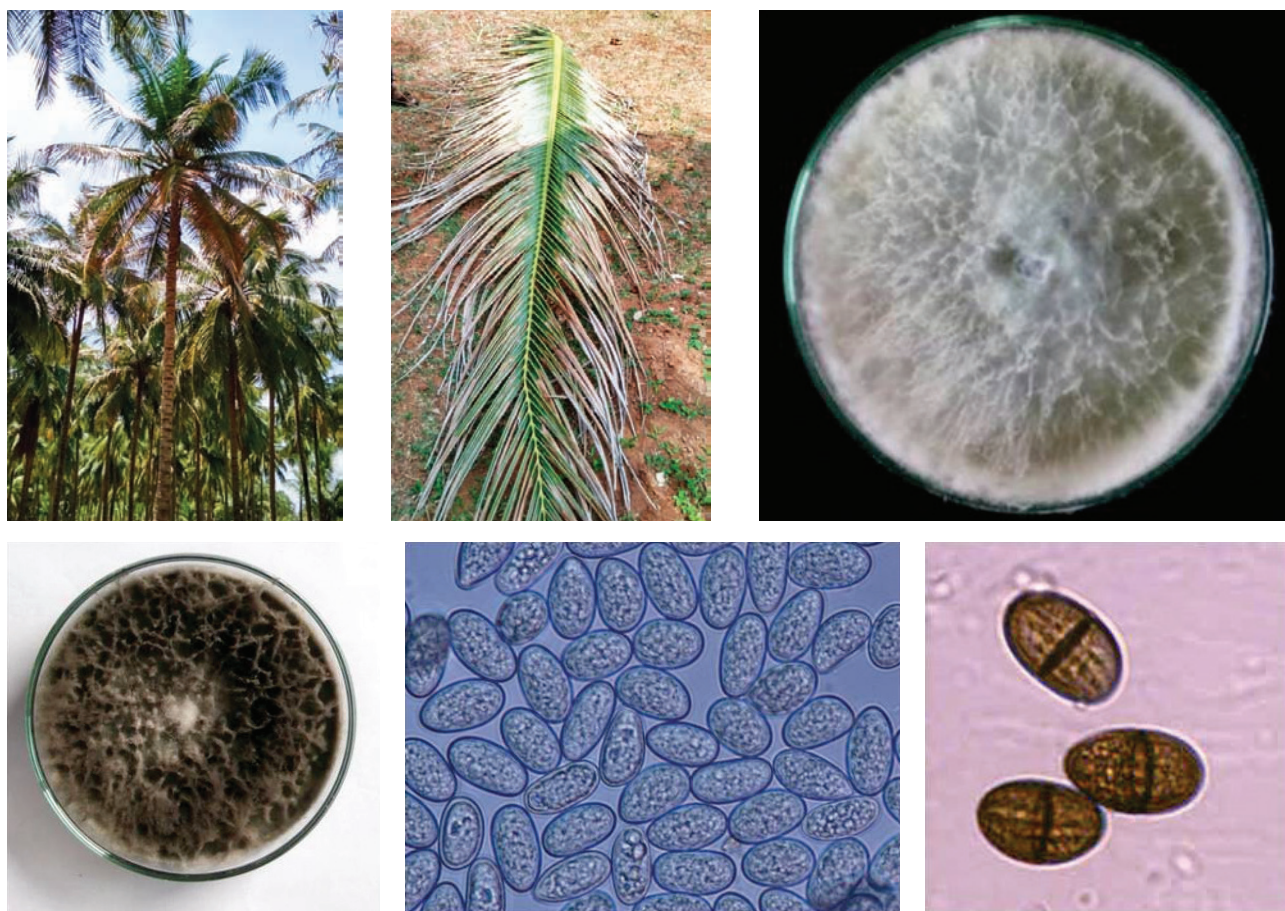
Eight fungicides were screened against *Colletotrichum gloeosporioides* under *in vitro* at various concentrations (0.01 to 0.2%). Among the fungicides tested, Carbendazim 25% + Flusilazole 12.5% SE, Carbendazim 50% WP, Carbendazim 12% + Mancozeb 63% and Propiconazole 25% EC, were found very effective by completely inhibiting the mycelial growth at 0.01%.

### 4.4. *Lasiodiplodia* diseases

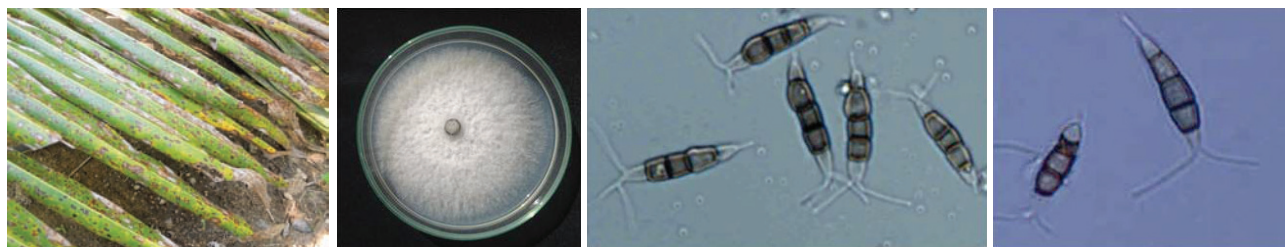
#### 4.4.1. Coconut leaf blight

##### 4.4.1.1. Survey and collection of samples

Survey conducted in coconut growing areas of Karnataka and Tamil Nadu during September 2016 revealed highest leaf blight disease incidence (80%) in Tirupur district of Tamil Nadu followed by Tumkur district of Karnataka (20%). The leaf blight symptoms were observed mainly on lower 3 to 4 whorls. The affected leaflets start drying from the tip downwards and exhibit a charred or burnt appearance (Fig. 89). Infected leaflets were collected from all the places surveyed and pathogen was isolated. These symptoms were different from the commonly known coconut grey leaf spot pathogen *Pestalotiopsis palmarum* (Fig. 90).



**Fig. 89. Symptoms of coconut leaf blight and cultures and spores of isolated pathogen *L. theobromae***



**Fig. 90. Identification and characterization of *Pestalotiopsis palmarum* causing grey leaf spot of coconut**

#### **4.4.1.2. Isolation and characterization of the pathogen**

In total, 20 isolates of *Lasiodiplodia theobromae* and 10 isolates of *Pestalotiopsis palmarum* were recovered from leaf blight affected coconut samples and morphological characterization was carried out (Table 14). PCR assay with *L. theobromae* species-specific primer pair Lt347-F/R, on sequencing, yielded a single band of 347 bp (Fig. 91). Nucleotide sequences of amplified DNA of 20 *L. theobromae* isolates showed 100% identity with *L. theobromae*.

### **4.5. Phytoplasma diseases**

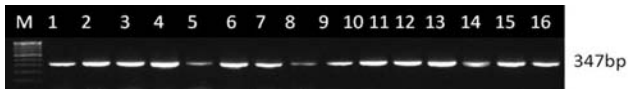
#### **4.5.1. Root (wilt) disease of coconut**

##### **4.5.1.1. PCR based detection**

Titre of phytoplasma in different palm tissue is always a concern which has vitiated the diagnosis of phytoplasma in coconut considerably. In order to enhance the titre of the phytoplasmal DNA in coconut, total DNA extracted from spear leaves, inflorescence rachillae and root tips of root (wilt) affected coconut palms were subjected to rolling circle amplification (RCA) using Illustra TempliPhi

**Table 14. Morphological characterization of coconut leaf spot and blight pathogens (*Lasiodiplodia theobromae* and *Pestalotiopsis palmarum*)**

Fungal pathogen	Colony morphology		Conidial morphology			Pathogenecity lesion size (mm)
	Colony Color	Colony Growth rate (mm/day)	Shape	Length (μm)	Width (μm)	
<i>Lasiodiplodia theobromae</i>	Colonies are initially white color and turned to greyish to black colour, fluffy with abundant aerial mycelium	9.5±1.5	Oval shaped and hyaline initially, later turned in to brown color with single septa	14.2-18.3	10.0-13.3	13-15
<i>Pestalotiopsis palmarum</i>	White color colonies with medium aerial mycelia	8.0±0.2	Fusiform shaped, consists of three brown colored median cells and hyaline apical and basal cells with two to three hyaline appendages	21.2-30.0	5.0-6.4	8 – 12



**Fig. 91. Identification of *Lasiodiplodia theobromae* through PCR using species specific primer pair, Lt347-F/R (lane 1 to 16 *L. theobromae* isolates, LT1-LT16)**

DNA Amplification Kit. The RCA products were subjected to PCR using phytoplasma and bacteria specific primers. No consistent amplification of diagnostic value was observed with any of these primers. The bacterial primers F27/R1492 produced amplification at 1500 bp which on subsequent sequencing showed similarity to chloroplast DNA of coconut.

#### 4.5.1.2. Collection, identification and cataloguing of auchenorrhynchan fauna in coconut ecosystem

Grassland leafhopper, *Exitianus indicus* (Distant), Orange and blue spotted leafhopper, *Austroagallia* sp., sesamum leafhopper *Orosius albicinctus* (Distant) and zigzag leafhopper, *Maiestas dorsalis* (Motschulsky) were routinely encountered in light trap catches in coconut ecosystem.

#### Phytoplasma from auchenorrhynchan fauna and weeds

Molecular detection of phytoplasma in different auchenorrhyncha fauna collected in coconut ecosystem using phytoplasma-specific universal primers (P1/P6-R16F2n/R16R2) indicated

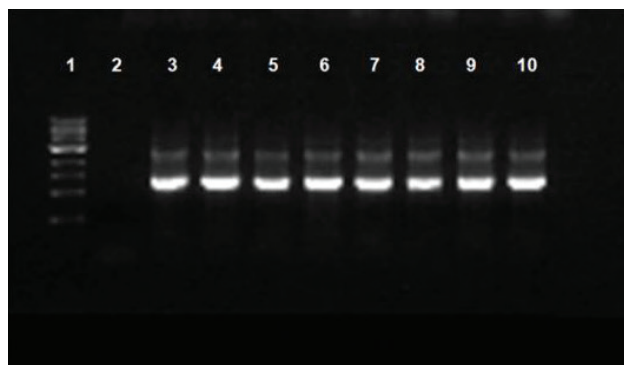
positive amplification at 1250 bp for *Orosius albicinctus* (Distant), indicating its vectoral role in transmission of phytoplasma disease especially in *Sesamum* sp. phyllody group. DNA extracted from the planthopper, *Proutisa moesta* obtained after different acquisition access and incubation periods viz., 12 days (seven lots @ 4 insects lot<sup>-1</sup>), 30 days (two lots @ 4 insects lot<sup>-1</sup>) and 43 days (one lot @ 2 insects lot<sup>-1</sup>) on root (wilt) disease affected palms, when subjected to PCR using universal primers, showed faint and inconsistent amplification for one lot each under incubation periods for 12 and 43 days.

The phytoplasma causing phyllody in wild *Sesamum* sp. and *Cleome viscosa*, a common weed in coconut plantations, was identified as “*Candidatus* Phytoplasma australasiae”-related strain belonging to subgroup 16SrII (Fig.92). Molecular characterization of phytoplasma from



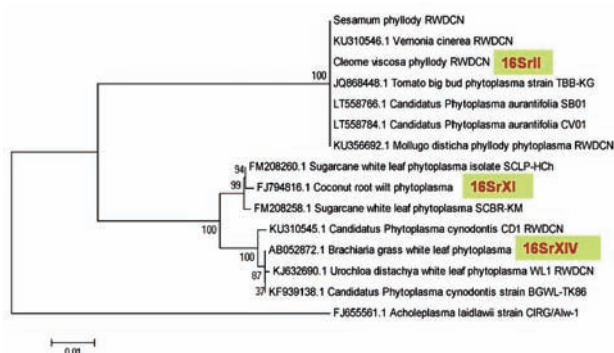
**Fig. 92. Phyllody symptoms on *Cleome viscosa* (a) and *Sesamum* sp.(b) in root (wilt) affected coconut gardens**

symptomatic weeds in root (wilt) affected coconut plantations showed the presence of 16Sr II group in dicot weeds and 16 Sr XIV group in monocot



**Fig. 92. c. PCR based detection of phytoplasma associated with weeds in coconut root (wilt) affected garden (P1/P6-R16F2n/R16R2). Lane1: 1 kb DNA Ladder, 2: Non-template control, 3: Lane 3-6: *Cleome viscosa* (CLP1-4), 7-10: *Sesamum phyllody***

weeds (*Urochloa distachya* and *Cynodon dactylon*) indicating that these weeds do not serve as the hosts for RWD phytoplasma (Fig. 93).



**Fig. 93. Phylogenetic tree constructed using the 16Sr RNA gene sequences of phytoplasma obtained from symptomatic weeds in RWD affected plantations**



## MANAGING PESTS AND NEMATODES

**P**est management interventions in palms and cocoa have been vastly refined, augmenting ecological stability and environmental sustainability. Botanical preparations, biological suppression and semio-chemical strategies are inextricably intertwined to make IPM more realistic, innovative and farmer-centric through a community participatory mode. Agro-ecosystem based ecological bio-engineering approaches towards crop health management have been projected as viable options in combating the pest menace. Greater impetus has been bestowed upon tactfully controlling down invasive pests and developing an emergency preparedness module for the potential invasive species waiting at our doorsteps. The refined IPM strategies in the long-term pest suppression of key pests of coconut, arecanut and cocoa such as rhinoceros beetle, red palm weevil, eriophyid mite, white grub and the invasive pest rugose spiralling whitefly is presented.

### 5.1. Coconut

#### 5.1.1. Rhinoceros beetle (*Oryctes rhinoceros* Linn.)

This ubiquitous and cosmopolitan pest has become the greatest impediment in the early establishment of juvenile palms causing more than 20 % damage through collar entry. Growth of juvenile palms gets stunted and twisted, which leads to their improper establishment (Fig.94 a). Of late, the beetle has also been found to cause damage in tender nuts (Fig. 94 b).



#### 5.1.1.1. Botanical cake

To counter rhinoceros beetle infestation on juvenile palms, a botanical cake and a botanical paste have been developed for prophylactic leaf axil placement. Placement of two cakes weighing 3 g on top most three leaf axils and swiping of the paste on the spear leaf and adjoining petiole of juvenile palms during June, October and February resulted in significant reduction in leaf damage by 51.3 % and 53.8 %, respectively. These treatments were found to be superior to placement of chlorantraniliprole sachets (5 g) which evinced reduction in leaf damage by 24.5 %. Botanical cake in tablet mode has been further refined to pellets for effective field delivery and suppression of rhinoceros beetle damage (Fig. 95).

#### 5.1.1.2. Ecological bioengineering

An agro-ecosystem based pest regression strategy through ecological bio-engineering was designed using the root (wilt) tolerant coconut hybrid, Kalpa Sankara (CGD x WCT) admixed with spices and fruit trees. Rhinoceros beetle inflicted lesser damage (15.8 %) on the inner lines of 19 Kalpa Sankara palms (51 months old) under the influence of mixed-volatile cues of crop plurality (rambutan, nutmeg, curry leaf, banana, turmeric, red gram, papaya) compared to palms in outer lines (30 %). Infestation by rugose spiralling whitefly (*Aleurodicus rugioperculatus* Martin) was found to be lower in the diversification plot (<5 live colonies leaflet<sup>-1</sup>) than in



**Fig. 94. Damage caused by rhinoceros beetle in juvenile palm (a) and tender nuts (b)**



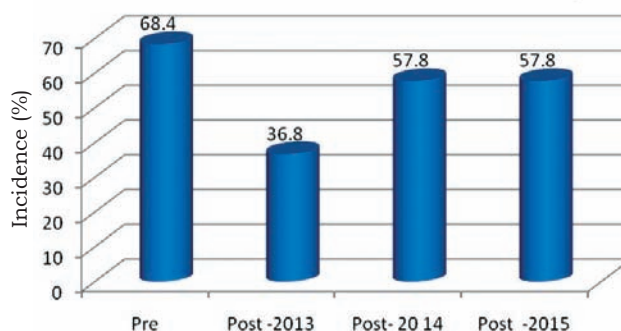
**Fig. 95. Botanical pellets in two colour forms (a, b) and botanical cake (c) in tablet mode**

garden with coconut as monocrop (>15 live colonies leaflet<sup>-1</sup>). Average yield of Kalpa Sankara was found to be 131 nuts palm<sup>-1</sup> year<sup>-1</sup>. *In situ* stimulo-deterrent diversionary strategy infused less pest damage and encouraged more defender population through eco-feast crops (*Antigonon leptopus*) and diversity in fruit crops. In addition to pest regression, continuous employment and income is generated fostering closer care to palms, complementing the concept of an ‘inch of land and a bunch of crops’.

#### 5.1.1.3. Pheromone dispensation

Studies were conducted at Kayamkulam, Kerala, a pest endemic region during 2014-2016 (June-May) on the beetle catch using two different modes of pheromone dispensation viz., ‘Chemtica’ (polymer membrane) and ICAR-CPCRI (Nanoporous matrix), on a standardized PVC tube with two windows. The pheromone lures were hung from the top of the tube and coir pith compost formed the breeding odour at the bottom of the PVC tube. The traps were installed in a 25 years old West Coast Tall plamtation @ 1 trap ha<sup>-1</sup> in at least four different locations. Number of beetles trapped in each trap at different location was recorded at monthly intervals for the two years period. In addition to the beetle catch, pest incidence on 25 palms around the traps was also recorded at six monthly intervals. Results indicated at least one major peak and two minor peaks of beetle population based on trap catches. The maximum beetles entrapped were found to be highest (67 beetles month<sup>-1</sup>) for nanoporous matrix during July-August and minor peaks ranged from 12-15 beetles month<sup>-1</sup> during October-November and January-February, respectively. Significantly lower beetle catch could only be realized for the ‘Chemtica’ lures for most of the period under study. The beetle catch was significantly lower during the second year (2015-2016) compared to that of the first year (2014-2015) due to the low floating population. Pest incidence on the palms around the trap was found to

be reduced marginally from 68 % to 58 %, but was found non-significant indicating that trapped beetles could only moderately subdue the pest attack on the palms (Fig. 96). The superiority of nanoporous matrix in trapping more number of beetles in the field has been recorded. Area-wide community level approach in large plantations would be the better option rather than for operation in homestead gardens of Kerala.



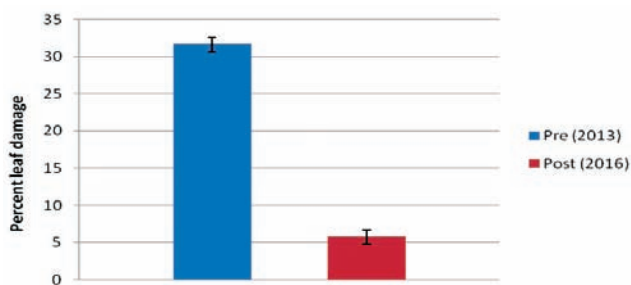
**Fig. 96. Incidence of rhinoceros beetle on coconut palms around the trap**

#### 5.1.1.4. Area wide participatory approach

Area-wide (1400 ha) implementation of IPM technologies for the past three years (2013-2016) in three locations at Alappuzha district, Kerala, involving prophylactic leaf axil filling of botanical cakes admixed with sand, incorporation of *Metarhizium anisopliae* and the weed, *Clerodendron infortunatum* and release of *Oryctes rhinoceros* nudiviruses inoculated beetle, could reduce beetle damage by 81.2 % (Fig. 97).

#### 5.1.1.5. Olfactometer screening of essential oils

Eighteen essential oils (1:10 dilution) were tested for their repellent property against rhinoceros beetle along with pheromone as control. All the essential oils tested had repelled the adult beetles, significantly. Based on repellency values (RV %), clove bud oil (82.5%) was found to be the most effective, followed by vetiver oil (75%), lemon grass oil (67.5%), peppermint



**Fig. 97. Rhinoceros beetle damage per palm**

oil (65.0%) and black pepper oil (62.5%). Pheromone (ethyl 4 - methyl octanoate) as control had the lowest RV (12.5%).

#### 5.1.1.6. Toxic effect of clove

The toxicity of clove (*Syzygium aromaticum*) in two forms *viz.*, clove bud powder and clove essential oil, was tested against grubs of rhinoceros beetles under laboratory conditions. Clove bud powder was tested against the larvae at 1, 3, 5, 10 and 15% concentrations and the clove essential oil concentrations tested were 1, 2, 3, 5 and 10%. Larval mortality varied from 3.3 to 93.3% with increasing concentrations of clove bud oil from 1% to 10% respectively. Larval mortality ranged from 10.0 to 96.6% with clove flower bud powder concentrations of 1% and 15%.

#### 5.1.2. Red palm weevil (*Rhynchophorus ferrugineus* Olivier)

Red palm weevil (RPW) is the most destructive pest of coconut palm. The pest is assuming higher proportions (1.5-2.0 %) with the introduction of dwarf coconut cultivars, which are highly susceptible, and adoption of unscientific cultivation practices.

##### 5.1.2.1. Sexual dimorphism

A new morphological feature on sexual dimorphism in RPW could be established. Presence of thick setae could be observed on tibia as well as femur of male red palm weevil (Fig. 98). The hairs arranged on the inner side on male tibia and femurs are quite long and these extraneous growths of hairs could be involved in copulation for effective clasp of females during

the process of mating. Female weevils were found to be absolutely devoid of these hairs. Extreme modulation in size and colour morphs of RPW could be observed based on morphometric analysis indicating robustness in specimens of RPW from Tamil Nadu and smaller size of specimens from Kerala, which could be an adaptation to palm health status (Fig. 99).



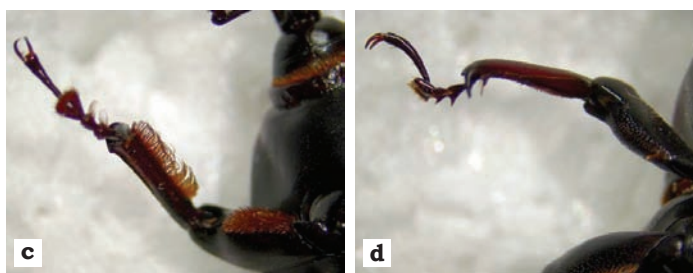
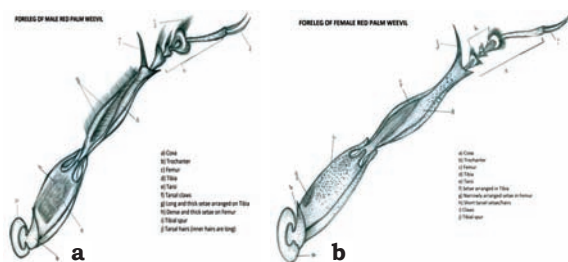
**Fig. 99. Variation of size morphs of red palm weevil collected from different zones**

##### 5.1.2.2. Effect of lufenuron

As part of studies on the biology of RPW, a total of ten larval instars could be demarcated using Dyar's law, with linear increase of head capsule width from one instar to the next in the ratio of 1.16 ( $Y=0.541x$  with  $R^2$  value 0.9244). More larval instars in RPW led to enhanced susceptibility to lufenuron, the chitin synthesis inhibitor. Median effective dose of lufenuron against RPW was found to be 0.00779% and at this concentration, 50 % of the RPW grubs turn malformed. Lufenuron @ 0.00779% was found compatible with the entomopathogen, *Beauveria bassiana*.

##### 5.1.2.3. Gut microbiome

Luminal microbes of RPW play a vital role in cellular disintegration of palm tissues during the feeding process. Nine predominant and distinct bacterial colonies were isolated from the gut of *R. ferrugineus* and were characterized with both biochemical and molecular tools. Based on the key diagnostic tests, nine culturable bacterial strains could be identified as *Serratia marcescens*, *Enterococcus casseliflavus*,



**Fig. 98. Sexual dimorphism in red palm weevil male (a & c), female (b & d)**

**Table 15. Gut microbes in red palm weevil and associated putative functions**

Microbe	Putative functions
<i>Serratia marcescens</i>	Cellulose degradation & host fitness against parasitoids
<i>Enterococcus casseliflavus</i>	Synergistic effect on entomopathogens
<i>Klebsiella</i> spp.	Survive on high C/N ratio medium
<i>Stenotrophomonas maltophilia</i>	Imparts resistance against fungal invasion
<i>Bacillus aryabhattai</i>	Ability to withstand harsh environment
<i>Bacillus megaterium</i>	Imparts immunity against fungi, bacteria and virus due to the presence of antifungal and antiviral principles
<i>Paenibacillus cineris</i>	Produce antimicrobial substances which imparts immunity
<i>Citrobacter</i> sp.	Nitrogen fixation

*Klebsiella variicola*, *Klebsiella pneumoniae*, *Stenotrophomonas maltophilia*, *Citrobacter amalonaticus*, *Paenibacillus cineris*, *Bacillus aryabhattai* and *Bacillus megaterium*. These microbes have different functional roles in the fitness behaviour of the insect (Table 15).

In the phylogenetic tree, the gut microbes delineated into two major clusters: Gram negative group comprising of *Klebsiella pneumoniae*, *Klebsiella variicola*, *Serratia marcescens*, *Citrobacter* sp. and *Stenotrophomonas maltophilia* and Gram positive bacteria that includes *Paenibacillus cineris*, *Enterococcus casseliflavus*, *Bacillus aryabhattai* and *Bacillus megaterium* (Fig. 100). Functional differences among the two groups are not quite explicit; however,

the first group is relatively involved in the nutritional role of RPW while the latter group imparts immunity to the insect against harsh environment.

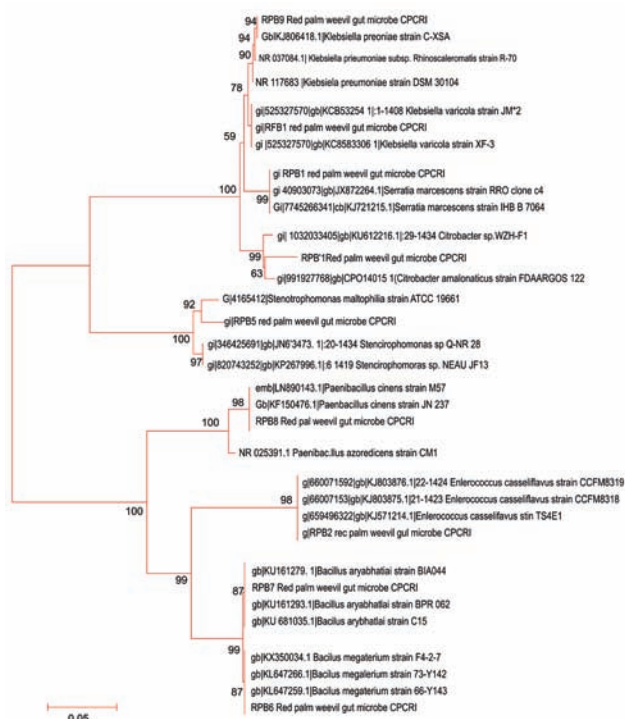
A holistic characterization of culturable and non-culturable bacterial colonies would hold key to understand the microbiome dynamics of RPW so as to exploit these insights for innovative pest management strategies.

#### 5.1.2.4. Refined pheromone trap

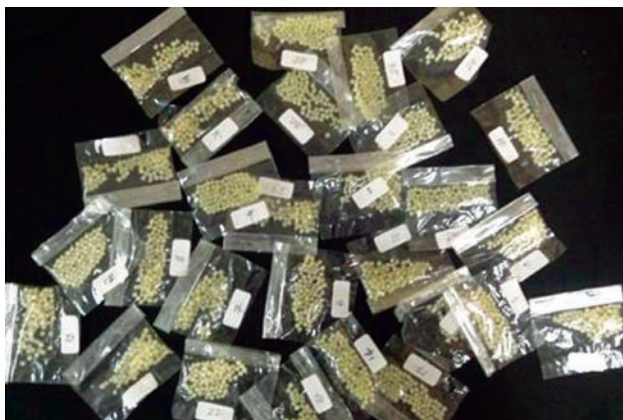
The plastic bucket trap used in the trapping of RPW was re-designed with an umbrella mode as well as PVC tube for enhanced durability and higher catch of weevils (Fig.101). The design aims to reduce the slippage of weevils and orient them perfectly in to the trap. On account of its PVC make, the durability of the trap is enhanced and the umbrella could reduce the dissipation loss of the aggregation pheromone considerably.

**Fig. 101. Re-designed trap for red palm weevil**

Field evaluation of the 'push pull strategy' by keeping repellents (5% citriodora oil impregnated calcium alginate beads) @ 5 g palm<sup>-1</sup> in two sachets on palm crown and pheromone trap outside the garden reduced the incidence from 5.19% to 1.30% over a period of three months. Based on gravimetric assay,

**Fig. 100. Phylogenetic tree of 16S rRNA sequences of bacterial isolates from gut of red palm weevil**

dissipation of citriodora oil from sodium alginate beads was observed to be 12.04, 20.31, 25.31 and 34.11 % respectively at weekly intervals up to four weeks. Para-pheromone (9:1 mixture of 4-methyl 6- nonanol and 4- methyl 5 - nonanone) loaded in calcium alginate matrix (Fig. 102) could trap the RPW beetles effectively up to 45 days; thereafter, its efficacy was reduced.



**Fig. 102. Citriodora oil impregnated calcium alginate beads**

### 5.1.3. Rugose spiralling whitefly (*Aleurodicus rugioperculatus* Martin)

Rugose Spiralling Whitefly (RSW) (*Aleurodicus rugioperculatus* Martin) is an invasive pest on coconut reported from Pollachi (Tamil Nadu) and Palakkad (Kerala) during July-August 2016. It was first reported in coconut during 2004 at Belize and Mexico and later from Florida, USA during 2009. In a period of seven months after it was first noticed, spread of RSW was observed in Kerala (Palakkad, Malappuram, Thrissur, Kozhikode, Kannur, Kasaragod, Ernakulam, Pathanamthitta, Alappuzha, Kollam, Kottayam and Thiruvananthapuram districts), Tamil Nadu (Pollachi and Pattukottai), Andhra Pradesh (Kadiyampalanka) and Karnataka

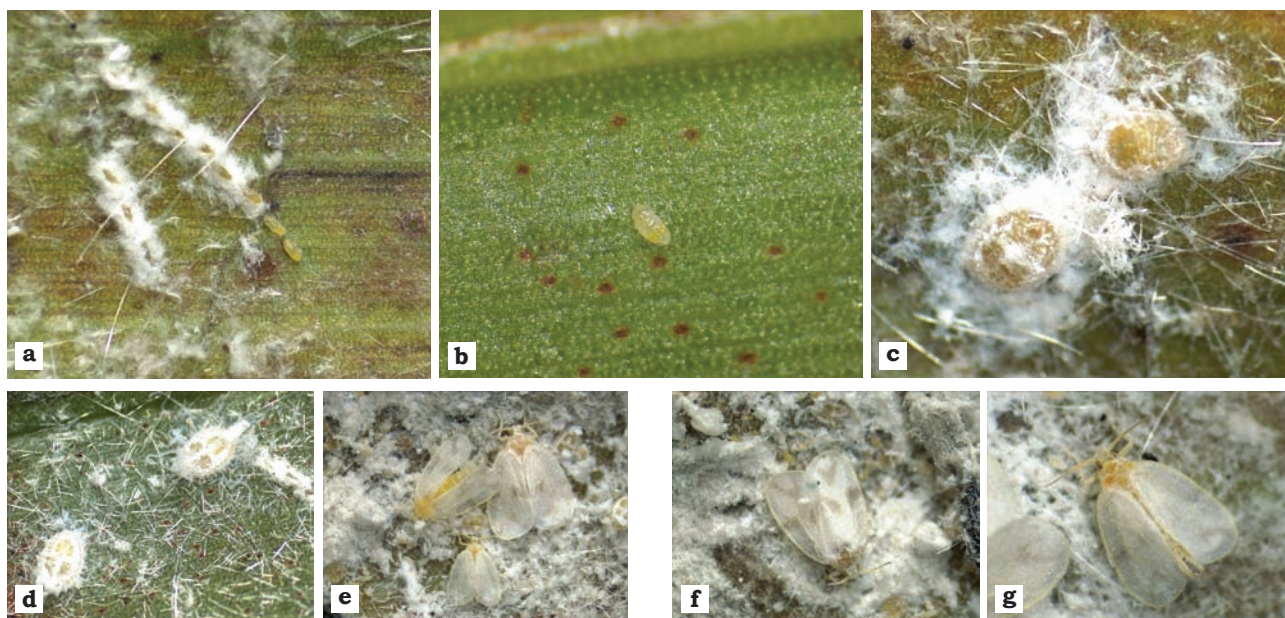
(Udupi). The distribution of the pest is uneven, mostly along the National and State Highways, isolated gardens near water bodies and restricted gardens in midland regions. Presence of sooty mould and the prevalence of active egg spirals and adult whiteflies are the marked symptoms of infestation. Though the pest has been reported in different districts of Kerala, it has not caused any severe economic losses. Feeding was noticed to be confined mostly on the older whorl of coconut leaves. Extensive desapping of RSW would induce stress on the palms due to removal of water and nutrients, but neither colour change nor necrosis of leaves was observed. Even though there was loss of photosynthetic efficiency due to the formation of sooty mould fungus (*Capnodium* sp.), mortality of palms has not been observed. In case of severe attack, egg spirals could be located on leaf petiole as well as on tender coconuts which is very unique and observed for the first time (Fig. 103).

#### 5.1.3.1. Morphology

RSW has a body length of about 2.5 mm, relatively larger than common whiteflies. Presence of a pair of irregular light brown bands across the wings is one of the identifying features of RSW. Male flies are slightly smaller than females and have elongate claspers at the distal end of the abdomen. Eggs are elliptical and yellowish in colour, 0.3 mm long, translucent with a short stalk and are laid singly and associated with irregularly spiralling deposits of white flocculent wax surrounding each egg in a semi-circular spiralling fashion (Fig. 104). The spiralling of waxy material is the feature from which its common name 'spiralling' whitefly is derived. The first-instar crawlers are the immature stage with functional legs and distinct antennae and are mobile. Subsequent larval stages are sedentary and have oval shaped soft bodies with cream colour, studded with white waxy material on the sides. Immature stages become more convex with the advancement of life cycle. Presence of rugose operculum with triangular and acute lingula, presence



**Fig. 103. Incidence of rugose spiralling whitefly on (a) leaflets, (b) petiole and (c) nuts**



**Fig. 104. Life stages of RSW (a) eggs, (b) mobile crawler, (c) nymphs, (d) nymph with single fluff, (e) colony of RSW, (f) female, (g) male**

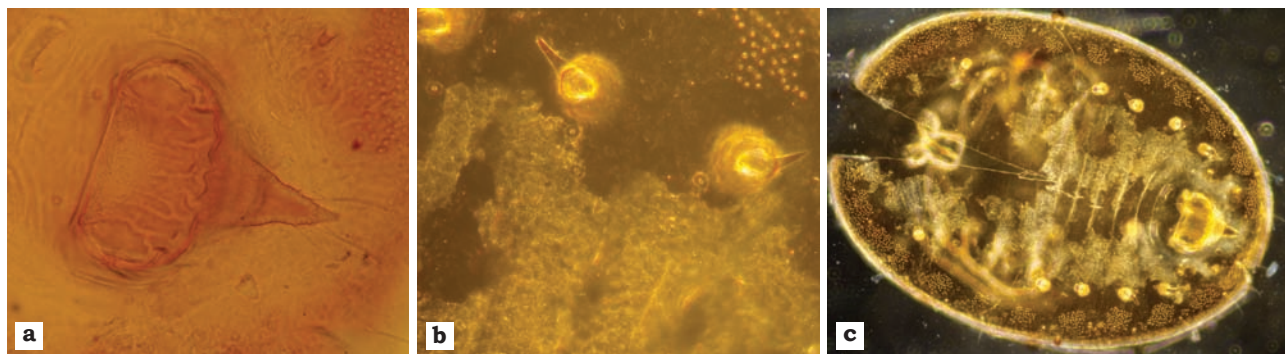
of dagger-like compound pores and the occurrence of smaller compound pores on the abdominal segment of VII and VIII are the characteristic identification features of RSW (Fig.105). Nymphs have a fused broader fluff on the posterior side.

#### 5.1.3.2. Molecular characterization

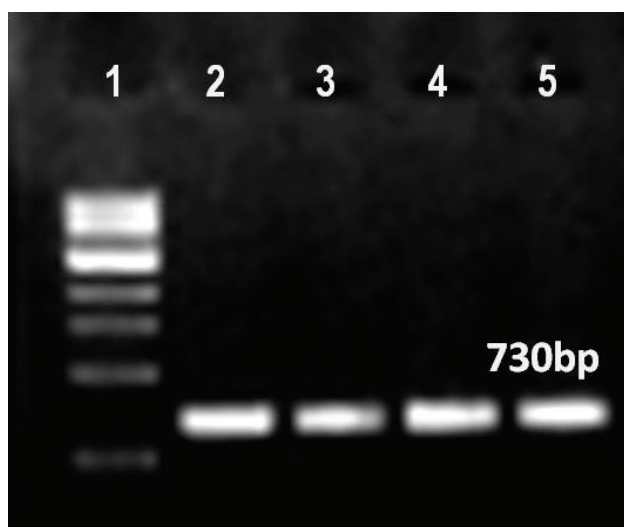
Molecular characterization of mitochondrial cytochrome oxidase 1 gene (*COI*) of *Aleurodicus* sp. collected from coconut in Chathenkari, Pathanamthitta (WFPT1, Genbank accession no. KY574536), Kozhinjampara, Palakkad (CN-WFP1a, KY574535), Oachira, Kollam (CN-WFKOa, KY499623), Kumarakom, Kottayam (WFKT1, KY574534), Krishnapuram, Alappuzha (WFAL1, KY574533) and Vellangallur, Thrissur (WFTb2, KY574537) in Kerala and Pollachi, Coimbatore

(WFTN2, KY574538), Tamil Nadu, indicated 100% similarity with that of mitochondrial *COI* sequence of *A. rugioeperculatus* reported from Florida, USA (KP032219) thus confirming the molecular taxonomic identity as *A. rugioeperculatus* in conjunction with the species-specific morphological characters (Fig. 106).

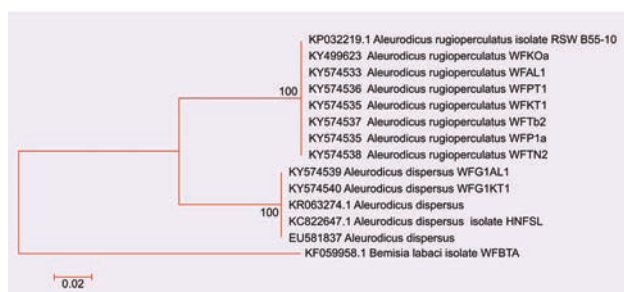
On the other hand, *Aleurodicus* sp. collected from guava in Krishnapuram, Alappuzha (WFG1AL1, KY574539) and Kumarakom, Kottayam (WFG1KT1, KY574540), both in Kerala, was identified as *Aleurodicus dispersus* based on morphological taxonomic keys and showed 100% similarity with *COI* sequences of *A. dispersus* (KC822647) thus confirming its taxonomic identity (Fig.107). Morphological identity of these species of spiralling whiteflies was also confirmed by staining of puparia.



**Fig. 105. Taxonomic features of RSW (a) Rugose operculum with triangular lingula, (b) compound pores with dagger-like process, (c) smaller but prominent compound pores in VII and VIII segments**



**Fig. 106. Amplification of COI gene of *A. rugiopectulatus***  
Lane 1: 1 Kb DNA ladder, 2-5: *A. rugiopectulatus* from different locations



**Fig. 107. Phylogenetic tree constructed using the COI gene sequences of *A. rugiopectulatus* and *A. dispersus* by neighbor joining method. COI gene sequence of *B. tabaci* (Accession no. KF059958.1) used as out group**

#### 5.1.3.3. Host range

In a recent survey, 12 alternate host plants (*Psidium guajava*, *Musa* sp. (Fig. 108), *Myristica fragrans*, *Colocasia* sp., *Garcinia* sp., *Annona muricata*, *Murraya koenigii*, *Spondias mombin*, *Mangifera indica*, *Heliconia stricta* (Fig. 109), *Strelitzia reginae* and *Artocarpus heterophyllus*) have been enumerated in coconut homesteads; the pest was found to be relatively more confined to coconut, indicating its host preference. Despite egg laying noticed in other crops, *A. rugiopectulatus* could not complete its life cycle in other crop hosts, except for banana and *H. stricta* to a small extent.

#### 5.1.3.4. Weather factors

The year 2016 experienced 40% deficit in monsoon and at least 2°C increase in temperature during summer months compared to that of the previous



**Fig. 108. RSW on banana**



**Fig. 109. RSW on *Heliconia stricta***

year. There was also a reduction of afternoon relative humidity to the tune of 7% during the post-monsoon period (61 to 66%). These modulations in weather factors could have been one of the reasons for the flare up of the *A. rugiopectulatus*.

#### 5.1.3.5. Biological suppression

It was observed that more than 50 % of the whitefly was parasitized by the aphelinid parasitoid, *Encarsia guadeloupae* in Chathenkari (Alappuzha district) and Kumarakom (Kottayam district) in Kerala indicating the natural build of the parasitoids. This is one of the classical biological control strategies and any disturbance in the build-up of *E. guadeloupae* would invariably affect the long term approach in pest bio-

suppression. Adult *E. guadeloupae* is identified by the presence of a yellow scutellum (a triangular plate on their back between the wings; the thorax area) against their brownish body and dark coloured head (Fig.110 & 111). During October 2016, parasitism was found to be about 30 % in both the regions; however, in January 2017, the parasitism rose up to 70.4 % at Chathenkari and 58.4 % in Kumarakom inferring significant enhancement in parasitism in a period of four months ( $t=5.64$ ;  $p<0.05$ ) (Fig. 112). Enhancement in the level of parasitism resulted in considerable diminishment in the population of RSW in both regions. In addition, lady beetles belonging to *Jauravia* sp. (Fig. 113) and *Sasajiscymnus* sp. and a wide array of spiders were also noticed in the system. With the emergence of RSW in coconut and natural build up of *E. guadeloupae* in Kerala and Tamil Nadu, it is of paramount importance that the delicate pest-defender system should be carefully conserved in the region.

#### 5.1.3.6. Integrated pest management

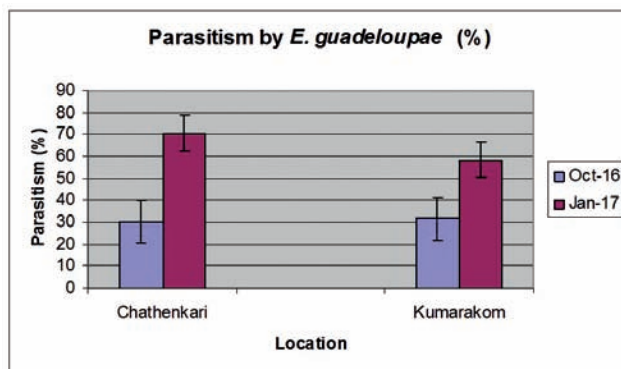
Use of insecticides is not a viable option for the management of whitefly as it causes a reduction in the build of natural enemies, especially *E. guadeloupae*. Therefore, population build-up of natural enemies, either through biological control or introduction of parasitized pupae, would be a more feasible and sustainable alternative approach at this point of time for the long-term bio-suppression of RSW.



**Fig. 110. *Encarsia guadeloupae***



**Fig. 111. Parasitism by *E. guadeloupae* (a) Parasitized pupa, (b) exit hole of emerged *E. guadeloupae***



**Fig. 112. Parasitic potential of *E. guadeloupae* in Chathenkari and Kumarakom**



**Fig. 113. *Jauravia* sp.**

The integrated pest management strategies to be adopted are as follows:

1. The pest population is likely to recede with monsoon showers and hence, insecticide application should be totally avoided so as to enhance the build up of natural enemies.
2. Application of 1% starch on the sooty mould affected leaves to flake out the mould,
3. Fixing of an yellow sticky trap of one metre width painted with white grease or castor oil on the trunk of infested palms to trap the adult whiteflies.
4. Conservation and re-introduction of parasitized pupae, *E. guadeloupae* for long-term pest suppression.
5. Spraying neem oil @ 0.5% targeting the lower whorls of fronds in severally infested gardens.

#### 5.1.4. Lingering nature of minor pests in coconut system

Insects sustain biotic balance in every ecosystem and coconut is no exception. Occurrence of coconut scale insect, *Aspidiotus destructor* Sign. (Diaspididae : Hemiptera), infesting leaves, spadix

and nuts, was reported from an isolated garden near Kayamkulam, Kerala during July 2016 at moderate levels. Though this was a sporadic outbreak, it was suppressed all of sudden by the emergence of a natural ladybird predator, *Sasajiscymnus dwipakalpa* (Ghorpade) (Coccinellidae: Coleoptera). Immature stages of the beetle, resembling a mealy bug, as well as the adult beetles voraciously fed on all the life stages of *A. destructor* bringing down the pest population very significantly. As much as 56 % of natural parasitism by aphelinid parasitoid *Aphytis melinus* was also noticed on *A. destructor*. Another coccinellid predator, *Chilocorus nigrita* was also abundantly present in scales infested coconut nursery (Fig. 114 & 115). A perfect co-existence of pest-predator linkage in coconut system thus creates a niche for minor pests to remain under control.

#### 5.1.4.1. Emerging pests

The coreid bug, *Paradasynus rostratus* Dist. has attained the status of a potential emerging pest of

coconut palms in South India in recent years causing shedding of button and immature nuts to the tune 18-66 %. Among the various botanicals and new generation molecules evaluated against coreid bug in coconut, palms treated with chlorantraniliprole (0.018 %) and nimbidine (1 %) reduced coreid bug infestation by 91.02 % and 63.21 %, respectively.

Occurrence of leaf webworm, *Acria meyrinki* sp., causing defoliation, was observed in Kasaragod during October to December. The flat green-coloured caterpillar inside the silken web, feeds voraciously on coconut seedlings at random (Fig. 116). Adult moth is yellow coloured with prominent labial palpi. It is also reported as a minor pest in oil palm.

### 5.2. Arecanut

#### 5.2.1. Ambrosia beetle (*Crossotarsus* sp.)

A new pest, ambrosia beetle, *Crossotarsus* sp. (Curculionidae) was recorded from an arecanut garden in Bantwal taluk of Dakshina Kannada district

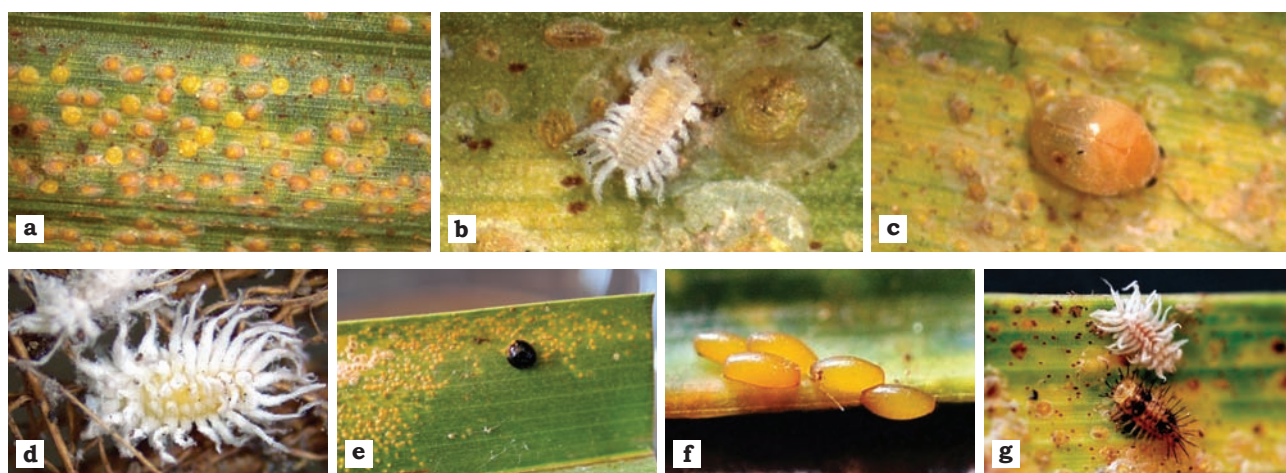


Fig. 114. a) Coconut scale, b) Predatory grub feeding on scale insects, c) Lady beetle *Sasajiscymnus dwipakalpa*, d) close view of a grub of lady beetle, e) *Chilocorus nigrita* predating on scale insect, f) Eggs of *C. nigrita* g) predator

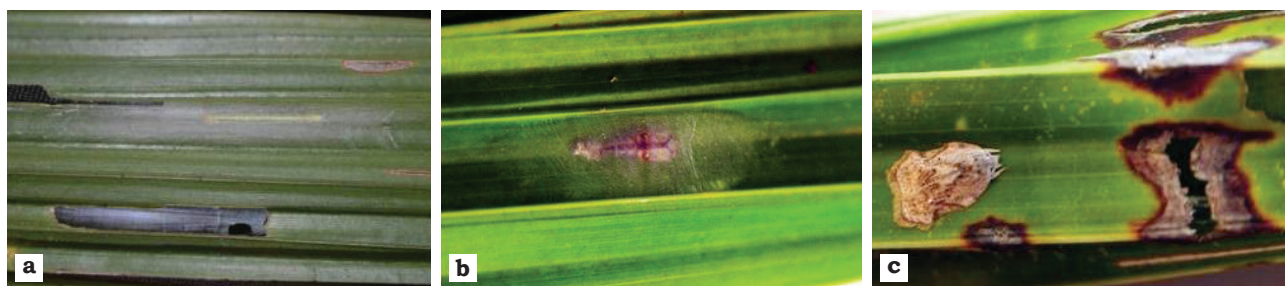


Fig. 115. Aphelinid parasitoid, *Aphytis melinus*, on *A. dispersus*

(Fig. 117). Oozing of yellowish gummy exudates from the point of entry of beetle is the most conspicuous symptom (Fig. 118). After removal of the gummy exudates, the beetles could be extracted from pin size holes. It was identified as *Crossotarsus* sp. at UAS, Bengaluru and the samples were deposited at insect museum (Accession numbers UASB01723051 - UASB01723060).

#### 5.2.2. Root grub

To assess the diversity and distribution of arecanut root grub, surveys were conducted in Malnad region and Dakshina Kannada district of Karnataka. On the basis of raster character of grub, it was



**Fig. 116. Larva of *Acria meyrinki* sp. (a) inside silken web, (b) pupa and (c) adult moth**



**Fig. 117. (a) *Crossotarsus* sp. (a) Male, (b) Female**



**Fig. 118. Yellowish gummy exudates oozing from *Crossotarsus* sp. infested arecanut stem.**

confirmed that *Leucopholis lepidophora* was the dominant root grub species in Thirthahalli taluk of Shivamogga district and *Leucopholis burmeisteri* was the dominant species in Dakshina Kannada district. Adult emergence pattern of *L. burmeisteri* was studied in root grub infested garden at Kundadika village of Bantwal taluk. For molecular characterization of *L. burmeisteri*, a 644 bp mitochondrial cytochrome oxidase I (*COI*) was successfully sequenced from *L. burmeisteri* and deposited in NCBI database (Accession no. KX009511.1).

Field evaluation of Lesenta 80 WG (Fipronil + Imidacloprid) on arecanut white grubs indicated that all treatments were superior to control providing root zone protection. Root zone application of Lesenta 80 WG @ 0.6 g palm<sup>-1</sup> reduced *L. burmeisteri* population significantly and was found on par with chlorpyrifos @ 7 ml palm<sup>-1</sup> and imidacloprid 70 WG @ 0.4 g palm<sup>-1</sup>. Plots treated with Lesenta 80 WG @ 0.6 g palm<sup>-1</sup> induced 63.5%, 67.5%, 58.7% , 62.41% , 71.11% and 51.48% reduction in white grub population at 15, 30, 45, 60, 75 and 90 days after application. Lesenta, fipronil and imidacloprid @ 2 ppm were

found inhibitory to *Trichoderma harzianum* (ICAR-CPCRI TR 28 isolate).

The refined IPM strategy of white grubs in arecanut garden consists of :

- Hand picking and destruction of adult beetles during emergence period (in June)
- Soil application of bifenthrin @ 2 kg ai/ha (Talstar 10 EC @ 20 litres ha<sup>-1</sup> in 500 l of water) when first instar stage of grubs dominate in the field (July-August)
- Root zone application of entomopathogenic nematode (EPN), *Steinernema carpocapsae* @ 1.5 billion IJs / ha and imidacloprid 17.8 SL @ 0.25 ml / litre during September-October. Need based repeated application of EPN.
- Regular ploughing to expose the grubs to predators

### 5.3. Cocoa

#### 5.3.1. Mealy bugs

*Planococcus lilacinus* Cockerell was the predominant mealy bug species infesting cocoa pods, cherelles, flower cushions and leaves in Kerala, Tamil Nadu and Karnataka. Other species include *Ferrisia virgata* (Fig. 119) and *Crissicoccus hirsutus*. Seasonal incidence of mealy bugs on cherelles and pods indicated pest build up during February with peak incidence during March to May.



Fig. 119. *Ferrisia virgata* infestation on cocoa pods

Two natural enemies viz., *Acerophagus papayae* Noyes & Schauff and *Aenasius arizonensis* (Girault) were found dominant in cocoa ecosystem for natural bio-suppression of mealy bug population.

#### 5.3.2. Cocoa pod borer (*Conogethes punctiferalis* Guenee)

*Conogethes punctiferalis* is one of the emerging insect pests of cocoa in Karnataka (Fig. 120). The pest incidence was very low (2.07%) during 2013 which increased to 40% during 2016 due to change in weather factors.



Fig. 120. *Conogethes punctiferalis* infestation on cocoa pods

#### 5.3.3. Ambrosia beetle

The ambrosia beetle *Crossotarsus* sp. was also reported from cocoa and the visible symptoms of attack include appearance of numerous round bore holes on the tree trunk and branches and extrusion of fibrous dust frass from the tree trunk (Fig. 121).

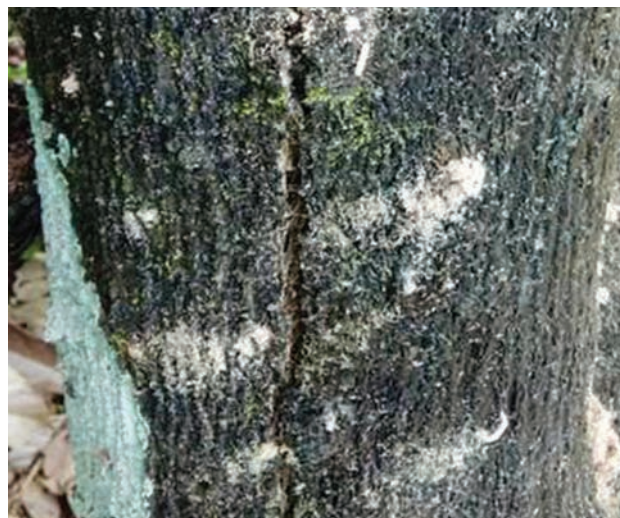


Fig. 121. Extrusion of fibrous dust frass from *Crossotarsus* sp. infested cocoa stem.

#### 5.3.4. Stilted bug (*Metacanthus pulchellus* Dallas)

The phytophagous bug *Metacanthus pulchellus* Dallas (Berytidae) was observed in cocoa (Fig. 122). Population of this bug was observed throughout the year on cocoa.



**Fig. 122. *Metacanthus pulchellus* - Adults**

#### 5.4. Plant parasitic nematodes

The incidence of root-knot nematode (*Meloidogyne incognita*) in papaya in coconut gardens varied from 40 to 60 % with root knot index (RKI) 2 to 4.5 during 2016 (Fig. 123). Among the three cultivated varieties, 'Arka Prabhat' had higher incidence followed by 'Co-6' and 'Red Lady' in sandy soils of Kayamkulam, Kerala. Integrated nematode management (INM) strategies include planting of marigold (*Tagetes erecta*) around the palm basin and application of *Trichoderma* enriched neem seed kernel powder @ 1-2 kg plant<sup>-1</sup>. Repetitive application can be taken up at three month interval till the proper establishment of seedlings in main field.

##### 5.4.1. Effect of crop sequences

Sequential cropping system of *Tagetes* (5 months) followed by turmeric (7 months) in the inter-spaces of coconut resulted in lower root-knot nematode index (1.6) on turmeric (Fig. 124).



**Fig. 123. a) Yellowing of papaya, b) Knots/galls on roots caused by *M. incognita*, c) Severely infested papaya roots having bigger knots/galls**



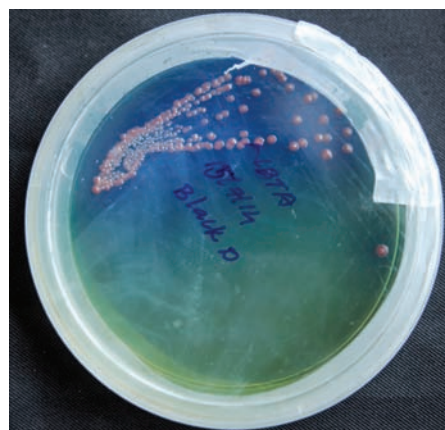
**Fig. 124. a) View of a healthy turmeric crop in coconut, b) Small knots/galls on turmeric roots caused by *M. incognita***

#### 5.5. Entomopathogenic nematodes (EPNs)

A new strain of *Heterorhabditis indica* has been reported from the root grub infested arecanut gardens in Udma panchayat, Kasaragod district of Kerala that induced 90% mortality of early instar grubs.

##### 5.5.1. Symbiont bacteria

Morphological identification of the symbiotic bacteria associated with the local *S. carpocapsae* isolate was found as *Xenorhabdus nematophila* based on the colony characteristics (formation of single red colonies overlaid by dark blue colonies) and positive reaction for glucose, sucrose and lactose fermentation biochemical tests (Fig. 125).



**Fig. 125. Red colonies of *Xenorhabdus nematophila* surrounded by dark blue colonies**

### 5.5.2. Area-wide demonstration of root grub bio-suppression

EPN, *Steinernema carpocapsae* (1.5 billion IJs ha<sup>-1</sup>), in combination with 0.0045 % imidacloprid and 2 kg neem cake palm<sup>-1</sup> for root grub management in arecanut was carried out in Karnataka in two different locations *viz.*, Sringeri and Sullia (2 acres) (Fig. 126). Tremendous reduction of root grub population by 91.8 % was recorded in the treated plots. Palm mortality was reduced from 6.4 % to 0.3 % with yield enhancement by 62.1 % in treated palms over a period of two years.

### 5.5.3. Shelf life of aqua formulation

For easy handling, storage and transportation of formulated EPN (*S. carpocapsae*), reusable polypropylene covers were tested for its suitability. Respiration studies indicated insignificant decrease in O<sub>2</sub> from 19.8 % to 19.4 % as well as increase in CO<sub>2</sub> from 0.15 % to 0.32 % over a period of 30 days of storage.

Polypropylene packages (60µ) ensured better gas exchange, higher metabolic activity of stored IJs and significantly higher survival (94.6 %) of nematodes under laboratory conditions (temperature 25 - 27°C, RH 58 to 64 %) up to three months and 55% survival at six months (Fig. 127). The virulence of the stored IJs of *S. carpocapsae* when tested on *G. mellonella* larvae, showed 100 % mortality in 48 hours.



**Fig. 126. A view of the demonstration plot on biosuppression of root grub at Sullia**



**Fig. 127. An aqua formulation of EPN in polythene sachet**

# PHYSIOLOGY, BIOCHEMISTRY AND POST-HARVEST TECHNOLOGY



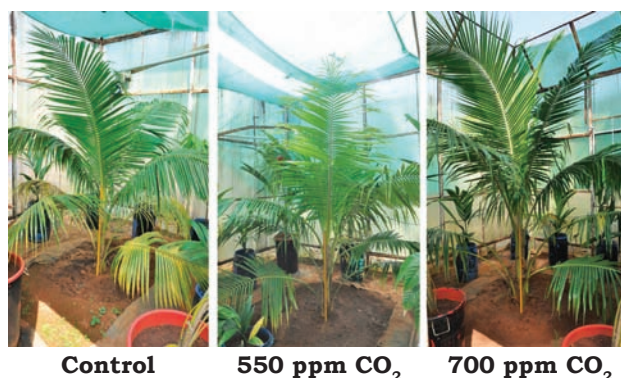
## 6.1. Phenotyping for climate resilient adaptation and mitigation strategies

### 6.1.1. Interaction effect of elevated CO<sub>2</sub> [ECO<sub>2</sub>] and elevated temperature [ET] with water deficit stress in OTC (open top chamber) grown coconut seedlings

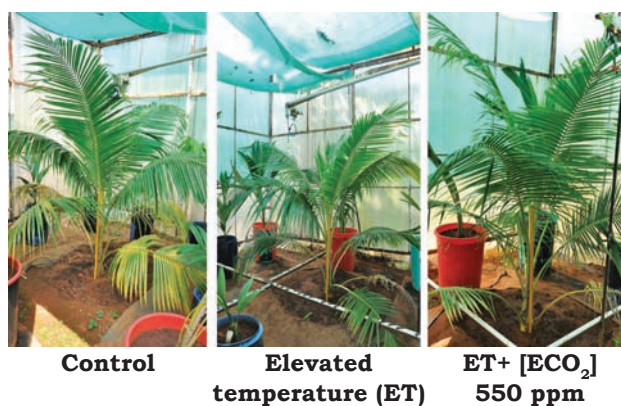
The interaction effect of climate change variables viz., CO<sub>2</sub> and elevated temperature (ET) with moisture-deficit, on growth and development of coconut seedlings, was studied in an Open Top Chamber (OTC) at Kasaragod. Seedlings were exposed to elevated CO<sub>2</sub> [ECO<sub>2</sub>] (550 and 700 ppm), ET (3°C above ambient) and ET+ECO<sub>2</sub> (550 ppm CO<sub>2</sub> + 3°C). In each OTC, a set of palms were subjected to water deficit stress (50 % field capacity (FC)), while the other set was under 100 % FC. Plants accumulated significantly higher biomass when grown under ECO<sub>2</sub> which was 1.13 and 1.98 kg palm<sup>-1</sup> with 550 and 700 ppm CO<sub>2</sub> respectively as against 1.10 kg palm<sup>-1</sup> under ambient conditions. Biomass accumulation was found to be least in ET treatment (0.91 kg palm<sup>-1</sup>). As a consequence, the ECO<sub>2</sub> treatment had higher Water Use Efficiency (WUE) of 2.73 and 3.17 g litre<sup>-1</sup> at 550 and 700 ppm respectively as against 1.79 g litre<sup>-1</sup> under ambient and 1.37 g litre<sup>-1</sup> under ET treatment. Thus, the water requirement to produce unit biomass in ECO<sub>2</sub> treatment is less. This indicates that to produce the present biomass level in the future climatic scenario with elevated CO<sub>2</sub>, the water requirement of coconut plant would be less (52 % less at 550 ppm); however, at high temperature, it would be more (23 % more at 3°C above ambient). WUE under water deficit stress was significantly reduced in all the treatments.

In order to study the response of coconut to ECO<sub>2</sub> and ET at reproductive phase, a dwarf coconut seedling was transplanted during June, 2015 in each OTC. Above ground plant growth was almost 1.5-fold high at 550 ppm, and 2-fold high at 700 ppm CO<sub>2</sub> compared to chamber control (Fig. 128). Growth was significantly low with [ET] (Fig. 129). Elevated CO<sub>2</sub> compensated the growth loss with [ET] to a certain extent. Photosynthesis (25 % increase), leaf area (27 % increase) and other physiological parameters were

recorded in palms subjected to ECO<sub>2</sub> treatment. As a result, the intrinsic WUE was high in plants grown under ECO<sub>2</sub> (3.2 g litre<sup>-1</sup>) compared to control (2.5 g litre<sup>-1</sup>) that could be due to lower stomatal conductance.



**Fig. 128. Effect of elevated CO<sub>2</sub> [ECO<sub>2</sub>] 550 and 700 ppm CO<sub>2</sub> on MYD coconut seedlings in comparison to control**



**Fig. 129. Effect of elevated temperature (ET) and ET+ [ECO<sub>2</sub>] 550 ppm on MYD coconut seedlings in comparison to control**

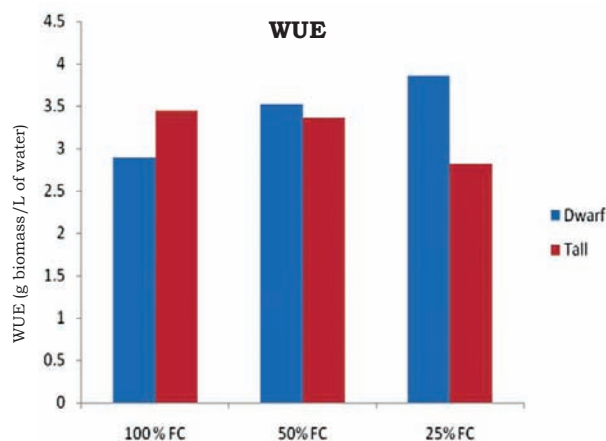
#### 6.1.1.1. Whole plant water use efficiency

To circumvent the effect of moisture-deficit in coconut, which is an imminent threat under climate change, improving crop water use efficiency (WUE) is a most important strategy for sustained nut production.

The WUE is commonly measured at the leaf level, because equipments used for measuring leaf gas exchange rates aid in simultaneous measurement of photosynthesis and transpiration. However, leaf level estimation of WUE has certain limitations and hence, an attempt has been made to measure the whole plant WUE of coconut seedlings.

The relative WUE of container-grown seedlings of tall and dwarf coconut genotypes was determined from November, 2015 to June, 2016 by comparing water consumption values and potential evapotranspiration rates, along with growth rates. While WUE for tall genotypes was high under non-stress conditions ( $3.5 \text{ g litre}^{-1}$ ), it was relatively low under stress condition ( $2.6 \text{ g litre}^{-1}$ ). On the other hand, dwarf cultivars showed low WUE under non-stress condition ( $2.9 \text{ g litre}^{-1}$ ) and showed comparatively high WUE under water deficit stress ( $3.8 \text{ g litre}^{-1}$ ) (Fig. 130). This indicates that tall cultivars are efficient while dwarfs are inefficient in utilizing water resources under water deficit stress. Stomatal resistance of tall and dwarfs was on par under non-stress, however, under stress, resistance was significantly high in tall ( $12 \text{ s cm}^{-2}$ ) compared to dwarfs ( $5.8 \text{ s cm}^{-2}$ ) suggesting that stomata of dwarfs are insensitive to water deficit. However, further studies are required to infer whether insensitive stomata of dwarfs contribute to high WUE under stress conditions (Fig. 130).

Studies on leaf epicuticular wax (ECW) content revealed that the tall cultivars *i.e.*, Kalpa Pratibha ( $54.70 \pm 13.20 \text{ } \mu\text{g cm}^{-2}$ ) and Kalpatharu ( $77.51 \pm$



**Fig. 130. Mean WUE of tall and dwarf coconut genotypes at different moisture regimes (CD at 5% 0.8)**

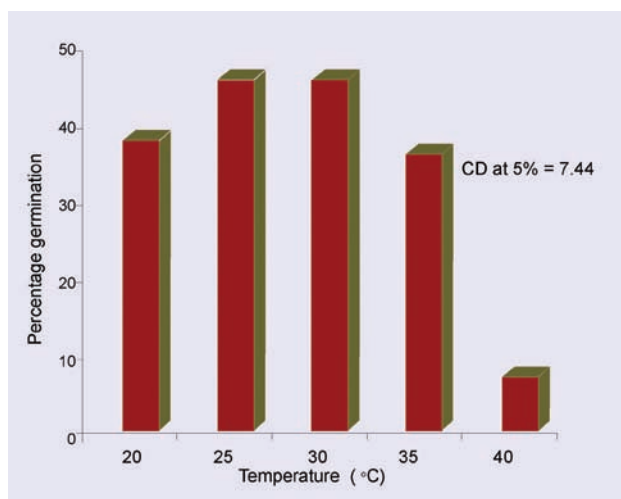
$10.74 \text{ } \mu\text{g cm}^{-2}$ ) showed relatively high wax content than dwarf cultivars such as Malayan Yellow Dwarf (MYD) ( $52.33 \pm 12.44 \text{ } \mu\text{g cm}^{-2}$ ) and Chowghat Green Dwarf (CGD) ( $53.04 \pm 5 \text{ } \mu\text{g cm}^{-2}$ ). Furthermore, seedlings of tall cultivars subjected to water stress (grown under 50 % and 25 % field capacity) showed increase in leaf epicuticular wax. Kalpa Pratibha showed 4.86 % and 24.38 % increase in ECW when subjected to 50 % and 25 % field capacity water stress respectively whereas corresponding values for Kalpatharu were 1.63 % and 2.26 %. Seedlings of dwarf cultivars did not show significant increase in wax content despite under moisture-deficit stress (Table 16).

**Table 16. Epicuticular wax content of the leaves in coconut seedlings under water-deficit stress**

Moisture regime (Field capacity)	Coconut variety	Wax content ( $\mu\text{g cm}^{-2}$ )						
		I	II	III	IV	V	Mean	SD
100%	Kalpa Pratibha	40.38	63.88	41.29	69.25	58.70	54.70	13.20
50%	Kalpa Pratibha	40.55	62.96	40.92	79.07	68.33	57.36	16.50
25%	Kalpa Pratibha	60.75	64.07	70.37	80.92	64.07	68.04	7.99
100%	Kalpatharu	72.40	71.48	70.18	96.11	77.40	77.51	10.74
50%	Kalpatharu	59.44	93.00	68.70	96.29	76.48	78.78	15.73
25%	Kalpatharu	70.76	82.77	89.44	78.88	74.44	79.26	7.27
100%	MYD	47.03	50.92	47.59	73.89	42.22	52.33	12.44
50%	MYD	49.25	44.81	46.11	67.40	44.07	50.33	9.74
25%	MYD	54.23	40.18	51.11	67.77	46.85	52.03	10.25
100%	CGD	54.67	47.40	48.14	58.51	56.48	53.04	5.00
50%	CGD	42.76	46.48	46.66	67.40	47.96	50.25	9.78
25%	CGD	51.51	52.22	58.88	54.24	48.51	53.07	3.84

### 6.1.2. *In vitro* coconut pollen germination and its viability

Pollen germination was observed in 11 genotypes at temperatures ranging from 10°C to 50°C at an interval of 5°C for two hours (Fig. 131). The optimum temperature required for pollen germination ranged from 24.55°C to 29.31°C with a mean of 27.28°C. Higher optimum temperature of 29.31 °C for pollen germination was required for Laccadive Micro Tall (LMT) (a tall variety), Malayan Yellow Dwarf (MYD) x West Coast Tall (WCT) (hybrid) and Malayan Yellow Dwarf (a dwarf cultivar). On the other hand, comparatively low optimum temperature (25.7 °C) for pollen germination was observed with Chowghat Orange Dwarf, Chowghat Orange Dwarf x West Coast Tall and Chowghat Green Dwarf.

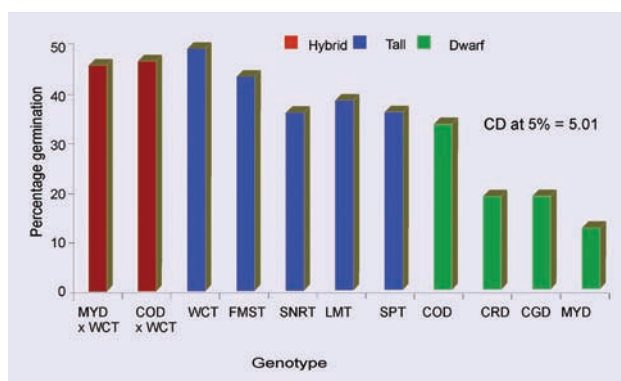


**Fig. 131. Percentage pollen germination at different temperatures averaged over all genotypes**

Tall cultivars, in general, maintained an acceptable level of germination (more than 45 %) from 20°C to 35°C, but showed a decline of about 35 % when the temperature rose to 40°C. Dwarfs, on the other hand, showed a germination percentage of 30-32 % only at near-optimum temperatures, i.e. 25°C and 30°C. At temperatures higher or lower than that, germination was significantly reduced (at 35 °C by 23% and at 20 °C by 28 %) and at 40°C, germination was lower than 5%. Hence, based on this preliminary analysis it is highly likely that tall and dwarfs show contrasting pollen germination response to high temperature (Fig. 132).

### 6.1.3. Carbon sequestration potential

Carbon content of soil and biomass was measured in different crop and plantation eco-systems. Forest ecosystem in NE India recorded highest soil organic carbon (SOC) at 0-30 cm (0.917 %) and at 30-60



**Fig. 132. Mean percentage pollen germination of various genotypes averaged over the studied temperature range**

cm (0.694 %). Soil organic carbon sequestered upto 0-60 cm soil depth was 63.327 t ha<sup>-1</sup>, 52.796 t ha<sup>-1</sup>, 44.541 t ha<sup>-1</sup> for forest, arecanut-based high density multi-species cropping system (HDMSCS) and fallow land respectively.

In coconut-based HDMSCS, above ground C sequestration has been studied for two consecutive years. It was estimated that a 48 year old tree has 417.30 kg palm<sup>-1</sup> of stem dry weight [36.93 tons ha<sup>-1</sup>] which is equivalent to 135.54 tons CO<sub>2</sub> ha<sup>-1</sup> carbon sequestration. The annual increment of carbon sequestration has been estimated to be 0.48 tons C ha<sup>-1</sup>. Among different species of fruit crops, biomass, carbon and CO<sub>2</sub> sequestration was highest in *Syzygium cumini* (130.51 kg tree<sup>-1</sup>, 9.79 and 35.92 t ha<sup>-1</sup>) followed by *Mangifera indica* (70.76 kg tree<sup>-1</sup>, 5.31 and 19.48 t ha<sup>-1</sup>) and was the least in *Garcinia indica* (25.19 kg tree<sup>-1</sup>, 6.93 and 30.11 t ha<sup>-1</sup>).

### 6.1.4. Kalparasa yield

Sap yield is influenced by many factors such as palms, genotype, farm locations, skill of the tappers and environment etc. Further, diurnal, and seasonal variations were also observed in sap yield which is also influenced by the tree and the spadices it produce. Significant differences were seen for sap production between farms. In general, a high sap yield was recorded in irrigated farms of Goa, Pollachi (Tamil Nadu), West Bengal, and Palakkad (Kerala) compared to the rainfed tracts of Kasaragod (Kerala). Under irrigated conditions, on an average 3 to 4 litres of sap was collected while under rainfed condition it was 1 to 2 litres per day. Sap flow was found to be higher during cool nights of winter months and rainy season compared to summer months. In Kasaragod condition most of the tall and hybrids yielded 2 to 4 litres a day while dwarf yield was 1 to 1.5 litres a day. On an average, a spadix could produce 1.5 to 3.0 litres of sap per day or 60 to 80 litres in a span

of 40 to 45 days. Even if the sap produced from six of the twelve spadices are tapped and the remaining were allowed to produce nuts, around 400 litres of sap and few nuts could be harvested per tree per year. The sap yield is again influenced by the skill of the tappers. Highly skilled tappers could tap the spadix for two months as against average tapping of 30-45 days.

## 6.2. Product Diversification

### 6.2.1. Kalpa Bar Dark Chocolate

Kalpa Bar, a coconut sugar based chocolate purely made from plant based ingredients without dairy milk (Fig.133), is a joint venture between ICAR-CPCRI and CAMPCO (Central Arecanut and Cocoa Marketing and Processing Cooperative Ltd.). It contains cocoa powder, coconut sugar, natural vanilla extract and GMO free sunflower lecithin as ingredients. Also, it does not contain any added artificial ingredients. It is a delicious dark chocolate for a healthy life as it is low in glycemic index. It can be stored under room temperature as it does not melt and is made available in 40 g slabs.



**Fig. 133. Kalpa Bar - A coconut sugar based dark chocolate**

### 6.2.2. Kalpa Krunch

Coconut milk residue (CMR) is the main underutilized by-product of virgin coconut oil processing, which is rich in dietary fibre, protein, polyphenols and antioxidants. Towards encouraging optimum utilization of by-products generated in the process and ensuring higher economic returns and viability of the VCO technology healthy, natural and crispy

extrudates from coconut milk residue was developed and christened as *Kalpa Krunch* (Fig. 134). It is a coconut milk residue enriched ready to eat extruded snack. The optimized formulation is rice flour (60%), corn flour (25%) and coconut milk residue flour (15%). It is coated with natural and healthy flavours like coriander, garlic, turmeric, clove, cinnamon, chilli, mint, cardamom, tomato and celery. No microflora was detected even after three months of storage in two layer packaging film. *Kalpa Krunch* is rich in fibre, protein, fat and carbohydrate with antioxidant activity; it is therefore a healthy, nutritious and crunchy snack food for people of all age groups. *Kalpa Krunch* technology was released for commercialization during the 'Kisan Mela' organized at ICAR-CPCRI Regional Station, Kayamkulam on 29<sup>th</sup> September 2016 by Hon'ble Union Minister of Agriculture and Farmers Welfare, Govt. of India.



**Fig. 134. Kalpa Krunch - A coconut milk residue based crispy extrudate snack**

#### 6.2.2.1. Coconut milk residue and composition of mixed flours

The nutrient profile of coconut milk residue (CMR), enumerating its moisture content, carbohydrate, protein, fat and ash content, are presented in Table 17. The proximate analyses of the mixed flour indicate that protein content of flour after extrusion was slightly higher than that of flour before extrusion. The fat content of flour after extrusion (5.95 %) was lower than that of flour before extrusion, which could be attributed to the interaction between amylose and lipid during extrusion. The ash content of the mixed flour before extrusion was less than that of flour after extrusion.

**Table 17. Proximate analysis of CMR and mixed flour composition**

Composition	Moisture (%)	Carbohydrate (%)	Protein (%)	Fat (%)	Ash (%)
CMR	6.523 (0.04)	23.46 (0.16)	4.80 (0.08)	43.192 (0.19)	0.960 (0.02)
FBE	14 (0.14)	71.92 (1.13)	5.03 (0.06)	7.550 (0.08)	0.744 (0.04)
FAE	3.312 (0.06)	76.31 (1.22)	7.85 (0.14)	5.951 (0.11)	1.927 (0.05)

CMR-Coconut milk residue, FBE- Flour before extrusion, FAE-Flour after extrusion

\*Values in parenthesis represent the standard deviation

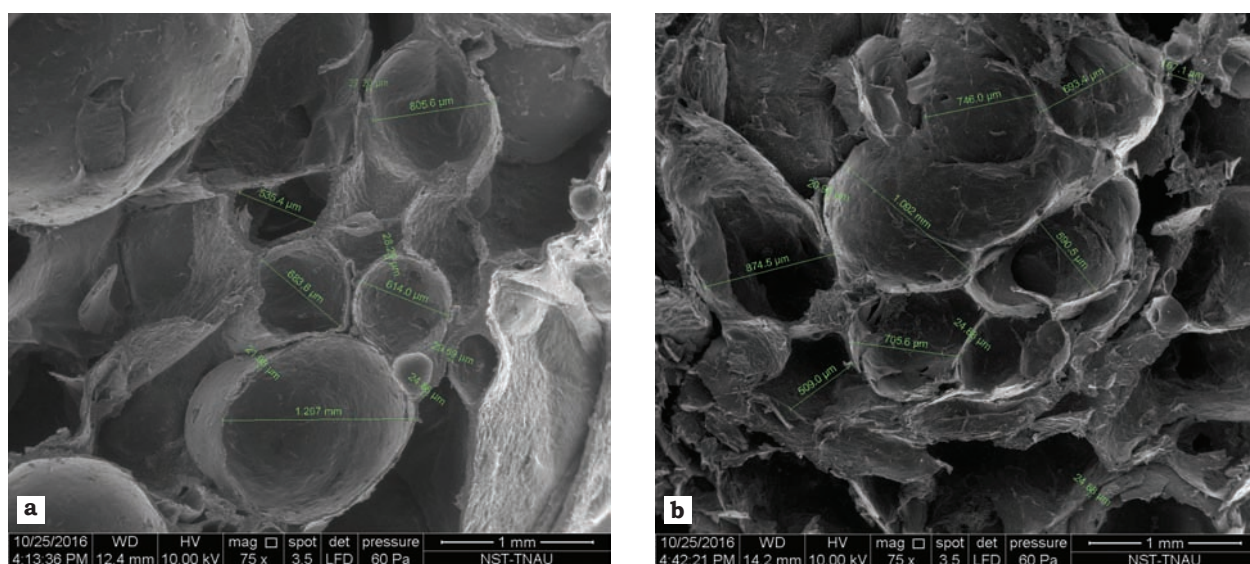
#### 6.2.2.2. Scanning electron microscopy of extruded product: Kalpa Krunch

The ultra structure of the CMR enriched extrudates was studied with scanning electron microscope (Fig. 135). The scanning electron micrographs revealed that the extrudates containing 15 % CMR formed a dense network and more compact texture. Further, number of cells per unit area was found to be increased and the cell size was apparently smaller compared to extrudates from corn and rice flour. Also, the cell sizes in the centre of the extrudate were larger than those on the edges. It is evident that increasing fibre content in the form of CMR caused premature rupture of cells and the cell walls have become thicker.

#### 6.2.3. Feasibility of coconut milk residue for cold extrusion

Pasta is the main product prepared through cold extrusion method. An experiment was carried out to explore the feasibility of using coconut milk residue (CMR), a nutritious underutilized co-product of coconut milk, for the preparation of fibre enriched pasta. Coconut milk residue was added at the rate of 0-20 % to durum wheat semolina to prepare pasta (Fig. 136). The proximate composition analysis of the CMR based pasta is presented in Table 18.

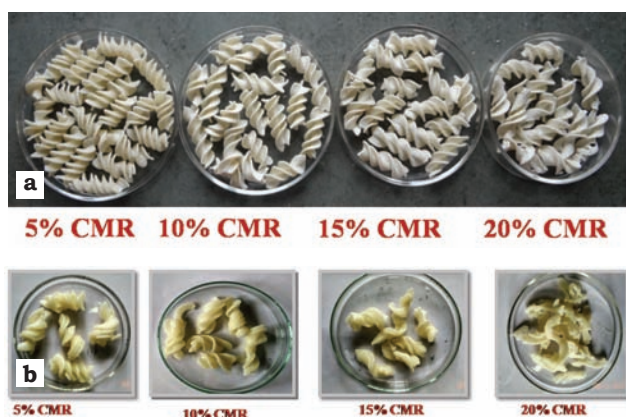
Significant improvement was observed for all parameters of cooking quality such as cooking time, swelling index, gruel loss, water absorption and



**Fig. 135. Scanning electron micrographs of control (a) and CMR enriched (b) extrudate**

**Table 18. Proximate analysis of the ingredients of coconut milk residue (CMR) based pasta**

Ingredients	Average composition $\pm$ SD					
	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Carbohydrate (%)	Crude fibre (%)
CMR	2.23 $\pm$ 0.31	5.00 $\pm$ 0.02	41.55 $\pm$ 0.13	0.97 $\pm$ 0.02	26.24 $\pm$ 0.67	24.03 $\pm$ 0.50
Wheat semolina	13.5 $\pm$ 0.14	11.67 $\pm$ 0.15	1.79 $\pm$ 0.03	0.5 $\pm$ 0.02	71.07 $\pm$ 0.24	1.42 $\pm$ 0.03



**Fig. 136. Raw (a) and cooked (b) coconut milk residue (CMR) enriched (0-20% incorporation) pasta**

texture. The average cooking time varied from 6.6 to 8 minutes. Swelling index was maximum for pasta with 20 g CMR 100g<sup>-1</sup>. About 0.84 to 1.34 % gruel loss was observed among the treatments. Higher water absorption was observed in the cooked pasta samples containing higher concentration of CMR (114.52 to 182.4 % for 0 to 20 % CMR incorporation respectively), which is due to the weaker gluten network. Firmness value reduced significantly ( $p < 0.01$ ) after the addition of CMR. Significant colour change due to incorporation of CMR was evident from the higher L\* (lightness) value obtained in the raw and cooked pasta as compared to the control. Overall, a high sensory score was obtained for the control which was followed by pasta with 10 % CMR. Based on the cooking qualities and sensory attributes, pasta with 10 % CMR was selected for further storage studies. Effect of storage time was not significant on the quality of pasta indicating that pasta was acceptable up to three months when stored in polyethylene bag of 100  $\mu$  thickness without addition of any preservative under ambient condition.

#### 6.2.4. Formulation of coconut milk residue based rusk

Rusk is a hard, dry biscuit or twice-baked bread. The major ingredient of rusk is refined wheat flour. Efforts were made to formulate coconut milk residue based rusk to enrich the fibre content of the final product, apart from enriching other nutrients such as protein and minerals. Standardization of rusk preparation was done with different combinations of the composite flours consisting of coconut milk residue, refined wheat flour and soy flour. The treatments which yielded preferred attributes in terms of baking quality and appearance comparable with commercially available rusk were taken for biochemical and sensory evaluation. Based on the sensory evaluation, rusk with 50 % refined wheat

flour, 40 % coconut milk residue and 10 % soy flour was identified as the best combination (Fig. 137). The biochemical evaluation of the optimized product is given in Table 19.



**Fig. 137. Nutrient enriched coconut milk residue (CMR) based rusk**

**Table 19. Biochemical constituents of coconut milk residue (CMR) based rusk**

Composition	g / 100 g
Moisture	2.5
Carbohydrate	61.6
Protein	10.2
Crude fat	25.7
Crude fibre	38.5
Minerals	2.0

#### 6.2.5. Formulation of coconut milk residue based fried snacks

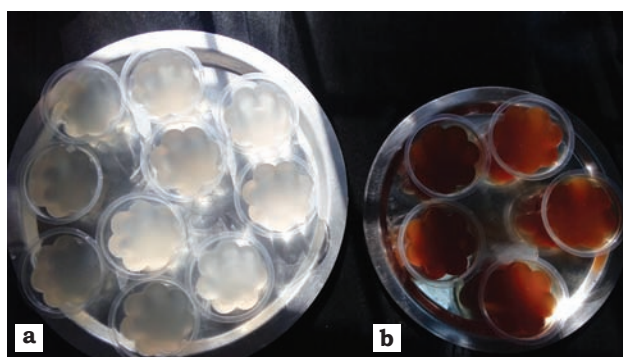
Traditional fried snacks are made from refined wheat flour (RWF)/Bengal gram/rice flour either alone or in combination. Feasibility of using CMR for fried snacks was evaluated by incorporating it at the rate of 0- 30 % (Fig. 138) . The optimized combination comprise 28 % RWF, 30 % Bengal gram, 20 % CMR, 20 % rice flour and 2 % salt. Higher CMR concentration resulted in more oil absorption hence not desirable.

#### 6.2.6. Tender nut water jelly

A delicacy called tender nut water jelly has been prepared from tender coconut water with the addition of a gelling agent (Fig. 139). Pectin, citric acid, sugar and water are the four essential ingredients of jelly. Among the factorial combinations of 65, 75, 85 and 95°C temperature and 5, 10 and 15 minutes of heating 85°C for 10 minutes was optimized. Replacement of



**Fig. 138. Coconut milk residue (CMR) enriched fried snacks**



**Fig. 139. Tender nut water jelly prepared by blending cane sugar (a) and coconut sugar (b)**

tender nut water with coconut inflorescence sap and cane sugar with coconut sugar were also undertaken for enrichment of nutrients and minerals. The experiments were conducted with three different combinations (one litre coconut inflorescence sap + 100 g coconut sugar, one litre tender nut water + 150 g coconut sugar and one litre tender nut water + 150 g cane sugar) at the optimized level of heating temperature and time. Among the various blends, tender coconut water (84 %), cane sugar (15 %) and agar (1 %) combination scored maximum acceptability in organoleptic evaluation.

#### 6.2.6.1. Biochemical constituents

Studies were conducted to identify the biochemical constituents of the jelly prepared. Replacement of coconut sugar with cane sugar significantly increased the biochemical constituents like soluble proteins, amino acids, vitamin C, phenolics, antioxidant potential, potassium, sodium, phosphorous and iron content in the final product. Similar type of changes in the biochemical composition was observed in the jelly prepared by replacing the tender coconut water with coconut sap (Table 20). Though the nutrient and minerals were rich in coconut inflorescence sap and coconut sugar based jelly, the sensory score was highest in tender nut water and cane sugar based jelly.

**Table 20. Biochemical constituents of coconut water/sap based jelly**

Parameters	Tender nut water+ cane sugar	Tender nut water+ neera sugar	Neera + neera sugar
Moisture (%)	73.27±1.20	76.63±0.05	67.49±1.21
Total sugar (g)	12.81±1.88	15.58±1.16	14.45±3.42
Reducing sugar (g)	3.93±0.23	2.90±1.72	3.93±1.89
Amino acids (mg)	44.92±13	78.64±14	111.37±56
Protein (mg)	210.92±55	234.84±89	309.37±64
Vitamin C (mg)	1.55±0.31	3.30±0.10	7.74±0.10
Phenolics (mg GAE)	16.16±4.9	37.89±2.12	47.11±8.72
Antioxidative activity* (mg TE)	31.94±6.45	98.47±9.30	130.32±4.6
Sodium (mg)	5.54±1.19	22.15±1.34	23.81±1.77
Potassium (mg)	171.11±1.29	220.44±0.58	171.85±0.44
Phosphorus (mg)	5.23±0.01	15.33±0.31	16.87±0.25
Iron (mg)	0.233±0.04	0.375±0.04	0.577±0.10
Overall acceptability (Sensory score)	7.5±1.21	6.25±1.27	6.75±1.32

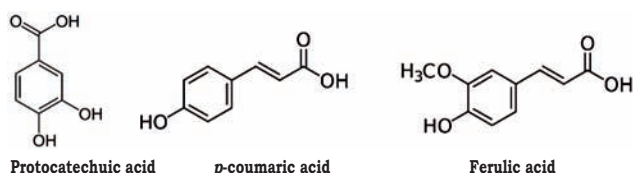
Values are in mean± SD. All values are in 100 g fresh weight basis; GAE – Gallic acid equivalent; TE – Trolox Equivalent

\*Antioxidant activity measured by CUPRAC method

#### 6.3. Identification of anti-oxidant potential of coconut testa

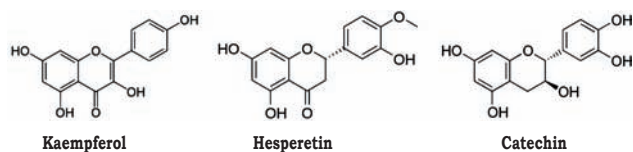
Coconut testa is one of the richest sources of polyphenolic compounds with high antioxidant potential. A study was conducted to identify the individual phenolic acids and flavonoid constituents

present in the coconut testa using Acquity UPLC-H class coupled with TQD-MS/MS with ESI source. Polyphenolic compounds from testa were extracted using different solvent systems and the identification of individual phenolic compounds was carried out by comparing the retention times, the MS and MS/MS spectral data with those obtained for the available standards. A total number of 16 phenolic acids were identified in different solvent extracts and conformed with commercial standards. Out of 16 phenolic acids, three belonged to monohydroxy benzoic acid derivatives (salicylic acid, *p*-hydroxy benzoic acid and 3-hydroxy benzoic acid); four belonged to dihydroxy benzoic acid derivatives (protocatechuic acid, vanillic acid, 2,4-dihydroxy benzoic acid, gentisic acid); two of trihydroxy benzoic acid derivatives (gallic acid and syringic acid) and seven belonged to hydroxyl cinnamic acid derivatives (chlorogenic acid, ferulic acid, caffeic acid, *p*-coumaric acid, *o*-coumaric acid, sinapic acid and cinnamic acid). Major phenolic acids identified were protocatechuic acid, *p*-coumaric acid and ferulic acid (Fig. 140).



**Fig. 140. Major phenolic acids identified in coconut testa**

About 12 flavonoids were identified in coconut testa extracted with different solvent systems. Among them, three belonged to flavan-3-ol (catechin, epicatechin and epigallocatechin); three to flavonol (myristin, quercetin and kaempferol); and a flavonol glycoside (rutin); two of flavone (leteolin and apigenin); two of flavanone (naringenin and hesperetin) and a coumarin derivative (umbelliferone). Major flavonoids identified were kaempferol, hesperetin, and catechin (Fig. 141).



**Fig. 141. Major flavonoids identified in coconut testa**

Nature of the solvents significantly influenced the extractability of individual phenolic acids and flavonoid compounds from the coconut testa. Acidified acetone was found to be the suitable solvent system for the extraction of phenolic acids

whereas flavonoids are better extracted with both pure and acidified ethanol followed by acidified methanol.

## 6.4. Machineries and gadgets for gender mainstreaming

### 6.4.1. Prototype of self loading arecanut dehusking machine

A beating type arecanut de-husking machine has been developed in the Institute (Fig. 142.). The machine has a capacity to de-husk 48 kg (*chali*) hour<sup>-1</sup>. It could reach up to 55 kg h<sup>-1</sup>, if the nuts are uniform in shape and the machine has an automatic feeding device. An arecanut grading unit was fabricated with an automatic feeding mechanism to avoid manual feeding of arecanut (Fig. 143). Since the machine works based on beating action of the nylon shafts, a large quantity of dust is produced especially when old nuts were de-husked. In order ensure the safe disposal of the dust formed, a dust collection chamber was developed and connected to the outlet of the blower. Technical performance of the dehusking machine was conducted both in the institute farm and in the farmers' field. It could reduce the labour cost of dehusking to one fifth of the cost incurred in manual dehusking.



**Fig. 142. Arecanut dehusking machine with self-loading device and dust collection chamber**



**Fig. 143. Arecanut grading machine and the self-loading mechanism of the grading machine**

### 6.5. Techno-socio-economic assessment of soil and water conservation and water harvesting structures

Technical soundness of water harvesting/conservation structures developed under the Rural Infrastructure Development Fund of NABARD executed by the Dept. of Soil Survey and Soil Conservation, Govt. of Kerala, was evaluated. Concrete structures, check dam and ventilated cross bar were observed to be technically superior. Terracing was the best soil-water conservation

intervention observed for coconut. The water table improved by 1m (0.5 m to 1.5 m depth of water) in May by terracing 13 acres of land with a slope of 30%. Equivalent water availability in May was 48750 litres day<sup>-1</sup>. Together, terracing and improved irrigation, enhanced coconut yield from 40 nuts/ tree/ year to 70 nuts/ tree/ year (57 %). Nearly one thousand cubic meters (1033 m<sup>3</sup>) of soil was accumulated in three years in the Kariyottuchal watershed from 765 numbers of loose boulder check dams (Fig. 144).



**Fig. 144. Water harvesting structures comprising concrete structures, check dam - ventilated cross bar**



# TECHNOLOGY TRANSFER, ECONOMICS AND STATISTICAL MODELS

## 7.1. Technology transfer and co-learning action research approaches

### 7.1.1. 'Kalparasa' for higher income from coconut farming - the success story of a young farmer

The success story of a young farmer, Mr. Shaju from Udayagiri village in the hilly terrain of Kannur district, who is earning a substantial income from Kalparasa extraction and marketing, is quite an inspiring one. Mr. Shaju came to know about Kalparasa from the office bearers of Udayagiri Coconut Producer Federation under the Thejaswini Coconut Producer Company and also from farm news and publications including ICAR-CPCRI. With the preliminary information he could gather on Kalparasa, he developed keen interest for planning the production of Kalparasa from the coconut palms in his farm. Mr. Shaju turned to farming after completing his pre-degree course. From childhood onwards, he used to climb coconut and arecanut palms. He attended the Kalparasa technician training programme for 1 ½ months duration conducted by the Udayagiri Coconut Producer Federation and acquired the required skill in Kalparasa tapping. After the successful completion of the training, Shaju started tapping Kalparasa from 12 selected coconut palms in his garden (Fig. 145).

The 'coconut sap chiller' device developed by ICAR-CPCRI and other necessary gadgets for Kalparasa extraction was made available by the Coconut

Federation. He collects Kalparasa from the coconut palms twice a day (morning between 6.00 am and 10.00 a.m and evening between 4.00 pm and 7.30 p.m). Mr. Shaju is able to collect on an average three litres of Kalparasa per palm, and from some palms the yield goes up to five litres per day. Neera is sold in the sales counter of Udayagiri Coconut Federation @ ₹ 70/-per litre. Hence, Mr. Shaju is able to realize a substantial income from sales of Kalparasa, on an average @ ₹ 75000/- per month from 12 palms tapped, apart from the income from the other components in his farm including vegetables, milch cows etc. After he started Kalparasa collection and marketing, he was able to repay the bank loan taken for rubber cultivation and other purposes. He gets support in farming from his wife Mrs. Lusy and childrens, Ms. Diya and Mr. Jithu.

### 7.1.2. Harvesting wisdom of coconut growers

A team of scientists from ICAR-CPCRI visited the identified farmers' gardens and documented experiences of successful coconut growers. Farmers were selected in consultation with the concerned State Agriculture/Horticulture Departments, Coconut Development Board, All India Co-ordinated Research Project (Palms) Centres functioning under ICAR-CPCRI and Krishi Vigyan Kendras. The team of scientists identified for each state interacted with the above agencies and finalized the list of selected farmers. A structured interview schedule was employed for collecting socio-personal profile of the coconut farmers, details of the coconut gardens, extent of adoption of improved farming practices including improved varieties and quality planting materials, effective water management and irrigation techniques, integrated nutrient management, multiple cropping and integrated farming, integrated pest and disease management, value addition through product diversification, innovative farming practices evolved, economics of coconut farming, marketing practices, efforts made for disseminating improved coconut production technologies among other farmers and linkages with research, development and extension institutions. The invaluable experiences of 100 innovative coconut



**Fig. 145. Mr. Shaju along with the team from ICAR-CPCRI in his coconut garden**

growers across 12 major coconut growing tracts are documented as a book 'Harvesting Wisdom of Coconut Growers'. The innovative farmers were honored by Dr. Trilochan Mohapatra, Secretary DARE and Director General ICAR, New Delhi on 10<sup>th</sup> December, 2016 at ICAR-CPCRI, Kasaragod (Fig. 146-147).



**Fig. 146. Shri Radha Mohan Singh, Hon'ble Union Minister for Agriculture and Farmers' Welfare interacting with innovative coconut growers**



**Fig. 147. Honouring innovative coconut growers during centenary celebrations at ICAR-CPCRI, Kasaragod**

### 7.1.3. Frontline Demonstrations

#### 7.1.3.1. Demonstration on soil health management for enhancing productivity of coconut

The multi-institutional farmer participatory project, funded by the Kerala State Planning Board, was implemented in farmers' fields across the diverse agro-ecosystems of the Kerala state to demonstrate that productivity of coconut could be substantially enhanced through the use of appropriate external inputs and management strategies. A total of 60 coconut gardens spread over six districts of Kerala viz., Kannur, Kozhikode, Ernakulam, Alappuzha, Kollam and Pathanamthitta (10 coconut gardens each with 30-40 palms per district) were selected for demonstrating the interventions. Observations on

pre-treatment yield were recorded and subsequently, changes were monitored.

#### 7.1.3.2. Coconut root (wilt) disease management

Frontline demonstrations were established in 35 ha of farmers' gardens (5 ha in each district) in the panchayaths of Elakamon in Thiruvananthapuram, Kulasekharapuram in Kollam, Cherthala South in Alappuzha, Nedumpuram in Pathanamthitta, Kooroppada in Kottayam, Vellangallur in Thrissur and Parakkadavu in Kozhikode districts in Kerala. The project focuses on farmer-participatory strategies linking with the Keragramam scheme being implemented by the Department of Farmers' Welfare and Agricultural Development, Govt. of Kerala. The scientists of ICAR-CPCRI facilitate technology implementation, awareness - building and documentation (Fig. 148). Extension officials of Department of Agriculture, local panchayaths, coconut farmers' organization and farmers are partners in these front line demonstrations. The management strategies adopted were soil test based nutrition management, leaf rot disease management using biological and chemical means, *Metarhizium* treatment in breeding sites of rhinoceros beetle (farm yard manure pits), prophylactic leaf axil filling in seedlings, basin management with cowpea and community based red palm weevil management. The observable impact was 50 per cent reduction in leaf rot disease.



**Fig. 148. Demonstration on management of coconut root (wilt) disease**

Training programmes, documentation of palms and farmers profile, field visits along with linkages with Department of Agriculture and Farmers' Welfare and coconut farmers' organizations were done. Leaf rot disease was reduced by 48 percent and knowledge of the participant farmers improved by 60 to 80 percent. Reduction in general yellowing was also reported due to the interventions. The total area is 35 ha @ 5 ha contiguous area in farmers' fields/ panchayath with

120 farmers and 2000 palms in total. The average disease index was 33.2 indicating predominance of palms in the 'disease middle' categories.

#### 7.1.3.3. Farmers' participatory research - cum demonstration plots on cocoa

Fifty demonstration plots (comprising of one ha each) on cocoa technologies were maintained in five districts viz., West Godavari, East Godavari, Krishna, Vishakapatnam and Vizianagaram in Andhra Pradesh (Fig. 149). In twenty five plots, the focus was on improved varieties, five plots each on pruning, integrated nutrient management, organic farming, pest and disease management and post harvest processing were maintained. Training programmes, farm advisory visits and technical guidance were provided for realizing higher productivity and profitability from cocoa farming. Techno-socio-economic feasibility of the technologies is being assessed on a participatory mode.



**Fig. 149. Demonstration plot on integrated nutrient management in cocoa in West Godavari**

#### 7.1.3.4. Management of root grubs in arecanut

Demonstration of EPN formulation for the bio-suppression of root grub in arecanut ecosystem was conducted in farmers' gardens at Sullia taluk of Karnataka (Fig. 150-151). Treating the palms with liquid culture of EPN, *Steinernema carpocapsae* @ 1.5 billion IJs (infective juveniles) ha<sup>-1</sup> during June-July, in combination with imidacloprid (0.0045 %) during September-October and application of neem cake @ 2 kg palm<sup>-1</sup> during post monsoon effectively reduced the root grub population (about 91 %) in gardens.

#### 7.1.3.5. Participatory demonstration plots on arecanut based multi-species cropping system

Eight farmers with one ha each of arecanut gardens (three in Belthangady taluk, two in Bantwal taluk, one each in Mangaluru, Puttur and Sullia taluks of



**Fig. 150. Application of EPN in the palm basin**



**Fig. 151. Root grub infected with EPN**

Dakshina Kannada district, Karnataka) were selected for establishing demonstration plots on Arecanut Based Multispecies Cropping System funded by the Directorate of Arecanut and Spices Development (DASD). Data on farming practices, income and expenditure of farmers were collected. Beneficiary farmers were supplied with cocoa grafts, pepper cuttings and banana suckers and technical advice on cultivation of arecanut, cocoa, black pepper and banana was also imparted. Various transfer of technology programmes including field days and training programmes on arecanut based multi species cropping system were organized.

#### 7.1.4. Cocoa as an intercrop in coconut in Andhra Pradesh: A successful model for doubling farmers' income

'A multi-dimensional analysis' of cocoa farming in Andhra Pradesh was conducted among 60 cocoa growers selected randomly from two major cocoa growing areas viz., West Godavari and East Godavari districts of Andhra Pradesh. Data were collected during 2016 through personal interview, non-participant observation technique and focus group discussions. Majority of the farmers (72 %) belonged to middle age category, 87 % of them were literates, 78 per cent of farmers had more than seven years of experience in cocoa cultivation, 62 per cent were

very big farmers, majority (60 %) had cattle and poultry as a livestock component and 58 per cent had undergone training on cocoa. However, only 35 per cent of farmers maintained farm records and soil testing was done by only 32 per cent farmers. Average age of the cocoa trees was 8.4 years with cocoa population of 1795 per farmer. KAU and ICAR-CPCRI were the source of cocoa seed pods whereas, seedlings were distributed mainly by Mondelez India Foods Pvt. Ltd.

Farm yard manure was used by majority (90 %) of the farmers, followed by NPK fertilizers (87 %), green leaf manure/crop residues (82 %), neem cake (68 %) etc. Major pests/deficiencies which caused economic losses were, rodents/civets (8.5 %), leaf eating insects (5 %), mealy bugs (4.5 %) and Zn deficiency (3.8 %). With respect to diseases, pod rot (6.4 %) caused maximum economic loss followed by charcoal pod rot (3.9 %), cherrille wilt (3.2 %) and canker (2.2 %). All the farmers processed the beans by fermentation and drying, which was marketed through mainly traders and Mondelez India Foods Pvt. Ltd. Majority of cocoa growers (72 %) had medium level of knowledge about scientific cultivation. Correlation analysis showed that education, farming experience, extension orientation and training attended had a positive and significant relationship with knowledge. *Garret's ranking* revealed that additional income (2.53), suitable intercrop in coconut (2.31) and enriching soil fertility (1.93) were the main advantages of cocoa as perceived by farmers. Mean yield of cocoa was found to be 1.94 kg tree<sup>-1</sup>year<sup>-1</sup> and 970 kg ha<sup>-1</sup>year<sup>-1</sup>. Gross returns realized from cocoa was calculated as ₹ 407 tree<sup>-1</sup>year<sup>-1</sup> and ₹ 2,03,700 ha<sup>-1</sup> year<sup>-1</sup>. Non-availability of skilled labour, non-availability of quality inputs, lack of knowledge about scientific farming practices, incidence of pests and diseases and nutrient deficiencies were the major constraints.

### 7.1.5. Kisan Mela

#### Kayamkulam (Kerala)

'National Meet on Prospects of Coconut Sector' and 'Kisan Mela 2016' were organized during 29-30 September, 2016 at ICAR-CPCRI, Regional Station, Kayamkulam. Shri Radha Mohan Singh, Hon'ble Union Minister of Agriculture and Farmers' Welfare inaugurated the meet, (Fig. 152 - 153) which was attended by more than 3500 farmers. A digital initiative 'e-Kalpa' (mobile based app) for technology delivery, interactive learning and real time data recording was launched during the occasion for the benefit of farmers and other stakeholders. An exhibition was organized in which various stakeholders displayed their latest technologies for the benefit of the farming community.



**Fig. 152. Inauguration of Kisan Mela by Shri. Radha Mohan Singh, Honourable Union Minister for Agriculture and Farmers' Welfare, Govt. of India**



**Fig. 153. Shri Radha Mohan Singh, Honourable Union Minister for Agriculture and Farmers' Welfare, Govt. of India addressing the gathering**

#### Mohitnagar (West Bengal)

A Kisan Mela-cum-Workshop on Horticulture Development for sub-Himalayan Terai region was organized during 20<sup>th</sup>-21<sup>st</sup> October, 2016 at ICAR-CPCRI, Research Centre, Mohitnagar (Fig. 154). Farmers' interface programme and a seminar on 'Recent Advances in Cocoa Production Technology' were conducted. More than 1000 farmers participated in the event.

#### Kasaragod (Kerala)

Kisan Mela-cum-Centenary Expo was held during 10-13<sup>th</sup> December 2016 at ICAR-CPCRI, Kasaragod. Shri Radha Mohan Singh, Hon'ble Union Minister of Agriculture and Farmers' Welfare, Govt. of India, was the chief guest and inaugurated the Kisan Mela on 10<sup>th</sup> December 2016 (Fig. 155-156). More than 5000 farmers participated in the Kisan Mela. Interface programmes, farm produce show, demonstrations and exhibitions were also organized benefiting more than one lakh stakeholders. Hon. Union Minister also inaugurated centenary building, Kalpaka guest house



**Fig. 154. Exhibition and Kisan Mela inaugurated by Shri Khageswar Roy, Hon'ble Member of Legislative Assembly (Rajganj), Govt. of West Bengal**



**Fig. 155. Inauguration of Kisan Mela and Centenary Expo by Shri Radha Mohan Singh, Honourable Union Minister for Agriculture and Farmers' Welfare, Govt. of India, at Kasaragod**



and centenary park. Shri E. Chandrasekharan Nair, Hon. Minister for Revenue, Govt. of Kerala, also graced the occasion.

#### **7.1.6. Workshop on coconut leaf craft**

A workshop on coconut leaf craft was organized during 6-8<sup>th</sup> September, 2016 at Kasaragod in collaboration with Folkland, Kasaragod and Indian National

Trust for Art and Cultural Heritage (Fig. 157-158). One hundred participants, covering craft artists, scientists and other stakeholders, participated in the workshop. An interaction with artists, scientists and students was also organized along with the workshop on 7<sup>th</sup> September, 2016. A seminar on 'Coconut Leaf and Kerala Community: Art, Rituals, Crafts and Sustainability' was organized on 8<sup>th</sup> September, 2016.



**Fig. 156. Address by Chief Guest Shri Radha Mohan Singh, Honourable Union Minister for Agriculture and Farmers' Welfare, Govt. of India**



**Fig. 157. Honouring leaf craft artist by Director, ICAR-CPCRI**

#### 7.1.7. Exhibitions

The Institute has participated in 33 exhibitions (Kasaragod-14 (Fig. 159), Kayamkulam-5 (Fig. 160), Vittal-4, Kidu-3, Kahikuchi -3 and Mohitnagar-4), providing an insight on the activities of ICAR-CPCRI to large number of farmers, college and school students, industrialists and general public. Technologies on



**Fig. 159. Shri Radha Mohan Singh visiting Exhibition stall of ICAR-CPCRI arranged during Centenary Expo at Kasaragod**



**Fig. 160. Shri Radha Mohan Singh interacting with scientists at Regional Station, Kayamkulam**



**Fig. 158. Leaf crafts prepared during the workshop**

varieties, crop production, protection and processing were displayed to provide first-hand information to the visitors. Institute has bagged the first prize in the Regional Horti Fair held during 15<sup>th</sup> January 2017 at ICAR-IIHR, Bengaluru.

#### 7.1.8. ICT based technology transfer initiatives

Interface programmes through interactive video conferencing (Fig. 161) were organized involving various stakeholders. In addition, mobile applications have been developed for real time data documentation, field problem solving, synchronized farming application for new farmers, farmer's diary and website. Considering the high density of mobile telephones and the ever increasing reach of the digital network in India, an Android based Mobile Application 'e- kalpa' was developed for reaching out to farming communities (Fig. 162). The contents are now available in multi-language formats. This mobile App consists of the knowledge base (coconut, arecanut and cocoa), farmers' field problems/issue management system (multi mode farm reporting of field problems and receiving advisories), online farmers' diary, synchronized farming (for new farmers and FLD/PTD farmers) and notifications (meetings/trainings/announcements). A total of 500 farmers registered and 312 farmers interacted for field problem reporting, diagnosis and solutions online. The e-kalpa will be made offline with technology snippets in local languages also.

An e-Plantation Survey App was also developed for accurate GPS tagged data collection for research projects and extension activities. The survey App could be used for any survey enabling paperless, time saving and real time data documentation in any of the csv formats for analysis without any manual data entry. This App is being used for field data collections and documentations. These applications will be integrated for enhancing usage efficiency.



**Fig. 161. Video conferencing programme with Dr. T. Mohapatra, Secretary, DARE and DG, ICAR**



**Fig. 162. Launching of e-kalpa during Kisan Mela at Kayamkulam**

#### 7.1.9. Utilization of mass media

Video films on 'ICAR-CPCRI in the service of farming community' and 'Integrated pest management in coconut' were produced in English and regional languages. Fifty four popular articles in English and regional languages, showcasing various technologies and success stories, nine radio programmes and seven TV programmes were used for dissemination of technologies to a large number of stakeholders.

#### 7.1.10. 'World Soil Day' celebrations

'World Soil Day' was celebrated at Panayal, Kasaragod in collaboration with Department of Soil Survey, Kasaragod, Govt. of Kerala on 5<sup>th</sup> December 2016, in which soil health cards were distributed to 120 farmers (Fig. 163). Interface programme on 'Soil Health Management' was organized for the benefit of more than 200 farmers and other stakeholders.



**Fig. 163. World Soil Day celebrations at Panayal, Kasaragod**

#### 7.1.11. 'World Coconut Day' celebrations

World Coconut Day celebration was organized by Coimbatore Coconut Producers Company and Vinayaka Coconut Producers Company, Pollachi in collaboration with ICAR- CPCRI, Kasaragod at Minnal Mahal, Pollachi in Coimbatore district of Tamil Nadu on 2<sup>nd</sup> September 2016 (Fig. 164). Discussions on the potential of coconut for livelihood sustainability were held among 1200 farmers and other stakeholders. ICAR-CPCRI has participated in the exhibition and displayed the key technologies on value addition for the benefit of participating farmers.



**Fig. 164. World Coconut Day celebrations at Pollachi, Coimbatore district**

#### 7.1.12. Capacity building programmes

##### 7.1.12.1. Programmes for extension personnel

A total of 23 training programmes were organized in collaboration with Department of Agriculture/ Horticulture, ATMA and other agencies for the benefit of 607 extension personnel (Kasaragod: 6 (185 participants); Kayamkulam: 8 (217 participants); Vittal: 2 (65 participants); Mohitnagar: 5 (100 participants); Kahikuchi: 2 (40 participants)).

1. Training programme on 'Advances in Arecanut and Cocoa Production Technology' was organized for officers from Department of Horticulture,



Coimbatore, Tamil Nadu at Regional Station, Vittal on 1<sup>st</sup> April 2016

2. Training on 'Hybridization techniques in coconut' for extension personnel was organized on 15<sup>th</sup> April 2016 at Kasaragod.
3. Training on 'Coconut production technology' was organized for 40 stockmen trainees from Goa on 8<sup>th</sup> August 2016 at Kasaragod.
4. Two batches of five days training programme on 'Hybridization techniques and plant health management in coconut' for extension personnel and coconut climbers from Kerala were organised during 12<sup>th</sup>-16<sup>th</sup> April, 2016 and 11<sup>th</sup>-15<sup>th</sup>, November, 2016 organized at Regional Station, Kayamkulam.
5. Three batches of five day long capacity building programmes on 'Techniques for soil health assessment' was conducted at Regional Station, Kayamkulam during 27<sup>th</sup> June to 1<sup>st</sup> July, 2016, 19<sup>th</sup> to 23<sup>rd</sup> July, 2016 and 24<sup>th</sup> to 28<sup>th</sup> October, 2016 funded by State Department of Agriculture Development and Farmers' Welfare. Fifty seven Agricultural Officers/Scientific Assistants of Krishi Bhavans and District Soil Testing Laboratories attended the programme.
6. Training on 'Cutting-edge technologies in crop protection' was organized for 25 Agricultural Assistants from Kayamkulam on 10<sup>th</sup> August 2016 at Regional Station, Kayamkulam.
7. 'Good Agricultural Practices in coconut' was organized for 90 Agricultural Officers and Assistants from Kattakada on 22<sup>nd</sup> August 2016 at Regional Station, Kayamkulam.
8. Training on 'Mass production of biocontrol agents fostering coconut health management' for 19 Assistant Agricultural Officers of the Department of Agriculture and Farmers' Welfare during 20<sup>th</sup> to 23<sup>rd</sup> February 2016 and training on 'Mass production of biocontrol agents and health management in coconut' was organized for 21 Assistant Directors and Agricultural Officers of the Department of Agriculture and Farmers' Welfare from 27<sup>th</sup> February to 2<sup>nd</sup> March, 2017 at Regional Station, Kayamkulam.
9. Training on 'Coconut production technology' was organized on 13<sup>th</sup> February 2017 for 20 officers of Coconut Cultivation Board, Sri Lanka (Fig. 165) in collaboration with Indian Institute of Plantation Management (IIPM), Benagaluru as part of the training programme on Sustainable Plantation Management at Kasaragod.



**Fig. 165. Training on coconut production technology for Officials from Sri Lanka**

#### 7.1.12.2. Programmes for farmers

Training programmes on hybridization techniques, nursery management, crop production, protection and value addition on mandate crops were conducted for the benefit of farmers. A total of 92 training programmes were organized for the benefit of 4179 farmers. Kasaragod: 35 (1470 participants); Kayamkulam: 33 (1286 participants); Vittal: 8 (630 participants); Mohitnagar: 8 (368 participants) and Kahikuchi: 8 (425 participants).

1. ATMA inter-state farmers training programme on 'Integrated crop management and value addition in coconut' was organized for 214 coconut farmers from nine districts of Tamil Nadu (nine batches) at Kasaragod
2. Training on 'Value addition in coconut and neera production' was organized on 27<sup>th</sup> May 2016 at Kasaragod for 48 farmers of NITTE Coconut Producers' Society, Uttara Kannada, Karnataka.
3. Training on 'Coconut production technologies' was organized for 25 farmers of Shivamogga, Karnataka during 24<sup>th</sup>-25<sup>th</sup> July 2016 at Kasaragod.
4. Training on 'Crop management in coconut' was organized for 60 farmers from Narsipatnam, Vishakapatnam on 21<sup>st</sup> September 2016 at Kasaragod.
5. Three batches of five days training on 'Hybridization techniques and palm health management in coconut' for 42 farmers/climbers of Kottayam, Pathanamthitta, Kollam and Alappuzha districts of Kerala were organized at Regional Station, Kayamkulam.
6. Training programme on '*Trichoderma* mass multiplication and training cum exposure visit on advances in arecanut and cocoa production

and processing technology' was organized for 25 farmers from Cocoa Growers Association and Balpa Grama Vikasa, Balpa, Sullia Tk., Dakshina Kannada Dt., Karnataka at Regional Station, Vittal on 4<sup>th</sup> October 2016.

7. Training programme for women farmers of Karnataka on 'Multi species cropping system in arecanut garden for higher income' sponsored by the Directorate of Arecanut and Spices Development (DASD) was organized at Research Center, Kidu on 5<sup>th</sup> November 2016. More than 125 participants attended the training.

#### 7.1.12.3. Programmes for students

Training programmes on mandate crops were also organized for the benefit of students [Kasaragod: 4 (185 participants); Kayamkulam: 15 (664 participants) and Vittal: 3 (84 participants)].

1. RAWE programme for nine B.Sc (Agriculture) students of Gandhigram Rural Institute, Dindigul, Tamil Nadu during 23<sup>rd</sup> May – 10<sup>th</sup> June 2016 at Kasaragod.
2. Training for students of College of Horticulture, University of Horticultural Sciences, Bagalkot on 12<sup>th</sup> July 2016 at Kasaragod (Fig. 166).



**Fig. 166. Students of University of Horticultural Sciences, Bagalkot visiting coconut based cropping system**

3. RAWE programme for B.Tech students of College of Agriculture, Hassan (University of Agricultural Sciences, Bengaluru) during 16<sup>th</sup> – 17<sup>th</sup> September, 2016 at Kasaragod.
4. RAWE programme for 11 B.Sc (Agriculture) students of College of Agriculture, Padannakkad (KAU) during 27<sup>th</sup> February 2017 to 4<sup>th</sup> March, 2017 at Kasaragod.
5. ASPIRE-2016 with the theme 'Infusing Farming Instincts in Young Minds' (IFIYM-2016) was conducted at Regional Station, Kayamkulam on 27<sup>th</sup> May 2016, in which 47 students participated.

6. RAWE programme for six days for 11 B.Sc. (Agriculture) students from College of Horticulture, Vellanikkara, Thrissur (KAU) at Regional Station, Kayamkulam during 2<sup>nd</sup>-6<sup>th</sup> April, 2016.

#### 7.1.12.4. Exposure visits for the farmers and other stakeholders

Exposure visits on 'Improved technologies on mandate crops' were organized [Kasaragod: 45 (8536); Kayamkulam: 38 (6574); Vittal: 48 (1922); Mohitnagar: 14 (1200) and Kahikuchi: 8 (641)] for the farmers and other stakeholders from different states. Lecture-cum-discussion and field visits on crop improvement, production, protection and processing technologies of coconut, arecanut and cocoa were organized.

#### 7.1.12.5. Stakeholder Interface Programmes

Stakeholder interface programmes [Kasaragod: 10 (834); Kayamkulam: 6 (552) and Vittal: 3 (213)] were organized on different aspects of mandate crops in different states.

1. Farmer-Scientist Interface programme was organized on 23<sup>rd</sup> June 2016 at Kanjikuzhi, Alappuzha by Regional Station, Kayamkulam to mark the successful completion of the NABARD funded project on "Community Based Bio-Resource Management for Sustaining Production and Livelihood Security Under Coconut Based Farming Systems".
2. A Stakeholder Interface was organized at Farmers' First Project location at Pathiyoor Panchayath on 26<sup>th</sup> November 2017 on 'Problem prioritization and need analysis in coconut based farming systems, wherein 63 stakeholder representatives actively participated.
3. Interface programme on 'Value addition in coconut' was organized during 10<sup>th</sup> -11<sup>th</sup> January 2017 at MYRADA-KVK, Erode, Tamil Nadu.
4. 'Stakeholder interface meeting on palmyrah neera and its value addition' was organized on 25<sup>th</sup> February 2017 at Professor Jayashankar Telangana State Agricultural University, Hyderabad.

#### 7.1.12.6. Farm Field Schools

Farm Field Schools on 'Integrated management of rhinoceros beetle and red palm weevil' were conducted in Thekkekkara, Alappuzha, Kerala covering 96 farmers. Emphasis was given for experiential learning and discovery learning for managing these pests in coconut.

## 7.2. Impact analysis of capacity building programmes

### 7.2.1. Impact analysis of capacity building programmes on coconut

Technological innovations and diffusion of new technologies are the key drivers to enhance the productivity and profitability of coconut farming. Krishi Vigyan Kendras (KVKs) established under the Indian Council of Agricultural Research (ICAR) in all rural districts, are disseminating frontline technologies, imparting knowledge and critical input support to the farmers. Coconut being a perennial crop, field level integration of improved technologies at the grass root level should be strengthened through institutions like KVKs.

In this context, with the objective of enhancing and updating the knowledge levels of Subject Matter Specialists (SMSs) of KVKs, a training on improved technologies of coconut was organized by ICAR-CPCRI, Kasaragod in collaboration with ICAR-ATARI, Bengaluru for SMSs from the states of Kerala, Karnataka and Tamil Nadu during February 2016 in two batches. Impact analysis was done on different aspects *viz.*, gain in knowledge, level of satisfaction of trainees, usefulness of the topics covered and overall grading of the training. Data were collected using structured interview schedule and a questionnaire before and after the programme. Majority (67.6 %) of the trainees belonged to middle age category, 65 % were male respondents, about 60 % possessed a doctoral degree, 50 % had specialization in horticulture, 53 % trainees were from Kerala and 15 % trainees had attended the training on coconut before. Paired 't' test conducted for testing the statistical significance of difference in scores in pre and post evaluation revealed that training had significant impact on enhancing the knowledge level of the respondents in all subjects of coconut technologies. Average gain in knowledge was estimated to be 18.36 per cent. There was a difference in knowledge levels in pre evaluation and in knowledge gain among age groups wherein, youngsters were having high knowledge gain. Similarly, knowledge gain was higher among respondents who had undergone training earlier. Majority (79 %) of the respondents were highly satisfied with the course contents and training delivery methods. More than 75 per cent of the respondents opined that the subjects like planting materials production, disease management, post harvest technologies and social sciences were highly useful. Sixty one per cent of the respondents graded training course as excellent.

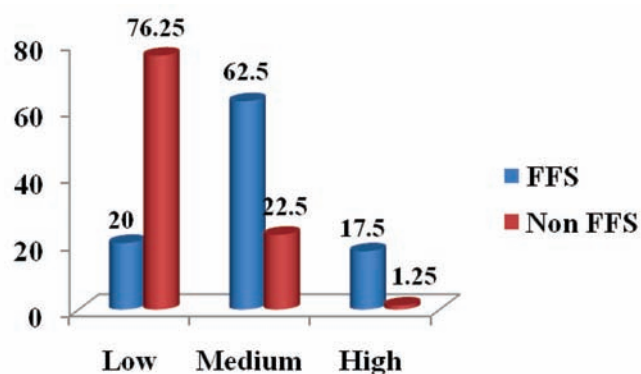
After the training, about 38 per cent of KVKs initiated OFTs and FLDs on coconut technologies for better

technology integration. Impact analysis indicates that it was highly effective to conduct such type of capacity building programmes for enhancing the competency level of SMSs of KVKs at grass root level, and also suggests the research institutes to integrate such programme in the training schedule.

### 7.2.2. Impact of Farm Field School on coconut

Two farm field schools were organized in Alappuzha district on 'Biomangement of rhinoceros beetle involving 10 coconut farmers' groups during the year 2015-16. The impact of the FFS on the knowledge of the participants were analyzed and the results indicated significant improvement among FFS participants compared to non FFS farmers. The FFS curriculum enables them for an experiential learning process and the learning will be sustainable compared to other programme modes.

The overall knowledge level of the FFS farmers was higher when compared to non-FFS farmers as shown in Fig 167. Eighty per cent of the FFS farmers were in either medium or high level of knowledge. There was 65 per cent knowledge gap between FFS participants and non participants.



**Fig. 167. Knowledge of participants on management of rhinoceros beetle**

The overall knowledge level of the FFS and Non FFS farmers showed statistically significant difference, indicating the effectiveness of FFS methodology in improving the knowledge of participating farmers as indicated in the table 21. Hence it could be inferred that, FFS is an appropriate extension methodology

**Table 21. Comparison of knowledge level between FFS and non-FFS farmers (n=240)**

Category of farmers	Mean	Standard deviation	't' value
FFS	51.76	17.75	9.369**
Non-FFS	31.35	12.75	

Significant at  $p < 0.01$  level

for improving knowledge based decision making in technology adoption.

### 7.3. Single window system to serve farmers (ATIC)

ATIC at Kasaragod provided technology advisory services, quality planting materials and other technology inputs/products through a single window system (Table 22).

**Table 22. Sale of planting materials/technology products/publications**

Sl. No.	Item	Total	
		Qty.	Amount (₹)
1	Books	118	6743
2	CD Rom	5	740
3	Earth worms	9950	7861
4	Vermicompost/vermiwash	6183	60946
5	Coirpith compost	454	4994
6	Coconuts	13425	120261
7	Mushroom/mushroom spawn	40.5	3586
8	Coconut seedlings - Talls	9929	823384
9	Coconut seedlings - Dwarfs	3668	407880
10	Coconut seedlings - Hybrids	24762	6117540
11	Polybag coconut seedlings	969	180560
12	Coconut seednuts	48	2563
13	Kera probio	582	16005
	<b>Total</b>		<b>77,53,063</b>

As part of farm advisory services, farmer's queries related to production, protection and value addition aspects of coconut, arecanut and cocoa were promptly attended to. A total of 3869 queries raised by farmers and other stakeholders were answered through phone, postal and email. Maximum number of queries raised by farmers and other stakeholders were related to availability of planting materials (2707), integrated pest management (142), integrated disease management (137), post harvest technologies (87), TOT programmes (81), extension publications (65) and integrated nutrient management (52).

### 7.4. Agri-business Incubation (ABI) Centre

A record number of 52 MoAs on transfer of technology know-how were executed during 2016-17 realizing a revenue of ₹ 15,62,000. Among the technologies transferred in the year, 43 were on protocols for coconut processing, virgin coconut oil (15), coconut chips (14), Kalparasa and sugar (10), Kalpa Krunch (2) and carbonated tendernut water(2). Another higher-end technology commercialized in the year

was the nanomatrix for pheromone delivery (priced at ₹ 3 lakhs) which was jointly developed by ICAR-CPCRI and Jawaharlal Nehru Centre for Advanced Scientific Research, Bengaluru for which two MoAs were signed.

Two incubatees have registered for using the production facility for activated shell carbon. The ABI infrastructure was strengthened with an effluent treatment plant.

As part of entrepreneurship development activities of the ABI centre, a Workshop on 'Coconut Based Business Ventures' was conducted at Kasaragod during 9<sup>th</sup> and 10<sup>th</sup> September 2016 in collaboration with Coconut Development Board (CDB), Kochi. Members of the Coconut Producer Companies (CPCs) registered with CDB were the participants. Dr H.P. Singh, former DDG (Hort. Sci.), ICAR inaugurated (Fig. 168) the Workshop in the presence of Dr. P. Chowdappa, Director, ICAR-CPCRI, Shri S. R. Satheeshchandra, President, CAMPCO Ltd., Shri. Sankaranarayana Bhat, Vice President, CAMPCO Ltd. and Shri C. Kamraj, President, Federation of All India Coir and Coconut Manufacturers Association, Pollachi. In the first technical session on 'Innovative business models', seven selected CPCs presented their business plans submitted for the 'Dream Big Kalpa' business plan competition. In the second session, 'Business aspirations', presentations on various technologies were made by Dr. K.B. Hebbar, Head, Division of Physiology, Biochemistry and Post Harvest Technology, ICAR-CPCRI, Kasaragod and Mr. Radhakrishnan, Coir Board, Kochi. Thereafter, Mr. Sarath, District Industry Centre, Kasaragod and Mr. S. S. Choyal, Deputy Director, Coconut Development Board, Kochi interacted with the participants. In the session on 'Enhancing competitiveness' presentations were by Dr. K. Prakash, Chairman, Agricultural Price Commission, Government of Karnataka, Shri. C. Rajan,



**Fig. 168. Dr. H. P. Singh, Former DDG (Hort. Sci.), ICAR inaugurating the workshop on 'Coconut based business ventures'**

Chairman, Dinesh Food, Kannur, and Dr. Omkumar Krishnan, IIM-Kozhikode. The first prize for the best business plan was won by Thejaswini Coconut Producers Company Pvt. Ltd., Kannur while the second and third prizes were awarded to Perambra CPC Perambra, and Vinayaga CPC, Devambady, respectively. The following are the action points that emerged in the Workshop:

1. A National Consortium of Coconut Producer Companies should be formed as an apex body to co-ordinate business plans and marketing of coconut value added products of CPCs.
2. In order to enter the international market of coconut value added products, there is an urgent need to scale up the production in compliance with the international food safety standards. Conglomeration of companies having common product lines is the plausible option in this regard.
3. For better communication and interaction among CPCs, social media may be effectively used.

#### 7.4.1. Intellectual property management and transfer/commercialization of agricultural technology

The Institute Technology Management Committee had nine meetings in the year in connection with activities related to IP management. Technology transfer fee for three technologies were fixed (nanomatrix for pheromone delivery; carbonated tendernut water and Kalpa Krunch) and fee for seven technologies were revised. Cost of one each of contractual research, consultancy and overseas training programmes were also finalized. National patent for 'Coconut testa removing machine' (No. 278013) has been granted on 8<sup>th</sup> December 2016 (Fig. 169).

On the auspices of ITMU, the annual series programme christened as 'Dream Big - Kalpa'



**Fig. 169. Union Minister for Agriculture and Farmers Welfare, Shri Radha Mohan Singh, handing over the MoA on nanomatrix for pheromone delivery to M/s Rajshree Biosolutions, Chennai**

was organized on 31<sup>st</sup> January 2017 (Fig. 170). Shri P. V. Velayudan, Director, MSME-DI, Thrissur inaugurated the programme in the presence of Dr. P. Chowdappa, Director, ICAR-CPCRI, Shri Jyotis Jagannathan, DGM, NABARD, Shri Rajendran, General Manager, DIC, Kasaragod and Shri C. M. Kamaraj, an industrialist from Coimbatore. More than 125 entrepreneurs from Kerala, Tamil Nadu and Karnataka participated in the programme. Ten MoAs on technology transfer also materialized during the event (Fig. 171). Other important programmes conducted by ITMU are (i) Interface meeting on value addition in coconut (9<sup>th</sup> January 2017 at MYRAD-KVK, Erode); (ii) Seminar on 'Business opportunities in coconut' (10<sup>th</sup> January 2017 at Bannariamman Institute of Agriculture and Technology, Sathyamangalam) and (iii) Interface meeting on value addition in coconut and palmyrah (25<sup>th</sup> February 2017 at Prof. Jayashankar Telengana State Agricultural University, Hyderabad).



**Fig. 170. Shri P. V. Velayudan, Director, MSME-DI, Thrissur inaugurating 'Dream-Big Kalpa 2017'**



**Fig. 171. Mrs. Pavitra, an entrepreneur from Coimbatore, receiving the MoAs on 'Kalparasa' and 'carbonated tender coconut water'**

#### 7.5. Evolving sectoral innovation system of 'Neera'

As part of the assessment of field level utilisation of technologies in coconut sector, an analysis was done on the evolving sectoral innovation system of 'Neera' in the state of Kerala (Fig. 172). Though the Government of Kerala has come out with a pro-



**Fig. 172. A neera outlet at Payyannur, Kerala**

farmer policy frame for the production and promotion of neera, it is still (partially) under the control of the Excise department. In a span of three years, a total of 220 licenses have been granted for neera production. Barring few public sector agencies, the licensees are mostly the Coconut Producer Federations (CPFs) of Coconut Producer Societies (CPSs). Only 57 CPFs are continuing the neera production though 94 CPSs initiated the production activities, which point towards the already experienced commodity problematique in the sector. The farmer share in the value chain is just 17% of the consumer price and neera-tapper's share is 20%. Issues concerned with neera production at policy level include the ceiling for the number of coconut palms to be tapped/day, the selling controls on the product, the registration formalities, etc.

On the production front, scarcity of skilled tappers and lack of adequate infrastructure for processing are the major problems. Marketing of neera also poses challenges as consumer perception and buyer segment studies are completely lacking and profit analyses are based only on projections without any structured marketing studies. Further to compete with other similar products, it has to be appropriately positioned in the market for its nutritional edge. Since it is an evolving product, lack of product uniformity may hamper the market penetration. However, the unexplored markets and preparedness to meet the demand are the opportunities. Above all, from April 2017 onwards, ASEAN products may flood the Indian market with the phasing out of customs import duty as per the trade agreement, and the real competition will be set in motion then onwards.

## **7.6. Organic farming: An analysis of field level scenario and stakeholders perspectives**

Kasaragod was declared as the first organic district in Kerala four years back. There are

farmer's apprehension and policy level interest in understanding the implications of the initiative and hence as a model to analyze the impact of organic farming, a study was taken up in the district.

### **7.6.1. Perception of extension personnel and researchers**

Data on the perception about the policies and programmes on organic farming in Kasaragod district were collected from 24 extension personnel from Nileswar, Parappa and Kanhangad blocks of Kasaragod district and 29 researchers from College of Agriculture, Padannakkad and ICAR-CPCRI, Kasaragod.

Researchers (41 %) perceived that switching over to organic farming is rational and that the organic farming is a viable option for the farmers of Kasaragod district. However, only 31 % of the researchers perceived that the implementation of organic farming policy/programme is effective. They perceived that organic farming technologies should be validated before implementing in farmers' fields. Facilitating Participatory Guarantee System (PGS) for organic certification in small and marginal farms through Krishi Bhavans, ensuring the availability of organic inputs and creation of awareness on pest and diseases management through organic means were the other important suggestions from researchers for the effective implementation of organic farming policy in Kasaragod district.

Extension personnel (46 %) perceived that complete conversion of farming in the district to organic mode is practically possible. Majority (63 %) of extension personnel perceived that non-availability of technologies for effective pest and disease management and nutrient management under organic production system as a major constraint.

### **7.6.2. Focused Group Discussions (FGD) on organic farming**

Focused group discussions involving farmers on the organic farming policy for the district, field level implementation of organic farming interventions, and constraints in adopting organic farming practices etc. were conducted at Kanhangad, Valiyaparamba, Choyangode and Meeyapadavu, which represent major coconut growing agro-ecological units in Kasaragod district. A total of 68 farmers actively participated in the FGDs where they shared their experience and constraints faced in organic farming. Among the participants, 46% of the farmers were practicing organic farming. Rest of the farmers adopted farming integrating organic and chemical inputs/methods. Major limitations of organic

farming according to these farmers were low yield of crops under organic farming and difficulty in pest and disease management through organic means. Majority (57 %) of the farmers perceived that the policy for organic farming in the district was rational and could be practically implemented. However, a sizeable segment of the participants (44 %) of FGDs perceived that implementation of organic farming schemes were not effective.

The important constraints faced by them were lack of premium price for organic products, lack of marketing facilities, lack of effective extension support, lack of labour, lack of availability of quality organic inputs, high cost of production in organic farming etc.

Major suggestions put forth for the effective implementation of the schemes under organic farming were to provide subsidy through organic cluster, panchayath level mechanism for procuring and marketing organic farm produce, ensuring the timely supply of organic inputs, making available labour for farming operations through NREGS scheme, effective extension support, evolving effective organic methods of pest and disease management, etc.

As was the case revealed from primary data collected from individual farmers, FGDs also indicated the fact that majority were not convinced about the rationality and feasibility of switching over to organic farming. Besides, the inadequacies in the promotional schemes implemented for promoting organic farming in the district, constraints experienced in adopting organic farming and suggestions to overcome the problems experienced in organic farming were also highlighted through the FGDs conducted.

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

NABARD supported (Farm Innovation and Promotion Fund) Project on community based bio-resource management was implemented in Kanjikuzhy Block of Alappuzha District during 2014-16. The major objectives of the project were (a) to strengthen the capacities of farmers on biomass recycling and enrichment of organics with beneficial microbes to ensure sustainability in agricultural production and (b) to increase the productivity and income from coconut based farming system through integrated nutrient management with emphasis on bio-resource management, soil and water conservation techniques and crop diversification

The major problems faced by farmers practicing organic farming in the area were lack of proper knowledge on the organic inputs to be used and

availability of quality organic inputs. Apart from this, the project area (Kanjikuzhy block) having littoral sandy soil characterized by low organic matter content and poor water holding capacity, was found to have several constraints with regard to soil fertility status. Major constraints like chronic shortage of potassium, magnesium and boron and higher level of calcium and phosphorus (most of which linked to over-liming) resulted in poor productivity of the main crop (coconut) rather than intercrops.

As part of capacity development, the selected farmers were trained on composting techniques, microbial enrichment of organics and soil test based nutrient application with special emphasis on bioresource management and imparted large number of skill development programmes, based on which the farmers could adopt site-specific management practices and further replicate to farmers of the entire block area. A total number of 84 programmes including awareness programmes, training - cum demonstrations, small group discussions, farmer field schools and household level trainings were conducted with 806 beneficiaries. Awareness creation and application of lime and other nutrients based on regular soil testing resulted in increased setting percentage and gradual improvement in the yield of coconut.

Master farmers and SHGs were trained on effective utilization of bioresources like enriched composts and organic manure mixes and produced 30 MT *Trichoderma* enriched organic manures and 3500 *Trichoderma* cakes. The farmer groups produced 159 good quality bioprimered coconut seedlings (from 200 seednuts sown) having average collar girth of 17 cm, nine fronds and 160 cm height.

Eight native strains of *Trichoderma* were isolated from Kanjikuzhy Block Panchayat area and among them, *Trichoderma* isolate KKT-6 showed highest antagonistic activity to leaf rot and stem bleeding pathogens of coconut under *in vitro* and field conditions. Based on the evaluation of locally available organic substrates for mass multiplication of *Trichoderma* sp., two organic mixes *viz.*, cowdung + neem cake (4:1) and coir pith compost + neem cake + poultry manure + cowdung (2:1:1:1) were found ideal in terms of higher *Trichoderma* population in soil, higher nutrient status of soil and high and steady crop yield. Based on the results, recommendations were provided in the soil health cards to apply these enriched organic mixes to coconut, vegetables, ginger, turmeric, pepper etc., based on the soil test results. Identification of ideal organic substrates/substrate combinations for enrichment with beneficial microbes and formulation of two enriched organic manures

for organic farming tracts encouraged the farmers to bring more area under intercropping and to achieve sustainable income from intercropping, in addition to the generation of supplementary income through the sale of enriched organic manure.

Soil health cards, indicating site-specific nutrient management recommendations based on soil test results, were provided to 52 master farmers and the Agricultural officers and ATMA functionaries coming under the project area were also educated on the general nutrient status of the area so as to ensure site-specific nutrient management under various programmes.

Pre and post test knowledge levels indicated improvement in knowledge indices related to bio-resource management (44 to 96 %), integrated nutrient management (54 to 95 %) and coconut cultivation practices (59 to 92 %). The adoption index related to coconut cultivation practices recorded improvement from 41 to 84 %.

An improvement in setting percentage of 32.44 % was observed in the observational palms one year after introducing the interventions (during 2015), which was reflected in the yield improvement of 30.64 % in the subsequent year (during 2016). Further improvement (45.48 %) was observed in the setting percentage during 2016. Average yield, in general, from the demonstration gardens also recorded an improvement to the tune of 25.47 % over a period of two years. The average area under intercropping increased by 80 % and income from intercropping doubled over the project period. The income from coconut recorded 26 % improvement, and that of intercropping by 142.91 % and livestock and other enterprises to the tune of 30.88 %, contributing to an increase in the average farm income from ₹ 1.17 to 2.91 lakhs ha<sup>-1</sup> (149.84 %) over the project period.

Community level production of quality bio inputs resulted in ensuring its availability of at grass root level. Similarly, participatory demonstration on the ideal organic substrate combination for microbial enrichment for improving organic resource use efficiency could bring in improvement in the area under organic farming which resulted in enhanced productivity. Soil test based recommendations for nutrient management resulted in improved setting percentage and yield in coconut. Among the interventions, production of bio-primed coconut seedlings was rated as the most useful technology all the farmers. Availability of registered cultures of bio agents for large scale production and sale and occasional contamination of cultures in local production units were the major constraints faced.

Farmer participatory action management, involving experiential learning and adoption coupled with continuous field level assessment and refinement, was found to strengthen the confidence of the farmers to accept farming as a profitable enterprise. Community based bio resource management was accepted as a model project by local self government and included in the Alappuzha district panchayath plan 2017-18.

### **7.8. Farmers FIRST: Participatory technology integration to empower and ensure livelihood security of farmers**

The prestigious Farmers' FIRST project is being implemented at Pathiyoor panchayath in 1657 ha involving the farming communities of the entire area since November 2016. The major activities are being organized under six modules *viz.*, coconut based systems, horticulture based module, livestock/poultry based modules, NRM based modules, value addition/product diversification module and integrated farming system module. Participatory rural appraisal tools like resource and social mapping, transect analysis, problem tree and cause effect diagrams for problem prioritization, time line and farm mapping have been completed.

Benchmark survey for documenting farm/farmer/crop (pre- project data) has been completed covering 740 sample farmers. Stakeholders meetings have been organized for initiating the FFP programme and documenting general farming situation and farming issues. Besides, 19 focus group meetings (in which 996 stakeholder representatives participated) and seven training programmes benefitting 568 participants, were also organized.

At present, the number of farmers directly involved in various modules is 830. The technologies introduced for participatory appraisal, evaluation and experimentation are: Prathibha turmeric variety (ICAR-IISR), Suvarna turmeric variety, Sreekeerthi (*Dioscorea* from ICAR-CTCRI), Gajendra (*Amorphophallus* from APAU), white sesame variety (SVPR-1 from TNAU), drudgery reduction of women farmers in paddy cultivation through use of farmer refined paddy seed drill (Fig. 173), rural enterprise on Virgin Coconut Oil and other coconut based products of ICAR-CPCRI, mushroom cultivation, bio-input multiplication (*Trichoderma*) (three units initiated), released vegetable varieties of ICAR-IIHR, black pepper varieties (eight from ICAR-IISR), mastitis management of livestock as a participatory model programme, fodder supplement during summer through hydroponics fodder production by seven farmers with more than 6-10 milch animals per



**Fig. 173. Drudgery reduction through farmer refined machinery**

unit, bio-digestion technology of CSIR- NIIST, one tissue culture banana hardening unit by rural youth with 10,000 plantlets of nendran, njalipoovan, red banana, grandnina and robusta, pro-tray seedling production of turmeric and mini sett method of tubers. A participatory technology integration and dissemination model for doubling the farmers income is also in vogue (Fig. 174-175).



**Fig. 174. Community volunteered planting material production**

Other activities undertaken are grid based soil sampling (5 ha grids) with participation and involvement of coconut producers society and women self help groups in campaign mode with technical facilitation and supervision for sample collection, community extension approach for pest and disease management in coconut with supervision and participatory leadership of respective CPS and crop intensification of coconut gardens, rejuvenation of traditional farming of sesame and Navara (paddy) and formulation of technical groups, crops based groups and enterprise based groups.



**Fig. 175. Plant protection demonstration at Pathiyoor panchayath under FFP**

Eight extension literatures were published and three radio programmes, print media (success story of white sesamum), 12 training programmes (691 participants), one stake holder meeting and 19 farmers focused group meetings (996 participants) were organized. Institute advisory committee (IAC) meetings and village level meetings were formulated and convened.

The other interventions in progress are model coconut gardens for income improvement through technology and resource integration, farmers/ women farmer managed fodder banks with improved high yielding fodder crops for improving green fodder availability and milk production, networking farmers groups for efficient resource utilization like paddy farmers/ fodder farmers to be linked with livestock farmers, 200 model coconut gardens for income improvement, farmer participatory coconut root (wilt) disease management in farmers fields, program for involving students in farming and resource recycling through vermicomposting techniques.

## **7.9. Socio-economic dimensions and value chain dynamics in policy perspective**

### **7.9.1. Understanding the price dynamics of coconut oil**

Price analysis revealed that the price wedge of coconut oil (between domestic and international) from the year 2013 onwards has led to price instability and price crash of the domestic coconut oil as the price sensitive consumers switched to cheaper oils. It was observed that low palm oil prices act as a downward anchor, and only a demand pulled price rise can

sustain the coconut prices in the country. The time series price movement of coconut oil (domestic as well as international) for the last 13 years (from the year 2004 onwards) revealed that whenever there is rise in domestic coconut oil price, the international prices exerted a pull-down-force to make the prices integrated (Fig. 176). This aspect very well validates the international trade theory on price integration of primary commodities in the trade liberalized regime. The crucial interpretation is that dependency on single commodity like coconut oil will never provide the adequate margin to sustain for a longer period.



**Fig. 176. Price movement of coconut oil**

### 7.9.2. Trade competitiveness of coconut value added products

It is imperative to analyze the international trade scenario of coconut value added products to understand the country-wise trade competency. While comparing with other major global exporters, the share of India in coconut product exports is meagre. Though it is an accepted fact that India holds a robust domestic market in the coconut sector, it is high time that we emerge as a major export player by upgrading our position in the global value chain

of coconut exports. The Philippines and Indonesia together contribute to the major export share of coconut oil, copra meal and desiccated coconut. Sri Lanka too contributes substantially to the international exports of coconut milk, shell charcoal and coir products.

It is noteworthy that almost major proportion of the domestic production of coconuts in India is consumed in the domestic market itself. On the other hand, the Philippines consumes only 25 per cent of its coconut production domestically. The economic logic always point towards the correlation between the domestic consumption and export growth. In most of the cases, when there is market surplus there is a need to develop outward market orientation and thereby, in the long run, a robust export market for the product can be developed. This is what exactly happened with the Philippines and now they are the most competent exporter with respect to coconut and coconut products. Nevertheless, India, of late, has been making concerted effort to position their products in the high value export segments (Table 23).

The analysis suggests the need to formulate plausible strategies to reach the overseas market and capture the optimal share in market segments (Table 24). Though we have a strong domestic market base, it is an indubitable fact that in the near future, due to

**Table 24. Consumption-production balance (Copra equivalent)**

Country	Production*	Consumption*	C:P ratio
India	3.1	3.04	0.98
Philippines	2.22	0.77	0.35
Indonesia	3.01	2.17	0.72
Sri Lanka	0.56	0.4	0.71

\*million tonnes

**Table 23. Market share of major countries in the coconut products export**

Country	Coconut oil	Desiccated coconut	Coconut milk	Copra meal	Shell charcoal	Coir/coir products
India	0.3	1.2	—	0.004	7.0	25
Indonesia	35.2	19.7	50.7	34	70.2	10
Malaysia	8.6	2.2	—	—	—	—
Philippines	41.4	24.7	3.6	64	20.3	—
Sri Lanka	—	11.6	—	—	2.5	42
Vietnam	—	9.1	45.4	—	—	—
Others	14.5	30.6	0.3	1.996	—	23
World (MT)	<b>2190911</b>	<b>440983</b>	<b>38343</b>	<b>866441</b>	<b>355288</b>	<b>331021</b>

Source: Calculation from APCC Statistical Year Books

Note: Figures are in percentage share of the world total; '—' represents insignificant/nil

the evolving trade agreements even in the domestic sector, we may confront fierce price competition from the overseas export. Hence, we need to chalk out modalities and action plans to elevate our export competitiveness and comparative advantage.

#### 7.10. Policy analysis and its implications in arecanut

The cost of production of arecanut (chali) was worked out following the standard cultivation practices in a well-maintained garden, wherein on an average (in different regions of Kerala and Karnataka) 25 quintal chali ha<sup>-1</sup> is expected. In this case, the cost of production per kilogram of chali would be ₹ 200/-. Adding 25 percent profit margin to the cost of production, the meeting on arecanut market intervention conducted at ICAR-CPCRI Kasaragod recommended ₹ 250 per kilogram of chali as Minimum Support Price (MSP). Policy brief on MSP for arecanut was presented in the stakeholder's meeting and the proceedings were sent to the Ministry of Commerce.

The cost of production for fixation of MSP was suggested as ₹ 76 kg<sup>-1</sup> of copra and presented to the CACP. Policy note on raw coconut procurement was also prepared and submitted to the CACP. In view of the efficient raw coconut procurement, it was suggested to establish panchayat level hubs with forward and backward integration under the supervision of CPS networks.

#### 7.11. Economic impact studies on technology adoption in coconut

Economic impact of technology adoption in coconut farming in Kannur and Kasaragod districts of northern Kerala was assessed based on a field survey with a structured schedule. The study mainly concentrated on field level adoption of improved coconut varieties/hybrids, coconut based cropping systems, and vermicomposting. It was observed that the adoption of technology is highly individual-centric and thereby reflects a scattered pattern of adoption. Though the awareness on beneficial aspects and economic advantages of the technology adoption is well known among the farmers, the proactive adoption and experimentation is quite lacking. It was revealed that majority of the respondents adopts cropping systems as per their own convenience and not in tune with the recommended scientific pattern. Even though, farmers unequivocally expressed the comparative yield benefits and higher economic returns of the improved coconut varieties *vis a vis* local varieties, the comparison is mostly based on the few numbers of improved palms scattered in the field with that of senile local palms cultivated in large area, which turns out to be erroneous. With regard to the adoption of

organic farming, farmers are quite apprehensive on the low yield in the initial years, high labour costs and rudimentary marketing system.

#### 7.12. Development of statistical and computational techniques for improving research methodology

##### 7.12.1. Crop-weather relationship

The relationship between weather variables and the yield of arecanut and cocoa has been investigated. In the case of arecanut, 12 years of average annual yield and monthly weather data (maximum temperature, minimum temperature, rainfall and rainy days) at Regional Station, Vittal were used for the study. It has been observed that the maximum temperature during November, December, January, July and September have positive correlation with yield and rainfall and number of rainy days during November and July have negative correlation with yield (Table 25).

**Table 25. Correlation between arecanut yield and weather variables**

Weather variable	Month	Correlation coefficient
Maximum Temperature	November*	0.73
	December*	0.56
	January	0.65
	July	0.64
	September	0.65
Rainfall	November*	-0.76
	July	-0.70
Rainy days	November*	-0.78
	July	-0.52

\*Previous year

Stepwise regression with annual yield as response variable and the monthly weather data as independent variable is used to predict the annual yield of arecanut and the resultant regression function ( $R^2=0.92$ ) is given as:

$$y = -1952 + 42.23x_1 + 65.67x_2 - 145.65x_3 + 108.89x_4 + 4.23x_5 - 33.44x_6 - 16.22x_7$$

where y is the annual yield (July to June) of arecanut (chali palm<sup>-1</sup> in kg),  $x_1$  is the average maximum temperature during December (previous year),  $x_2$  is the average maximum temperature during January (previous year),  $x_3$  is the average maximum temperature during July,  $x_4$  is the average maximum temperature during September,  $x_5$  is the total rainfall during July,  $x_6$  is the number of rainy days during November (previous year) and  $x_7$  is the number of rainy days during July.

The probable impact of climate change on arecanut yield was also investigated. Locally weighted least squares regression (LOWESS) technique was used to fit the long term trend in weather variables to study the impact of climate change on yield.

In the case of cocoa, annual yield (average of 14 years) and monthly weather data (maximum temperature, minimum temperature, rainfall and number of rainy days) at Regional Station, Vittal were used for the study. It has been observed that the maximum temperature during June and February, minimum temperature during June and October and the number of rainy days during August have significant correlation with the annual yield of cocoa (Table 26).

**Table 26. Correlation between cocoa yield (dry bean) and weather variables**

Weather variable	Month	Correlation coefficient
Maximum temperature	June*	0.60
	February	0.61
Minimum temperature	June*	0.58
	October	0.66
Rainy days	August	-0.60

\*Previous year

Stepwise regression with annual yield of cocoa as response variable and the monthly weather data as independent variable was used to predict the annual yield of cocoa and the resultant regression function ( $R^2=0.68$ ) is given as:

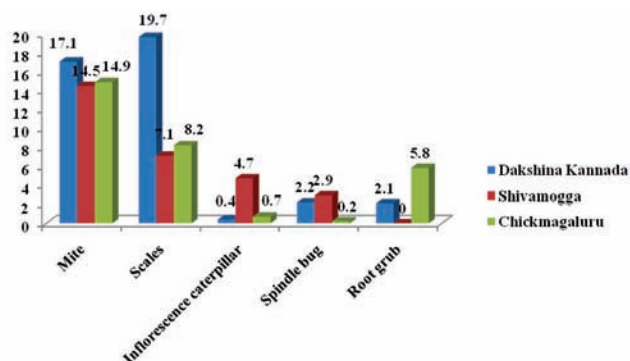
$$y = -771.4 + 13.35x_1 + 22.83x_2$$

where  $y$  is the annual yield (July to June) of cocoa (dry bean tree<sup>-1</sup> in kg),  $x_1$  is the average minimum temperature during June (previous year) and  $x_2$  is the average minimum temperature during October.

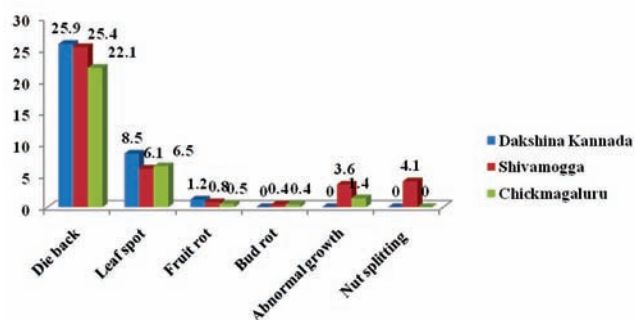
### 7.13. Field survey to assess incidence of pests and diseases

Field survey was conducted in Chickmagalur, Shivamogaa and Dakshina Kannada districts of Karnataka to assess the incidence of major pests, diseases and disorders of arecanut. It was revealed that the major pests of arecanut were, mite, scale insect, inflorescence caterpillar, spindle bug and root grub as given in Fig.177.

With respect to the diseases, intensity of die back was more in all the districts followed by leaf spot, fruit rot and bud rot. Among the disorders, abnormal growth and nut splitting were observed (Fig. 178).



**Fig. 177. Intensity of pests in arecanut (% of palms affected)**



**Fig. 178. Intensity of diseases/disorders in arecanut (% of palms affected)**

Field survey was also conducted in Kasaragod district to assess the incidence of major pests and diseases of coconut. It was observed that the major pests of coconut were rhinoceros beetle (8.46%), red palm weevil (0.15%), eriophyid mite (0.73%) and coreid bug (2.23%). Bud rot (2.38%), stem bleeding (2.27%) and Thanjavur wilt (0.62%) were the major diseases of coconut in Kasaragod district.

#### 7.13.1. Refining disease index

A survey was conducted in Theni district of Tamil Nadu for accommodating regional and temporal changes in root (wilt) disease (RWD) expression into the disease index. RWD symptoms in Theni district was highly varying as compared to the symptoms on which the present indexing method has been developed and hence existing index cannot be used for indexing the disease symptoms observed in Theni.

### 7.14. Need based computer programs

Computer programs for genotypic/phenotypic variance and covariance, heritability, correlations etc. were customised in R environment. Methodology for panel data analysis (three stage) was refined and the programs were developed in SAS for its application. An online database on production statistics of mandate crops was developed in MySQL and PHP script.

# ICAR-ALL INDIA COORDINATED RESEARCH PROJECT ON PALMS



The All India Coordinated Research Project (AICRP) on Palms started functioning from 1972 with the objective of conducting location-specific research on coconut, oil palm, palmyrah and sulphi palm. In the XII plan, arecanut has also been included and at present the project is being implemented in 29 centres. Its headquarters is at Kasaragod with fifteen centres working on coconut, eight on oil palm, four on arecanut, two on palmyrah and one on sulphi palm. The coordinating centres are located at 13 states and one union territory covering 13 SAUs/SHUs, one CAU and four ICAR institutes (Fig. 179).



**Fig. 179. Coordinating Centres of AICRP on Palms**

The budget for the year 2016-17 was ₹ 360 lakhs and the scheme was implemented through the respective state Agricultural/Horticultural Universities on 75:25 basis, with 75% ICAR share and with 100% ICAR funding in the case of Central Agricultural University and ICAR Institutes.

## 8.1. Coconut

### 8.1.1. Crop Improvement

At Aliyarnagar centre, five location-specific hybrid combinations are under evaluation. The trial is four

years old and among the combinations, Malayan Green Dwarf x Aliyarnagar Tall was observed to be the earliest to start flowering (34 months). The crosses Chowghat Orange Dwarf x Aliyarnagar (65 nuts palm<sup>-1</sup> year<sup>-1</sup>) and Aliyarnagar Tall x Malayan Green Dwarf (58 nuts palm<sup>-1</sup> year<sup>-1</sup>) (Fig. 180) were found to be promising.



**Fig. 180. Aliyarnagar Tall x Malayan Green Dwarf hybrid**

- Evaluation of released varieties/hybrids in coconut at HRS, Ambajipeta revealed that the hybrids, VHC-1 and Godavari Ganga (Fig. 181) performed better with higher nut yield of 139 and



**Fig. 181. Godavari Ganga**

136 nuts palm<sup>-1</sup> year<sup>-1</sup>. However, significantly higher copra content nut<sup>-1</sup> was recorded in Chandra Sankara (168.7 g) and was on par with VHC-2 (166.8 g).

### 8.1.2. Crop Production

- In coconut + cocoa + banana + pine apple cropping system, Integrated Nutrient Management (INM) recorded 11 per cent higher net income (3.28 lakhs ha<sup>-1</sup>) than fully organic treatment at Aliyarnagar centre (Fig. 182).
- At Ambajipeta, experiment on evaluation of nutrient management for high density cropping systems for different agro climatic regions (Fig. 183) revealed that application of 75 % recommended dose of NPK + organic recycling with vermi compost (T<sub>1</sub>) recorded higher nut yield of coconut, followed by application of 50% recommended NPK + organic recycling with vermi compost (179, 173 nuts palm<sup>-1</sup> year<sup>-1</sup> respectively) and component crops with B: C ratio of 2.68 and 2.30 respectively,



**Fig. 182. Coconut based integrated cropping system at Aliyarnagar centre**



**Fig. 183. Coconut based integrated cropping system at Ambajipeta centre**

compared to coconut monocrop (142 nuts with B : C ratio of 1.52).

- At Arsikere centre, the integrated farming system with coconut + pasture crops (*Cenchrus ciliaris* + *Stylosanthes hamata*) + fodder trees (drum stick and *Sesbania grandiflora*) + sheep recorded highest net income of ₹ 44124/- ha<sup>-1</sup> with B:C ratio 1.82 as against ₹ 24856/- ha<sup>-1</sup> net income from monocrop of coconut.

### 8.1.3. Crop Protection

#### 8.1.3.1. Survey and surveillance of coconut diseases

- Roving survey conducted in three states viz., Andhra Pradesh, Tamil Nadu and Karnataka for the major diseases of coconut revealed occurrence of basal stem rot, stem bleeding, leaf spot, leaf blight and bud rot. The incidence of basal stem rot was highest in Andhra Pradesh with PDI of 9.35%, followed by Karnataka (3.13%) and Tamil Nadu (1.46%). Stem bleeding disease was also more severe in Andhra Pradesh with PDI of 2.43%, followed by Karnataka (1.95%) and Tamil Nadu (0.05%).
- Fixed plot survey conducted at different locations in three states revealed a general increase in severity and spread of basal stem rot and stem bleeding disease over a period of one year. Foliar diseases like leaf blight and leaf spot were reduced over a period of one year.

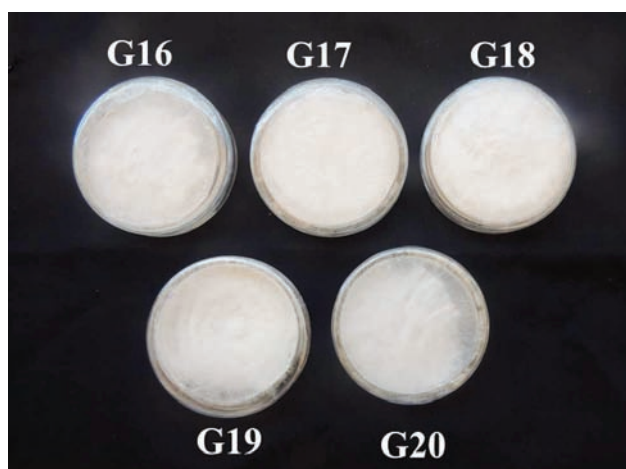
#### Basal stem rot disease

#### Collection of *Ganoderma* isolates from various locations to analyze diversity

- Thirteen isolates of *Ganoderma* were collected from Karnataka (Fig.184), Tamil Nadu and Andhra Pradesh (Fig.185) and their variations have been characterized.



**Fig. 184. *Ganoderma* isolates collected at Arsikere centre**



**Fig. 185. *Ganoderma* isolates collected at HRS, Ambajipeta**

- *Ganoderma* isolates took around 15 months to kill coconut seedling under artificial inoculation conditions.

#### **Epidemiology and disease forecasting**

- There was a positive correlation of basal stem rot disease index with maximum temperature
- Among the different intercropped gardens, banana intercropped gardens recorded lesser incidence of basal stem rot disease at Andhra Pradesh and Karnataka.

#### **Management of basal stem rot disease in coconut**

- Soil application of talc based formulation of 125 g each of *Trichoderma reesei* and *Pseudomonas fluorescens* + 5 kg of neem cake per palm at yearly interval and soil application of talc based formulation of 125 g each of *Trichoderma reesei* and *Pseudomonas fluorescens* + 5 kg of neem cake per palm at yearly interval + root feeding of 1ml of Hexaconazole in 100 ml water thrice in a year + micro nutrient application @ 1 kg palm<sup>-1</sup> year<sup>-1</sup> recorded lesser disease incidence.

#### **Stem bleeding disease management**

- Root feeding of Propiconazole @ 2 ml + 100 ml water at quarterly interval recorded the lowest disease index.

#### **8.1.3.2. Entomology**

##### **Rugose spiralling whitefly**

- Incidence of a new invasive spiralling whitefly was noticed in coconut during August 2016, during surveys in several villages of Anaimalai block, Coimbatore district, Tamil Nadu. The species was identified and confirmed as

rugose spiralling whitefly (RSW), *Aleurodicus rugioperculatus* Martin (Fig. 186).

- Observations on the natural enemy fauna in the infested gardens revealed a diverse array of coccinellids (Fig.187) along with an aphelinid parasitoid, *Encarsia guadeloupae* (Fig.188). Parasitisation by *E. guadeloupae* was observed



**Fig. 186. Adults of RSW**



**Fig. 187. Coccinellid predator, *Menochilus* sp**



**Fig. 188. Parasitoid, *E. guadeloupae***

to an extent of 78.2 per cent at Kaliyapuram village, Anaimalai block, Coimbatore district, subsequently leading to biosuppression of the RSW.

### Black headed caterpillar

- During 2016-17, incidence of coconut black headed caterpillar, *Opisina arenosella* was noticed in Andhra Pradesh, Tamil Nadu, Karnataka and Maharashtra for which larval parasitoids viz., *Bracon brevicornis* and *Goniozus nephantidis* were successfully mass reared and distributed by different AICRP (Palms) centres (Table 27 and Fig.189).

**Table 27: List of parasitoids distributed from different centres**

Centres	Parasitoids (in nos.)	
	<i>Bracon brevicornis</i> /B. <i>hebetor</i>	<i>Goniozus nephantidis</i>
Aliyarnagar	4,44,000	45,000
Ambajpeta	12,43,500	9,62,000
Ratnagiri	45,600	38,200
Arsikere	19,25,000	37,00,000
<b>Total</b>	<b>36,58,100</b>	<b>47,45,200</b>



**Fig. 189. Parasitoid production at Arsikere centre**

## 8.2. Oil palm

### 8.2.1. Crop Improvement

- In the hybrid combinations of NRCOP 11 to 20 (planted during 2006), under evaluation at Pattukotai (TN), the FFB yield realized during 2016-17 was significantly higher with NRCOP 17 (21.8 t ha<sup>-1</sup>) and was on par with NRCOP 20 (20.8 t ha<sup>-1</sup>).
- The hybrid combinations, NRCOP-1 to 10, planted during 2007 at Mulde centre, the FFB

yield data during 2016-17 indicated that, the hybrid NRCOP-2 recorded significantly higher FFB yield (22.2 t ha<sup>-1</sup>). Similarly, NRCOP-4 recorded significantly higher FFB yield (16.4 t ha<sup>-1</sup>) at Gangavathi centre (Fig. 190). At Vijayarai centre, NRCOP-9 recorded significantly higher FFB yield (25.2 t ha<sup>-1</sup>).

- Under progeny evaluation trial planted during 2009-10, the hybrid NRCOP-31 performed better as compared to other hybrids with respect to FFB yield (13.5 t ha<sup>-1</sup>) at Mulde centre (Fig. 191). At Vijayarai centre, NRCOP-39 gave significantly higher FFB yield (23.7 t ha<sup>-1</sup>).



**Fig. 190. NRCOP-4 at Gangavathi centre**



**Fig. 191. NRCOP-31 at Mulde centre**

## 8.3. Post Harvest Technology in Palmyrah

- By HTST (High Temperature Short Time) sterilisation of fresh inflorescence sap (collected through ICAR-CPCRI method), there was no significant quality change upto 10 days and it could be stored for 15 days under refrigerated condition. Shelf life of carbonated/ Sulphited (0.01 % KMS) neera under refrigerated conditions was upto 14 days and it can be extended upto 30 days by carrying out pasteurization.

- Palmyrah syrup prepared by concentrating inflorescence sap collected through ICAR-CPCRI method (upto 68° Brix) was found superior in quality compared to traditional method and shelf life of palmyrah syrup at TSS of 63-68° Brix under refrigerated condition was upto three months and at ambient condition it was upto 30 days.

#### 8.4. 25<sup>th</sup> Annual Group Meeting of AICRP on Palms

The XXV Annual Group Meeting of ICAR-All India Coordinated Research Project on Palms was held at ICAR- CPCRI, Kasaragod from 19<sup>th</sup> to 21<sup>st</sup> May 2016. The inaugural meeting was graced by the presence of Dr. K. Ramasamy, Vice Chancellor, Tamil Nadu Agricultural University, Coimbatore, Dr. P. Chowdappa, Director, ICAR- CPCRI, Kasaragod, Dr. R. K. Mathur, Director, ICAR- Indian Institute of Oil Palm Research, Pedavegi, Dr. P. L. Saroj, Director, Directorate of Cashew Research, Puttur, scientists working in various centres of the project and scientists from various research stations of ICAR-CPCRI, Kasaragod. Dr. H. P. Maheshwarappa, Project Coordinator, presented a brief report highlighting the activities carried out during last year in various centres of the project. He informed the house that AICRP on Palms was bestowed with the Chaudhary Devi Lal Best AICRP award for 2014 (amongst 72 AICRPs operating in the country) during the 87<sup>th</sup> Foundation Day of ICAR, held at Patna in 2015.

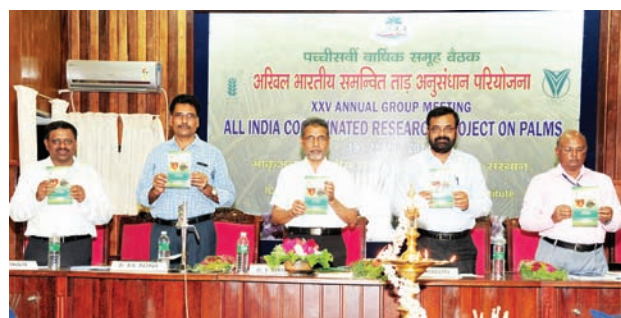
During 2015-16, a Tall × Tall coconut hybrid was recommended for release and promising high yielding oil palm hybrids have been evaluated, which could help in release of the first hybrid of the country in coming years. In crop production, coconut based cropping systems with organic nutrient management was successfully demonstrated at various centres and incorporation of flower crops as intercrops was found to be a profitable option at different centres. Black headed caterpillar was found to be a growing concern in the states of Tamil Nadu and Karnataka and successful management of the pest through mass release of the bio-control agents was demonstrated at various centres. Slug caterpillar incidence was reported in Andhra Pradesh and Karnataka, and its successful management was demonstrated using light traps. A number of activities including demonstrations, trainings and diagnostic field visits were carried out during the year for the benefits of the stakeholders.

Dr. P. L. Saroj emphasized that considering the changing scenario, improved varieties should be developed for multiple traits including those for various purposes and locations. Package of practices need

to be developed or modified considering the existing varieties, local climate and resource availability. Dr. R. K. Mathur opined that as the challenges of price fluctuation are growing, intercropping has become the need of the hour. Integrated nutrient management is highly relevant in the present context as it reduces the dependence on inorganic fertilizers, reduces production cost and improves soil health.

Dr. K. Ramasamy, while addressing the gathering suggested that, research works is being carried out in isolation and emphasized the need for coordinated research. He opined that the resources are scarce, so their utilization should be done in efficient way. In order to reduce the dependence on the imports, efforts should be made to promote and market the local produce with minimum support price. Value addition of coconut with diversified products could help in improving the profitability of the farmers and he emphasized the importance of skill development and identification of potential markets for tapping the potential of value added products.

Four publications were released from the AICRP centres during the inaugural session (Fig. 192). The performance of AICRP centres is being evaluated every year and during 2015-16, AICRP centre, Aliyarnagar was judged as the best performing centre.



**Fig. 192. Release of publications during inaugural session**

The plenary session was held on 21<sup>st</sup> May, 2016 under the chairmanship of Dr. N.K. Krishna Kumar, DDG (Hort. Sci.), ICAR, New Delhi and Dr. P. Chowdappa, Director, ICAR-CPCRI and Dr. R.K. Mathur, Director, ICAR- IIPOR, Pedavegi were also present at the occasion. Dr. H.P. Maheswarappa, Project Coordinator (Palms), briefed about the group meeting programme held for two days along with recommendations. DDG (Horticulture Science) gave away the certificate and memento to scientists of the best performing centre (Fig. 193). Recommendations from the various sessions were presented for approval of the session. In the chairman's remarks, DDG suggested inclusion

of cocoa as a mandate crop under AICRP on Palms to address the problems of cocoa crop and renaming the project as AICRP on Palms & Cocoa. During the programme, 10 publications were released for the benefits of the stakeholders.

Following suggestions were given by the DDG (Hort. Science) for further improving the output from the centres.

- The publications released during AGM may be circulated to Agricultural/Horticultural universities, Plant Protection Adviser, Govt. of India, Secretary DARE, Horticulture Commissioner, Govt. of Karnataka, Coconut Development Board, State Department of Agriculture and Horticulture.
- Cocoa crop should be included in AICRP in the following centres as intercrops in different states:



**Fig. 193. Award of certificate to best performing centre (Aliyarnagar)**

- Tamil Nadu, Veppankulam, Andhra Pradesh, Ambajipeta – Coconut + Cocoa
- Karnataka, Shivamogga – Arecanut + Cocoa
- Kerala, Trichur – Coconut + Cocoa
- Andhra Pradesh, Vijayrai – Oil palm + Cocoa

# KRISHI VIGYAN KENDRAS



## 9.1. Krishi Vigyan Kendra, Kasaragod

**K**rishivi Vigyan Kendra (KVK), Kasaragod had undertaken five on farm trials and 16 front line demonstrations during 2016-17 as a part of its mandatory activities. Besides, 63 on campus and 37 off-campus training programmes were also conducted benefitting 2,985 farmers. Further, various extension programmes including field visits to farmers' plots, advisories to farmers over phone, diagnostic visits, agricultural seminars, workshops, field days etc. were also organized benefitting more than 15,000 farm men and women. The Kendra also organized and participated in nine exhibitions and prepared 121 Technology display sheets depicting pest, disease and nutrient management of major crops cultivated in the district.

### 9.1.1. Major extension events undertaken

#### 9.1.1.1. Awareness Meeting on Pradhan Mantri Fasal Bima Yojana

ICAR-Krishi Vigyan Kendra, Kasaragod organized the Pradhan Mantri Fasal Bima Yojana Awareness Programme and an exhibition on 28<sup>th</sup> May 2016 at ICAR-CPCRI, Kasaragod. Dr. P. Chowdappa, Director, ICAR-CPCRI delivered the welcome address and Shri N.A. Nellikkunnu, hon. MLA (Kasaragod) delivered the presidential address. Shri P. Karunakaran, hon. Member of Parliament (Kasaragod), in his inaugural speech, opined that price fluctuations need to be included under PMFBY to mitigate losses to farmers (Fig. 194). More than 250 farmers and 50 extension



**Fig. 194. Shri P. Karunakaran, Hon'ble MP, Kasaragod addressing the gathering on PMFBY at ICAR-CPCRI, Kasaragod**

personnel from the Department of Agricultural Development and Farmers Welfare participated in the meeting. Further, 4,000 leaflets in Malayalam and 3,000 leaflets in Kannada were prepared and distributed among the farming community for creation of awareness on the benefits of the scheme.

#### 9.1.1.2. Entrepreneurship Development Programmes (EDP)

A project for promoting a farmer-producer organization at a total project cost of ₹ 9.06 lakhs was sanctioned by NABARD to KVK, ICAR-CPCRI, Kasaragod. As part of the programme, a sensitization programme was organized at Kasaragod on 10<sup>th</sup> June 2016 with the participation of 63 farmers. KVK has facilitated the registration procedures for the new company, 'Tulunadu Ecogreen Farmers Producer Company Limited'. The company has initiated its operation in Kinanoor Karindalam panchayats, Kasaragod district, by hiring a factory and more than one tonne of honey was agglomerated from farmers. For ensuring higher value to the local produce of farming community through value addition, the company has obtained various licences. The staffs were trained at KVK and production of jackfruit products were initiated.

KVK promoted minimal processing of fruits and vegetables (especially jackfruit) in schools and among women groups on community basis. Women SHGs were mobilized for production and sales of coconut based nutraceutical/medicinal products and nutraceutical foods and value added products of tapioca/sweet potato/raw jackfruit with minimal processing.

#### 9.1.1.3. Technology advisory meeting

A technology advisory meeting was organized under the joint auspices of ATMA, Department of Agricultural Development and Farmers Welfare, ICAR-CPCRI and KVK, Kasaragod at Kasaragod on 28<sup>th</sup> April 2016. Dr. P Chowdappa, Director, ICAR-CPCRI inaugurated the programme and the farmer-friendly technologies developed by ICAR-CPCRI were demonstrated during the meeting. Technology display sheets prepared by KVK depicting pest, disease and nutrient management of commonly

cultivated crops in the district were handed over for display in the Plant Health Clinics. Further, KVK staff were associated with technology demonstration in the farmers fields through front line demonstrations of the Department of Agricultural Development and Farmers Welfare and ATMA schemes under various Krishi Bahvans.

#### 9.1.1.4. Jai Kisan Jai Vigyan Diwas

‘Jai Kisan Jai Vigyan’ Diwas was celebrated at Ajanur panchayath, Kasaragod district on 29<sup>th</sup> December 2016. Two agricultural seminars were conducted on ‘Role of pulse crops in food and nutritional security’ and ‘Scientific banana cultivation’ with the participation of 50 farmers.

#### 9.1.1.5. Technology Meet

Technology Week was organized (in collaboration with ATMA) at Nileshwar, Kasaragod on 18<sup>th</sup> and 19<sup>th</sup> November 2016 with six seminars, interface programmes, exhibitions (with 25 stalls showcasing technologies by ICAR-CPCRI, KVK, developmental departments, private companies etc.), in which over 4000 farmers participated.

#### 9.1.1.6. Harvest Festival

Under the auspices of KVK, ICAR-CPCRI, Kasaragod, a Harvest Festival was organized at Paramba, West Eleri panchayath, Kasaragod district on 10<sup>th</sup> January, 2017 in connection with the Front Line Demonstration on ‘Introduction of greater yam (*Dioscorea alata*) var. ‘Sree Keerthi’ and lesser yam (*Dioscorea esculenta*) var. ‘Sree Latha’, (released by ICAR-CTCRI) in coconut based homesteads’ (Fig. 195). The average yield of greater yam and lesser yam were 23.75 and 8.82 tonnes ha<sup>-1</sup> respectively. Due to this intervention, farmers could raise an income of ₹ 34,980/- and ₹ 20,532/- respectively from 50 cents of cultivated area. Greater yam was observed to be a climate resilient crop as it has performed well and given good yield in spite of long spell of drought as perceived by farmers.



Fig. 195. Field day -FLD on greater yam and lesser yam

#### 9.1.1.7. Rabi Sammelan

‘Rabi Sammelan’ was organized during the centenary celebrations of ICAR-CPCRI from 10<sup>th</sup> to 13<sup>th</sup> December, 2016. As part of the ‘World Soil Day’ celebrations, a seminar on ‘Soil health management and drought mitigation measures’ was organized on 10<sup>th</sup> December, followed by the “Farmer- Scientist Interaction” session. On 11<sup>th</sup> December, 2016 seminars on ‘Scientific practices in dairy management’ and ‘Profitable goat rearing’ were conducted. More than 300 farmers participated in the seminar and obtained advisories on their field issues from the expert panel.

#### 9.1.2. Scientific Advisory Committee Meeting of KVK Kasaragod

The 21<sup>st</sup> Scientific Advisory Committee meeting of KVK, Kasaragod was conducted on 28<sup>th</sup> January 2017 at ICAR-CPCRI, Kasaragod. The meeting was attended by 30 members including the Director of Extension, KAU, scientists from ICAR-ATARI, Bengaluru, heads of divisions, ICAR-CPCRI and heads of various line departments from the district. The major recommendations were

1. Programmes to manage *Ganoderma* wilt and stem bleeding need to be taken up in Kasaragod and adjoining district as common intervention.
2. Skill development training programmes need to be given more emphasis.
3. Drought mitigation measures should be demonstrated in coconut gardens through mass campaigns for rejuvenation.
4. The interventions made in home science need to be categorized and up scaled.
5. Activities in veterinary and fisheries disciplines need to be undertaken with department and neighbouring KVKs.
6. Validation of ITKs should be taken up.



### 9.1.3. Ecological engineering for management of rice pests

A trial to study the effect of ecological engineering measures in paddy cultivation by planting nectar providing flowering plants combined with trap plants on the bunds of paddy fields at Uduma and Seed Farm, Karandakkad (covering an area of 5 ha), Kasaragod was conducted. Marigold was planted around on bunds (Fig. 196) which helped in the build-up of natural enemy population by providing pollen and nectar; sesamum flowers attracted natural enemies of paddy pests and the vetiver plants served as trap crop for stem borers. The pest incidence recorded was below threshold levels in the trial plot. In the trial plots, predators such as dragon flies, damsel flies, praying mantises and spiders were observed in large numbers as compared with control fields. Further, no incidence of stem borer and leaf roller was recorded over and above threshold levels in the trial plot. Generally three to four sprays are given for the management of pests alone during each crop season. They opined that the new technology is highly encouraging and promising and by adopting this technique, around ₹ 10,000/- could be saved towards pesticidal application besides environmental benefits. More over, they could get an additional income of ₹ 5,000/- through the sales of marigold flowers and vetiver roots.



**Fig. 196. Ecological engineering measures with marigold plants in paddy cultivation**

#### Soil, water and plant analysis

KVK could analyze 204 soil samples for major, secondary and micro nutrients during the period. The soil in Kasaragod district was found to be acidic (pH : 4.5 - 5.5) and deficiency disorder with respect to secondary nutrients like Ca and Mg as well as micronutrients such as B and Zn were observed. Among the major nutrients, average available K is in the range of 5.5 kg ha<sup>-1</sup>, which is very low and P was also found to be 9.8 kg ha<sup>-1</sup> which is also in the lower range.

### 9.1.4. Production and supply of technology products

The various technology products produced/sold by KVK include 17 kg of vegetable seeds, 59,272 planting materials of arecanut, papaya, drumstick, black pepper and vegetables, 791 kg bioproducts, 207 pheromone blocks and 1,000 fish fingerlings. Also, 225 kg of cereal based nutraceutical products, 318 kg honey, 10 kg of coconut oil based value added products, 110 kg of mushroom spawn and different chutney mixes were produced and sold. KVK generated a revenue of ₹ 9,06,126 through the revolving fund activity.

### 9.1.5. Success Stories

#### 9.1.5.1. Bee keeping for sustainable livelihood, food and nutritional security

Shri Devaraj, aged 41 years, belonging to Kundamkuzhi village of Bedadka Panchayath Kasaragod, is an enterprising youth willing to practice recent trends in the area of farming. His main occupation is farming activities. He frequently contacts KVK and Agriculture department for new varieties of vegetable crops. He owns around one acre of land where he cultivates coconut and arecanut; in addition, he also cultivates vegetable crops in around 80 cents owned by one of his relatives. To do his farming organically, he maintains two cows also.

#### 9.1.5.2. Intervention process

He came to know about bee keeping as a remunerative enterprise and approached KVK for getting trained on the same. He attended the vocational training programmes on bee keeping and stingless bee keeping organized by KVK, ICAR-CPCRI, Kasaragod during the year 2014-2015.

#### 9.1.5.3. Intervention technology

As a part of the training programme, he was given ten bee colonies with 50% subsidy from SHM. He managed the colonies very well as per scientific norms and was able to divide the colonies to around 30 by the honey flow season of 2015-2016 (December - January). Once he obtained trained on bee keeping enterprise, he resigned his temporary job and expanded his farming activities.

#### 9.1.5.4. Impact - Economic gains

During the current year, his total earnings was ₹ 1,90,000/- as compared against previous year's ₹ 1,35,000/- (4 qtl of arecanut, 2000 coconuts and around 10 qt. of different vegetable crops). This year he obtained an additional income of ₹ 55,000/- from the sales of 1.7 quintals of honey from Indian

bees and 3 kg from stingless bees so far. He expects three harvests of honey more during the ongoing season and more yield from crops due to enhanced pollination.

#### 9.1.5.5. Impact - Horizontal spread

This bee keeping unit serves as a model for aspirant youth who like to integrate bee keeping along with farming and he extends all help to them. Around 30 rural youth from the area has approached KVK for getting trained on bee keeping which is an evidence for the spread of the technology.

#### 9.1.5.6. Employment generation

Rearing of Indian bees and stingless bees provided self employment opportunities for him as well as his family members (Fig. 197). Self employment opportunities are also created to those who had taken colonies from them.



**Fig. 197. Shri Devaraj - a successful beekeeper**

#### 9.1.6. Organic Vegetable Cultivation

Shri B. Kunhiraman is a senior (aged 73 years) and innovative farmer belonging to Bare village of Uduma panchayath, Kasaragod. He owns 2.5 acres of land out of which one acre is earmarked for vegetable cultivation alone. He practices integrated farming system in 1.5 acres with coconut as main crop, banana, pine apple, arecanut as subsidiary crops and poultry diary as allied enterprises (Fig. 198).

##### 9.1.6.1. Intervention process

KVK, ICAR-CPCRI, Kasaragod collaborated with Krishi Bhavan, Uduma to conduct a Farm School on 'Organic vegetable cultivation' and in connection with this, Shri Kunhuraman and the members of his group were extended all technological and information support by way of training programmes, skill demonstrations and supply of organic inputs.

##### 9.1.6.2. Impact-Economic gains

The total income from the vegetable plot during the year 2014 – 2015 was ₹ 2,48,000/-. They had spent



**Fig. 198. Shri Kunhiraman in his organic vegetable cultivation plot**

around ₹ 95,000/- only towards cost of cultivation. They had utilized all locally available crop residues for in-situ composting and around 90% of the organic manures were produced or recycled in their own farms and they never engaged outside labourers.

##### 9.1.6.3. Impact-Horizontal spread

The success story of this farmer and his group was published in *Karshakan* (December 2015 issue) and since then many farmers have contacted him for necessary guidance and support for organic cultivation of vegetables. The farm school revealed that the benefits of organic farming practices are low capital investment (farming activities carried out by farmers themselves), farm level recycling of crop wastes, maintenance of soil health and pollution free agroecological system. Further, they are able to make use of indigenous knowledge which sustains mainly with locally available resources and minimum external inputs.

##### 9.1.6.4. Employment generation

In the succeeding year, several self help groups have started organic vegetable cultivation and are seeking advice and suggestions from Shri Kunhuraman, which created employment opportunities for rural youth of nearby areas.

#### 9.1.7. Popularization of brined jackfruit processing through community approach

A Front Line Demonstration (FLD) on 'Promotion of indigenous method of brining of jackfruit' was proposed with refinement and standardization for an amount of ₹ 10,000/- three years back, considering the availability of jackfruit in glut and its under utilization due to labour intensive processing techniques and lack of motivation for group initiatives for processing and promotion of

the farm produce. Traditionally jackfruit brining was done using hand measure and the shelf life of the product was more than a year. Brined jackfruit is used in the form of curry and is a special delicacy in the region of Kasaragod district and South Karnataka. However this technique was familiar only to few of the elderly women, who managed to process it for their household use. Considering its demand and its low cost, it was felt that the fruit can be used effectively by revival of this technique through standardization of the same and community approach. Large scale processing and bulk utilization of the raw fruit to achieve food security was the major focus of the activity. On determining the brining percentage, the technology was demonstrated in a few schools with school lunch programmes, involving teachers and students and women SHG's. The technology has been taken up at Sri Bharathi Vidyapeeta at Mungangavu and Badiadka, Sri Durga Parameshwari High School, Dharmathadka, Holy Family Convent, Kumbala, Sadguru Sri Nithyananda Vidyapeeta, Kondevoor and by two women entrepreneurs (Table 28).

Through community approach in schools involving parents, students and teachers, the traditional technique has been familiarized for revival of the same for the future generations. The activity is made innovative to sustain it further by taking it up regularly under their curriculum of science activity and also saved on a considerable amount of money on purchase of vegetables. The brined jackfruit is served in the form of curry at least twice a week in schools in different forms. The importance of natural food forms and effective utilization of our own farm produce to the maximum extent in place of purchased vegetables from the market in view of health and safety and significance of the usage of natural /organic forms with minimum processing which is the main objective of this activity is well taken with a very positive implication. The brined

jackfruit which was earlier stored in large pots or plastic containers is also made available in small standing pouches with attractive packaging and labeling and sold @ ₹ 150/- kg<sup>-1</sup>. Value added products from brined jackfruit like *Nippattu* and *Undalakalu* (supplemented with sprouted ragi flour) has also standardized and promoted through the two women entrepreneurs.

## 9.2. Krishi Vigyan Kendra, Alappuzha

### 9.2.1. Technologies Assessed and Transferred

Seven on farm testing (OFTs) trials and 14 front line demonstrations (FLDs) were taken up in farmers field during the year (Tables 29, 30 and Fig. 199, 200, 201, 202).

### 9.2.2. Capacity building programmes

Ninety eight training programmes were organized during 2016-17 benefitting 2856 participants (Table 31).

### 9.2.3. National Innovations on Climate Resilient Agriculture

The NICRA project is funded by ICAR and coordinated by ICAR-CRIDA, Hyderabad through ICAR-ATARI, Bengaluru. Technology Demonstration Component of the project is implemented at Muttar village (Veliyanad block, Kuttanad taluk) in Alappuzha district by the KVK. The following technology demonstrations were taken up during the year.

#### 9.2.3.1. Large scale composting of aquatic weeds using EM solution and use for vegetable cultivation in grow bags

Aquatic weeds from 64 ha paddy fields amounting to 5500 m<sup>3</sup> were removed and composted using EM solution to produce 60 t of compost which was utilized for banana and vegetables crops in the field and for media preparation for grow bag cultivation of vegetables. About 400 farm women were involved in this activity.

**Table 28. Organizations/women entrepreneurs who have taken up jackfruit processing**

Organizations/farm women	Qty of raw jackfruit processed (in Kgs)		
	2014	2015	2016
Sri Bharathi Vidyapeeta, Mungangavu	500	500	750
Sri Bharathi Vidyapeeta, Badiadka	1000	500	500
Sri Durga Parameshwari High School, Dharmathadka	-	-	750
Holy Family Convent, Kumbala	-	500	500
Sadguru Sri Nithyananda Vidyapeeta, Kondevoor	-	-	1,500
Smt. Lakshmi Bhat	200	100	100
Smt. Vijayashree	100	100	100
Total	1800	1700	4200

**Table 29. Details of on farm testing trials (OFTs) taken up by KVK-Alappuzha**

Title	Technology	Location
Assessing the performance of newly released KAU paddy varieties	KAU paddy varieties – Uma, Prathyasa, Sreyas	Muttar
Assessing the performance of short duration cassava varieties in coconut gardens	ICAR-CTCRI tapioca varieties – Sree Jaya, Sree Vijaya and Sree Pavithra	Mararikulam, Mannanchery
Assessing the effect of nutrient mix 'Ayar' in Banana cultivation	Recommended soil test based INM practices + 'Ayar' (secondary and micro nutrient mix) @100 g plant <sup>-1</sup> in 2 & 4 months after planting	Mararikulam, Mannanchery
Assessing the effect of border line planting of turmeric in tapioca fields for rodent management	Planting turmeric as border line in comparison to planting <i>Plumbago</i> as border line in tapioca field	Mararikulam, Mannanchery
Assessing bio formulations for pseudo-stem weevil management in banana	Entomopathogenic nematode leaf axil filling (KAU) in comparison to Neem soap (IHR) 5% Leaf axil filling and spraying of 'Nanma' twice	Venmony
Assessing the performance of fodder crops in coastal plains of Alappuzha district	TNAU varieties - Fodder Sorghum CO (FS)-29 and Hybrid Napier var.CO 4	Mararikulam
Management of ruminal acidosis due to beer waste feeding in lactating dairy cows	Commercial feed @ 200 g l <sup>-1</sup> milk yield + beer waste @ 300 g l <sup>-1</sup> milk yield + Green fodder + TANUVAS – GRAND supplement @ 20 ml day <sup>-1</sup> + Mineral mixture supplement @ 40 g day <sup>-1</sup>	Mararikulam

**Table 30. Details of front line demonstrations (FLDs) taken up during the year 2016-17**

Title	Technology	Location
Enhancing productivity of coconut based cropping system in coastal sandy soils	Soil moisture conservation by coconut husk burial in trenches and addition of organic manures for crop production (CPCRI)	Mararikulam
Demonstration on integrated approach for enhancing profitability of root wilt affected coconut palms	INM – Basin management and IPDM (CPCRI)	Mararikulam
Eco friendly management practices against leaf spot in amaranthus	Pseudomonas seed treatment, seedling dip and 2% foliar spray and Trichoderma soil application (KAU)	Mararikulam, Mannanchery
Demonstration on resource conserving and eco friendly technologies of paddy in Kuttanad	Soil test based dolomite and nutrient management, Sowing using drum seeder, and eco friendly pest and disease management (KAU)	Edathwa, Thakazhy, Neelamperoor, Ramankary
Demonstration on Green gram variety Co (Gg) 8 in coastal plains of Alappuzha district	Green gram variety Co (Gg) 8 (TNAU)	Mararikulam, Mannanchery
Demonstration on black gram variety Co 6 in coastal plains of Alappuzha district	Black gram variety Co 6 (TNAU)	Mararikulam, Mannanchery
Demonstration of organic cultivation of winged bean in homesteads	Organic cultivation of protein rich winged bean which is less susceptible to pests and diseases (KAU)	Mararikulam, Mannanchery
Demonstration of EM composting of plant residues for organic manure production	<i>In situ</i> composting of plant residues using EM solution for converting them into organic manures	Mararikulam, Mannanchery, Nedumudy

Fungal disease management in cowpea using bioagents	<i>Pseudomonas fluorescens</i> seed treatment $10\text{g l}^{-1}$ and foliar spray 2%; <i>Trichoderma</i> soil application by multiplying it in neem cake – cow dung; and Dolomite application $0.5\text{ kg pit}^{-1}$ (KAU)	Mararikulam, Mannanchery
Oyster mushroom production using banana pseudostem waste and value addition	Oyster mushroom production using banana pseudostem waste and value addition	Mararikulam, Mannanchery, Chunakkara
Demonstration on cluster based integrated pest management practices against mango fruit fly	Reducing the pest population by destruction of infested fruits, raking of soil, setting up of MET, monitoring pest population, bait spray on need basis, and hot water treatment of harvested fruits (KAU)	Mararikulam, Mannanchery
Introduction of Aseel breed in backyard system of poultry rearing	Aseel breed (TANUVAS)	Mannanchery
Demonstration of Hydroponics method of fodder production for dairy	Production of fodder grass by Hydroponics method (NIANP)	Mararikulam, Mannanchery
Demonstration of value added products from Robusta banana	RTS (TNAU) and cake from Robusta banana	Mannanchery, Chingoli and Palamel

**Table 31. Capacity building programmes**

Training	No. of Programmes	Participants		
		Men	Women	Total
On campus	36	502	486	988
Off campus	55	780	861	1641
Extension Officials	4	53	86	139
Sponsored	3	46	42	88
Total	98	1381	1475	2856

**Fig. 199. EDP on banana value addition****Fig. 200. Field day of FLD on Mushroom**

Tissue culture banana cultivation in poly bags during initial period and main field cultivation after receding the monsoon flood was taken up in fifteen farmers' plots and the B:C ratio could be increased from 1.15 to 1.66 by this technology.

**Fig. 201. Field day of FLD on Amaranthus cultivation**



**Fig. 202. FLD on fodder production through hydroponics**

#### **9.2.3.2. Cultivation of high yielding short duration cassava variety (Sree Jaya)**

The short duration variety was introduced to escape flood during monsoon season.

#### **9.2.3.3. Planting of different tree species having flood tolerance and green foliage**

To promote afforestation for climate resilience, six different species of plants (mango, jack, rose wood, guava, curry leaf and neermaruthu) were planted at 350 farmers plots.

#### **9.2.3.4. Soil health card for better nutrient management**

Two hundred and fourteen soil samples, covering about 220 ha area including upland and low land fields, were collected and analyzed for major and micronutrients and soil health cards issued to about 1000 farmers.

#### **9.2.3.5. Milky mushroom cultivation for income generation during summer**

In order to overcome the lower productivity of oyster mushroom during summer, cultivation of milky mushroom was introduced to increase the income generation during the summer season.

#### **9.2.3.6. Resource conserving and eco friendly management practices in paddy cultivation**

The technology package was demonstrated in 31 ha area involving 24 farmers during the year which resulted in an yield increase of 11% (from 6.1 to 6.8 t ha<sup>-1</sup>) enhancing the B:C ratio from 1.68 to 2.48 (Fig. 203).

#### **9.2.3.7. Demonstration of fish silage as supplementing feed for backyard poultry during flood situations**

Fish silage (fish waste treated with 3.5% formic acid) preparation and feeding to homestead poultry was demonstrated in 100 homesteads which could manage



**Fig. 203. Paddy harvest festival at Muttar**

of protein deficiency in homestead poultry and increase the egg production. Moreover, fish waste could be effectively utilized which improved cleanliness.

#### **9.2.3.8. Demonstration of low cost hydroponics fodder sprouts production for dairy units**

Four low cost hydroponics fodder production units were established in partnership with dairy farmers which proved as an effective and efficient fodder production system of high quality which in turn enhanced the returns to farmers.

#### **9.2.4. Enhancing economic viability of coconut based land use systems for land use planning in Kerala state**

KVK implemented the demonstration component of the Kerala State Planning Board funded project on 'Enhancing the economic viability of coconut based land use system for land use planning in Kerala state' at Chettikulangara, representing the Onattukara Sandy soils (AEU-3) and Mayyanad panchayath representing Southern Coastal Plains (AEU-1). Started in April 2015, this project aims at increasing the returns from coconut based land use system through increasing productivity of coconut palms by improving the soil health through organic residue recycling and soil test based nutrient management. Ten demonstration plots, each having 30-40 palms, are maintained in both the locations with management practices including soil test based fertilizer application in two splits, prophylactic plant protection measures, and residue recycling in the basins. Recording of yield and related observations are being taken up to assess the effect of these management practices.

#### **9.2.5. New initiatives in entrepreneurship development: Farmer Producer Company under the aegis of KVK**

NABARD has sanctioned a new project under the Produce Fund Scheme to KVK-Alappuzha

for promoting a farmer producer company on spices with a budget outlay of ₹ 9.06 lakhs. The 'Onattukara Spices Farmers Producer Company' covering Bharanikkavu block of Alappuzha district has been registered with the Registrar of Companies on 7<sup>th</sup> December 2016 with the objectives of organizing spices farmers (mainly turmeric, ginger, pepper, and garcinia) to undertake scientific cultivation, seed production, centralized nursery for seedling production, processing, branding, and marketing, and expanding the activities on commercial basis so as to enhance the income of the share holding member farmers. The first general body meeting was conducted on 2<sup>nd</sup> March 2017 which elected a 11 member Director Board. Till 31<sup>st</sup> March 2017, 209 farmers have become share holders of the company. About 2 t seed rhizomes of turmeric HYV (IISR-Prathibha) has been made available to the share holding farmers for the expansion of cultivation and about 7 t of rhizomes procured for processing and value addition during the year. Training programmes for the scientific cultivation of ginger and turmeric are conducted in different locations for the benefit of the shareholder farmers.

#### 9.2.6. Impact of KVK interventions on value addition of vegetables in the state

Various interventions of the Govt. of Kerala and other agencies have resulted in increased vegetable production in the state during the last few years, but farmers face problems of seasonal glut and low price, highly perishable nature of the vegetables,

lack of centralized marketing system, and lack of cold storage facilities. Vegetables like amaranthus, oriental pickling melon, ash gourd, bitter gourd, bottle gourd, cow pea, pumpkin, snake gourd, ridge gourd, tomato, chilly and brinjal are the commonly cultivated vegetables in Kerala which are prone to wastage in peak seasons. Processing and value addition of these perishables is one of the effective ways to overcome this situation which can prolong the shelf life and assure economic returns when taken up as a group activity especially for women farmers. ICAR-KVK-Alappuzha has developed/ refined several technologies for value addition of vegetables with prolonged shelf life and marketability (Fig. 204, 205 & Table 32).



**Fig. 204. Value added products from vegetables exhibited in VAIGA 2016**

**Table 32. Technologies standardized /refined by KVK-Alappuzha**

Vegetable/fruit	Parts used	Possible products
Cucumber	Juice	Squash, RTS (Ready to serve) beverage, Fresh Juice, Bath Soap
	Flesh	Pickle, halwa, kondattam, tutti-fruitti, neer dosa
	Placenta	Face pack
Amaranthus	Extract	Squash, RTS beverage
	Stem	Cutlet, baji, pickle
Ash gourd	Flesh	Halwa, pickle, peda, kondattam, neer dosa
	Juice	Juice (fresh juice without sugar)
Snake gourd	whole	Halwa, pickle
Bhindi, Cowpea, Brinjal	Whole	Ready to cook dehydrated forms/ pickles
Pumpkin	Immature	Pickle, sauce with green chilly, neer dosa
	Mature	Halwa, Jam, Kondattam
Tomato	Whole	Pulp, pickle, ready to cook dehydrated forms
Bitter gourd	Whole	Fresh juice, pickle, vattals
Bottle gourd	Whole	Fresh juice, halwa, pickle, kondattam, neer dosa



**Fig. 205. Value added products from vegetables**

### 9.2.7. Interventions of KVK Alappuzha in value addition of vegetables

During 2013-14, through an Entrepreneurship Development Programme (EDP), a woman group of Cheriyanad Panchayath of Chengannur Block was equipped to prepare the products from oriental pickling melon which generated good demand in exhibitions and the women group could earn profitable income from the products. Knowing about the value addition technologies of oriental pickling melon farmers from Perumbalam, Tholikkode, Venmony, and Kanjikkuzhy Panchayaths approached KVK for technical knowhow and hands on training were given to them.

Following the success of these enterprises, during 2015-16, based on request from the Department of

Agriculture, Govt. of Kerala, the KVK has trained selected farmers of 'A' grade vegetable clusters from all the 14 districts of Kerala on 'value addition of vegetables' under the scheme 'Project based assistance for value addition in vegetables' and the programme was conducted in eight batches from January to March, 2016. The project aimed to establish value addition units of vegetables/fruits in 72 'A' grade clusters and Block Level Federated Organizations formed under Vegetable Development Programme of the Department of Agriculture with the technical guidance of KVK-Alappuzha. These groups were provided with a financial support of ₹ 2 lakhs by the Department to set up a farm level processing and value addition unit of vegetables and seasonal fruits. Besides the hands on experience in producing various value added products, the groups were oriented on licensing procedures, various aspects of project proposal preparation and credits and loans available from different financial institutions etc. After the training they were provided with project proposals for the purchase of machineries.

In order to assess the impact of this training programme and follow up technical support, a survey was conducted among these 188 participant trainees within six months of the completion of the programme. All of them responded to the survey. Out of them, 76 had initiated the processing enterprise and collectively established 20 units which are running successfully (Table 33). Sixteen of the trainees had to discontinue their enterprises due to various reasons.

**Table 33. District wise participation of farmers in the training programme and no. of adopters**

District	No. of participants	No. of adopters	No. of units established
Thiruvananthapuram	22	9	3
Kollam	13	-	-
Pathanamthitta	10	4	2
Alappuzha	32	15	4
Kottayam	14	2	1
Idukki	11	2	1
Ernakulam	11	2	1
Thrissur	07	2	1
Palakkad	09	-	-
Malappuram	15	4	1
Kozhikkode	11	8	2
Wayanad	13	6	2
Kannur	11	3	1
Kasaragod	09	3	1
<b>Total</b>	<b>188</b>	<b>60</b>	<b>20</b>

### Outcome

Many of the trainees either individually or in group initiated value addition of vegetables and marketing along with other activities during off seasons. Achievements of some of them are listed out (Table 34).

### Impact

Two to five members of the vegetable cluster are actively involved in the processing and value addition

of vegetables (Fig. 206). Weekly twice or thrice, they are involved in the processing activity. Surplus vegetables (unsold) from the eco-shops are utilized for value addition and products are also sold through these shops. During off season, they are engaged in farming activities and value addition of seasonal fruits, tubers and cereal and spice powders.

As a result of the various interventions of KVK-Alappuzha in this sector, nearly 5000 man days could be generated and 20 tons of good quality

**Table 34. Some of the successful entrepreneurs in value addition of vegetables**

Name and Address	Products from vegetables/fruits	Returns per month* (₹)	Other activities
Shini P.S., Vellamunda, Wayanad	Vattal, Vatak, Kondattam Pickle (Using vegetables), Ginger and amla candy	1,00,000	Products from spices and fruits
Johnson T.A., Wayanad Eco-shop, Patinjarethara Wayanad	Halwa using cucumber and Papaya, Pickle using different vegetables, Squash from amaranthus and cucumber	20,000	Involving in cultivation of vegetables and spices
Mary Mathew, Jaivikam Vegetable Cluster, Koorachund, Calicut	Pickle using different vegetables Squash using cucumber and pineapple Kondattam	25,000	Chips making and fruit jams
Remya R., Thanima Vegetable Cluster, Palamel Alappuzha	Pickle using different vegetables, Halwa using snake gourd, cucumber, carrot, jackfruit, beetroot etc., Squash from cucumber, amaranthus, Vattals, soap	30,000	Products from seasonal fruit, spices powder Squash, halwa and Jam
Bobby M.D., Malayali Vegetable Cluster, Tholicode Thiruvananthapuram	Cucumber soap, Squash from cucumber, amaranthus and banana pseudo stem, Pickle using different vegetables, Halwa from pumpkin and cucumber, Cutlet from vegetables on demand	15,000	Members of the Karshika Karma Sena engaged in cultivation of vegetables, paddy, banana etc
Sudha Devi, Farm Fresh Vegetable Cluster, Kuzhur, Thrissur	Pickles cucumber, ash gourd and Bitter gourd, Brined vegetables Squash	11,000	Chips
Jijimon C.P., Gramin Fresh Chettikkode, Ernakulam	Soap using – cucumber, ash gourd, turmeric and lemon Pickles from cucumber, ash gourd and Bittergourd, Squash from cucumber and pineapple	20,000	Chips
Usha Prasannan, Bheemanadi Vegetable Cluster, Kasaragod	Pickles using seasonally available vegetables, Halwa using cucumber, Squash from cucumber, amaranthus, Vattals	9,000	Jack fruit products in season
Padma Sasikumar, Thejus Agrifood Processing Unit, Kulanada, Pathanamthitta	Fresh cut Ready to cook vegetables, Pickles From vegetables and fruits, Squash	15,000	Rice flour Spice powder Chutney powder And chips
Subhadramma, Sivam Vegetable Cluster Chunakkara, Alappuzha	Squash from cucumber, amaranthus and banana pseudo stem, Pickle using different vegetables, Halwa from pumpkin and cucumber, Soap	15,000	Chips from banana and tapioca Pickles using fruits

Name and Address	Products from vegetables/fruits	Returns per month* (₹)	Other activities
Vijayamma, Udayam Vegetable Cluster, Venmony, Alappuzha	Pickles using seasonally available vegetables, Halwa using cucumber, carrot Squash from cucumber, amaranthus, Jam using beetroot Fruit products	15,000	Fruit products ,Jackfruit products
Sanjayan, Ujjwala Vegetable Cluster, Aryanad, Thiruvananthapuram	Squash using cucumber and amaranthus, Soap using cucumber, Pickle using vegetables, Halwa using pumpkin and cucumber	20,000	Chips from banana, tapioca, Potato
Suresh, Sree Haritha FIG, Perumbalam, Alappuzha	Cucumber soap and Squash	10,000	Regularly preparing soap
Sandhya Chalunkal, Haritha Vegetable Cluster, Kanjikkuzhy, Alappuzha	Cucumber soap, Squash from Amaranthus, cucumberPickle from Amaranthus	10,000-15,000	Products from fruit and vegetables
Sarala Gopalan, Samridhi Vegetable Cluster, Cheriyanad, Alappuzha	Cucumber soap, Squash and pickle, Face pack	15,000	Actively engaged in vegetable cultivation

\*From value addition of vegetables alone



**Fig. 206. Vegetable value addition unit at Kanjikkuzhy and Perumbalam**

products prepared from vegetables resulting in an income of about ₹ 44.5 lakhs within a short period of six months during 2016. These processing units/

activities are mainly concentrated in the rural area, which enhances the livelihood of rural population and serve as inspiring models for others to follow.

# LIBRARY AND INFORMATION SERVICES

The ICAR-CPCRI Library and Information Centre is one of the finest libraries in India housing a rich collection of resources on plantation crops catering to the information requirements of the scientific, technical and administrative staff of the institute, the researchers from universities, under graduate and post graduate students, industries on plantation crops and other related organizations.

## Services

### The Library Web Page

The library web page under the institute website gives an overall view of activities and services provided by the library.

- The Online Public Access Catalogue (OPAC)
- Institute publications
- Institute Digital Repository
- Consortium of E-resources in Agriculture (CeRA)/Krishikosh/Krishiprabha/Agricat
- Links to subscribed e-books/online databases
- Online journals/archives
- Databases developed in-house
- Open access resources

### ICAR-CPCRI Digital Repository

The institute digital repository, holding a literature collection to the tune of 6600, is user friendly with six communities and provides full text access to its resources through the intranet. The access to the digital repository is provided in the institute website under the webpage for library. The usage of the digital repository came to around 471 hits per month.

- Research Papers by ICAR-CPCRI Staff
- Institute Publications
- Mandate Crops-Other than ICAR-CPCRI
- Deputation Reports
- Reprints
- RPF
- Theses/Project Reports

### Online Journals / Databases / E-books

The institute provided links to access the subscribed e-journals, archives of e-journals, e-databases and e-books in the library page of the institute website.

### Document Delivery Service

As part of the Resource Sharing Programme under CeRA, the library provided online Document Delivery Service to the tune of 255 articles, on demand.

### Newspaper Clippings Service (Glimpse)

"The glimpse", a newspaper clippings service covering news items related to agriculture and allied sciences was brought out every month. News items related to the institute were made available under ICAR-CPCRI in media in the institute web site.

### Reprography Service

Library and Information Centre provided reprography service such as scanning / photocopying of resources to clientele as well as to visitors.

### Exchange of Publications

The institute received around 250 publications such as Annual Reports, Research Highlights and Vision on exchange from other institutes.

## Research Articles

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## TECHNOLOGIES

## IX.

## Varieties and hybrids

## Coconut

**Kalpa Shatabdi:** A high yielding coconut variety with high copra out turn of 28.65 kg palm<sup>-1</sup> year<sup>-1</sup>, under Kasaragod conditions, with large fruits, and higher copra content (272.9 g). The tender nut water is good to taste with TSS of 6.12° Brix and large in quantity (612 ml). The variety is recommended for cultivation in Kerala, Karnataka and Tamil Nadu.



Kalpa Shatabdi

## Arecanut

**Shatamangala:** A high-yielding arecanut selection VTL-146, with dry kernel yield of 3.91 kg palm<sup>-1</sup> year<sup>-1</sup> and tender nut yield of 3.26 kg palm<sup>-1</sup> year<sup>-1</sup> was released for dual purpose.



Shatamangala

## Cocoa

**Nethra Centura:** A high yielding cocoa hybrid variety of IC 565554 x IC 565559, with a bean yield of 3.2 kg dry beans tree<sup>-1</sup> year<sup>-1</sup>. The pods are green to yellow. The hybrid is recommended for Karnataka, Kerala, Tamil Nadu and Andhra Pradesh.



Nethra Centura

## Machineries and gadgets for gender mainstreaming

## Self loading arecanut dehusking machine along with a grading unit

A beating type arecanut dehusker of 0.5 HP has been developed to remove the husk from matured dried arecanuts. The grading of arecanut by three different



Arecanut dehusking machine



**Arecanut grading unit**

sizes (3-4cm, 4-5cm and >5 cm) is made before dehusking. The husk and dust separated by means of blowers and collected in collection chamber. The capacity of the developed machine is 120-150 nuts minute<sup>-1</sup>. The dehusker with the built-in feeding device along with the grading unit can substantially reduce the drudgery and the labour cost to one fifth of the cost incurred in manual dehusker.

### Value added products

#### Kalpa Krunch

An extruded snack, prepared by incorporating coconut milk residue along with rice (60 %) and corn flour (25 %), has been commercialized as Kalpa Krunch. The flavours has been formulated with different spices and vegetables (coriander, garlic, turmeric, clove, cinnamon, chilli, mint, cardamom, tomato and celery). Kalpa Krunch is rich in dietary fiber, protein,



**Kalpa Krunch**

fat and carbohydrate and high in antioxidant activity. It is crispy and puffy in nature. This technology has already been transferred to three entrepreneurs.

#### VCO cake based muffins

A formulation of muffins was made by replacing refined wheat flour (RWF) with virgin coconut oil cake. The standardized formulation contains VCO cake (15.6 g 100 g<sup>-1</sup>), RWF (10.4 g 100 g<sup>-1</sup>), sugar (26 g 100 g<sup>-1</sup>), egg (21 g 100 g<sup>-1</sup>), full fat milk (13 g 100 g<sup>-1</sup>), shortening (12 g 100 g<sup>-1</sup>), sodium bicarbonate (1.1 g 100 g<sup>-1</sup>) and salt (0.1 g 100 g<sup>-1</sup>). It is enriched with protein (8.49 g 100 g<sup>-1</sup>), fat (18.46 g 100 g<sup>-1</sup>), crude fibre (1.14 g 100 g<sup>-1</sup>) and minerals (1.15 g 100 g<sup>-1</sup>).



**VCO cake based muffin**

#### Coconut water jelly

A coconut water based jelly has been prepared with the addition of a gelling agent. The heating regimen was optimized at 85°C for 10 minutes. Mature coconut water, obtained during the production of copra, virgin coconut oil, coconut milk and desiccated coconut powder, can also used for the preparation of jelly. It contains 73.3 g moisture, 12.8 g total sugar, 0.2 g protein, 171.1 mg potassium, 1.5 mg vitamin C and 16.2 mg GAE phenolics.



**Coconut water jelly**

### Kalpa Dark Chocolate

Kalpa Dark Chocolate is a coconut sugar based dark chocolate purely from plant based ingredients without any dairy ingredients such as milk. It is a joint venture between ICAR-CPCRI and CAMPCO (Central



**Kalpa Dark Chocolate**

Arecanut and Cocoa Marketing and Processing Cooperative Ltd.). It contains cocoa powder, coconut sugar, natural vanilla extract and GMO free sunflower lecithin. It is low in glycemic index. It does not contain any added artificial ingredients. It is delicious dark chocolate for a healthy life and can be stored under room temperature and does not melt. It is available in 30 g slabs.

### Kalpa Drinking Chocolate

Kalpa Drinking Chocolate is an instantised blend of low GI coconut sugar, crafted from fine cocoa powder formulated to produce the delicious drinking chocolate. It is to titillate the taste buds of



**Kalpa Drinking Chocolate**

drinking chocolate lovers who want a healthier life style. It does not contain any artificial ingredients. The product is produced by a unique technology of instantisation and agglomeration technique that makes the product soluble instantly in hot or cold milk releasing the chocolate aroma. The product is filled in 200 g PET jars duly sealed, case corrugated.

**Best Oral Paper Presentation Awards**

The research paper entitled 'In vitro shoot regeneration from immature inflorescence of coconut', by Shareefa, M., Thomas, R.J., Sreelekshmi, J.S., Raju, C.R. and Anitha Karun was awarded the best oral paper presentation award in the Technical Session 'Biotechnology for Crop Improvement' during *3<sup>rd</sup> International Symposium on Coconut Research and Development (ISOCRAD-3)* held at ICAR-CPCRI, Kasaragod during 10<sup>th</sup>-12<sup>th</sup> December, 2016.

The research paper entitled 'Controlled delivery of ethyl 4-methyl octonate, the pheromone of coconut rhinoceros beetle, *Oryctes rhinoceros* L.' by Subaharan, K., Eswarmoorthy, Pavankumar, B.V.V.S., Vibina Venugopal, Chalapathi Rao, N., Gaurav, S., Rajamanickam, S., Ganesan, S., Josephraj Kumar, A., Maheswarappa, H.P., and Raveendran, P. has been awarded the best oral presentation award in the Technical Session 'Management of Pests' during *3<sup>rd</sup> International Symposium on Coconut Research and Development (ISOCRAD-3)* held at ICAR-CPCRI, Kasaragod during 10<sup>th</sup>-12<sup>th</sup> December, 2016.

The research paper entitled 'Optimization and evaluation of ready to eat extruded snack from virgin coconut oil cake' by Shameena Beegum, Manikantan, M.R., Monika Sharma, Arivalagan, M., Hebbar, K.B. and Gupta, R.K. has been awarded the best oral presentation award in the Technical Session "Value addition and product diversification" of *3<sup>rd</sup> International Symposium on Coconut Research and Development (ISOCRAD-3)* held at ICAR-CPCRI, Kasaragod during 10<sup>th</sup>-12<sup>th</sup> December, 2016.

Best oral presentation award was presented to Ms. T.N. Ranjini, Scientist, for a paper on 'Variability studies in a multi potent medicinal tree *Terminalia chebula* Retz. at National Seminar on Forest and Tree Based Land Use Systems for Livelihood, Nutritional and Environmental Security' held at the Navasari Agricultural University, Gujarat during 21<sup>st</sup> - 23<sup>rd</sup> December, 2016.

Mrs. Jissy George (Subject Matter Specialist-Home Science) of KVK-Alappuzha bagged the best paper

award for the paper on Processing and value addition of vegetables as a high income enterprises for women SHGs in the session on "Processing and Value Addition and Market led Extension Programmes" in the Second KVK Symposium conducted during 7<sup>th</sup> - 8<sup>th</sup> March, 2017 at TNAU, Coimbatore.

Award for the best oral paper presented at the National Conference on "Frontiers in Genetics & Genomics", organized by Dept. of Genome Science, School of Biological Science, Central University of Kerala, Padannakad, Kasaragod, Kerala during 7<sup>th</sup>-8<sup>th</sup> April, 2016, was bagged by the research paper entitled, 'Comparative gene expression profiling during *in vitro* regeneration in two coconut cultivars' authored by Bhavyashree, U., Rachana, K.E., Lakshmi Jayaraj, K., Rajesh M.K. and Anitha Karun.

**Best Poster Awards**

Dr. Jeena Mathew was awarded the Best Poster Award for the paper entitled "Assessment of major and secondary nutrient profile of coconut palms grown in different Agro Ecological Zones of South Kerala" in the Technical Session "Enhancing Input Use Efficiency" at *3<sup>rd</sup> International Symposium on Coconut Research and Development (ISOCRAD-3)* held at ICAR-CPCRI, Kasaragod from 10<sup>th</sup> - 12<sup>th</sup> December, 2016.

Award for the best poster presented in the Technical Session "Biotechnology for Crop improvement" at *3<sup>rd</sup> International Symposium on Coconut Research and Development (ISOCRAD-3)* held during 10<sup>th</sup>-12<sup>th</sup> December, 2016, at ICAR-CPCRI, Kasaragod was bagged by the poster entitled, 'Anther and isolated microspore culture of coconut (*Cocos nucifera* L.)' presented by Rajesh, M.K., Muralikrishna, K.S., Sajini K.K. and Karun, A.

Best poster award was bestowed upon the research paper on 'e-kalpa cloud based interactive mobile application for coconut farmers and stakeholders' by Anithakumari, P., Merin Babu, Chowdappa, P., and Krishnakumar, V. in the Technical Session on "Research Extension Interface and policy issues" during *3<sup>rd</sup> International Symposium on Coconut Research and Development (ISOCRAD-3)* held at ICAR-CPCRI, Kasaragod during 10<sup>th</sup>-12<sup>th</sup> December, 2016.

Best poster award was received by Jaganathan, D. in the Technical Session on “Research Extension Interface and policy issues” during *3<sup>rd</sup> International Symposium on Coconut Research and Development (ISOCRAD-3)* held at ICAR-CPCRI, Kasaragod during 10<sup>th</sup>-12<sup>th</sup> December, 2016.

Best poster award was presented in the 22<sup>nd</sup> Plantation Crops Symposium (PLACROSYM 22) for the paper authored by Jayasekhar, S., Chandran, K.P., Thampan, C., Jaganathan, D. and Muralidhran K. entitled, “Sectoral innovation system of coconuts in India: Institutional voids and organizational resilience”, during 15<sup>th</sup>-17<sup>th</sup> December, 2016, ICAR-CPCRI, Kasaragod.

### Other Awards

Manikantan, M.R., Mathew, A.C. and Man Mohan Deo were awarded first prize for the paper ‘Value added products of coconut’ (in Hindi) in 2016 Vol (1), Issue (2) of Basanti Agricultural Research Journal of ICAR-Directorate of Rapeseed-Mustard Research.

Regi Jacob Thomas, Principal Scientist received a citation and memento from Shri V.S. Sunilkumar, Hon’ble Minister of Agriculture Development & Farmers’ Welfare, Government of Kerala for his meritorious service as member of State Agricultural Award Evaluation Committee during the Farmers Day celebration & Award Distribution ceremony organized at Town Hall, Palakkad on 16<sup>th</sup> August 2016.



**Shri V.S. Sunil Kumar handing over the award to Dr. Regi Jacob Thomas**

Mrs. Jissy George (Subject Matter Specialist-Home Science) of KVK-Alappuzha was felicitated by Jackfruit Promotion Council, Kerala for her efforts to popularize and promote the prospects of value addition of jackfruit and entrepreneurship in jackfruit based products through trainings, seminars and technical facilitations as a part of KVK activities. She was honoured by Shri V.S. Sunilkumar, Hon. Minister of Agricultural Department and Farmers’ Welfare, Govt. of Kerala on the occasion of the Jackfruit Promotion Campaign jointly organized by Jackfruit Promotion Council, Small Farmers Agribusiness Consortium and Centre for Innovation in Science & Social Action which was held at Vizhinjam on 20<sup>th</sup> July, 2016.

### Training on Soil Testing for Sustainable Agriculture

**A** hands on training on “Soil Testing for Sustainable Agriculture” was organized for 16 Agricultural Officers/ Technical Personnel of the Department of Agriculture at ICAR-CPCRI, Kasaragod during 26<sup>th</sup>-30<sup>th</sup> September, 2016 in connection with distribution of ‘Soil Health Card’ to farmers under ‘National Mission on Sustainable Agriculture’.



**Dr. P. Chowdappa, Director, ICAR-CPCRI, along with the trainees at ICAR-CPCRI, Kasaragod**

### Training on Recent Trends in Plant Health Management

One day training cum refresher course on “Recent trends in plant health management with special emphasis on emerging and invasive pests and diseases of palms and cocoa” was organized on 15<sup>th</sup> July, 2016 for surveillance squad of ICAR-CPCRI at Kasaragod. A total of 22 staff attended the course. The training module comprised upcoming issues and challenges pertaining to pest and disease problem in palms and cocoa, eco-friendly management of pests of palms and cocoa, emerging pests of cocoa and arecanut, diagnosis and management, foliar mite on arecanut and its management, integrated management of diseases in arecanut with a special emphasis on *Phytophthora* and *Ganoderma* diseases, wilt disease complex in cocoa, plant parasitic nematodes associated with coconut based cropping systems and nutrient deficiency disorders in palms and cocoa.

### HUMAN RESOURCES DEVELOPMENT

#### Physical targets and achievements

Category	No. of trainings planned as per ATP	No. of employees who have undergone training	% realization of trainings planned
Scientist	22	17	77
Technical	27	6	22
Administrative & Finance	16	3	19
Skilled Supporting Staff	20	-	-
Total	85	26	

#### Financial targets and achievements

RE 2016-17 for HRD ( ₹ in Lakh )			Actual Expenditure 2016-17 for HRD ( ₹ in Lakh )
Plan	Non plan	Total	
-	6.00	6.00	6.47

Category	No. of Employees	No. of employees trained	Expenditure incurred ( ₹ in lakhs )
Scientist	69	17	6.47
Technical	90	6	-
Administrative & Finance	63	3	-
SSS	131	-	-
Total	353	26	-

#### Higher Education

Shri Sandip Shil, Scientist was awarded Ph.D in Statistics for his thesis “An empirical study on support vector machine with functional genomic datasets specific to plantation crops” under guidance of Prof. Kishore K. Das, Department of Statistics, Gauhati University, Guwahati.

Dr. Regi Jacob Thomas, Principal Scientist was awarded Post Graduate Diploma in Intellectual Property Rights from IGNOU, New Delhi. He has successfully completed the programme in December, 2016.

**Category-wise training attended by staff**

Name of the staff & Designation	Title of training programme	Date	Venue
<b>Category: Scientific</b>			
Dr. Vinayaka Hegde, Head	MDP on leadership development (pre-RMP) training.	7-06-2016 to 18-06-2016	ICAR-NAARM, Hyderabad
Mr. Diwakar, Y., Scientist	Summer school on Contemporary methods of conservation and management of horticultural genetic resources	7-06-2016 to 27-06-2016	ICAR-IIHR, Bengaluru
Mrs. Shameena Beegum, P.P., Scientist	Entrepreneurship development programme on milk and milk products processing.	11-07-2016 to 20-07-2016	ICAR-NDRI, Karnal
Shri Bhavishya, Scientist	Winter school on “Genomics and phenomics for enhancement of nutrient use efficiency”	01-09-2016 to 21-09-2016	ICAR-NRC Plant Biotechnology, New Delhi
Ms. T.N. Ranjini, Scientist	Three months professional attachment training on Crop Improvement & Biotechnology	11-05-2016 to 10-08-2016	ICAR-IISR, Kozhikode
Mrs. M. Suchithra, Scientist	Three months professional attachment training on Crop Improvement & Biotechnology	11-05-2016 to 10-08-2016	ICAR-IISR, Kozhikode
Mr. R. Thava Prakasa Pandian, Scientist	Three months professional attachment training on Plant Pathology	11-05-2016 to 10-08-2016	ICAR-IISR, Kozhikode
Mrs. Jilu V. Sajan, Scientist	Three months professional attachment training on Agril. Entomology and nematology	11-05-2016 to 10-08-2016	ICAR-IIHR, Bengaluru
Mr. Pandiselvam, Scientist	Three months professional attachment training on spray drying, minimal processing and packaging	11-05-2016 to 10-08-2016	ICAR-CIFT, Kochi
Mrs. Saneera E.K. Scientist	Three months professional attachment training on mass production of biocontrol agents	11-05-2016 to 10-08-2016	ICAR-NBAIR, Bengaluru
Dr. C. Thamban, Principal Scientist	Managing technologies in value chain	27-02-2017 to 03-03-2017	Admn. Staff College, Hyderabad
Dr. K.P. Chandran, Sr. Scientist	Flexible regression	10-10-2016 to 14-10-2016	Mangalore University, Mangalore
Mr. Shivaji Hausrao Thube, Scientist	Taxonomy of insects and mites	24-01-2017 to 13-02-2017	UAS, GKVK, Bengaluru
Ms T.N. Ranjini, Scientist	BD-NCBS COE Flow Cytometry	17-01-2017 to 20-01-2017	National Centre for Biological Sciences, Bengaluru
Dr. V. Niral, Principal Scientist	Competency enhancement programme for effective implementation of training functions by HRD Nodal Officers of ICAR	20-02-2017 to 22-02-2017	ICAR-NAARM, Hyderabad
Dr. Sandip Shil, Scientist	Computational approaches for Next generation sequencing (NGS) data analysis in agriculture”	08-02-2017 to 28-02-2017	IASRI, New Delhi
Mrs. Jilu V. Sajan, Scientist	Advances and innovations in promotion and utilization of microbes for biological control of crops pests	14-12-2016 to 24-12-2016	National Bureau of Agricultural Insect Resources, Bengaluru
<b>Category: Technical</b>			
Shri Abdul Aziz, Sr. Tech. Asstt.	Training programme for the Technical staff “Dairy farm and milk plant management”	19-09-2016 to 24-09-2016	Southern Regional Station of ICAR- NDRI, Adugodi, Bengaluru
Shri Bhavani Shanker Naik, Sr. Technician	Training programme for the Technical staff “Dairy farm and milk plant management”	19-09-2016 to 24-09-2016	Southern Regional Station of ICAR- NDRI, Adugodi, Bengaluru
Shri Shareefuddeen Hassan Karangothi, Technical Assistant	Training programme on “Integrated crop management and value addition in coconut”	20-06-16 to 27-06-16	ICAR-CPCRI, Kasaragod

Name of the staff & Designation	Title of training programme	Date	Venue
Dr. R. Rajiv, Asstt. Chief Tech. Officer	Training to nodal officers of the public authority related to RTI online portal of DoPT	25-10-2016	NAARM, Hyderabad
Mrs. K. Shobha, Asstt. Chief Tech. Officer	Training-cum-awareness programme on J-Gate@CeRA	27-01-2017	Directorate of Knowledge Management in Agriculture, Bangaluru
Shri Prakash Burman, Sr. Technician	General management of experimental farms/ sample collection	29-10-2016 to 04-10-2016	ICAR-CPCRI, Kasaragod
<b>Category: Administrative</b>			
Shri Jayarama Naik, K.M., Administrative Officer	Training on “e-procurement of ICAR Institute”	21-07-2016 to 22-07-2016	ICAR-NDRI, Karnal
Shri K.T. Unni, Personal Assistant	Training on “Enhancing efficiency and behavioural skills”	28-07-2016 to 03-08-2016	ICAR-NAARM, Hyderabad
Shri T.J. Saji	Administrative/finance procedures/rules and regulations	23-12-2016 to 06-01-2017	ICAR-CPCRI Kasaragod

# CENTENARY CELEBRATIONS OF ICAR-CPCRI: A RETROSPECTIVE

XII.

The year 2016 was a memorable one in the history of ICAR-Central Plantation Crops Research Institute (ICAR-CPCRI) and coconut research in India alike, on completing 100 glorious years in service of the nation. The centenary celebrations were ceremoniously flagged off on 12<sup>th</sup> March, 2016 in a unique way with simultaneous planting of 100 coconut seedlings by 100 farmers in a minute in the Centenary Coconut Park (a feat recorded in the Limca Book of Records), a massive Kisan Mela and a host/plethora of other programmes later in the day. The year-long celebrations concluded with the Kisan Mela on 10<sup>th</sup> December, 2016, graced by the Hon'ble Union Minister of Agriculture and Farmer's Welfare, Shri Radha Mohan Singh Ji and a host of other dignitaries, followed by the 3<sup>rd</sup> International Symposium on Coconut Research and Development (ISOCRAD-III) during 10<sup>th</sup>-12<sup>th</sup> December and the 22<sup>nd</sup> edition of PLACROSYM shortly thereafter. The Hon'ble Minister also inaugurated the new Centenary Building and the renovated Kalpaka Guest House, released a few commemorative publications ('CPCRI: 100 Years of Scientific Excellence', 'Harvesting Wisdom of Coconut Growers', and a special issue of the journal, 'Indian Horticulture'), besides launching the value-added product from coconut, 'Kalpa Chocolate Bar' (jointly developed by ICAR-CPCRI and CAMPCO) on the occasion. In between, there was a host of programmes catering to all sections of the stakeholders - a series of Kisan Melas and mass contact programmes all over the country, training programmes for farmers and extension personnel, workshops/seminars and brain-storming sessions for the scientific community, agri-business meets for sensitizing the potential agri-business entrepreneurs and SHGs.

## A recap of its history

ICAR-Central Plantation Crops Research Institute (ICAR-CPCRI) had its modest beginning as a small coconut research station started way back in 1916 in the sleepy village of Kudlu in Kasaragod under the erstwhile Madras Presidency. The turning point was in 1947, when the Indian Central Coconut Committee took over the Coconut Research Station at Kudlu (Kasaragod) and established the Central

Coconut Research Station (CCRS), Kasaragod and a little later in 1949, the Central Coconut Research Station (CCRS) at Kayamkulam, exclusively for tackling diseases in coconut. Coconut research became an integral part of the national agricultural research system of the country in 1966 when the Indian Central Coconut Committee was abolished and the coconut research was taken over directly by the Indian Council of Agricultural Research. The defining moment in history was in 1970, when ICAR established the Central Plantation Crops Research Institute with headquarters at Kasaragod, by merging the Central Coconut Research Stations at Kasaragod and Kayamkulam and the Central Arecanut Research Station at Vittal along with its five substations at Kannara, Mohitnagar, Kahikuchi, Hirehalli and Palode.

Since 1986, crops like spices, cashew, and oil palm were taken out of the ambit of the institute with the formation of dedicated research institutions like IISR, Kozhikode, DCR, Puttur and IOPR, Pedvegi. Some of the erstwhile Research Centres at Hirehalli, Palode, Appangala, Kannara, Port Blair and Minicoy either handed over to sister ICAR institutions or phased out. At present, the mandated crops are limited to coconut, arecanut and cocoa and the research and frontline extension aspects of these crops are undertaken under five divisions *viz.*, Crop Improvement, Crop Production, Crop Protection, Physiology, Biochemistry and Post Harvest Technology and Social Sciences at the institute. The Regional Station at Kayamkulam (Kerala) is mandated to work on pests and disease problems in coconut, while the Regional Station at Vittal (Karnataka) caters to research and extension in arecanut and cocoa. The Research Centres at Kahikuchi (Assam) and Mohitnagar (West Bengal) undertake location-specific research in these crops, while the Research Centre at Kidu (Karnataka) hosts the National/ International Coconut Gene Bank for South-Asia (ICG-SA) and also caters to the large-scale production of quality planting materials in the mandate crops.

## Launching the centenary celebrations

The centenary celebrations were formally launched on 12<sup>th</sup> March, 2016 in a unique way with the

planting of 100 coconut seedlings (of 18 varieties released by CPCRI) by 100 farmers in a minute in the Centenary Coconut Park, established in the campus. Dr. N.K. Krishnakumar, the then DDG (Horticultural Science), ICAR inaugurated the Kisan Mela and Dr. P. Chowdappa, Director, ICAR-CPCRI presided over the function. “Problems of farmers are identical everywhere in India and joining hands with business ventures in private-public partnership mode for efficient marketing their produce is the way out”, said Dr. Krishnakumar. Shri S.R. Sathishchandra, President, CAMPCO, Directors of various horticultural institutes of ICAR and former Directors of ICAR-CPCRI also spoke on the occasion.

Three publications (“CPCRI: A Century of Service to the Nation”, “Empowering stakeholders”, and “Diseases of Field and Horticultural Crops”), and a value-added product from coconut, “Kalpa Chocolate Bar” (a special chocolate with coconut sugar) and two organic products (“Kalpa Organic Gold” and “Kalpa Soil Care”) were also released during the function. More than 3000 farmers attended the programme. The occasion was also marked by the unveiling of the centenary logo along with a painting by artist Shri P.S. Punichithaya, depicting his impressions on the 100 years journey of ICAR-CPCRI. An exhibition was also arranged on the sidelines of the Kisan Mela, showcasing various technologies and products emanating from horticultural research.



**Aerial view of planting in the centenary coconut park**



**Inauguration of Kisan Mela**



**Launching of centenary logo**



**Unveiling of centenary painting**

### **A century of programmes and caring for every stakeholder: An account of the select events**

Meticulous planning and fool-proof execution, drawing on the institutional strength of ICAR-CPCRI and the whole-hearted support from the staff members, were the hallmarks of the celebrations. Realizing that proper planning is critical in the success of such a colossal event, a calendar of events outlining 100 programmes in commemoration of 100 years, covering all the mandate crops, catering to all sections and regions/states in the country, to be executed over the year, was outlined in the beginning itself and brought out as a publication, “CPCRI: A Century of Service to the Nation - Empowering Stakeholders” for ready reference. These programmes were aimed at strengthening the linkages with stakeholders, to highlight the achievements of the institute and to facilitate better utilization of technologies evolved by the institute for enhancing productivity and income from farming. Once set in motion, the events unfolded one after the other in clock-work precision, exactly as planned.

### **Kisan Melas and other farmer-outreach programmes**

Kisan Melas are a congregation of farmers and other stakeholders in the sector in same time and space, a most cost-effective TOT tool to reach out to maximum number of clients, addressing their issues and offering solutions in real time drawing on the synergy of group psychology, peer learning, information delivery and effective motivation.

Farmers are the prime movers in the agricultural system and no celebrations are complete and meaningful without them. ICAR-CPCRI has been on the forefront in organizing a series of five Kisan Melas all along the major coconut growing tracts, in its efforts to mass mobilize the farmers. In fact, the centenary celebrations were launched on 12<sup>th</sup> March 2016 with a Kisan Mela at ICAR-CPCRI, Kasaragod.

A Kisan Mela and the National Seminar on “Technological Options for Bringing Second Green Revolution in North East India”, the first in the series, was organized on 13-14 February 2016 at its Research Centre Kahikuchi in Assam, in collaboration with ATARI, Barapani and other ICAR institutes in the NE region. The Kisan Mela was inaugurated on the 14<sup>th</sup> February 2016 by Shri Radha Mohan Singh Ji, Hon’ble Union Minister of Agriculture and Farmers’ Welfare, Govt. of India. An agricultural exhibition was also arranged on the sidelines and over 2300 farmers from the NE region participated in the programme.



**Shri Radha Mohan Singh, Hon’ble Union Minister for Agriculture and Farmers Welfare, visiting the exhibition stall at Kahikuchi**

The third ‘Kisan Mela’ and the ‘National Meet on Prospects of Coconut Sector’ were organized during 29-30 September, 2016 at its Regional Station, Kayamkulam. Shri Radha Mohan Singh Ji, Hon’ble Union Minister of Agriculture and Farmers’ Welfare inaugurated the meet, attended by more than 3500 farmers, braving the inclement weather. “Low productivity and high labour wages are some of the problems presently faced by the coconut farmers, and hence ‘a comprehensive coconut care’ should be the focus for sustaining income”, he said. He also emphasized the need for maintenance of soil health and informed that the Govt. of India is taking necessary steps to distribute soil health cards to all farmers in the country by 2017-18. The Central Government would also take initiatives to ensure that the new technologies and research results evolved in



**Inaugural speech by Shri Radha Mohan Singh, Hon’ble Union Minister for Agriculture and Farmers Welfare at Kayamkulam**

agricultural research stations and universities in the country reach the farmers at their doorstep when they need it most.

Sri. V.S. Sunil Kumar, Hon’ble Minister of Agriculture, Govt. of Kerala called for synergy in research between central and state research organizations in the state keeping the interests of farmers foremost. He informed the government’s plan of establishing a chain of agro-parks to produce value-added products from agricultural produces in all districts of Kerala, of which four would be coconut-based parks. Sri. K.C. Venugopal, Hon’ble Member of Parliament, Alappuzha presided over the function. In his address, he emphasized the need for product diversification, value addition and marketing for improving the economic status of coconut farmers. A digital initiative ‘e-Kalpa’ (mobile based app) for technology delivery, interactive learning and real time data recording was launched during the occasion for the benefit of farmers and other stakeholders. An exhibition was also organized in which various stakeholders displayed their latest technologies for the benefit of the farming community. In the afternoon of 29<sup>th</sup> September, 2016, an interactive technical session on ‘Prospects of coconut sector’ was organized for coconut farmers and extension officials and also an interface programme on ‘Areca nut production technologies’ on the sidelines of the Kisan Mela in which over 700 stakeholders participated. Another seminar on ‘Advances in cocoa production technologies’ was organized on the next day with the participation of over 550 stakeholders.

The fourth Kisan Mela along with the Workshop on ‘Horticulture Development for sub-Himalayan Terai region’, the fourth event, was organized during 20-21 October, 2016 at its Research Centre, Mohitnagar. Shri Khageswar Roy, Hon’ble Member of Legislative Assembly (Rajganj), Govt. of West Bengal inaugurated the programme on 20<sup>th</sup> October, 2016. Dr. Chirantan Chattopadhyay, Vice Chancellor, Uttar Banga Krishi Viswavidyalaya, in his keynote address, urged the farmers to understand climatic change impact over



**Kisan Mela inauguration at Mohitnagar**

North Bengal and exhorted them to adopt the scientific cropping systems adapted to the changing climatic conditions. Further, the farmers were encouraged to take up initiative for making rain water harvesting structures across North Bengal region.

Dr. D. R. Singh, Director, ICAR-NRC for Orchids emphasized on the scope and opportunities of orchid cultivation and various vegetables along with plantation crops in Sub-Himalayan Terai regions. Dr. P. Chowdappa, Director, ICAR-CPCRI, Kasaragod while welcoming the gathering, highlighted that adoption of coconut/arecanut based cropping/mixed farming systems will certainly accelerate the economic growth of North Bengal region and also introduced the value added products from coconuts developed by the institute. In the afternoon of 20<sup>th</sup> October, 2016, an interactive technical session on 'Interface programme on arecanut based cropping system' was organized for farmers and extension officials. A farmers' interface programme and a seminar on 'Recent Advances in Cocoa Production Technology' were conducted on the second day, with the participation of over 1000 farmers.

Most befittingly, the celebrations were also concluded with the Kisan Mela (fifth in the series) organized during 10-13<sup>th</sup> December, 2016 at ICAR-CPCRI, Kasaragod. Shri Radha Mohan Singh Ji, Hon'ble Union Minister of Agriculture and Farmers' Welfare, Govt. of India, inaugurated the Kisan Mela on 10<sup>th</sup> December, 2016. More than 5000 farmers participated in the Kisan Mela. Interface programmes, farm produce show, demonstrations and exhibitions were also organized, benefiting more than one lakh stakeholders in the system.

#### **Stakeholders Interface Meeting on Palmyra Palm Based Products and Technologies**

It is estimated that more than two lakh households in Telangana state are dependent on toddy tapping of palmyra trees for their livelihood. However, farmers are not aware of the recent advancements in this

sector and the technologies available for production of various value-added products.

In order to create awareness on palmyra neera and various value-added products from neera, a Stakeholders Meeting cum Exhibition on 'Palmyrah, neera and its value added products' was organized at Prof. Jayashankar Telengana State Agricultural University, Hyderabad on 25<sup>th</sup> February, 2017. Dr. Bora Narasaiah Goud, Member of Parliament, Bhongir, Telengana presided over the meeting. Dr. P. Chowdappa presented the case study of how the adoption of advanced tapping technology and production/sale of value added products improved the income of coconut farmers in South India. Dr. V. Praveen Rao, Vice Chancellor, Prof. Jayashankar, Telengana State Agricultural University emphasized the need for close collaboration between ICAR-CPCRI and Telengana Agricultural University for promoting dissemination and adoption of the latest technologies by the stakeholders. Dr. K.B. Hebbar, ICAR-CPCRI gave a detailed account of the tapping technology and Dr. P.C. Vengaiah, Scientist from Pandirami made a detailed presentation on value addition of palmyra neera and other products. ICAR-CPCRI and the AICRP Center, Pandirami also exhibited Kalparasa and value added products from coconut and palmyra. A demonstration on how to collect fresh and unfermented 'Kalparasa' using coco-sap chiller was arranged for the benefit of stakeholders. About 400 palmyra growers, tappers, and peoples' representatives from Hyderabad and adjoining districts participated in the programme.

#### **Capacity building programmes for farmers**

Studies conducted at ICAR-CPCRI show that there exists a situation where many farmers do not possess sufficient knowledge about the available technologies for enhancing the production and productivity of coconut. Organizing need-based training programmes enhances the technology utilization and thereby, income of coconut farmers.

Over a 100 capacity building programmes on all aspects relevant to the mandate crops, ranging from hybridization techniques, nursery management, crop production, protection and value addition, were conducted for the benefit of farmers at Kasaragod, Kayamkulam, Vittal, Mohitnagar and Kahikuchi. Some of the most important training programmes were:

- ATMA inter-state farmers training programme on 'Integrated Crop Management and Value Addition in Coconut' organized for 214 coconut farmers from nine districts of Tamil Nadu (nine batches) at ICAR-CPCRI, Kasaragod

- Training on 'Value Addition in Coconut and Neera Production' organized on 27<sup>th</sup> May, 2016 at Kasaragod for 48 farmers of NITTE Coconut Producers' Society, Uttara Kannada district of Karnataka.
- Training on 'Coconut Production Technologies' organized for 25 farmers of Shivamogga, Karnataka during 24<sup>th</sup>-25<sup>th</sup> July, 2016 at Kasaragod.
- Training on 'Crop Management in Coconut' organized for 60 farmers from Narsipatnam, Vishakapatnam on 21<sup>st</sup> September, 2016 at Kasaragod.
- Training on 'Hybridization Techniques and Palm Health Management in Coconut' organized at Kayamkulam for 42 farmers/climbers from Kottayam, Pathanamthitta, Kollam and Alappuzha districts of Kerala (three batches).
- Training programme on 'Trichoderma Mass Multiplication' and 'Training-cum-Exposure Visit on Advances in Arecanut and Cocoa Production and Processing Technology' organized for 25 farmers from Cocoa Growers Association and Balpa Grama Vikasa, Balpa, Sullia at Regional Station, Vittal on 4<sup>th</sup> October, 2016
- Training programme for 125 women farmers of Karnataka on 'Multi Species Cropping System in Arecanut Garden for Higher Income' (sponsored by the Directorate of Arecanut and Spices Development, Kozhikode) was organized at its Research Center, Kidu, on 5<sup>th</sup> November, 2016.
- Training on 'Cocoa Production and Processing Technology' conducted at Regional Station, Vittal from 1<sup>st</sup> to 3<sup>rd</sup> December, 2016. Among 55 farmers participated, there were 34 women and 23 of them from tribal communities.

#### Capacity building programmes for extension personnel

Training of extension personnel enhance their knowledge and skill, inculcate appropriate attitude, provide on-the-job experience and develop professional behaviour, thus enabling them to extend better service to clients (the farmers), which is the ultimate aim of all training interventions. Taking into cognizance the importance of technology transfer, systematic training programmes catering to the needs of extension personnel engaged in the development of our mandate crops were organized at ICAR-CPCRI.

Over 23 training programmes were organized at Kasaragod, its Regional Stations at Kayamkulam and Vittal, and Research Centres at Mohitnagar and Kahikuchi, in collaboration with the Department of

Agriculture/Horticulture, ATMA and other agencies for the benefit of over 600 extension personnel from the various states. The extension personnel were imparted training on improved technologies of the mandate crops. Some of the most important training programmes were:

- Training programme on 'Advances in Arecanut and Cocoa Production Technology' organized at Regional Station, Vittal on 1<sup>st</sup> April, 2016 for officers from the Department of Horticulture, Coimbatore, Tamil Nadu.
- Training on 'Hybridization Techniques in Coconut' for extension personnel at ICAR-CPCRI, Kasaragod on 15<sup>th</sup> April, 2016
- Training on 'Coconut Production Technology' organized at ICAR-CPCRI, Kasaragod on 8<sup>th</sup> August, 2016 for 40 stockmen trainees from Goa
- Training programmes (2 batches) on 'Hybridization Techniques and Plant Health Management in Coconut' at Kayamkulam (during 12-16 April, 2016 and 11-15 November, 2016) for extension personnel and coconut climbers from Kerala.
- Capacity building programmes on 'Techniques for Soil Health Assessment' at Regional Station, Kayamkulam during 27<sup>th</sup> June - 1<sup>st</sup> July, 2016, 19-23<sup>th</sup> July, 2016 and 24-28<sup>th</sup> October, 2016) benefitting 57 Agricultural Officers/ Scientific Assistants of Krishi Bhavans and District Soil Testing Laboratories from Kerala.
- Training programme on 'Cutting-edge Technologies in Crop Protection' organized at Kayamkulam on 10<sup>th</sup> August, 2016 for the benefit of 25 Agricultural Assistants from Kerala.
- 'Good Agricultural Practices in Coconut' organized for 90 Agricultural Officers and Assistants from Kattakada on 22<sup>th</sup> August, 2016
- Training on 'Mass Production of Biocontrol Agents Fostering Coconut Health Management' for 40 Assistant Agricultural Officers/ Assistant Directors of the Department of Agriculture and Farmers' Welfare, Govt. of Kerala (20-23<sup>rd</sup> February, 2016 and 27<sup>th</sup> February - 02<sup>nd</sup> March, 2017) at ICAR-CPCRI, RS, Kayamkulam.
- Training on 'Coconut Production Technology' organized on 13<sup>th</sup> February, 2017 for 20 officers of Coconut Cultivation Board, Sri Lanka, in collaboration with Indian Institute of Plantation Management (IIPM), Bengaluru.

#### Exposure visits for the farmers and other stakeholders

Exposure visits on improved technologies on mandate crops were organized for the farmers and

other stakeholders from different states, with over 9000 farmers visiting Kasaragod, over 9000 at Kayamkulam, about 7000 farmers visiting Vittal, over 2000 at Mohitnagar and 1200 at Kahikuchi. Lecture-cum-discussion and field visits covering crop improvement, production, protection and processing technologies of coconut, arecanut and cocoa were organized for the visiting farmers.

### **Awareness programmes on government schemes for farmers**

It is an accepted fact that many flag-ship schemes of the Central government for the benefit of farmers and other socially vulnerable groups do not reach a large section of the potential beneficiaries, largely due to lack of awareness on the benefits and the timely modalities to be followed for availing the potential benefits. Realizing this ground reality, the institute has taken the initiative to spread the message of 'Pradhan Mantri Fasal Bima Yojana' (PMFBY) launched by the Govt. of India, across the farming community.

#### **Pradhan Mantri Fasal Bima Yojana**

An Awareness Programme on 'Pradhan Mantri Fasal Bima Yojana' (PMFBY) was organized on 28<sup>th</sup> May, 2016 for the benefit of farming community of Kasaragod district. Shri P. Karunakaran, Member of Parliament, Kasaragod, in his inaugural address, felt that this would be a great support to the farmers in the eventuality of climate change and consequent calamities. He further desired that crop insurance should also cover price fall of the agricultural commodities. Shri N.A. Nellikkunnu, MLA, Kasaragod wished that maximum farmers be benefited by PMFBY and that more and more people in the district take up farming as their main livelihood occupation by virtue of this scheme. Dr. P. Chowdappa, Director, ICAR-CPCRI outlined the overall benefits of PMFBY to the farmers in overcoming crop losses due to natural calamities mainly, drought, flood, pest and disease epidemics. He specifically highlighted the advantage that the premium payable for availing this crop insurance is very low and affordable for the farmers at just 2.0 % for Kharif, 1.5 % for Rabi and 5 % for commercial and horticulture crops. Shri A.A. Jaleel, Panchayat President, Mogral Puthur panchayat, Shri Janardanan, Chief Manager, SBI (RBO), Kannur, Smt. Veenarani, ADA, Nileshwar and Shri Jyothis Jagannath, AGM, NABARD, Kasaragod were also present. The inaugural session was followed by technical sessions and a farmer interface programme.

The second awareness programme was organized at Pathirappally in the Alappuzha district of Kerala on 20<sup>th</sup> June, 2016. The district level programme



**Inauguration of PMFBY awareness programme by Shri P. Karunakaran, Hon'ble MP, Kasaragod**

was inaugurated by Shri K. C. Venugopal, Hon'ble Member of Parliament, Alappuzha. He emphasized the importance of converging new agricultural technologies to help farmers to improve their income and livelihood and wished that more crops especially coconut and spice crops which are important in Kerala, which are added under the PMFBY scheme. He urged the farmers to utilize the benefits of all the schemes in mitigating their sufferings in adverse conditions and urged the insurance companies to settle the claims of the farmers at the earliest and in a hassle-free manner. Dr. P. Chowdappa, Director, ICAR-CPCRI, explained various technologies developed by the institute for the benefit of farmers. The agricultural seminar organized on the sidelines of the meeting included sessions on "PMFBY: Features and Benefits", "Integrated Pest Management in Coconut", and "New technologies for dairy farming and schemes of the Dairy Development Department", handled by resource persons from Agricultural Insurance Company of India, IFFCO, Dairy Development Department and KVK. More than 300 persons including farmers, farm women, rural youth, office bearers of farmers' organizations, SHG members, extension officials, and Panchayath members actively participated in the programme.

A third programme on 'Pradhan Mantri Fasal Bima Yojana' was conducted on the 23<sup>rd</sup> May, 2016 at its Research Centre, Kahikuchi in Assam, where a large number of farmers from the locality participated in the programme.

### **Soil Health Cards: 'Know your soil before you apply fertilizers'**

Soil health management is one of the key factors in improving the productivity and the profitability of the farmers, to be sustained over a long period of time. In addition to the inherent difference in the nature of soil, the different cropping systems and manuring practices followed by the farmers also influences the

soil health over time. Therefore, soil health is spatially and temporally very dynamic, which warrants site-specific soil health assessment periodically at farm level and recommending the tailor-made management practices. In recent times, the deteriorating soil health is observed to be a major concern in all major agricultural tracts in India. Soil health cards, tailor-made for the site-specific soil health information and recommendation, will be a promising tool to ensure higher productivity and profitability in a sustainable manner.

In furtherance of this objective, soil samples were collected from the farmer's fields and analyzed at the institute. Based on the test results, 500 soil health cards with the soil health information and soil test based fertilizer recommendations for different crops were prepared and distributed to the farmers. For achieving the Government's target to issue soil health cards to all farmers within the time schedule, it is important to train other agencies involved in this great mission. To strengthen the analytical knowledge and required skills for interpretation of the soil test results and generating the soil test based site-specific recommendation for major crops, hands-on training programmes were conducted for the officials from the Department of Agriculture involved in the soil health card distribution. Besides, several awareness programmes highlighting the need, benefits and modalities of soil test based manuring were organized by the institute during the year.



**Distribution of soil health card by  
Shri P. Karunakaran, Hon'ble MP, Kasaragod**

### **Programmes for agri-enteprenuers and women SHGs**

The price of coconut is highly dependent on the prevailing price of coconut oil, which in turn is highly dependent on the overall supply-demand chain of oils and fats in the country. In many ways, value addition and by-product utilization play a crucial role in the stabilization of this coconut oil-driven domestic market and the key to reorienting and engineering

the Indian coconut industry to be cost-effective and globally competitive.

Traditionally, the share of value added products from coconut (apart from coir and coir based products) in the Indian export basket is very negligible, though the situation has started changing over the last few years. Undoubtedly, there exists a huge scope for coconut based agri-business in India in order to increase the present 8 % level of value addition to 25 %. Value added products can become a deciding factor in the price movement of coconut to ensure fair, reasonable and steady price to coconut farmers. In an effort towards value addition, the institute has developed complete 'technology packages' for production of virgin coconut oil, coconut chips, coconut honey, jaggery, sugar, ice creams, extruded products and sugar based chocolates and drinking chocolates and sweets.

### **Workshop on Coconut Based Business Ventures**

A Workshop on 'Coconut Based Business Ventures' was held at ICAR-CPCRI, Kasaragod on 09<sup>th</sup> September 2016, opening a window to this unlimited possibilities that the sector offers. Dr. P. Chowdappa, Director, ICAR-CPCRI, in his presidential address, emphasized the significance of positioning coconut as a nutraceutical food through effective value addition technologies, and highlighted the crucial role that the Coconut Producer Companies (CPCs) can play in commercializing the value-added technologies of coconut. Dr H.P. Singh, formerly DDG (Horticultural Sciences), ICAR in his inaugural address, wanted coconut farmers to comprehend the changing market trends and accordingly orient their production and marketing activities. Shri S. R. Satheeshchandra, President, CAMPCO, highlighted the issues of decelerating commodity prices in the current liberalized trade regime and the importance of competitiveness in marketing and value addition of the coconut products. Subsequently, seven coconut producer companies presented their business plans followed by presentations from the Coir Board and the District Industry Department on the Prime Minister's Employment Generation Programme (PMEGP) for entrepreneurship development. In B2B meet that followed, Mr. Krishnakumar from CAMPCO, Mr. S. S. Choyal, Dy. Director, Coconut Development Board, Kochi, Dr. Anitha Karun, Dr. K.B. Hebbar and Dr. Ravi Bhat, Heads of Divisions, ICAR-CPCRI, Kasaragod made presentations.

The session on 'Enhancing Competitiveness' was chaired by Dr. K. Prakash, Chairman, Karnataka Agricultural Price Commission, Bengaluru on 10<sup>th</sup> September, 2016 in which Shri C. Rajan,

Chairman, Dinesh Foods, Kannur; Dr. Omkumar Krishnan, management expert from IIM-Kozhikode; Mr. Sibi Mathew, Magico Enterprise, Kasaragod; Shri Mahesh Bhat, Sri Kalpa Industries, Kumbla; Shri Dinesh, We & Co Carbon Pvt Ltd, Kangayam; Shri C.V.S. Das, Pilot Smith India Pvt Ltd., Thrissur; Shri Nagaraj, Pro B Products Pvt. Ltd., Bengaluru and Shri Rajesh Kartha, CEO, ESSAR Techins, Kochi made presentations. The valedictory session of the workshop was chaired by Dr. Narayana Gowda, former Vice Chancellor, UAS, Bangalore. He presented the business plan competition prizes to Thejaswini Coconut Producers Company Pvt. Ltd, Kannur, Perambra Coconut Producers Company, Perambra, and Vinayaga Coconut Producers Company, Devambady. A Whatsapp social group named “Kalpa” for the CPCs was also launched on the occasion.



**Inauguration of the workshop on coconut based business ventures**

### **Dream Big – Kalpa 2017**

The ‘Workshop on Coconut Based Business Ventures’ was followed up with an Institute-Industry Interface, ‘Dream Big-KALPA 2017’ on 31<sup>st</sup> January, 2017 at ICAR-CPCRI, Kasaragod under the auspices of Agri-Business Incubation Centre (NAIF). Entrepreneurs, industrialists and leaders of Farmer Producer Organizations (FPOs) from Kerala, Karnataka, Goa and Tamil Nadu participated in the programme.

Dr. P. Chowdappa, Director, ICAR-CPCRI, Kasaragod, in his presidential address, flagged off issues related to competitive production of value-added products and successful marketing. He briefly described the various activities of the Institute that are having direct relevance to the policy formulation and technology up-scaling. Shri P. V. Velayudan, Director, MSME-DI, Thrissur while inaugurating the programme called upon the participants to make use of the new initiatives of Union Government on strengthening entrepreneurship in the country. He also elaborated on the various schemes of Micro, Small and Medium

Enterprises (MSME) Department for the upcoming entrepreneurs. Shri Jyotis Jagannathan, DGM, NABARD enlightened on credit availability and Shri D. Rajendran, General Manager, DIC, Kasaragod on assistance available from the Industry Department for starting business ventures. Shri C. M. Kamaraj, Industrialist, Coimbatore, appraised on the emerging domestic and international markets for coconut products like virgin coconut oil (VCO) and coconut milk. The presentation on commercially important technologies developed at ICAR-CPCRI was followed by a panel discussion. MoAs were signed for transfer of 12 technologies such as ‘Kalparasa and sugar’, VCO, coconut chips, ‘Kalpa Krunch’, etc. during this interface.



**Inauguration of Dream Big - Kalpa 2017**

### **Workshop on coconut leaf craft: A clarion call to conserve our heritage and cultural traditions**

As part of centenary celebrations of ICAR-CPCRI, a workshop on ‘Coconut leaf craft’ was organized during 6-8<sup>th</sup> September, 2016 in collaboration with Folkland, Kasaragod and Indian National Trust for Art and Cultural Heritage. The workshop was inaugurated on 6<sup>th</sup> September by the well known art historian, Shri K. K. Marar. Shri Marar, in his inaugural speech, said that traditional coconut crafts were once an integral part of our life, culture and identity and sadly, we have witnessed in recent times the vanishing of the coconut crafts, especially crafts made from the coconut leaves. Hence, a redemption of the traditional coconut leaf crafts is a commitment to the coconut sector, highlighting our ethnic identity. Dr. P. Chowdappa, Director, ICAR-CPCRI emphasized the importance of research efforts for improving the longevity of crafts made of coconut leaves, opening up the possibility of replacing plastics and other environment-hazardous materials with processed coconut leaves. He urged that the society should promote the traditional decorations using coconut leaves and inflorescence during auspicious ceremonies like marriages which may open up commercial vistas for crafts made from coconut palm. Dr. V. Jayarajan, Chairman, Folkland, Kasaragod, in his remarks, emphasized the importance of coconut

leaves and their role in socio-cultural life of people in the rural landscape of entire Kerala and most parts of Karnataka, literally starting from the childhood and it goes up to the last rites.

Over one hundred participants covering craft artists, scientists and other stakeholders participated in the workshop. An interaction with artists, scientists and students was also arranged along with the workshop on 7<sup>th</sup> September, 2016. A seminar on 'Coconut leaf and Kerala community: Art, rituals, crafts and sustainability' was organized on 8<sup>th</sup> September, 2016. Dr. Shree Ram Shetty, Professor and Head, Department of Kannada, Mangalore University was the chief guest. Dr. Shetty enlightened the audience on the significance of reviving ancient art traditions, including coconut leaf craft.



**Workshop on coconut leaf craft**

### Scientific meetings fostering national/international linkages in research

The post World Trade Agreement (WTA) and ASEAN Treaty regime witnessed integration of coconut economies across the globe that resulted in fierce competition among the coconut producing countries. Enhancing farm level income through adoption of competitive and sustainable production techniques, product diversification and demand creations for coconut products are the need of the hour. It is a matter of serious concern that despite economic, nutritive and health contributions of coconut, coconut farming across the world has been becoming less profitable in the recent years. It is pertinent to note that the failure to respond to changing patterns of the world trade in coconut products will have adverse effect on the employment and revenue of the major coconut producing countries in the Asia - Pacific region. Therefore, it is important to define the factors that drive international coconut markets, identify threats to the sector and accordingly reorient the research and developmental activities of the major institutions across the world. Keeping these points in view, the 3<sup>rd</sup> International Symposium on Coconut Research and Development (ISOCRAD 3) was organized from 10-12 December 2016 at ICAR-Central Plantation Crops Research Institute, Kasaragod, Kerala.

### International Symposium on Coconut Research and Development

The symposium started with a welcome address by Dr. P. Chowdappa, Director, ICAR-CPCRI. Dr. Trilochan Mohapatra, Secretary, DARE and Director General, ICAR, inaugurated the symposium and called upon employment of genomic research to accelerate breeding and disease management. Dr. Uron N. Salum, Executive Director, Asia Pacific Coconut Community, Jakarta, in his address, congratulated Government of India, ICAR-CPCRI and Indian coconut farmers for organizing various programmes for commemorating the centenary of coconut research. Efforts of Coconut Development Board in promoting coconut producer companies for realizing better income for coconut farmers through adoption of scientific cultivations practices and value addition were described by Dr. A. K. Singh, Chairman, Coconut Development Board, India. Dr. P. K. R. Nair, Distinguished Professor, University of Florida, USA suggested to adopt a holistic approach focusing on the overall productivity and sustainability of the coconut-based agroecosystem as a whole, to cope with the increasing threats posed by climate change. Dr. N. M. Nayar, Formerly Director, ICAR-CPCRI in his key note address, outlined the present day impasse on policies on coconut sector (on trade, development and research) and suggested certain remedial steps such as bringing coconut as a mandate crop of World Agroforestry Centre and initiate a consortium to address issues related to pests and diseases.

The symposium comprised of eight technical sessions: Germplasm conservation and utilization, Biotechnology for crop improvement, Enhancing input use efficiency, Management of pests and diseases, Climate change: Effects and mitigation, Value addition and product diversification, Agribusiness and entrepreneurship, and Research-extension



**Dr. Trilochan Mohapatra, Hon'ble Secretary, DARE & Director General, ICAR inaugurating ISOCRAD 3**



**Delegates of ISOCRAD 3**

interface and policy issues. Recommendations which emerged from the technical sessions were compiled presented in the valedictory session. The major recommendations are (i) prevail upon CGIAR to include coconut as a mandate crop under ICRAF/WAC for better coordinated research among nations, (ii) make available the mapping population developed in Côte d'Ivoire to COGENT member countries for QTL mapping studies, (iii) networking of international laboratories for cryogene banking of pollen and cryopreservation of zygotic embryos/plumular tissues, (iv) evaluation of economics of organic farming studies over the years and replication of successful models, (v) address biosecurity issues of coconut in the wake of climate change, globalization, free trade and increased travel across the globe; a 'Global Initiative on Pest and Disease Network of coconut' need to be formed involving all the coconut growing countries and organizations like COGENT and APCC, (vi) strict implementation of domestic quarantine to prevent the spread of diseases/pests, (vii) validation of the InfoCrop-COCOENUT model in other coconut producing countries, (viii) promotion of value added coconut products through market promotion, brand promotion and attractive and hygienic packing, and (ix) initiating policies and developmental interventions for enhancing the farmers' share in the value chain.

Encompassing these recommendations, the following 'Kasaragod Resolution' was adopted in the Symposium: 'The Third International Symposium on Coconut Research and Development (ISOCRAD 3), held at ICAR-Central Plantation Crops Research Institute, Kasaragod, India during 10<sup>th</sup>-12<sup>th</sup> December 2016, resolves that COGENT should be strengthened and made vibrant to cater to conventional and complementary strategies like cryopreservation and pollen conservation of coconut germplasm and promote its safe international exchange, and support the establishment of international networks of

coconut tissue culture, pests and diseases of coconut, genome analysis and special breeding programmes for abiotic and biotic stress management."

### **Plantation Crops Symposium**

A unique initiative of research and development institutions associated with plantation crops in India is the organization of Symposia on Plantation Crops (PLACROSYM) biennially. The main objective of the symposia is to provide a common forum for interaction among academia, industry and extension and development agencies engaged in plantation crops research and development. The key to accelerated transformation of the plantation sector, in the face of globalization, is strengthening the linkages between plantations and industry through enhanced value added processing and exports. PLACROSYM22, 22<sup>nd</sup> in the series, was organized from 15<sup>th</sup>-17<sup>th</sup> December, 2016 at ICAR-Central Plantation Crops Research Institute, Kasaragod, Kerala with the theme 'Leveraging Innovation System in Plantation Sector through Value Addition'.

The inaugural session of the symposium commenced with a welcome address by Dr. P. Chowdappa, Director, ICAR-CPCRI, in which he highlighted the need for impetus for increased value addition to overcome the vulnerability of plantation sector to intermittent vagaries of price risks, market dynamics and climate changes. Dr. W.S. Dhillon, ADG (Horticultural Science), ICAR, in his inaugural address, emphasized the huge scope for plantation crops-based agribusiness in India with reference to processing and value added products.

The three day symposium was divided into seven technical sessions: 'Genetic resources and genomics', 'Input use efficiency', 'Plantation health management', 'Impact of climate change on plantation sector', 'Mechanization & product development', 'Agribusiness & policy issues' and 'Reaching stakeholders'. The recommendations emerging from each of the technical sessions were compiled and

presented in the valedictory session. The major recommendations include (i) greater synergy between the conventional breeding programmes and modern molecular tools and bioinformatics for reaping quick dividends in crop improvement, (ii) demonstration of technologies developed by Institutes in farmers' fields for achieving the goal of doubling the farmer's income, (iii) utilization of soil health cards for achieving higher nutrient use efficiency, (iv) prepare land suitability map for different plantation crops, taking into consideration the future climate scenario, (v) compilation of data available on growth, yield and quality parameters in different plantation crops and its correlation with climatic data to ascertain climate influence on plantation crops, (vi) concerted efforts need to be taken to establish 4-5 incubation centers in every state for hands-on training to entrepreneurs, (vii) perceived attributes of pest management technologies to be taken into account for development of farmer-friendly technologies for enhancing adoption, (viii) hand-holding of entrepreneurs for income and employment generation as achieved in spice sector to be replicated in suitable regions with funding from initiatives like "Make in India" and "Startup India", and (ix) large scale multiplication and distribution of bioagents for the management of pests should be strengthened by enhancing participation of local farming community.



**Inauguration of PLACROSYM 22**

### **National Seminar on Plantation Based Cropping System for Improving Livelihood Security**

A National Seminar on 'Plantation Based Cropping System for improving Livelihood Security' was held during 22<sup>nd</sup>-23<sup>rd</sup> July, 2016 at ICAR-CPCRI, Kasaragod. Dr. K.L. Chadha, Formerly DDG (Hort.), ICAR, New Delhi inaugurated the Seminar. The Technical Sessions dealt with the cropping/farming systems in coconut, arecanut, oil palm, cashew and spices. In each Session, there were lead talks by the experts followed by research paper presentation by the scientists from ICAR Institutes and Agricultural/Horticultural Universities. The presentations mainly focused on opportunities and

technologies for enhancing income generation and nutritional security through intercropping in palm based cropping systems with tubers, spices etc., both in the mature as well as juvenile plantations. The seminar also reviewed the research on beneficial microorganisms, biomass recycling in coconut based eco-system towards making it as an ideal system for circular carbon.

### **National Workshop on Cryopreservation of Plant Germplasm**

National Workshop on 'Cryopreservation of Plant Germplasm' was conducted at Kasaragod on 2<sup>nd</sup> November, 2016. Dr. K. Nirmal Babu, Director, ICAR-IISR inaugurated the workshop and delivered a talk on 'In vitro conservation technique in spices plant genetic resource management'. Scientists from ICAR institutes, over 80 Ph. D scholars and Post Graduate students from Kerala Agricultural University, Central University of Kerala, Mangalore University and St. Aloysius College, Mangalore participated in the Workshop.

### **Culmination of the Centenary Celebrations**

The valedictory session of the year-long centenary celebrations of the Central Plantation Crops Research Institute was on 10<sup>th</sup> December, 2016 at ICAR-CPCRI, Kasaragod, with the Union Minister for Agriculture and Farmers Welfare, Shri Radha Mohan Singh lauding the contribution of scientists and innovative farmers for helping the country become the global leader in coconut production. 'Data from the agricultural census during 2010-11 suggest that the average land size holding in Kerala is 0.22 hectares against the national average of 1.15 hectares. It is, therefore, imperative to adopt high-value crops and a unified agriculture system to turn the sector remunerative,' he said while inaugurating the Kisan Mela. There is a need to adopt multi-crop system by including pepper, banana, pineapple, ginger, turmeric, in coconut gardens, he said addressing the farmers.

The Hon'ble Minister also spoke on the new policies of the Government and also touched upon the problems being faced by the farmers. He enlightened the participants on the Prime Minister's Krishi Sinchayi Yojana and the Crop Insurance scheme. 'Fields would lose fertility due to imbalanced use of chemicals and fertilizers. Keeping this in view, a soil health card scheme for farmers was launched in 2014-15 and this initiative would help farmers assess soil fertility along with recommendation of appropriate quantity of nutritious elements', he said. He also exhorted the farmers to take up fish culture by taking advantage of the vast inland and marine water bodies, which the southern states are blessed with.

The announcement of Minimum Support Price for agriculture produce, bringing down the price of agricultural inputs and making available fertilisers at subsidised price are all aimed to bring relief and succor to the farmers. He also spoke on the government policy of digital and cashless economy and the advantages it has over dealing with cash. He also touched upon e- markets for agricultural products in the country, which is highly advantageous to the farming community.

In commemoration of the centenary celebrations, the Hon'ble Minister also released three books ("CPCRI-100 years of scientific excellence", "Harvesting wisdom of coconut growers", and "Coconut") and a special issue of "Indian Horticulture" journal. "Kalpa Chocolate Bar", a value-added product from coconut, jointly developed by ICAR-CPCRI and CAMPCO was also released by the Hon'ble Minister on the occasion. Shri P. Karunakaran Hon'ble Member of

Parliament, Kasaragod, presided over the function. Shri E. Chandrashekharan, Hon'ble Minister of Revenue & Housing, Govt. of Kerala, Shri Anant Kumar Hegde, Hon'ble Member of Parliament, Uttara Kannada, Shri N.A. Nellikunnu, Hon'ble MLA, Kasaragod, Shri A.G.C. Basheer, President, Kasaragod District Panchayath, Shri Sathish Chandra, President CAMPCO, Shri P.R. Muralidharan, Member, Coconut Development Board offered felicitations. The Hon. Minister also inaugurated the grand exhibition organized at the same venue with 105 stalls covering horticultural crops, fisheries, animal husbandry and other allied enterprises. There was active participation of various ICAR institutes, Agriculture Universities, State Department of Agriculture, Agriculture Input Dealers and Self Help Groups in the programme.

Earlier in the day, Dr. Trilochan Mohapatra, Secretary, DARE & Director General of the Indian



**Shri Radha Mohan Singh, Hon'ble Union Minister for Agriculture and Farmers Welfare visiting the exhibition stalls at Kasaragod**



**Release of centenary commemorative book on ICAR-CPCRI by Shri Radha Mohan Singh, Hon'ble Union Minister for Agriculture and Farmers Welfare**



**Shri Radha Mohan Singh, Hon'ble Union Minister for Agriculture and Farmers Welfare addressing the gathering at Kasaragod**

Council of Agriculture Research, felicitated 100 select farmers from across the nation on the sidelines of the valedictory session. There is a need to reorient farm research by incorporating farmers' wisdom to suit ground-level requirements and the ecosystem, Dr. Mohapatra said. Dr. A.K. Singh, Chairman, Coconut Development Board and Dr. Uron N. Salum, Executive Director, Asia Pacific Coconut Community were also present.

### Centenary Publications

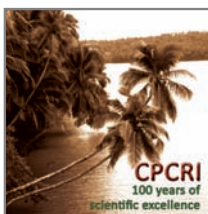
During the centenary year, about 100 extension publications (extension folders/technical bulletins) in English, Hindi and vernacular languages (Malayalam, Kannada, Tamil, Telugu, Assamese and Bengali), a few commemorative publications (ICAR-CPCRI: 100 years of scientific excellence", "Harvesting wisdom of coconut growers", and two souvenirs) and ten scientific books (scholarly volumes edited by scientists from ICAR-CPCRI with contributions from a large pool of experts from within and outside the organization) were also brought out during the year in arrangement with reputed publishers in India. These titles include 'Diseases of Field and Horticultural Crops', 'Diseases, Pests and Disorders of Plantation Crops', 'Biotechnology of Plantation Crops', 'Coconut', 'Planting Material Production in Coconut', 'Impact of Climate Change on Plantation Crops', 'Organic Farming in Plantation Crops', 'Soil Health Management in Plantation Crops', 'Mechanization in Plantation Crops' and 'Compendium of Phytophthora Diseases', released during the scientific fora like ISOCRAD 3 and PLACROSYM 22. Besides, two video films on 'ICAR-CPCRI in the service of farming community' and 'Integrated pest management in coconut' were produced in English and regional languages.

### A review of some select books

#### ICAR-CPCRI:100 years of scientific excellence

(Eds. P. Chowdappa, John George, M.K. Rajesh and H. Muralikrishna)

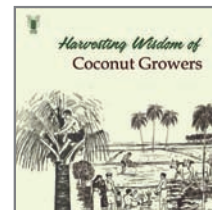
This book endeavours to open a window to the fascinating world of plantation crops in India and most pertinently ICAR-Central Plantation Crops Research Institute (CPCRI), the epicentre of plantation crops R&D, taking the reader along its 100 years journey from the its inception as a coconut research station at Kudlu in 1916, through its evolution, achievements, the present day realities in the plantation crops sector and a vision for the future.



#### Harvesting Wisdom of Coconut Growers

(Eds. C. Thamban, D. Jaganathan, S. Jayasekhar, K.P. Chandran and P. Chowdappa)

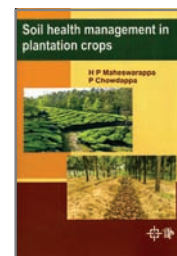
The invaluable experiences of one hundred innovative coconut growers across twelve major coconut growing tracts are documented in this book. Their socio-personal profile, details of their coconut gardens, extent of adoption of improved farming practices, innovative farming practices evolved by them, their insights on economics of coconut farming, marketing practices, efforts made for disseminating improved coconut production technologies among other farmers and linkages with research, development and extension institutions are beautifully collated in this book.



#### Soil Health Management in Plantation Crops

(Eds. H.P. Maheswarappa and P. Chowdappa)

The time has come to shift from a mere nutrient management to a holistic soil health management approach to unlock the stagnation in enhancing the crop productivity. To ensure the profitability of the unit agricultural land, soil health management practices should be practiced in a confined and closed system within the farm unit, with high *in situ* resource use efficiency. This book provides a glimpse of management options derived through intense research efforts, for preserving soil health for the sustained crop productivity in plantation crops sector.



#### Coconut

(Eds. P. Chowdappa, V. Niral, B.A. Jerard and K. Samsudeen)

The book, 'Coconut' provides an insight into this wonderful palm, traces its origin and domestication, describes the palm and its diversity, and presents the status of research and technology development to facilitate scientific coconut cultivation and social empowerment. The book is a treasure house of information for all coconut enthusiasts.

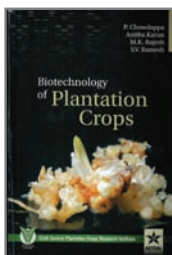


#### Biotechnology of Plantation Crops

(Eds. P. Chowdappa, Anitha Karun, M.K. Rajesh and S.V. Ramesh)

This compendium of research achievements in various fields of biotechnology in plantation crops is

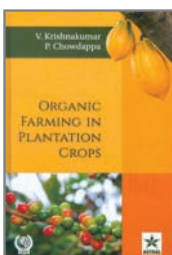
a multi-authored book and authors have been hand-picked based on their vast expertise in respective fields such as molecular markers, genomics, transcriptomics, *in vitro* culture and genetic engineering of plantation crops. This book has been brought out to serve post-graduate students, researchers and academicians involved in biotechnology related aspects of plantation crops, undoubtedly, a one-stop-shop for acquainting with recent developments in the field of plantation crops biotechnology.



### Organic Farming in Plantation Crops

(Eds. V. Krishnakumar and P. Chowdappa)

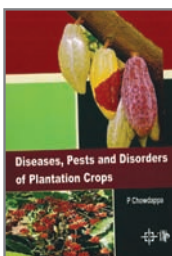
This book, written by experts in the field, is a valuable source of information to all those involved in organic farming including scientists, development personnel, policy makers, NGOs and farmers, with the hope of stimulating and motivating more intensified R & D efforts and favourable policy initiatives to spread organic farming of plantation crops at the grass roots level for the production of safe food under healthy environmental conditions.



### Diseases, Pests and Disorders of Plantation Crops

(Ed. P. Chowdappa)

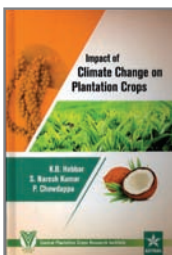
This ready-to-use compendium summarizes the biotic disorders, insect pests, abiotic stress induced disorders, and invasive and emerging threats for plantation crops production.



### Impact of Climate Change on Plantation Crops

(Eds. K.B. Hebbar, S. Naresh Kumar and P. Chowdappa)

Plantation crops, being perennial in growth pattern, are exposed to climatic stresses and experience climate change in every stage of their life cycle. Hence, it is of paramount importance to understand the impacts and developing adaptation and mitigation strategies for improving plantation productivity in changing climate scenario. This book summarizes the status information on all major plantation crops



in the climate change context, providing adaptation options and mitigation potential of plantation crops.

### Mechanization in Plantation Crops

(Eds. A.C. Mathew, M.R. Manikantan and P. Chowdappa)

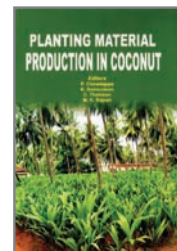
Plantation crops sector in India is demanding mechanization in every pre-and post harvest unit operation in view of reduction in availability of manpower, high wage levels and high levels of drudgery, all leading to an increase in cost of production. This book discusses all the developments in mechanization of major activities of land preparation, intercultural operations, irrigation, harvesting and post-harvest processing and value addition in major plantation and spice crops.



### Planting Material Production in Coconut

(Eds. P. Chowdappa, K. Samsudeen, C. Thamban and M.K. Rajesh)

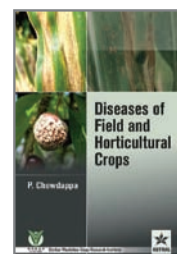
One of the important strategies for enhancing productivity in coconut is the development and cultivation of improved varieties. However, a major limitation is the non-availability of quality planting materials for replanting and area expansion, owing to a variety of reasons especially limited number of mother palms, huge area required for raising seed gardens, lack of skilled manpower and most importantly the absence of a mechanism to ensure the quality of planting materials in the distribution chain. This book provides comprehensive information on all aspects of planting material production in coconut, which will be useful to all stakeholders in the sector.



### Diseases of Field and Horticultural Crops

(Ed. P. Chowdappa)

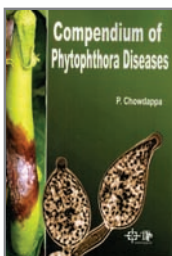
In keeping with the advancements in technology, this book is a comprehensive and up-to-date resource on the diseases of important field and horticultural crops, giving out information on causes, distribution, symptoms, epidemiology and integrated strategies for disease control in 30 crops.



### Compendium of Phytophthora Diseases

(Ed. P. Chowdappa)

This book provides practical information on the diagnosis and management of *Phytophthora* diseases and their management strategies, with an exclusive section on threats of exotic pathogens. It is equally useful for growers, crop consultants, researchers, extension agents, teachers and students alike.



### Commemorative special issues

Special issues of Indian Horticulture (January-February 2017), Indian Coconut Journal (November 2016), Indian Journal of Arecanut, Spices & Medicinal Plants (October-December 2016), and The Cashew & Cocoa Journal (October-December 2016), commemorating 100 years of ICAR-CPCRI and coconut research in India were brought out during the year.



### e-kalpa: A digital initiative for reaching out to farmers

Integrating technologies and knowledge system effectively among coconut farmers, predominantly small and marginal farmers, is a real challenge as they require sustainable technology facilitation and support services from multiple stakeholders. Utilizing the Information & Communication Technology (ICT) for problem solving, confidence building, improving yield and income from coconut farming through technology utilization, increasing the impact of research, is the need of the hour.

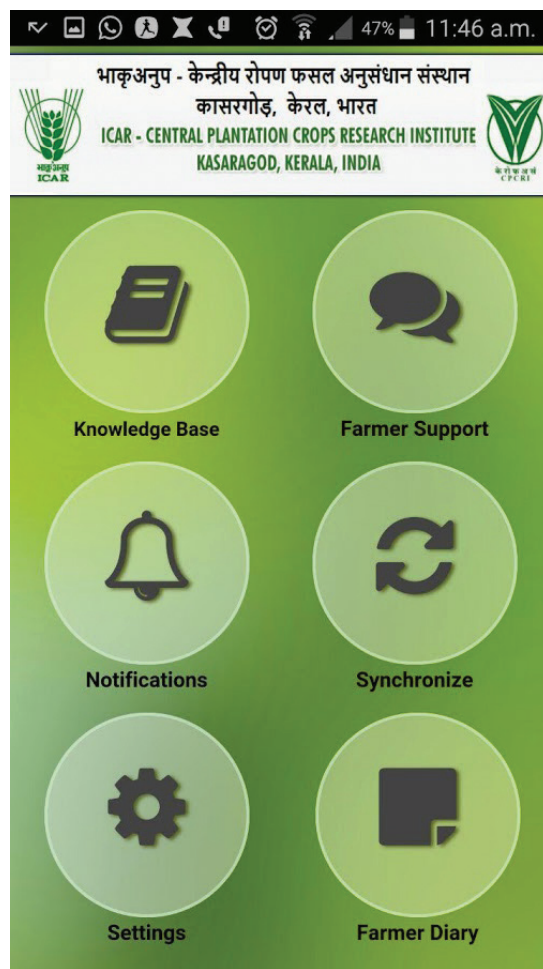
e-kalpa, an integrated Android based mobile App (presently available in two languages, English and Malayalam), was developed for the use of extension officials, farmers' organizations, NGOs, women SHGs, youths, students and all other stakeholders. It has the following modules:

- **Farmers issue reporting and supporting App:** Reporting field problem in audio, video, text or image mode directly. Scientists can respond within 10-15 minutes. Chatting facility is also offered.

- **Synchronized farming App:** Any farmer can register in this App, when he starts cultivation and in synchronized mode, timely customized advisories will be delivered to the farmers. Feedback on research recommendations and refinement needed also could be tracked.
- **Farmer diary App:** It is a virtual diary, for recording details of farmers' farming and scientists could facilitate their production, processing and marketing aspects. Adopted villages, Mera Gav Mera Gaurav, FLD/PTD farmers could utilize this module.
- **Knowledge base:** Multimode documentation, integration, maintenance, and updating will be done at the back end by the Institute

### Publicity and media coverage

Conscious efforts were made to meaningfully engage the visual and print media, along with the new-age social media platforms, to reach out to the varied



**e-kalpa: An Integrated Android based Mobile App.**

cliente and put the message across them. All the events/programmes conducted in connection with the centenary celebrations were widely covered and the achievements greatly highlighted in the national/vernacular dailies (225 instances across 18 dailies), with some of them bringing out exclusive supplements commemorating the centenary of ICAR-CPCRI and coconut research in India. The visual media was also equally appreciative of the efforts and they covered the programmes under their regular news broadcasts as well as airing special programmes commemorating the event.

### Commemorative postage stamp

The proposal for releasing a commemorative postage stamp on 100 years of ICAR-CPCRI and coconut research in India has been approved by the Department of Posts and the special stamp is expected to be ceremoniously released on a convenient date later this year.



### Epilogue

In retrospect, for an organization at its 100-year milestone, with 100 years of experience and excellence behind it, it takes tremendous engagement and commitment for positively impacting the lives of farmers in plantation crops sector, one of the most fragile and vulnerable section of the present day Indian agriculture. Ever since its inception, ICAR-CPCRI has served the cause of science and society with distinction through exemplary research, generation of appropriate technologies and reaching out to the farmers. In this centenary year, it had been our earnest endeavour to place ICAR-CPCRI in the right perspective, for a better understanding of its history and appreciation of its contributions to plantation crops. Undoubtedly, it has been an eventful journey in rediscovering our legacy of the past, a realistic assessment of the present and its achievements to be proud of, and cognizant of the limitless opportunities and responsibilities that the future beckons us.



# WORKSHOPS, SEMINARS AND FARMERS DAY

XIII.

## Interface Programme on 'Coconut Farming'

An Interface Programme on 'Coconut Farming' was conducted at Kasaragod on 15<sup>th</sup> June 2016 to evolve strategies for effectively implementing the 'Kera Suraksha Scheme' for the development of coconut farming in Kasaragod District, Kerala. The scheme is a joint effort between ICAR-CPCRI and Kasaragod District Panchayat. The interface programme was inaugurated by Shri A.G.C. Basheer, President, Kasaragod District Panchayat. Dr. P. Chowdappa, Director, ICAR-CPCRI gave the introductory remarks. Shri Arshad Vorkady, Chairman, Kasaragod District Panchayat Standing Committee, Shri Pradeep, Principal Agricultural Officer, Kasaragod and Shri V. Venu, Deputy Director of Agriculture, offered felicitations.



**Dr. P. Chowdappa inaugurating the research-extension-farmer's interface at Kasaragod**

## Seminar on Prospects of Cocoa Cultivation in Palm Based Cropping Systems

A district level seminar on 'Prospects of Cocoa cultivation in Palm Based Cropping Systems' was organized on 7<sup>th</sup> September, 2016 at Regional Station, Vittal with the sponsorship from Directorate of Cashew and Cocoa Development (DCCD), Kochi. About 168 participants, representing farmers and officials, attended the seminar. Dr. K. S. Ananda, ICAR-CPCRI, RS, Vittal welcomed the delegates and farmers as well as gave an overall introduction about prospects of cocoa cultivation in palm based cropping system. The seminar was inaugurated by Shri Konkodi Padmanabha, Director and Ex-President,

CAMPCO, Mangalore. In his inaugural speech, he stated that cocoa production should be increased to meet the increasing demands. To control the price volatility, more value added products should come out and appropriate regulation of price would aid cocoa farmers. He also highlighted the need for farmers to be trained on processing technologies to produce the good quality beans for getting premium price. Shri Krishna Prasad, a progressive farmer, was felicitated during the inaugural function. He gave a talk on his experience on cocoa cultivation. He also explained ways to obtain maximum profit from cocoa and arecanut cropping systems. Dr. P. Chowdappa, Director, ICAR-CPCRI, presided over the function. In his presidential address, he stressed that cocoa is the best companion crop with coconut and arecanut and



**Inauguration of seminar on Prospects of Cocoa Cultivation at Vittal**



**Field visit of seminar participants for pruning demonstration**

the prospect of the crop is very bright. ICAR-CPCRI produces more than one lakh quality seedlings, grafts and seed pods for the benefit of farmers. Scientific technologies developed by the institute should be adopted by the farmers to get higher yield and price.

### **Interactive Meet on Quality Planting Material Production**

An interactive meet on 'Quality Planting Material Production' was organized at ICAR-CPCRI, RC, Kidu, on 20<sup>th</sup> September, 2016. Dr. P. Chowdappa, Director, ICAR-CPCRI, chaired the interactive meet, which was presided by Smt. Sharadha, President, Village Panchayat, Bilinele; Shri Devaraj K.S., Director, DCC Bank, was the chief guest. More than 140 farmers of the region participated in the meet. Dr. P. Chowdappa, in his key note address, highlighted the efforts taken by ICAR-CPCRI towards planting material production sector by contributing in terms of high yielding varieties/hybrids and transfer of advanced production and protection technologies. Comprehensive and exhaustive discussions took place among the accomplished farmer participants and scientists with respect to the importance of quality planting materials, their selection criteria, nursery techniques and solutions to other practical issues of coconut, arecanut and cocoa farming.



**Inauguration of quality planting material production interactive meet by Dr. P. Chowdappa at Kidu**

### **Training on Cocoa Production and Processing Technology**

Training on 'Cocoa Production and Processing Technology' was conducted at ICAR-CPCRI, RS, Vittal from 1<sup>st</sup> to 3<sup>rd</sup> December, 2016 with funding from Directorate of Cashewnut and Cocoa Development (DCCD), Kochi. A total of 55 farmers, including 34 women, participated in the training programme.

# PARTICIPATION IN SEMINARS/ SYMPOSIA/ CONFERENCES/ WORKSHOPS

Name and designation	Title of the programme	Place and Date
Dr. D. Jaganathan, Scientist	National Seminar on Planting Material Production in Spices	Hotel Malabar Palace, Kozhikode, 21 <sup>st</sup> -22 <sup>nd</sup> April, 2016
Dr. P. Chowdappa, Director Dr. H.P. Maheswarappa, PC (Palms) Dr. Anitha Karun, Dr. Vinayaka Hegde, Dr. Ravi Bhat, Dr. K.B. Hebbar, Dr. V. Krishnakumar, Heads Dr. Chandrika Mohan, Dr. Augustine Jerard, Dr. C. Thamban, Dr. V. Niral, Dr. P. Subramanian, Dr. S. Elain Apshara, Dr. A. Joseph Rajkumar, Principal Scientists, Shri S. Jayasekhar, Scientist (SS), Dr. Merin Babu, Dr. Rajkumar, Mrs. Prathibha V.H. and Ms. Sumitha S., Scientists	XXV Annual Group Meeting of ICAR-All India Coordinated Research Project on Palms	ICAR-CPCRI, Kasaragod, 19 <sup>th</sup> -21 <sup>st</sup> May, 2016
Dr. Anitha Karun, Head Dr. Prathibha P.S., Mr. Krishna Prakash and Mrs. Aparna V., Scientists	Global Conference on Perspective of Future Challenges and Options in Agriculture-2016	Jalgaon, Maharashtra, 28 <sup>th</sup> - 31 <sup>st</sup> May 2016
Dr. H.P. Maheswarappa, PC (Palms)	National Level Seminar on Neera and Palm Gur Industry Under ABFPI, (Khadi Village Industries)	Patna, Bihar, 5 <sup>th</sup> -6 <sup>th</sup> June, 2016
Dr. P. Chowdappa, Director Dr. V. Niral and Dr. M.K. Rajesh, Principal Scientists	Group Meeting of Coconut Genome Sequencing	ICAR-NRCPB, New Delhi 10 <sup>th</sup> June, 2016
Dr. P. Chowdappa, Director Dr. K.B. Hebbar, Head	Group discussion on Neera- based Sweets and Felu Modak Sweets	Kolkatta, 07 <sup>th</sup> July 2016
Dr. P. Chowdappa, Director	Scientist - Farmer interface	ICAR-CPCRI, Regional Station, Kayamkulam, 13 <sup>th</sup> July, 2016
Dr. P. Chowdappa, Director Dr. H.P. Maheswarappa, PC (Palms) Dr. V. Krishnakumar, Dr. Vinayaka Hegde, Heads, Dr. Chandrika Mohan, Dr. A. Joseph Rajkumar, Principal Scientists, Dr. P.S. Prathibha and Dr. Sivaji Thube, Scientists	Group Meeting of Coconut Entomologists	ICAR-CPCRI, Regional Station, Kayamkulam, 13 <sup>th</sup> July, 2016

Name and designation	Title of the programme	Place and Date
Dr. P. Chowdappa, Director Dr. H.P. Maheswarappa, PC ( Palms) Dr. (Mrs.) Anitha Karun, Dr. Ravi Bhat, Dr. Vinayaka Hegde, Dr. K.B. Hebbar, Dr. C. Thamban, Dr. K. S. Ananda, Dr. V. Krishnakumar, Heads Dr. (Mrs) Alka Gupta, Dr. P. Subramanian, Dr. Murali Gopal, Pr. Scientists, Dr. Paulraj, Dr. K. Nihad, Dr. Rajkumar, Dr. V. Selvamani, Dr. D. Jaganathan, Dr. Karthika. K.S., Ms. Bhavishya, Mrs. Surekha, Ms. Sumitha S., Mrs. Panjavarnam G. and Dr. Neenu S., Scientists	National Seminar on “Plantation based Cropping System for Improving Livelihood Security”	ICAR-CPCRI, Kasaragod, 22 <sup>nd</sup> -23 <sup>th</sup> July 2016
Dr. P. Chowdappa, Director	SAC meeting of Kerala KVKs	ICAR-CPCRI, Regional Station, Kayamkulam, 31 <sup>st</sup> August, 2016
Dr. P. Chowdappa, Director	Technical Session of World Coconut Day organized by Coconut Development Board	Bhubaneswar, 02 <sup>nd</sup> September, 2016
Dr. C. Thamban and Dr. Vinayaka Hegde, Heads, Dr. Joseph Rajkumar, Principal Scientist and Dr. D. Jaganathan, Scientist	World Coconut Day celebrations & Interface programme on Crop Management and Value Addition in Coconut	Pollachi, Coimbatore, 2 <sup>nd</sup> September, 2016
Dr. P. Chowdappa, Director	State level sanctioning committee meeting of RKVY	Thiruvananthapuram, 06 <sup>th</sup> September, 2016
Dr. P. Chowdappa, Director Dr. H.P. Maheswarappa, PC (Palms) Dr. Anitha Karun, Dr. Ravi Bhat, Dr. Vinayaka Hegde, Dr. C.Thamban, Dr. K.B. Hebbar, Heads, Dr. K. Muralidharan, Dr. A.C. Mathew, Dr. P. Subramanian, Dr. Murali Gopal, Dr. K. Samsudeen, Pr. Scientists, Dr. Chandran. K. P., Dr. M.R. Manikantan, Sr. Scientists, Mr. S. Jayasekhar, Scientist (Sr. Scale), Dr. Jaganathan, Dr. V.H. Prathibha, Dr. Shameena Begum, Dr. Pandiselvam and Dr. Manmohan Deo, Scientists	Workshop on Coconut Based Business Ventures	ICAR-CPCRI, Kasaragod, 09 <sup>th</sup> -10 <sup>th</sup> September, 2016
Dr. P. Chowdappa, Director Dr. H.P. Maheswarappa, PC (Palms) Dr. V. Krishnakumar, Dr. C. Thamban, Dr. Anitha Karun, Dr. K.B. Hebbar, Dr. Ravi Bhat, Heads, Dr. K. Muralidharan, Dr. A.C. Mathew, Dr. S. Kalavathi, Dr. Chandrika Mohan, Dr. P. Anithakumari, Dr. A. Abdul Haris, Dr. Regi. J. Thomas, PS, Dr. A. Joseph Rajkumar, Principal Scientists, Dr. Merin Babu, Dr. M. Shareefa, Dr. K. Nihad, Dr. Jeena Mathew, Dr. S. Indhuja, Scientists	National Meet on Prospects of Coconut Sector and Kisan Mela 2016	ICAR-CPCRI, Regional Station, Kayamkulam, 29 <sup>th</sup> -30 <sup>th</sup> September, 2016

Name and designation	Title of the programme	Place and Date
Dr. A. Joseph Rajkumar, Principal Scientist	Third National Meet of Entomologists-2016	ICAR-IIHR, Bengaluru 7 <sup>th</sup> -8 <sup>th</sup> October, 2016
Dr. P. Chowdappa, Director	Kisan Mela	ICAR-CPCRI Research Centre, Kahikuchi, 20 <sup>th</sup> - 21 <sup>st</sup> October, 2016
Dr. K.B. Hebbar, Head	Workshop on Processing of Coconut Products	Kundapura 30 <sup>th</sup> October 2016
Dr. (Mrs) Anitha Karun, Dr. Ravi Bhat, Dr. Vinayaka Hegde, Dr. C. Thamban, Dr. K.B. Hebbar, Heads, Dr. V. Niral, Dr. K. Samsudeen, Dr. M. K. Rajesh, Dr. S. Elain Apshara, Dr. Regi Jacob Thomas Principal Scientists, Dr. K. Devakumar, Sr. Scientist, Dr. Shareefa M., Dr. N.R. Nagaraja, Ms. Suchitra M., Mr. Y. Diwakar, Dr. M. Neema, Dr. Aparna V., Ms. Ranjini T.N. Scientist, Dr. Muralikrishna, K.S. Technical Assistant.	Workshop on Cryopreservation of Plant Germplasm	ICAR-CPCRI, Kasaragod, 02 <sup>nd</sup> November, 2016
Dr. Elain Apshara S., Principal Scientist	7 <sup>th</sup> Indian Horticulture Congress-2016	ICAR- IARI, New Delhi, 5 <sup>th</sup> November, 2016
Dr. M.R. Manikantan, Sr. Scientist and Dr. R. Pandiselvam, Scientist	International Conference on Controlled Atmosphere and Fumigations	The Entomological Society of India, New Delhi, 7 <sup>th</sup> -11 <sup>th</sup> November 2016
Dr. S. Elain Apshara, Principal Scientist Dr. Nagaraja, N.R., Scientist	National Conference on Cashew and Cocoa: Production to Marketing	Hotel Fidalgo, Panaji, Goa, 07 <sup>th</sup> -8 <sup>th</sup> November, 2016
Dr. Arun Kumar Sit, Principal Scientist	West Bengal Regional Science Congress, 2016	Jalpaiguri, 7 <sup>th</sup> -8 <sup>th</sup> November, 2016
Dr. Ravi Bhat, Head	Seminar on Cultivation of Plantation Crops	ZA&HRS, Brahmavar, 15 <sup>th</sup> November, 2016
Dr. P. Chowdappa, Director	7 <sup>th</sup> Indian Horticulture Congress 2016	B.P. Pal Auditorium Pusa, New Delhi, 15 <sup>th</sup> -19 <sup>th</sup> November, 2016
Dr. S. Leena, CTO	State Level Workshop on Organic Farming Practices	RARS, Pilicode, Kasaragod, 17 <sup>th</sup> November, 2017
Dr. Sandip Shil, Scientist	International Conference	ICRISAT, Hyderabad, 20 <sup>th</sup> -23 <sup>rd</sup> November, 2016
Dr. P. Chowdappa, Director Dr. H. P. Maheswarappa, PC (Palms) Dr. Ravi Bhat, Dr. K.B. Hebbar, Dr. (Mrs.) Anitha Karun, Dr. Vinayaka Hegde, Dr. C. Thamban, Dr. K.S. Anand, Heads, Dr. V. K. Chaturvedi, Dr. K. Muralidharan, Dr. Murali Gopal, Dr. (Mrs.) Alka Gupta, Dr. (Mrs.) V. Niral, Dr. Elain Apshara S., Dr. P. Subramanian, Dr. K. Samsudeen, Dr. S. Kalavathi, Dr. Chandrika Mohan, Dr. P. Anithakumari, Dr. Regi J. Thomas, Dr. Joseph Rajkumar, Dr. C.T. Jose, Dr. S. Kalavathi, Dr. Chandrika Mohan, Dr. Anithakumari. P, Principal Scientists, Dr. Chandran K. P., Dr. K. Devakumar, Dr. V.K. Chaturvedi,	3rd International Symposium on Coconut Research and Development (ISOCRAD-3)	ICAR-CPCRI, Kasaragod, 10 <sup>th</sup> -12 <sup>th</sup> December, 2016

Name and designation	Title of the programme	Place and Date
Dr. Jayasekhar, S., Scientist Sr. Scale, Dr. S. Paulraj, Dr. Ramesh S.V., Dr. D. Jaganathan, Dr. Prathibha V.H., Dr. V. Selvamani, Dr. (Mrs.) P.S. Prathibha, Dr. Prathibha. V.H., Dr. Rajkumar, Mrs. Surekha Dr. (Mrs.) M. Sujithra, Mrs. S. Neenu, Dr. (Mrs.) M. Neema, Mrs. G. Panjavarnam, Dr. Mr. Man Mohan Deo, Ms. Jilu V. Sajan, Ms. Ranjini T.N., Dr. N.R. Nagaraja, Dr. Merin Babu, Dr. Shareefa.M, Dr. Jeena Mathew, Dr. Karthika K.S., Mr. Bhavishya, Mr. Thava Prakasha Pandian, Mr. Shivaji Hausrao Thube, Dr. Suchithra M., Mrs. Saneera E.K., Dr. Merin Babu, Dr. Shareefa M., Dr. Jeena Mathew, Scientists Dr. K.K. Sajini, CTO and Dr. K.S. Muralikrishna, Tech. Assistant		
Dr. P. Chowdappa, Director Dr. H. P. Maheswarappa, PC (Palms) Dr. Ravi Bhat, Dr. K.B. Hebbar, Dr. Vinayaka Hegde, Dr. (Mrs.) Anitha Karun, Dr. V. Krishnakumar, Dr. C. Thamban, Dr. K.S. Ananda, Dr. Manoj Kumar T.S., Sr. P. Muralidharan, Heads, Dr. K. Muralidharan, Dr. Murali Gopal, Dr. (Mrs.) Alka Gupta, Dr. (Mrs.) V. Niral, Dr. Elaine Apshara.S., Dr. Joseph Rajkumar, Dr. P. Subramanian, Dr. A.C. Mathew, Dr. K. Samsudeen, Dr. M.K. Rajesh, Dr. C.T. Jose, Principal Scientists, Dr. K.P. Chandran, Dr. M.R. Manikantan, Dr. K. Devakumar, Sr. Scientists, Mr. S. Jayasekhar, Scientist Sr. Scale, Dr. S. Paulraj, Dr. Ramesh S.V., Dr. Shareefa M., Dr. Indhuja, Sri Y. Diwakar, Dr. D. Jaganathan, Dr. V. Selvamani, Mr. M. Arivalagan, Dr. Rajkumar, Dr. Y. Diwakar., Dr. (Mrs.) V.H. Prathibha, Mrs. Surekha, Dr. (Mrs.) M. Sujithra, Mrs. S. Neenu, Dr. (Mrs.) M. Neema, Mrs. Shameena Begum, Mrs. G. Panjavarnam, Mr. Man Mohan Deo, Dr. N.R. Nagaraja, Shri Bhukya Narsimha Swamy, Mrs. Bandela Sravanthi, Mr. Shivaji Hausrao Thube, Mr. R. Thava Prakash Pandian, Mr. R. Pandiselvam, Ms. Ranjini T.N., Scientists, Dr. S. Leena, SMS, Dr. K.K. Sajini, Chief Technical Officer, M.S. Rajeev, T. Sivakumar, Asst Chief Tech. Officers and Dr. K.S. Muralikrishna, Technical Assistant.	Plantation Crops Symposium (PLACROSYM-22)	ICAR-CPCRI, Kasaragod, 15 <sup>th</sup> -17 <sup>th</sup> December, 2016
Dr. C. Thamban	National Conference cum- Workshop on 'Kasaragod Towards a New Regional Development Agenda'	Nehru Arts & Science College, Kanhangad, Kasaragod, 16 <sup>th</sup> January, 2017
Dr. A. Joseph Rajkumar, Pr. Scientist	National Seminar on Recent Trends in Life Sciences	University College, Thiruvananthapuram 19 <sup>th</sup> -20 <sup>th</sup> , January, 2017
Dr. P. Chowdappa, Director	49 <sup>th</sup> Project Approval Committee Meeting of Coconut Development Board	Kera Bhavan, Kochi, 23 <sup>rd</sup> January, 2017
Dr. Prathibha. P.S., Dr. Prathibha. V.H., Scientists	Fifth National Conference on Biological Control	ICAR-NBAIR, Bengaluru, 9 <sup>th</sup> -11 <sup>th</sup> February, 2017

Name and designation	Title of the programme	Place and Date
Dr. P. Chowdappa, Director	ICAR-AICRP Review Committee Meeting	New Delhi, 14 <sup>th</sup> February, 2017
Dr. P. Chowdappa, Director	Directors Conference	ICAR, New Delhi, 15 <sup>th</sup> February, 2017
Dr. P. Muralidharan	XIIth Agricultural Science Congress	UAS, Bengaluru, 21 <sup>st</sup> -24 <sup>th</sup> February, 2017
Shri . T. Sivakumar, SMS (ACTO)	National Seminar on Biodiversity Conservation and Farming Systems for Wetland Ecology	KAU (RARS), Kumarakam, 22 <sup>nd</sup> -23 <sup>rd</sup> February, 2017
Dr. P. Chowdappa, Director	Advisory Committee Meeting on Farmers First	ICAR-CPCRI, Regional Station, Kayamkulam 02 <sup>nd</sup> March, 2017
Dr. P. Chowdappa, Director	Tender Coconut Mela Jointly organised by CPCRI, NABARD and Karnataka Agricultural Prices Commission	Tumkur, Karnataka, 15 <sup>th</sup> March 2017
Dr. P. Chowdappa, Director	129 <sup>th</sup> Meeting of Coconut Development Board	Bengaluru 17 <sup>th</sup> March, 2017
Dr. P. Chowdappa, Director	Meeting at Karnataka Council for Technologies Upgradation with regard to Coconut Parks	Bengaluru, 18 <sup>th</sup> March, 2017
Dr. P. Antihakumari, Principal Scientist Dr. M. Shareefa, Scientist	National Review meeting and Sensitization Workshop of Farmer FIRST Project	ICAR-NAARM, Hyderabad, 18 <sup>th</sup> -19 <sup>th</sup> March, 2017
Dr. A. Joseph Rajkumar, Principal Scientist	Brainstorming on Invasive rugose spiraling whitefly, <i>Aleurodicus rugioperculatus</i>	TNAU, Coimbatore 21 <sup>st</sup> -22 <sup>nd</sup> March, 2017

**International**

APCC, Jakarta, Indonesia	Cooperation between coconut growing countries in the Asia – Pacific region.
Bioversity International	Coconut genetic resources, International Coconut Gene Bank for South Asia and socio-economic collaboration
Coconut Research Institute, Sri Lanka	Resistance breeding programme against coconut Weligama Wilt disease in Sri Lanka

**National****ICAR Institutes**

ICAR-CIARI, Port Blair	Coconut genetic resources and breeding
ICAR-CIAE, Bhopal	Development of labour saving machineries and gadgets
ICAR-CIFT, Kochi	Value addition of coconut based products
ICAR-CRIDA, Hyderabad	Climate change network and NICRA
ICAR-CTCRI, Thiruvananthapuram	Cassava and coconut based value added products, intercropping of tuber crops in coconut gardens
ICAR-IIHR, Bengaluru	Phytoplasma disease related studies, varietal screening, cropping systems, agricultural tools and machinery and horticultural IP related activities
ICAR-IISR, Kozhikode	Cropping system studies, <i>Phytophthora</i> diseases in plantation crops
ICAR-NBAII, Bengaluru	Biological control programmes
ICAR-NBAIM, Mau	Microbial research network
ICAR-NBPGR, New Delhi	Germplasm registration and exchange of PGR
ICAR-IIOPR, 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

**Others**

CAMPCO, Mangalore	Arecanut/ cocoa research and development
Coconut Development Board, Kochi	Research and development in coconut
Directorate of Arecanut and Spices Development, 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
NABARD, Mumbai	Developing/ demonstrating model coconut clusters in root (wilt) affected areas
PPV & FRA, New Delhi	DUS Centre on coconut and arecanut
KSCSTE, Thiruvananthapuram	Research in biotechnology and bioinformatics

## RESEARCH PROJECTS

XVI.

At present, there are 48 research projects, including 31 projects with funding provided by external agencies. Details of the same are provided below:

Projects/ Divisions	Crop Improvement	Crop Production	Crop Protection	Physiology, Biochemistry and PHT	Social Sciences	Total
<b>Institute Projects</b>	4	3	3	4	3	<b>17</b>
<b>NAIF/ Network</b>	1	3	4	1	2	<b>11</b>
<b>DBT/DST</b>	1	—	1	—	1	<b>3</b>
<b>CDB/DASD/ DCCD</b>	1	—	1	—	2	<b>4</b>
<b>KSCSTE</b>	1	—	—	—	—	<b>1</b>
<b>Others</b>	4	1	1	2	4	<b>12</b>
<b>Total</b>	<b>12</b>	<b>7</b>	<b>10</b>	<b>7</b>	<b>12</b>	<b>48</b>

## Institute Projects

Sl. No.	Code	Particulars	Project Leader	Project 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, A.K. Sit, L.S. Singh, Alpina Das, N.R. Nagaraja, K.B. Hebbar, Shameena Beegum, M. Senthil Amudhan, Keerthana U., Shivaji Hausrao Thube, C. Thamban, Regi Jacob Thomas, Ravi Bhat, Murali Gopal and M. Arivalagan, Y. Diwakar, T.N. Ranjini, M. Suchitra and a Scientist from CIARI, Andamans
2.	1000761029	Genetical investigations and breeding in coconut, arecanut and cocoa	V. Niral	K.S. Ananda, S. Elain Apshara, Regi Jacob Thomas, K. Samsudeen, M. Shareefa, A.K. Sit, N.R. Nagaraja, Merin Babu, A. Josephraj Kumar, L.S. Singh, M. Chaithra, Y. Diwakar, T.N. Ranjini, Scientist from ICAR-CIARI, Andaman, S. Sendur Kumaran (KVK, Kundrakudi)
3.	1000761031	Development of robust tissue culture techniques in coconut	Anitha Karun	M. K. Rajesh, K. Devakumar, M. Neema, Krishna Prakash, V. Aparna

Sl. No.	Code	Particulars	Project Leader	Project Associate (s)
4.	1000761030	Biotechnological applications in palms and cocoa	M.K. Rajesh	Anitha Karun, K.S. Ananda, Krishna Prakash, S. Elain Apshara, Regi Jacob Thomas, M. Shareefa, M. Neema, V. Aparna
5.	1000763057	Cropping/farming approaches for improving soil health and system productivity in coconut, arecanut and cocoa	P. Subramanian	Ravi Bhat, H. P. Maheshwarappa, V. Krishnakumar, Surekha, Panjavarnam, V. Selvamani, Alka Gupta, Bhavishya, A. Abdul Haris, Jeena Mathew, K. Nihad, Anok Uchoi, Arun Kumar Sit, S. Neenu, K.S. Karthika, Sumitha, Alpana Das, L. S. Singh, V. H. Prathibha
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, Neenu, A. Abdul Haris, Jeena Mathew, Sureka, Bhavishya, Karthika, K. S., Alka Gupta, Murali Gopal, Indhuja, Anok Uchoi, Arun Kumar Sit, S. Paulraj, G. Panjavarnam
7.	1000763055	Bioresources management in coconut, arecanut and cocoa	Alka Gupta	Murali Gopal, Ravi Bhat, P. Subramanian, Vinayaka Hegde, S. Indhuja, S. Neenu, K.S. Karthika, S. Paulraj, Jeena Mathew, Anok Uchoi, K. Samsudeen, S. Elain Apshara, K.S. Ananda, V. Niral, B. Augustine Jerard, Bhavishya, Surekha
8.	1000765039	Integrated approaches for management of fungal diseases of palms and cocoa	Vinayaka Hegde	V. H. Prathibha, M. Chaitra, Keerthana, U., Thava Prakash Pandian
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 and Keerthana, U.
10.	1000765041	Integrated pest management in coconut, arecanut and cocoa	Chandrika Mohan	A. Joseph Rajkumar P.S. Prathibha, Rajkumar, M. Sujithra, Shivaji H. Thube, Saneera E.K., Jilu V. Sajan, Merin Babu, M. Chaithra, Thava Prakasa Pandian, R., U. Keerthana, A.K. Sit
11.	1000766014	Phenotyping for climate resilient adaptation and mitigation strategies	K.B. Hebbar	V.K. Chaturvedi, Senthil Amudhan, Anok Uchoi
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, M. Senthil Amudhan, Shameena Beegum, Murali Gopal, Man Mohan Deo, S. Paulraj

Sl. No.	Code	Particulars	Project Leader	Project Associate (s)
13.	1000767016	Development of pilot level process and technology for the production of health foods from coconut milk residue and VCO cake	M.R. Manikantan	M. Arivalagan, A.C. Mathew, Shameena Beegum, S. Paulraj
14.	1000767017	Developing machineries and gadgets for gender mainstreaming in palms and cocoa	A.C. Mathew	M.R. Manikantan
15.	1000769019	Development of statistical and computational techniques for improving research methodology	C.T. Jose	Chandran K.P., C. Thamban
16.	1000769020	Technology transfer and co-learning action research approaches	C. Thamban	S. Kalavathy, P. Anithakumari D. Jaganathan, C.T. Jose, K. Muralidharan, P. Subramanian, A.C. Mathew, K.P. Chandran, S. Jayasekhar, Sandip Shil, Alpana Das, A.K. Sit, K. Nihad, Indhuja, S., L.S. Singh Anok Uchoi, Rajkumar
17.	1000769013	Socio-economic dimensions and value chain dynamics in policy perspective	Jayasekhar, S.	Chandran, K.P., C.T. Jose, Sandip Shil, K. Muralidharan, C. Thamban

### Externally Funded Projects

Sl. No.	Code	Particulars	Project Leader	Project Associate (s)
1.	1050761086	DUS Centre for coconut	V. Niral	B. Augustine Jerard, K. Samsudeen, K.S. Ananda, S. Elain Apshara
2.	1050761106	Consortium Research Platform on Agro-biodiversity	V. Niral	
3.	2010760004	Seed production in coconut, arecanut, cocoa	K. Samsudeen	K. S. Ananda, V Niral, B. A. Jerard, S. Elain Apshara, Regi Jacob Thomas, M. Shareefa, K. Devakumar and Surekha
4.	1050761107	Large-scale production of elite and hybrid seedlings of coconut for the root (wilt) disease prevalent tract	Regi Jacob Thomas	M. Shareefa, Merin Babu, S. Kalavathy
5.	1050761114	Development of DUS testing criteria and establishment of national genebank for arecanut	K.S. Ananda	

Sl. No.	Code	Particulars	Project Leader	Project Associate (s)
6.	1050761115	Development of DUS testing criteria and establishment of national gene bank for cocoa	S. Elain Apshara	
7.	1050231012	Development of a database for plantation crops for biologists (DBT)	M.K. Rajesh	P. Chowdappa and Anitha Karun
8.	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
9.	1050761097	Network Project on Organic Horticulture	P. Subramanian	H.P. Maheshwarappa, Surekha, V. Selvamani, Murali Gopal, V.H. Prathibha, Sujithra, V. Krishnakumar A. Abdul Haris, K. Nihad, S. Indhuja
10.	1050761098	Enhancing economic viability of coconut based land use system for land use planning in Kerala	V. Krishna Kumar	Jeena Mathew, A. Abdul Haris, Merin Babu, P. Anithakumari, Joseph Rajkumar, Ravi Bhat, V. Selvamani, C. Thamban, Chandran, K.P., S. Neenu
11.	1050761099	Network Project on Micronutrient management in horticultural crops for enhancing yield and quality	V. Selvamani	H.P. Maheswarappa, K.B. Hebbar, Ravi Bhat, Alka Gupta, S. Sujatha, Jeena Mathew, M. Arivalagan, Bhavishya
12.	1050761108	Outreach programme on fungal foliar diseases: Arecanut inflorescence die back and Coconut leaf blight disease	V.H. Prathibha	P. Chowdappa, Vinayaka Hegde, Merin Babu, U. Keerthana
13.	2010760009	Outreach project on <i>Phytophthora</i> , <i>Fusarium</i> and <i>Ralstonia</i> diseases of horticultural and field crops (Phytophthora diseases of coconut and cocoa)	Vinayaka Hegde	V.H. Prathibha, M. Chaitra, Thava Prakash Pandian R., U. Keerthana.
14.	1050761109	Mass production of plant growth promoting microbes and bio-control agents for sustainability of coconut based farming system	Vinayaka Hegde	
15.	1050761111	Outreach programme on fungal foliar diseases: Arecanut inflorescence die back and coconut leaf spot disease	Prathibha., V.H.	P. Chowdappa, Vinayaka Hegde, Merin Babu, U. Keerthana.

Sl. No.	Code	Particulars	Project Leader	Project Associate (s)
16.	1050761101	Outreach Programme on Management of Sucking Pests in Horticultural Crops (OPR-SP) - Coconut and Cocoa	Chandrika Mohan	Joseph Rajkumar, Prathibha, P.S., Sivaji Hausrao Thube
17.	1050761100	Consortium Research Platform on Borers in Network mode	A. Josephraj Kumar	Chandrika Mohan, Prathibha, P.S.
18.	1050761095	Development of forewarning model using regression and simulation approach for management of rice leaf folder, <i>Cnaphalocrosis medinalis</i> Guenee (Lepidoptera: Pyralidae)	N. Sujithra	
19.	1050761105	Demonstration of EPN in arecanut for the management of root grubs	Rajkumar	Jaganathan, D. and Shivaji Hausrao Thube
20.	2010760007	Intellectual property management and transfer/ commercialization of agricultural technology scheme	K. Muralidharann	A.C. Mathew, S. Jayasekhar
21.	1050761112	Techno-socio-economic assessment of soil & water conservation and water harvesting structures	A.C. Mathew	C. Thamban, P. Muralidharan, Jayasekhar S.
22.	1050761113	Design and development of an air blast sprayer for arecanut	A.C. Mathew	R. Pandiselvam, D. Dhalin
23.	1050761094	Organic farming in Kasaragod district –An analysis of field level scenario and Stakeholders' perspectives	C. Thamban	S. Jayasekhar, P. Subramanian

Sl. No.	Code	Particulars	Project Leader	Project Associate (s)
24.	1050761102	Assessment of incidence and intensity of pests and diseases of coconut in North Kerala	C. Thamban	
25.	1050761093	Area wide community approach for integrated management of red palm weevil of coconut using GPS/GIS as decision support and evaluation tools	P. Anithakumari	
26.	1050761092	Community based bio-resource management for sustaining production and livelihood security under coconut based farming systems	S. Kalavathi	
27.	1050233003	Farmers' Participatory Research cum Demonstration Plots on Arecanut Based Cropping System	D. Jaganathan	
28.	1050761104	Farmers' Participatory Research cum demonstration plots on cocoa	D. Jaganathan	
29.	2010761091	Business Planning and Development Unit, ICAR-CPCRI, Kasaragod	K. Muralidharan	
30.	1050761110	Establishment of Agri-Business Incubation (ABI) Center at ICAR-CPCRI, Kasaragod	K. Muralidharan	A.C. Mathew, S. Jayasekhar
31.	1050761103	Economic impact studies on crops diversification and technology adoption in horticulture	Jayasekhar S.	Chandran K.P., C. Thamban

# RESEARCH AND ORGANISATIONAL MANAGEMENT

## Institute Management Committee Meeting

A meeting of the Institute Management Committee (IMC) was held under the chairmanship of Dr. P. Chowdappa, Director on 28<sup>th</sup> July, 2016 at ICAR-CPCRI, Kasaragod. Dr. V.S. Devadas, Director of Research I/C, KAU, Vellanikkara, Dr. Roy Mathew, Addl. Director of Agriculture, Govt. of Kerala, Thiruvananthapuram, Dr. H.P. Maheswarappa, Project Coordinator (Palms), ICAR-CPCRI, Kasaragod, Dr. Anitha, Karun, Head, Crop Improvement, ICAR-CPCRI, Kasaragod and Shri Suresh Kumar, Chief Administrative Officer, ICAR-CPCRI, Kasaragod, were present. Programmes and achievements of ICAR-CPCRI were presented before the IMC. Action taken on the previous agenda items and fresh agenda were discussed and appropriate decisions were taken.



**Meeting of the Institute Management Committee at ICAR-CPCRI, Kasaragod**

## Research Advisory Committee meeting

The 19<sup>th</sup> Research Advisory Committee (RAC) meeting was convened at ICAR-CPCRI, Kasaragod on 18<sup>th</sup>-19<sup>th</sup> February, 2017, under the chairmanship of Dr. H.P. Singh, Former DDG (Horticultural Sciences), ICAR, New Delhi, with the participation of the RAC official members, Dr. N. Kumar, Ex-Dean, Tamil Nadu Agricultural University, Coimbatore Dr. R.T. Patil, Ex-Director, Central Institute of Post Harvest Engineering and Technology, Ludhiana Dr. D.M. Hegde, Ex- Director, ICAR- Directorate of Oilseeds Research, Dr. S.R. Bhat, Former Professor, National Research Centre on Plant Biotechnology, Dr. P. Chowdappa, Director ICAR-CPCRI, the

non-official members, Shri Suresh Kumar Shetty, Shri Shivakrishna Bhat and the member secretary Dr. K.B. Hebbar.

Dr. H.P. Singh, chairman RAC and other RAC members in their remarks, complimented the Director and scientists for their activities and achievements, and said that the coconut research and development has witnessed a sea change over the years, right from pre-independence era. Dr. H.P. Singh emphasized the leadership role played by ICAR-CPCRI in the development of cutting edge technologies and innovations and appreciated the work on neera and its products and partnership with industries for the benefit of the farmers. He stressed that the efforts should be reoriented towards nutrient management through fertigation and understanding the microbial associations in farming and cropping systems. Metagenomics could be used for understanding the interaction of microbes in cropping systems. The need for diversification in coconut sector was also highlighted to make it more competitive and to enhance farmers' income. To achieve that, research on cropping and farming system approach, improved varieties, production management systems, product development, etc. would need emphasis. Scientific studies on water requirement and climate resilience are required. ICAR-CPCRI should take up leadership role in making neera/ neera-like products from other crops such as date palm and palmyrah. The RAC Committee also recommended more studies on the health aspects of coconut in its various forms and stressed on revisiting the work on biotechnology.



**Dr. H.P. Singh addressing the scientists during RAC Meeting**

# INTELLECTUAL PROPERTY AND TECHNOLOGY MANAGEMENT

## Patent granted

A patent on 'Coconut testa removing machine' was granted (Inventors: A.C. Mathew, K. Madhavan and M.V. Krishnan, Patent No. 278013 dated 8<sup>th</sup> December 2016).



**Coconut testa removing machine**

## Consultancy services

A number of consultancy services and contract research projects were taken up as part of the professional service functions of the Institute.

Consultancy service	Client	Amount (₹)
Training on Kalparasa Collection	Coconut producers from Organization for Elango Refugee Rehabilitation (OfERR), Jaffna, Sri Lanka (9 <sup>th</sup> -11 <sup>th</sup> February, 2017)	2,40,300
Consultancy at Vittal	Stakeholders	46,975
Analysis of secondary nutrients and micronutrients	The Assistant Soil Chemist, Office of the Assistant Soil Chemist, Soil Testing Laboratory, Kasaragod, Kerala	9000
Nutrient analysis of neem cake, bone meal and organic manure	Malabar Agro Industries, KINFRA Small Industries Park, Seethangoli, Kasaragod, Kerala	2500

Consultancy service	Client	Amount (₹)
Nutrient analysis of organic manure samples	Mr. Abdul Nasar, Nellyyadi, Puttur, Karnataka	11250
	M/s. Agro Marine Industries, Kasaragod, Kerala	
	Agricultural Officer, Krishi Bhavan, Muliya, Kasaragod, Kerala	
	Agricultural Officer, Krishi Bhavan, Puthige, Kasaragod, Kerala	
	Chaithravahini Farmers Club, Konnakkad, Kasaragod, Kerala	
Nutrient analysis of neem cake and vermicompost	Agricultural Officer, Krishi Bhavan, Enmakaje, Kasaragod, Kerala	2500
Nutrient analysis of vermicompost	Agricultural Officer, Krishi Bhavan, Madhur, Kasaragod, Kerala	1250
Nutrient analysis of neem cake	Agricultural Officer, Krishi Bhavan, Enmakaje, Kasaragod, Kerala	8750
	Agricultural Officer, Krishi Bhavan, Puthige, Kasaragod, Kerala	
	Agricultural Officer, Krishi Bhavan, Vorkady, Kasaragod, Kerala	
	Agricultural Officer, Krishi Bhavan, Manjeshwar, Kasaragod, Kerala	
	Agricultural Officer, Krishi Bhavan, Kattappana, Kasaragod, Kerala	
	Agricultural Officer, Krishi Bhavan, Meenja, Kasaragod, Kerala	
Nutrient analysis of Agromix organic fertilizer	Madikai Service Co-operative Bank, Madikai, Kasaragod, Kerala	1250
Nutrient analysis of soil sample	Agricultural Officer, Krishi Bhavan, Madhur, Kasaragod, Kerala	2000
	Agricultural Officer, Krishi Bhavan, Mogral Puttur, Kasaragod, Kerala	
Nutrient analysis of leaf sample	Mr. Ajith Abraham, Angamaly, Kerala	300
Nutrient analysis of neem cake and bone meal	Agricultural Officer, Krishi Bhavan, Paivalike, Kasaragod, Kerala	2500
<b>Total</b>		<b>3,28,575</b>

### Technology commercialization

About 42 technologies were commercialized through non-exclusive licensing.

Technology transferred	Licensee	Fee (₹)
Production of virgin coconut oil by hot process	Mr. Praful Paunika, Vasco-Da-Gama, Goa	25,000
	Mr. M. Dhanabal, Pollachi, Coimbatore, Tamil Nadu	25,000
	Mr. Muhammed Gafoor, Tennala Kuttippala, Malappuram, Kerala	25,000
	Mr. Samir R. Audi, Vasco-Da-Gama, Goa	25,000
	Mr. K. Karunakaran, Thalassery, Kerala	25,000
	M/s Oam Merchandize, Chennai, Tamil Nadu	25,000
	Mrs. Jyothi Kanumuri, Hyderabad, Telangana	25,000

Technology transferred	Licensee	Fee (₹)
Production of virgin coconut oil by hot process	Mr. M.S. Ganesh Kumar, M/s Zeus Industries Private Limited, Kurnool District, Andhra Pradesh	25,000
	Smt. Karatt Sarojani, Maniyoore, Kannur, Kerala	25,000
	M/s Phalada Agro Research Foundation Pvt. Ltd., Bengaluru, Karnataka	25,000
	M/s Biogen, Kargal, Uttara Karnataka	40,000
	Mrs. Yamuna Ranjith, Kozhikode, Kerala	40,000
	M/s Kadathanad Coconut Producer Company Ltd, Mokeri, Kozhikode, Kerala	40,000
	Mr. Joseph L.R.Vaz, M/s Tycon Medical Devices Private Limited, Navelim, Goa	40,000
	Mr. P. Dayanand, Bengaluru, Karnataka	40,000
Collection of fresh and hygienic Kalparasa and production of natural coconut sugar	Mr. George V. Karnan, Punnarkulam, Kanyakumari District, Tamil Nadu	10,000
	Mr. Venugopalan K, Kanathur Post, Kasaragod, Kerala	10,000
	M/s Phalada Agro Research Foundation Pvt Ltd, Bangalore, Karnataka	10,000
	Dr. K. Narayana Gowda, Chairman, Kunigal Taluk Coconut Producers Company Limited, Hulivana, Tumkur District, Karnataka	15,000
	M/s Kalpavrutta Coconut Producer Company Ltd, Gavirangapura, Chitradurga District, Karnataka	15,000
	M/s Kadathanad Coconut Producer Company Ltd, Mokeri, Kozhikode, Kerala	15,000
	Mrs. Raksha Dayanand, Bengaluru, Karnataka	15,000
	Ms. Pavithra S., Coimbatore, Tamil Nadu	15,000
	Bihar Agricultural University, Sabour, Bhagalpur, Bihar	15,000
Coconut chips production	Mr. George V. Karnan, Punnarkulam, Azhagappapuram, Kanyakumari District, Tamil Nadu	10,000
	Mr. P.P. Mohammed Kunhi, M/s Keranadu Farmers Agri Business Pvt. Ltd., Taliparamba, Kannur, Kerala	10,000
	Mr. Samir R. Audi, Vasco-Da-Gama, Goa	10,000
	Mrs. Jyothi Kanumuri, Miyapur, Hyderabad, Telangana	10,000
	Mr. M.S. Ganesh Kumar, M/s Zeus Industries Private Limited, Kurnool District, Andhra Pradesh	10,000
	Mr. Usman B.A., Kasaragod, Kerala	10,000
	Smt. Karatt Sarojini, Maniyoore, Kannur, Kerala	10,000
	M/s Phalada Agro Research Foundation Pvt Ltd, Bengaluru, Karnataka	10,000
	Smt. G. Gomathi, Tiruchengode, Tamil Nadu	15,000
	Mrs. Yamuna Ranjith, Kunduparamba, Kozhikode, Kerala	15,000
	M/s Kadathanad Coconut Producer Company Ltd., Mokeri, Kozhikode, Kerala	15,000
	Mr. P. Dayanand, Bengaluru, Karnataka	15,000
	Mr Joseph Dominic, Kanjirapally, Kottayam, Kerala	15,000
	Mr Zakaria C. H., Kannur, Kerala	15,000

Technology transferred	Licensee	Fee (₹)
Shell fired copra dryer	Mr Prakash Kakamani, Pazhanchira, Kerala	5,000
Coconut deshelling machine	Mr. Prakash Kakamani, Pazhanchira, Kerala	1,000
Coconut grating machine	Mr. Prakash Kakamani, Pazhanchira, Kerala	1,000
Method of preparation of fresh coconut inflorescence sap (kalparasa) based milk sweets	Mr. Dey Baidyanath, Rishra, Hooghly, West Bengal	10,000
Nanomatrix for delivery of pheromone for the management of red palm weevil and rhinoceros beetle(Technology jointly developed of ICAR-CPCRI & JMCASR)	M/s Rajshree Biosolutions Coimbatore, Tamil Nadu	3,00,000
	M/s Bio Pel Organics & Formulations Pvt. Ltd., Secunderabad, Telengana	3,00,000
Preservation of carbonated tender coconut water	Mr. Sahil Kumar, Bokaro, Jharkhand	25,000
	Ms. Pavithra S., Coimbatore, Tamil Nadu	25,000
Coconut leaf vermicomposting technology	M/s Kadathanad Coconut Producer Company Ltd., Mokeri, Kozhikode, Kerala.	5,000
	Mr. K. Govinda Shastry, Mangalore, Karnataka	5,000
Technical knowhow of production of Kalpa Krunch	Mrs. Raksha Dayanand, Bengaluru, Karnataka	60,000
	M/s Perambra Coconut Producer Company, Perambra, Kozhikode, Kerala	60,000
Technical knowhow of production of coconut vinegar	Mr. Yeshwanth T.P., Bengaluru, Karnataka	10,000
	Mr. Ramesan Pilathottathil, Kozhikode, Kerala	10,000
Snow ball tender nut machine	Mr. Murali Gopalan, Peddathalapalli, Tamil Nadu	2,500
<b>Total</b>		<b>15,59,500</b>

### Sale of technology products

Item	Qty/ No.	Amount (₹)
Books	119	6893
CD-ROMs	5	740
Earth worms	9950	7861
Vermicompost	6177	60286
Mushrooms	1	110
Mushroom spawn (kg)	40	3476
Coir pith compost	454	4994
Vermiwash (bottles)	6	660
Arecanut seed nuts	516496	2835826
Arecanut seedlings	151562	3393285
Coconut seed nuts (tall varieties)	30751	514139
Coconut seedlings (tall varieties)	16910	1347709
Coconut seedlings (hybrids)	28410	6938340

Item	Qty/ No.	Amount (₹)
Coconut seedlings (dwarf varieties)	9463	987380
Coconut seednuts (dwarf varieties)	5246	284150
Polybag seedlings - coconut	1486	221920
Kera Probio	582	16005
Black pepper cuttings	9127	91270
Bay leaf air layer	6675	200250
Green black pepper (kg)	51	4080
Cocoa seedling	5558	55580
Cocoa grafts	16239	487170
Cocoa seed pods	737	24230
Acid lime cuttings	1114	11140
<b>Total</b>	<b>817159</b>	<b>17497494</b>

## Scientific

## Kasaragod

Sl. No.	Name	Designation
1.	Dr. Chowdappa P.	Director
2.	Dr. Maheswarappa H.P.	Project Coordinator (Palms)
3.	Dr. (Mrs.) Anitha Karun	Head (Crop Improvement)
4.	Dr. Ravi Bhat	Head (Crop Production)
5.	Dr. Hebbar K B.	Acting Head (PB & PHT)
6.	Dr. Vinayaka Hegde	Head (Crop Protection)
7.	Dr. Thamban C.	Acting Head (Social Sciences)
8.	Dr. Muralidharan K.	Principal Scientist (Agril. Statistics)
9.	Dr. Murali Gopal	Principal Scientist (Agril. Microbiology)
10.	Dr. (Mrs.) Alka Gupta	Principal Scientist (Agril. Microbiology)
11.	Dr. Subramanian P.	Principal Scientist (Agronomy)
12.	Dr. (Mrs.) Niral V.	Principal Scientist (Genetics)
13.	Dr. Mathew A.C.	Principal Scientist (Soil & Water Conservation Engg.)
14.	Dr. Samsudeen K.	Principal Scientist (Economic Botany)
15.	Dr. Rajesh M.K.	Principal Scientist (Agril. Biotechnology)
16.	Dr. Chandran K.P.	Senior Scientist (Agril. Statistics)
17.	Dr. Manikantan M.R.	Senior Scientist (Agril. Process Engg.)
18.	Dr. Devakumar K.	Senior Scientist (Agril. Biotechnology)
19.	Sri Jayasekhar S.	Scientist Sr. Scale (Agril. Economics)
20.	Dr. Jaganathan D.	Scientist (Agril. Extension)
21.	Dr. Selvamani V.	Scientist (Soil Science)
22.	Sri. Arivalagan M.	Scientist (Biochemistry)
23.	Dr. (Mrs.) Pratibha P.S.	Scientist (Agril. Entomology)
24.	Dr. Rajkumar	Scientist (Nematology)
25.	Dr. (Mrs.) Prathibha V.H.	Scientist (Plant Pathology)
26.	Mrs. Surekha	Scientist (Agronomy)
27.	Dr. Sujithra M.	Scientist (Agril. Entomology)
28.	Dr. (Mrs.) Neenu S.	Scientist (Soil Science)
29.	Dr.(Mrs.) Neema M.	Scientist (SPM&AP)
30.	Ms. Sumitha S.	Scientist (SPM&AP)
31.	Sri Krishna Prakash	Scientist (SPM&AP)
32.	Mrs. Aparna Veluru	Scientist (SPM&AP)
33.	Mrs. Shameena Begum	Scientist (SPM&AP)
34.	Mrs. G. Panjavarnam	Scientist (Fruit Science)
35.	Dr. Paulraj S.	Scientist (Microbiology)
36.	Mrs. Jilu V. Sajan	Scientist (Agril. Entomology)
37.	Dr. Pandiselvam R.	Scientist (Agril. Process Engg.)

Sl. No.	Name	Designation
38.	Ms. Ranjini T.N.	Scientist (SP&M&AP)
39.	Mrs. Keerthana Umapathy	Scientist (Plant Pathology)
40.	Dr. Ramesh S.V.	Scientist (Biotechnology)
41.	Dr. Sudha R.	Scientist (Fruit Science)

**KVK, Kasaragod**

42.	Dr. Manojkumar T.S.	Principal Scientist & Programme Coordinator, KVK
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**Kidu**

43.	Dr. Khadke Ganesh Navanath	Scientist (SPM & AP)
44.	Sri Diwakar Y.	Scientist (SPM & AP) (w.e.f. 02.05.16)

**Mohitnagar**

45.	Dr. Arunkumar Sit	Principal Scientist (Hort.)
46.	Dr. Sandip Shil	Scientist (Agril. Statistics)

**Kahikuchi**

47.	Dr. (Mrs.) Alpana Das	Senior Scientist (Agril. Biotechnology)
48.	Sri Anok Uchoi	Scientist (SPM&AP)
49.	Dr. Leichombam Singhajit Singh	Scientist (SPM&AP)

**Kayamkulam**

50.	Dr. Krishnakumar V.	Head
51.	Dr. Chandrika Mohan	Principal Scientist (Agril. Entomology)
52.	Dr. (Mrs.) Anitha Kumari P.	Principal Scientist (Agril. Extension)
53.	Dr. (Mrs.) Kalavathy S.	Principal Scientist (Agril. Extension)
54.	Dr. Chaturvedi V.K.	Senior Scientist (Biochemistry)
55.	Dr. Regi Jacob Thomas	Principal Scientist (Hort.)
56.	Dr. Joseph Rajkumar	Principal Scientist (Agril. Entomology)
57.	Dr. (Mrs.) Nihad K.	Scientist (Hort.)
58.	Dr. (Mrs.) Jeena Mathew	Scientist (Soil Science)
59.	Dr. (Mrs.) Shareefa M.	Scientist (Hort.)
60.	Dr. (Mrs.) Merin Babu	Scientist (Plant Pathology)
61.	Dr. Abdul Haris	Principal Scientist (Agronomy)
62.	Dr. (Mrs.) Indhuja S.	Scientist (Microbiology)
63.	Mrs. Daliamol	Scientist (Plant Pathology)
64.	Dr. Anes K.M.	Scientist (Nematology)

**KVK, Kayamkulam**

65.	Dr. Muralidharan P.	Pr. Scientist & Programme Coordinator, KVK
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**Vittal**

66.	Dr. Ananda K.S.	Head
67.	Dr. Jose C.T.	Principal Scientist (Agril. Statistics)
68.	Dr. Elain Apshara S.	Principal Scientist (Horticulture)
69.	Dr. Senthil Amudhan M.	Senior Scientist (Biochemistry)

Sl. No.	Name	Designation
70.	Dr. Nagaraj N.R.	Scientist (Plant Breeding)
71.	Ms. Chaithra M.	Scientist (Plant Pathology)
72.	Ms. Priya U.K.	Scientist (Soil Science)
73.	Mrs. Karthika K.S.	Scientist (Soil Science)
74.	Sri Bhavishya	Scientist (SPM&AP)
75.	Sri Shivaji Hausrao Thube	Scientist (Agril. Entomology)
76.	Mrs. Saneera E.K.	Scientist (Agril. Entomology)
77.	Ms. Suchithra M.	Scientist (SP&M&AP)
78.	Sri Thava Prakash Pandian R.	Scientist (Plant Pathology)
79.	Sri Najeeb Naduthodi	Scientist (Fruit Science)

### Technical

#### Kasaragod

Sl. No.	Name	Designation
80.	Sri Muralikrishna H .	Chief Technical Officer (Tech. Information)
81.	Dr. Sajini K.K.	Chief Technical Officer (Lab.)
82.	Sri John George	Chief Technical Officer (Lab.)
83.	Sri Sebastian George	Chief Technical Officer (Lab)
84.	Sri Mohammed Basheer B.M.	Chief Technical Officer (Lab)
85.	Smt. Shobha K.	Asst. Chief Technical Officer (Library)
86.	Sri Bikash Chowdhury	Asst. Chief Technical Officer (Field/Farm)
87.	Sri Devadas K.	Asst. Chief Technical Officer (Field/Farm)
88.	Smt. Sugatha Padmanabhan	Sr. Tech. Officer (Lab.)
89.	Sri Ramakrishnan N.	Sr. Tech. Officer (Field/Farm)
90.	Smt. Sreelatha K.	Sr. Tech. Officer (OL)
91.	Sri Krishnan M.	Tech. Officer (Field/Farm)
92.	Sri Sadanandan A.	Tech. Officer (Mech. Engg.)
93.	Sri Rajendran Nair M.P.	Tech. Officer (Mech. Engg.)
94.	Sri Hareesh G.S.	Tech. Officer (Instrumentation Engg.)
95.	Sri Balakrishnan K.	Tech. Officer (Field/Farm)
96.	Sri Ajith Kumar K.	Tech. Officer (Civil Engg.)
97.	Sri Gopalakrishnan V.K.	Tech. Officer (Civil Engg.)
98.	Sri Balakrishnan V.	Tech. Officer (Field/Farm)
99.	Sri Manohara S.	Tech. Officer (Vehicles)
100.	Sri Pankajakshan K.N.	Sr. Tech. Assistant (Vehicles)
101.	Sri Radhakrishnan Nambiar K.N.	Sr. Tech. Assistant (Field/Farm)
102.	Sri Suresh Kumar V.	Sr. Tech. Assistant (Field/Farm)
103.	Sri Krishnan Nair K.	Sr. Tech. Assistant (Field/Farm)
104.	Sri Sreedharan M.V.	Sr. Tech. Assistant (Field/Farm)
105.	Sri Devaraj K.	Sr. Tech. Assistant (Jr. Engineer )
106.	Sri Raghavan K.	Tech. Assistant (Field/Farm)
107.	Sri Madhavan M.V.	Tech. Assistant (Field/Farm)
108.	Sri Sanjeeva A.	Tech. Assistant (Field/Farm)
109.	Dr. Muralikrishna K.S.	Tech. Assistant (Field/Farm)

Sl. No.	Name	Designation
110.	Smt. Nivedhitha M.S.	Tech. Assistant (Field/Farm)
111.	Smt. Jesmi Vijayan	Tech. Assistant (Field/Farm)
112.	Sri Satheesh Kumar A.V.	Sr. Technician (Vehicles)
113.	Sri Panduranga	Sr. Technician (Field/Farm)
114.	Sri Krishnankutty P.K.	Sr. Technician (Field/Farm)
115.	Sri Bhavani Sankar Naik	Sr. Technician (Field/Farm)
116.	Sri Divakaran A.	Sr. Technician (Field/Farm)
117.	Sri Padmanabha Naik A.R.	Sr. Technician (Field/Farm)
118.	Sri Sebastian K. J.	Sr. Technician (Field/Farm)
119.	Sri Radhakrishnan V.	Sr. Technician (Field/Farm)
120.	Sri Dinesh Kumar N.	Sr. Technician (Field/Farm)
121.	Sri Varghese A.O.	Sr. Technician (Field/Farm)
122.	Sri Sunil S.	Sr. Technician (Ele. Engg.)
123.	Smt. Vimala M.	Sr. Technician (Field/Farm)

**KVK, Kasaragod**

124.	Dr. Leena S.	Chief Technical Officer (SMS-Entomology)
125.	Dr. Sanal Kumar R.	Chief Technical Officer (SMS-Plant Pathology)
126.	Dr. Saritha Hegde	Chief Technical Officer (SMS-Home Science)
127.	Dr. Neelofar Illiaskutty	Asst. CTO (Programme Assistant-Home Science)
128.	Sri Shyama Prasad K.	Asst. CTO(Programme Assistant -Audio -Visual)
129.	Smt. Jayashree M.P.	Sr. Tech. Officer (SMS-Agrl. Extension)
130.	Sri Manikandan K.	Sr. Tech. Officer (Programme Assistant(Hort.))
131.	Sri Ramadas A.K.	Tech. Asst. (Vehicles)

**Kayamkulam**

132.	Dr. Keshavan Nampoothiri C.	Asst. Chief Technical Officer (Statistics)
133.	Sri Thajuddin S.	Asst. Chief Technical Officer (Library)
134.	Dr. Rajeev G.	Asst. Chief Technical Officer (Lab.)
135.	Sri Jacob Kurian	Asst. Chief Technical Officer (Field/Farm)
136.	Dr. Shanavas M.	Asst. Chief Technical Officer (Lab.)
137.	Dr. Narayanan Namboothiri C.G.	Senior Tech. Officer (Field/Farm)
138.	Sri Sudhanandan K.K.	Senior Tech. Officer (Field/Farm)
139.	Sri Anilkumar B.	Tech. Officer (Field/Farm)
140.	Sri Rajendran K.	Tech. Officer (Field/Farm)
141.	Sri Asokan E.R.	Tech. Officer (Photography)
142.	Sri Udayabhanu K.P.	Tech. Officer (Field/Farm)
143.	Sri Sunny Thomas	Senior Tech. Assistant (Field/Farm)
144.	Sri Sunil Kumar P.K.	Tech. Assistant (Field/Farm)
145.	Sri Jinu Sivadasan	Tech. Assistant (Field/Farm)
146.	Sri Joy V.P.	Tech. Assistant (Field/Farm)

Sl. No.	Name	Designation
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**KVK, Kayamkulam**

147.	Sri Rajeev M.S.	Asst. Chief Technical Officer (SMS - Agronomy)
148.	Dr. Ravi S.	Asst. Chief Technical Officer (SMS - Animal husbandry)
149.	Sri Sivakumar T.	Asst.Chief Technical Officer (SMS - Agril.Entomology)
150.	Smt. Lekha G.	Asst.Chief Technical Officer (SMS - Plant Pathology)
151.	Smt. Jissy George	Asst.Chief Technical Officer (SMS - Home Science)
152.	Dr. Sajnanath	Asst.Chief Technical Officer (SMS - Soil Science)
153.	Smt. Arathy K. Balakrishnan	Sr. Tech. Asst (Prog.Asst.) (Agril. Extn.)
154.	Sri Ansary K.M.	Technical Assistant (Computer)
155.	Smt. Bijila P.V.	Technical Assistant (Hort)
156.	Sri Dayanandan Unnithan T.	Technical Assistant (Vehicles)

**Vittal**

157.	Dr. Moosa H.	Asst. Chief Technical Officer (Field/Farm)
158.	Smt. Meenakshy Patil	Sr. Technical Officer (Library)
159.	Sri Purandhara C.	Technical Officer (Field/Farm)
160.	Sri Adolpheno Francis Mascaranchas	Sr. Technical Assistant (Ele.Engg.)
161.	Sri Sreenivasa Bhat Y.	Sr. Technical Assistant (Field/Farm)
162.	Sri Abdul Aziz	Sr. Technical Assistant (Field/Farm)
163.	Sri Ananda Gowda B.	Technical Assistant (Field/Farm)
164.	Sri Chandrasekhara Shetty V.	Technical Assistant (Vehicles)
165.	Sri Ramanna Gowda	Technical Assistant (Vehicles)
166.	Sri Tharanatha Naik K.	Sr. Technician (Vehicles)
167.	Sri Santhosh Kumar P.	Technical Assistant (Field/Farm)

**Kidu**

168.	Sri Nagesh N.	Technical Officer (Field/Farm)
169.	Sri Chandra Nairy	Technical Officer (Field/Farm)
170.	Sri Manamohan	Technical Officer (Mech. Engg.)
171.	Sri Narayana Naik	Sr. Technical Assistant (Field/Farm)
172.	Sri Gopalakrishna A.S.	Sr. Technical Assistant (Field/Farm)

**Mohitnagar**

173.	Sri Avrajoyothi Ghosh	Sr. Technical Officer (Field/Farm)
174.	Sri Jagadish Roy Burman	Technical Assistant (Field/Farm)
175.	Sri Pratap Kumar Sarkar	Technical Assistant (Field/Farm)
176.	Sri Jagadish Roy	Technical Assistant (Vehicles)

**Kahikuchi**

177.	Sri Saran Kumar Rizal	Chief Technical Officer
178.	Sri Das N.C.	Technical Officer (Field/Farm)
179.	Sri Gopinath Malekar	Technical Assistant (Vehicles)
180.	Sri Prakash Burman	Sr. Technician (Field/Farm)

Sl. No.	Name	Designation
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**RC, Minicoy**

181.	Mr. P. Ravindran	Asst. Chief Technical Officer (Field/Farm)
182.	Mr. Shareefuddeen Hassan Karangothi	Technical Assistant (Field/Farm)
183.	Mr. M.I. Arif	Technician (Field/Farm)

**Administrative****Kasaragod**

184.	Sri Sureshkumar	Chief Administrative Officer
185.	Sri Bose S.K.C.	Sr. Finance & Accounts Officer
186.	Smt. Narayani K.	Private Secretary
187.	Smt. Girija Chandran	Private Secretary
188.	Smt. Sulochana Nair	Private Secretary
189.	Sri Kunhiraman Nair K.	Private Secretary (PS to Director)
190.	Sri Janardhanan T.E.	Assistant Administrative Officer
191.	Smt. Prabhavathy K.	Assistant Administrative Officer
192.	Sri Nithianandan K.R.	Assistant Administrative Officer
193.	Sri Bhageerath K.G.	Assistant Administrative Officer
194.	Smt.Reetha M.	Assistant Administrative Officer
195.	Smt. Luizy D'Souza	Assistant
196.	Smt. Vishalakshi K.S.	Assistant
197.	Sri Thomas P.M.	Assistant
198.	Sri Ramadasan K.	Assistant
199.	Smt. Sheenakumari K.T.K.	Assistant
200.	Sri Narayana Naik P.	Assistant
201.	Sri Unni K.T.	Personal Assistant
202.	Smt. Sheeja P.P.	Junior Accounts Officer
203.	Smt. Arathi A.R.	Stenographer Gr.III
204.	Smt. Rupa Manikandan	Upper Division Clerk
205.	Smt. Preethi K.	Upper Division Clerk
206.	Sri Paulson Sam George	Upper Division Clerk
207.	Smt. Remya T.R.	Lower Division Clerk
208.	Sri Gangadharan T.K.	Lower Division Clerk
209.	Smt. Mary A.J.	Lower Division Clerk
210.	Sri Udayakumar N.	Lower Division Clerk
211.	Sri Pramodkumar P.K.	Lower Division Clerk
212.	Sri Jayarajan Valiyaveetil	Lower Division Clerk
213.	Sri Umesh Kumar	Lower Division Clerk
214.	Sri Dinesh	Lower Division Clerk
215.	Sri Ratan Singh	Lower Division Clerk

**Kayamkulam**

216.	Sri Pradeep Kumar Vasu	Assistant Administrative Officer
217.	Sri Baburaj S.B.	Asst. Finance & Accounts Officer

Sl. No.	Name	Designation
218.	Sri Haridas K.	Assistant
219.	Sri Venugopal K.	Assistant
220.	Smt. Sreelatha K.	Assistant
221.	Sri Ramesh Babu C.	Personal Assistant
222.	Sri Prasanna Sarngan	Personal Assistant
223.	Smt. Madhavikutty V.	Upper Division Clerk
224.	Smt. Annamma N. Topino	Upper Division Clerk
225.	Smt. Rejitha K.R.	Stenographer Gr.III

**Vittal**

226.	Sri Krishna Naik P.	Asst. Admn. Officer
227.	Sri Sasi K.K.	Asst. Finance & Accounts Officer
228.	Sri Mohammed Haneefa P.K.	LDC
229.	Smt. Jayashree K.	UDC
230.	Sri Aswin Reghunath	UDC

**Kidu**

231.	Sri Ravindran M.	Assistant Administrative Officer
232.	Smt. Lakshmi Narayana	Lower Division Clerk
233.	Sri Arun N.K. Raj	Lower Division Clerk

**Mohitnagar**

234.	Sri Sushanta Roy	Assistant
235.	Sri Sathyabratha Moharana	Lower Division Clerk

**Kahikuchi**

236.	Sri Subash Paul	Assistant
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237.	Sri Saji T.J.	Upper Division Clerk
238.	Sri Deepak Meena	Lower Division Clerk
239.	Mr. T.N. Vidhyadharan	Assistant

**RC, Minicoy**

240.	Mr. T.N. Vidhyadharan	Assistant
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**Skilled Support Staff****Kasaragod**

Sl. No.	Name
241.	Sri M.Shankara
242.	Sri Bhaskara Velichapad
243.	Sri Srihari Ballaya
244.	Sri Haridas Poojary
245.	Sri Madhavan Nair P.
246.	Sri Narayanan Nair K.
247.	Sri Narayanan Nair P.

Sl. No.	Name
248.	Smt. Baby K.
249.	Sri Kunhikannan K.
250.	Sri Mohana A.
251.	Sri Keshava K.
252.	Smt. Banu K.
253.	Sri Sukumaran K.
254.	Sri Krishnan K.V.

Sl. No.	Name
255.	Sri Chaniya Naik P.A.
256.	Sri Kumaran P.
257.	Sri Pakeeran V.S.
258.	Smt. Thambai V.
259.	Smt. Kamala
260.	Sri Murugan M.
261.	Sri Sureshbabu K.G.
262.	Sri Ninan T.J.
263.	Sri Krishnankutty K.
264.	Smt. Chithralekha Kodoth
265.	Sri Chandrasahsa B.
266.	Sri Rameshan V.T.
267.	Sri Krishnankunhi K.
268.	Smt.Shobhana K.
269.	Sri Krishnan M.
270.	Smt. Leela V.A.
271.	Smt. Sarojini U.
272.	Sri Krishnankutty V.
273.	Sri Prabhakaran P.P.
274.	Sri Ramachandran B.
275.	Sri Sanjeeva Patali B.
276.	Smt. Sasikala N.V.
277.	Sri Lakshmana Naik
278.	Smt. Lalitha Bai
279.	Sri Velayudhan M.
280.	Smt. Mohini S.
281.	Sri Bhaskaran N.
282.	Sri Sundara B.
283.	Sri Suresan K.
284.	Sri Madhu A.
285.	Sri Madhavan K.A.
286.	Sri Babu K.
287.	Sri Aneesh E.M.
288.	Smt. Vanamalini K.

**Canteen Staff**

289.	Sri Jayaprakash K.
290.	Sri Balakrishnan B.
291.	Sri Vijayan K.

**Kayamkulam**

292.	Sri Sivan M.E.
293.	Sri Thankachan K.B.
294.	Sri Ravindran R.
295.	Sri Soman K.

Sl. No.	Name
296.	Sri Omanakuttan K.
297.	Sri Damodaran K.C.
298.	Sri Unnikrishnan V.T.
299.	Sri Mani T.K.
300.	Sri Ravi K.
301.	Sri Vijayan K.V.
302.	Sri Sreedharan K.K.
303.	Sri Sukumaran C.
304.	Smt. Valsala K.
305.	Sri Sundaran C.
306.	Sri Sajeew K.N.
307.	Sri Ibrahim K.P.
308.	Smt. Suma N.
309.	Sri Harikuttan A.T.
310.	Sri.Saseendra K.
311.	Sri Babu C.R.
312.	Sri Ajith Mattappadan
313.	Sri Rajesh R.
314.	Smt. Leena L.
315.	Sri Ancil Pereira
316.	Sri Rajesh S.
317.	Sri Reghu N.

**Canteen Staff**

318.	Sri Justin Jayaraj Das
319.	Sri Parameshwaran S.

**Vittal**

320.	Sri Narayana Paleri
321.	Sri Harischandra
322.	Sri Chandu Naik
323.	Sri Sudhakara
324.	Sri Gopala A.
325.	Sri Isubu D.
326.	Sri Dharmapala B.
327.	Sri Vinod K.
328.	Sri Ibrahim
329.	Sri Chinnappa K.C.
330.	Sri Choma B.
331.	Sri Mohana
332.	Sri Somappa K.
333.	Sri Ananda M.
334.	Sri Mahesan N.B.
335.	Sri Monappa Gowda K.

**Canteen Staff**

Sl. No.	Name
336.	Sri Shivarama Poojary A.

**RC, Minicoy**

337.	Mr. M.I. Abdulla
338.	Mr. Ibrahim D. Bidderge
339.	Mr. Valuge Ibrahim
340.	Mr. N. Reghu

**Kidu**

341.	Sri Baliappa Gowda
342.	Sri Medappa Gowda
343.	Sri Balappa Gowda
344.	Sri Venkataramana S.
345.	Sri Chennappa S.
346.	Smt. Bhavani N.
347.	Smt. Susheela S.
348.	Smt. Lolakshi
349.	Sri Janardhana S.
350.	Sri Dasappa Gowda
351.	Smt. Susheela T.
352.	Sri Padmayya Gowda
353.	Smt. Bhavani B.
354.	Sri Rukmini S.
355.	Sri Bhojappa S.

Sl. No.	Name
356.	Sri Narayana S.
357.	Smt. Komalangi
358.	Sri Chennappa V.
359.	Sri Jathappa Gowda V.
360.	Sri Sheenappa Gowda S.
361.	Sri Neelappa S.
362.	Sri Regappa S.
363.	Smt. Chandravathi S.
364.	Sri Durgesha M.

**Mohitnagar**

365.	Smt. Janaki Devi
366.	Sri Sailen Seal
367.	Sri Krishna Kr. Mandal
368.	Sri Nripendra Chandra Roy
369.	Sri Kartick Chandra Biswas
370.	Sri Sushanta Burman
371.	Sri Mahadev Misra

**Kahikuchi**

372.	Sri Gopal Thapa
373.	Sri Sathish Baishya
374.	Sri Pankaj Das

**As on 31-03-2017; Not a gradation list**

# DISTINGUISHED VISITORS

XX.

Name and designation	Date	Place visited
Shri Shakil P. Ahmed, IAS, Joint Secretary, Dept. of Agriculture & Cooperation	18 <sup>th</sup> April 2016	ICAR-CPCRI, Kasaragod
Dr. R. K. Mathur, Director, ICAR-IIOPR, Pedavegi, A.P.	6 <sup>th</sup> May 2016	ICAR-CPCRI, RC, Mohitnagar
Dr. A.K. Singh, Chairman, Coconut Development Board, Kochi	13 <sup>th</sup> May 2016	ICAR-CPCRI, RS, Kayamkulam
Dr. Trilochan Mohapatra, Secretary, DARE and Director General, ICAR	14 <sup>th</sup> May 2016	ICAR-CPCRI, RC, Kahikuchi
Shri P. Karunakaran, Member of Parliament, Kasaragod	28 <sup>th</sup> May 2016	ICAR-CPCRI, Kasaragod
Shri N.A. Nellikkunnu, MLA, Kasaragod	28 <sup>th</sup> May 2016	ICAR-CPCRI, Kasaragod
Dr. K.L. Chaddha, National Professor, ICAR	18 <sup>th</sup> June 2016	ICAR-CPCRI, Kasaragod
Dr. K. Ramasamy, Vice Chancellor, TNAU, Tamil Nadu	20 <sup>th</sup> June 2016	ICAR-CPCRI, Kasaragod
Dr. R.K. Mathur, Director, IOPR, Pedavegi	20 <sup>th</sup> June 2016	ICAR-CPCRI, Kasaragod
Dr. P.L. Saroj, Director, ICAR-DCR, Puttur	20 <sup>th</sup> June 2016	ICAR-CPCRI, Kasaragod
Dr. N.K. Krishna Kumar, DDG (Horticultural Science), ICAR, New Delhi	21 <sup>st</sup> June 2016	ICAR-CPCRI, Kasaragod
Padma Shri Dr. K.L. Chaddha, Former Deputy Director General (Hort.) and Dr. P. Rethinam, Former Executive Director, APCC, Indonesia	22 <sup>th</sup> - 23 <sup>rd</sup> July 2016	ICAR-CPCRI, Kasaragod
Dr. T.N. Prakash Kammardi, Chairman, Karnataka Agricultural Prices Commission, Bengaluru	19 <sup>th</sup> August 2016	ICAR-CPCRI, Kasaragod
Dr. H.P. Singh, Former Deputy Director General (Horticultural Science)	9 <sup>th</sup> September 2016	ICAR-CPCRI, Kasaragod
Shri Radha Mohan Singh, Hon'ble Union Minister of Agriculture and Farmers Welfare, Govt. of India, Shri V.S. Sunilkumar, Hon'ble Minister of Agriculture Development and Farmers Welfare, Govt. of Kerala, Shri Raju Narayana Swamy, IAS, Agricultural Production Commissioner & Principal Secretary (Agriculture), Shri Biju Prabhakar, IAS, Director, Agriculture Development and Farmers Welfare, Govt. of Kerala and Shri P.R. Murali, Member, Farmer's representative, Coconut Development Board, Kochi	29 <sup>th</sup> September, 2016	ICAR-CPCRI, Regional Station, Kayamkulam
Shri Khageswar Roy, Hon'ble Member of Legislative Assembly (Rajganj), Govt. of West Bengal; Dr. Chirantan Chattopadhyay, Hon'ble Vice Chancellor, Uttar Banga Krishi Viswavidyalaya; Dr. D. R. Singh, Director, ICAR-NRC (Orchid)	20 <sup>th</sup> October 2016	ICAR-CPCRI, Research Centre, Mohitnagar

Name and designation	Date	Place visited
Dr. K. Nirmal Babu, Director, ICAR-IISR, Kozhikode, Kerala	2 <sup>nd</sup> November 2016	ICAR-CPCRI, Kasaragod
Dr. W.S. Dhillon, ADG, Horticultural Science, ICAR, New Delhi and Dr. D.B. Singh, Director, ICAR-CITH, Srinagar, Jammu & Kashmir	3 <sup>rd</sup> November 2016	ICAR-CPCRI, RC, Kahikuchi
Shri Radha Mohan Singh, Hon'ble Union Minister of Agriculture and Farmer's Welfare, Govt. of India; Shri P. Karunakaran Hon'ble Member of Parliament, Kasaragod; Dr. Trilochan Mohapatra, Secretary DARE & Director General, ICAR, New Delhi; Shri E. Chandrashekharan, Hon'ble Minister of Revenue & Housing, Govt. of Kerala; Shri N.A. Nellikunnu, Hon'ble MLA, Kasaragod; Shri Anant Kumar Hegde, Hon'ble Member of Parliament, Uttara Kannada	10 <sup>th</sup> December 2016	ICAR-CPCRI, Kasaragod
Shri P. V. Velayudan, Director, MSME-DI, Thrissur	31 <sup>st</sup> January 2017	ICAR-CPCRI, Kasaragod
Dr. H.P. Singh, Former DDG (Horticultural Science), ICAR, New Delhi.	18 <sup>th</sup> February 2017	ICAR-CPCRI, Kasaragod

# MERA GAON MERA GAURAV

XXI.

The innovative initiative 'Mera Gaon Mera Gaurav' by Ministry of Agriculture and Farmers' Welfare, Govt. of India, has been planned to promote the direct interface of agricultural scientists with the farmers to hasten the lab to land process. The objective of this scheme is to provide farmers with required information, knowledge and advisories on regular basis by adopting villages. With this background, ICAR-CPCRI, Kasaragod and its regional stations and research centres have implemented the initiative as per the guidelines.

ICAR- CPCRI, Kasaragod and its regional stations and research centres have implemented the 'Mera Gaon Mera Gaurav' initiative in collaboration with other stakeholders viz., Department of Agriculture, Krishi Vigyan Kendra, grama panchayat, input dealers, progressive farmers, SHGs etc. During 2016-17, training programmes, demonstrations on improved practices, farm advisory visits, mobile advisory services etc., were organized in the selected villages for the benefit of farming community. A total of 64 scientists adopted 71 villages for the overall development of the villages as given below:

Venue	No. of scientists	No. of teams	No. of villages	Nodal Officer/Coordinators
Kasaragod	36	8	38	C. Thamban/ D. Jaganathan
Kayamkulam	13	3	16	C. T. Jose
Vittal	10	3	10	A. Joseph Rajkumar
Kahikuchi	2	1	3	Alpana Das
Mohitnagar	2	1	3	A. K. Sit
Kidu	1	1	1	Y. Diwakar
<b>Total</b>	<b>64</b>	<b>17</b>	<b>71</b>	

## MGMG – Summary of activities

Venue	Visit to village		Interface meetings		Demonstrations conducted		Trainings conducted		Mobile advisory services		Literature support provided	
	Nos.	No. of farmers	Nos.	No. of farmers	Nos.	No. of farmers	Nos.	No. of farmers	Nos.	No. of farmers	Nos.	No. of farmers
Kasaragod	43	1323	13	901	14	543	6	405	34	914	31	4632
Kayamkulam	209	3405	178	7120	73	1637	16	1745	93	2237	23	3326
Vittal	61	593	10	822	12	432	9	665	28	939	20	1508
Kahikuchi	14	109	8	95	6	113	3	55	8	113	8	93
Mohitnagar	14	332	6	196	—	—	5	140	13	148	9	165
Kidu	7	110	3	175	4	271	4	348	12	114	4	85
<b>Total</b>	<b>348</b>	<b>5872</b>	<b>218</b>	<b>9309</b>	<b>109</b>	<b>2996</b>	<b>43</b>	<b>3358</b>	<b>188</b>	<b>4465</b>	<b>95</b>	<b>9809</b>



**Training on arecanut based cropping system at Nirchal**



**Training on pest and disease management at Badiadka**



**Demonstration on pruning in cocoa at Kilingar**



**Farm advisory visit at Bela, Badiadka**



**Demonstration on soil and water conservation at Periya**



**Interface programme on soil health management**



**Farm advisory visit to Periya**



**Demonstration on management of basal stem rot at Velutholi**



**Interface programme at Kootakkani**



**Method demonstration on cocoa pruning at Berike**



**Farm advisory visit to Miyapadavu**



**Interface programme at Kayamkulam**



**Farm advisory visit at Velanchira**



**Interface programme at Cherthala South**



**Interface programme at Koppareth**



**Farmers meeting at Vettikode**



Farmers meeting at Kayamkulam



Farm advisory visit to Manchi



Demonstration on bordeaux mixture preparation



Field day at Palthady



Quiz competition at Palthady



Demonstration on cocoa pruning



Farm advisory visit to Bongora



Demonstration on palm climbing at Kahikuchi



**Field visit at South Matali, Jalpaiguri, West Bengal**



**Farm advisory visit at Pradhanpara, Jalpaiguri, West Bengal**



**Planting material production interface programme at Kidu**



**Farmers training at Kidu**

# SWACHH BHARAT ABHIYAN

**C**leaning drive was taken up at Headquarters, Regional Stations & Research Centres on every Fridays with the participation of all the staff. Public places adjoining ICAR-CPCRI campuses were kept clean by these activities. Continuation of the group activities of farm waste management through vegetable cultivation was done at Regional Station, Kayamkulam.

## Swachhta Pakhwada

Swachh Bharat Fortnight was observed in the Institute including headquarters, two Regional Stations as well as four Research Centres during 16<sup>th</sup>-31<sup>st</sup> May, 2016. Special cleaning drive along with oath taking by the staff was organized on 19<sup>th</sup> May, 2016. The Swachhta Pakhwada

activities (16<sup>th</sup>-31<sup>st</sup> October, 2016) were launched at ICAR-CPCRI, Kasaragod, its Regional Stations at Kayamkulam, Kerala and Vittal, Karnataka as well as Research Centres at Kahikuchi (Assam), Kidu (Karnataka), Minicoy (U.T. of Lakshadweep) and Mohitnagar (West Bengal) on 17<sup>th</sup> October, 2016. Launching was with Swachhta Shapath pledge, Dr. P. Chowdappa, administered the pledge at Kasaragod, Dr. V. Krishnakumar at Kayamkulam, Dr. K.S. Ananda at Vittal and respective Scientists In-Charge and Officer In-Charge have administered Swachhta Pledge in their respective stations.

Cleaning activities, carried out as per the ICAR prescribed parameters for a clean and green environment and eco-friendly and sustainable farming, are given below:



**ICAR-CPCRI staff taking Swachh Bharat pledge and taking part in cleaning activities at Kasaragod**



**Staff carrying out cleanliness activity around technology building at Kasaragod**



**Staff carrying out cleanliness activity around coconut seed storage building at Kasaragod**



**Cleaning operations in progress at Regional Station, Kayamkulam**



**Staff carrying out cleanliness activity in farm at Kasaragod**

### **Treatment of Bio-Degradable/ Non Bio-Degradable Wastes**

An awareness programme and a Staff Meeting was conducted at ICAR-CPCRI, Kasaragod on 31<sup>st</sup> October, 2016 under the chairmanship of Dr. P. Chowdappa, Director. Shri Kabeer B. Haroon, Managing Director, Clean Kerala Company was the chief guest. The Clean Kerala Company have joined hands with ICAR-CPCRI for solid waste management, especially for conversion of non-biodegradable wastes such as plastics.

Vermicomposting is being promoted at Regional Station, Kayamkulam for effective recycling of biomass from coconut palms and other waste

materials into good quality organic manure for application in the field. Biogas plant has been installed in the Dairy Unit for treatment of waste for production of biogas and slurry from the bio gas plant is used for fodder grass cultivation. Bio-degradable wastes were used for composting in pits and non bio-degradable wastes collected at Research Centre, Kidu which were sorted, burnt and buried depending upon the nature of the wastes. The bio degradable waste material collected at Research Centre, Mohitnagar were used for mulching the plants and also deposited in the compost pit. Non-biodegradable waste like plastic, bottle, glass handed over to the District Administration, Jalpaiguri for recycling.



**Vermicomposting from coconut fronds at Kayamkulam**

# WOMEN'S CELL ACTIVITIES

XXIII.

## International Women's Day

The International Women's Day was celebrated at the Institute on the 8<sup>th</sup> March 2017 with the active participation of all staff members. Dr. P. Chowdappa, Director, ICAR-CPCRI, presided over the function. Dr. V. Selvamani, member, Women's Cell, welcomed the gathering. Mrs. P.P. Maniamma, an advocate from Kasaragod, was the chief guest and delivered a talk on the general issues faced by working women in the society. Mrs. Sulochana Nair, Convener, Women's Cell, proposed the vote of thanks.

A demonstration class was also conducted on 'Empowerment through self-defense for women and girls' by Mr. Lakshmikant K., Indian Academy of Martial Arts, Mangalore. A food exhibition was also arranged concurrently by the members of the Women's Cell, including KVK beneficiaries.

The International Womens' Day was observed for creation of awareness and empowerment of women cell/ ladies club members of ICAR-CPCRI, RS, Vittal. A team of 25 members visited Central Coffee Research Institute (CCRI), Balehonnur on 08<sup>th</sup> March, 2017.



**Visit of the Women Cell members of ICAR-CPCRI, RS, Vittal to CCRI, Balehonnur**

## EVENTS OF NATIONAL AND INTERNATIONAL IMPORTANCE

### World Environment Day 2016

World Environment Day was organized at ICAR-CPCRI, Regional Station, Kayamkulam with a host of programmes aimed at creating awareness among the student fraternity. Nearly 50 students from RVLP School, Mukkada and Govt. U P School, Krishnapuram participated in this programme. Shri K.V. Dayal, a noted environmentalist from Muhamma, Alappuzha, was the Chief Guest. In his inspiring inaugural address, he called upon the students to engage in 'out of box' thinking and bring forth novel ideas for harnessing the science of the highest order to save the environment. He echoed the opinion that 'ecology is more important than economics' and urged the students to appreciate basics in sustainable and organic farming to advance it to an evergreen revolution. Dr. V. Krishnakumar, ICAR-CPCRI, Kayamkulam, in his presidential address, emphasized the role of students in biodiversity conservation and nurturing of trees to encounter and mitigate the effects of climate change. Shri Anilkumar, Member, Kayamkulam Municipality and Shri Viji, Member, Krishnapuram Grama Panchayat, offered felicitations and participated in the programme.

Shri K. Narendran, from Nambaruvikala, Karunagapally, Kollam, who is the recipient of



**Dr. V. Krishnakumar planting a sapling at Kalavoor School, Alappuzha, Kerala**

prestigious National Plant Genome Saviour Farmer Recognition-2013 award from PPV&FR, New Delhi, was also honoured during the occasion. The message of 'eco-restoration through mass tree-planting campaign' was provided a great impetus with these celebrations.

A quiz competition on 'Agriculture and Environment', followed by awareness talk on 'Environmental conservation through eco-friendly agricultural practices', were conducted by KVK, Alappuzha as a part of the World Environment Day celebrations at Govt. Higher Secondary School, Kalavoor on 6<sup>th</sup> June, 2016. The programmes witnessed the active participation of more than 50 students.

### International Yoga Day

International Day of Yoga was convened under the Chairmanship of Dr. P. Chowdappa, Director, ICAR-CPCRI on 21<sup>st</sup> June, 2016 at Kasaragod. Dr. K. Muralidharan, Nodal Officer, welcomed the gathering. Dr. A.B. Sapna, MBBS, DVD, MD, Dermatology Consultant, District Hospital, Kanhangad, and Spine Care Teacher, Art of Living Foundation, Bengaluru, delivered a talk on yoga followed by a practical session for the benefit of all staff members. Dr. Sapna urged the audience to practice yoga and make it a habit to get rid of modern day health issues that mostly arise due to fast paced life and other occupational hazards. An impressive display of yogasanas by students of Chaitanya,



**A view of the yoga performance as a part of International Yoga Day at Kasaragod**

Kasaragod was held at the end of the programme to create awareness and importance of yoga.

International Yoga Day 2016 was observed at ICAR-CPCRI, RS, Kayamkulam on 21<sup>st</sup> June, 2016 with a thought provoking lecture on the basics of yoga science followed by practical demonstration of yogasanas. In his presidential address, Dr. V. Krishnakumar, ICAR-CPCRI, RS, Kayamkulam called upon the staff members to make yoga an integral part of life to tide over all lifestyle diseases. He urged to embrace yoga for leading a hale and healthy life and ushering universal peace. He emphasized yoga as the gift to the world by India, symbolizing the union of body and consciousness. Dr. E.M.G. Nair, Founder and Chief Acharya, Pathanjali Pranayoga Vidyapeedom, Kottayam, inaugurated the session. In his inaugural address, he pointed out the importance of yoga for basic well-being of mankind. He expressed his views regarding the science of coordinated hormonal regulation in humans that was achieved through routine practice of yoga. This was followed by demonstration of yogasanas.



**International Yoga Day celebration at Vittal**

International Yoga Day also celebrated at ICAR-CPCRI, RS, Vittal. All the staff members attended the yoga session conducted by Dr. S. Elain Apshara, ICAR-CPCRI and Shri P. Ashok and Shri Venkappa Gowda, Ex Servicemen. International Yoga Day was also celebrated at ICAR-CPCRI, RC, Kahikuchi on 21<sup>st</sup> June, 2016.

### Independence Day

The 70<sup>th</sup> Independence Day of India was celebrated on 15<sup>th</sup> August, 2016 with a fervent feeling of patriotism and respect. Dr. P. Chowdappa, Director, ICAR-CPCRI, hoisted the National Flag and delivered the Independence Day address at Kasaragod. In his address, Dr. Chowdappa emphasized the importance of independence and its impact on the scientific progress of the country. Independence Day was also

celebrated in the Regional Stations at Kayamkulam and Vittal and Research Centre's at Kahikuchi, Kidu, Minicoy and Mohitnagar.

### World Coconut Day

World Coconut Day celebrations was organized in Pollachi, Tamil Nadu on 2<sup>nd</sup> September, 2016. Hon'ble Member of Parliament, Shri Mahendran inaugurated the programme and assured the coconut farmers that their problems will be addressed at the national level. The meeting was organized by Coimbatore Coconut Producers Company and Vinayaka Coconut Producers Company, Pollachi in collaboration with ICAR-CPCRI, Kasaragod. Dr. C. Thamban and Dr. Vinayaka Hegde, ICAR-CPCRI, in their addresses, highlighted the need for upliftment of coconut sector through price stability, organic recycling of residues, cropping system approach and value addition techniques. Though production has attained a plateau in the region, product diversification is still in infancy. Dr. A. Joseph Rajkumar, ICAR-CPCRI, highlighted the strategies for root (wilt) disease management through cultivation of tolerant varieties and nutritional management. Dr. Ramasamy, Vice-Chancellor, TNAU, offered his views on traditional approaches in coconut farming and water conservation strategies. Several dignitaries emphasized on the potential of coconut for livelihood sustainability. The meeting culminated with a debate on usefulness of coconut for the survival of mankind. An exhibition showcasing key ICAR-CPCRI technologies on value addition was organized concurrently for the benefit of participating farmers. The meeting was attended by over 1200 farmers.



**Dr. C. Thamban addressing the World Coconut Day gathering at Pollachi, Tamil Nadu**

### Technology Week celebration

Technology Week was celebrated in collaboration with ATMA from 18<sup>th</sup> to 24<sup>th</sup> November 2016 at

Nileshwar, Kasaragod, Kerala. Seminars, interface programmes and exhibitions with 25 stalls, showcasing technologies by ICAR-CPCRI and KVK, were organized. The celebration involved participation of various developmental departments and private firms participated, in addition to over 4000 farmers.

### **Republic Day**

Republic Day was observed in the headquarters, Regional Stations and Research Centres on 26<sup>th</sup> January 2017. Dr. P. Chowdappa, Director, delivered the Republic Day address at Kasaragod.



**Republic Day address by Dr. P. Chowdappa at Kasaragod**

# राजभाषा कार्यान्वयन रिपोर्ट

XXV.

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 दिशानिर्देशों के अनुसार राजभाषा कार्यान्वयन के सभी पहलुओं पर भरपूर प्रयास किया जाता है।

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 बैठकें तिमाही की अवधि पर आयोजित की जाती है। इस समिति में राजभाषा विभाग के वार्षिक कार्यक्रम के अनुसार राजभाषा कार्यान्वयन प्रगति तथा भारतीय कृषि अनुसंधान परिषद के राजभाषा कार्यान्वयन से संबंधित सभी आदेशों के अनुपालन पर चर्चा एवं समीक्षा की जाती है। प्रत्येक बैठक के कार्यवृत्त की समीक्षा निदेशक (राजभाषा) भारतीय कृषि अनुसंधान परिषद की ओर से की जाती है और समीक्षा रिपोर्ट के अनुसार अगली बैठक में चर्चा कर निदेशक महोदय की अनुमति से पुष्टि की जाती है।

अधीनस्थ प्रादेशिक केंद्रों / अनुसंधान केंद्रों को समय-समय पर राजभाषा कार्यान्वयन समिति की बैठकों के आयोजन एवं राजभाषा कार्यान्वयन कार्य की ओर दिशा निर्देश दिया जाता है। और अधीनस्थ केंद्रों से प्राप्त राजभाषा कार्यान्वयन की प्रगति रिपोर्ट और बैठकों के कार्यवृत्तों की समीक्षा की जाती है। तदनुसार आवश्यक मार्ग निर्देश दिया जाता है।

राजभाषा अधिनियम 1963 धारा 3(3) का अनुपालन सुनिश्चित करने हेतु मुख्यालय के विभिन्न अनुभागों द्वारा जारी किए जा रहे संविदा एवं निविदा प्रपत्रों, नोट एवं परिपत्रों को द्विभाषीकरण कर मार्गदर्शन दिया जाता है। प्रतिवेदनों का सारांश हिंदी में भी तैयार कर अधिनियम का अनुपालन शत प्रतिशत किया जाता है। तथा अधीनस्थ स्टेशनों/केंद्रों को इसपर मार्गदर्शन एवं सहायता दिया जाता है।

संस्थान की ओर से शताब्दी समारोह के सिलसिले में आयोजित बैठकों के बैनर, प्रदर्शनी बोर्ड एवं संगोष्ठी का निमंत्रण पत्र द्विभाषा

में प्रदर्शित कर राजभाषा नियम 1976 नियम 11 का अनुपालन शत प्रतिशत किया गया। उपर्युक्त अवधिपर प्रादेशिक केंद्रों / अनुसंधान केंद्रों में आयोजित किसान मेला और अन्य समारोह / बैठकों में भी बैनर/बोर्ड सभी द्विभाषा में प्रदर्शित किया गया।

राजभाषा नियम 1976 नियम 5 का अनुपालन सुनिश्चित करने हेतु हिंदी पत्रों की आवृत्ति प्रत्येक रजिस्टर में की जाती है और जावक रजिस्टर में हिंदी पत्रों के सामने लाल रंगीन कलम से एच चिह्न लगाकर हिंदी में भेजे जाने वाले पत्रों की आंकड़े के लिए बनाया गया जॉच बिंदु का अनुपालन किया जाता है। अधीनस्थ केंद्रों में भी इसका अनुपालन सुनिश्चित किया जाता है।

हिंदी में मूल पत्राचार बढ़ाने के लिए विभिन्न अनुभागों द्वारा जारी नेमी पत्रों को हिंदी में तैयार कर दिया जाता है और पत्राचार प्रतिशत बढ़ाया जाता है।

राजभाषा के प्रति जागरूकता पैदा कराने हेतु इस संस्थान में और अधीनस्थ प्रादेशिक केंद्रों और अनुसंधान केंद्रों में 14 सितंबर से हिंदी दिवस/पखवाड़ा समारोह विभिन्न प्रतियोगिताओं के साथ आयोजित की गई। उपर्युक्त अवधि में मुख्यालय में विभिन्न प्रतियोगिताओं जैसे हिंदी टंकण, फाइलों पर टिप्पणी एवं अनुवाद प्रतियोगिता, स्मरण प्रतियोगिता, चित्र देखों और लिखों प्रतियोगिताएँ आयोजित कर हिंदी समारोह सफलतापूर्वक मनायी गई। कुशल सहायक कर्मचारियों के लिए प्रत्येक रूप से प्रतियोगिताएँ आयोजित की गई। समापन समारोह के दिन डॉ. प्रवीण राजाराम बनसोडे, प्रबंधक (राजभाषा), कोर्पोरेशन बैंक, मंगलूर के मार्गदर्शन में यूनिकोड के प्रयोग पर हिंदी कार्यशाला भी आयोजित की गई और कार्यशाला के अंतिम सत्र में डॉ. पी. चौड़प्पा, निदेशक ने हिंदी समारोह की अवधि पर आयोजित विभिन्न प्रतियोगिताओं के विजेताओं का पुरस्कार वितरण किया। सरकारी काम काज में हिंदी का अधिकाधिक प्रयोग किए गए 10 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 है। समय-समय

पर यूनिकोड की सक्रियता सुनिश्चित की जाती है। यूनिकोड का उपयोग बढ़ाने हेतु प्रशिक्षण कक्षाएँ आयोजित की जाती हैं।

### वेबसाइट का प्रदर्शन

संस्थान वेबसाइट का मुख्य पृष्ठ के अतिरिक्त विभिन्न अनुभागों से संबंधित विवरण भी द्विभाषा में प्रदर्शित किया गया है।

### प्रशिक्षण कार्यक्रम

#### प्रबोध, प्रवीण एवं प्राज्ञ प्रशिक्षण

केंद्रीय हिंदी प्रशिक्षण संस्थान, राजभाषा विभाग, नई दिल्ली पत्राचार पाठ्यक्रम द्वारा प्रायोजित प्रबोध, प्रवीण, प्राज्ञ प्रशिक्षण में इस संस्थान से हिंदी का कार्यसाधक ज्ञान न रखनेवाले दो अधिकारियों को प्रबोध प्रशिक्षण के लिए नामित किया गया है।

#### हिंदी टंकण प्रशिक्षण

अवर श्रेणी लिपिकों के लिए अनिवार्य सेवाकालीन हिंदी टंकण प्रशिक्षण कार्यक्रम में मुख्यालय से नामित 7 लिपिकों में दो उत्तीर्ण हुए और अनुत्तीर्ण लिपिकों को पुनः परीक्षा में नामित किया गया। 3 लिपिकों ने पुनः परीक्षा में उत्तीर्ण हुए।

### हिंदी कार्यशाला

हिन्दी में आलेखन और टिप्पण पर दिनांक 23-08-2016 को नगर राजभाषा कार्यान्वयन समिति, कासरगोड़ के साथ संयुक्त हिंदी कार्यशाला आयोजित की गई। दिनांक 25-10-2016 को कंप्यूटर में हिंदी के प्रयोग पर तकनीकी हिंदी कार्यशाला आयोजित की गई।

### विशेष कार्य

सहायक निदेशक (कार्यान्वयन) क्षेत्रीय कार्यान्वयन कार्यालय, कोची के अनुरोध के अनुसार दिनांक 29-11-2016 को भारत संचार निगम, कण्णूर और कर्मचारी भविष्य निधि संगठन कण्णूर को राजभाषा पुरस्कारों के वितरण के लिए राजभाषा कार्यान्वयन रिपोर्टों का भौतिक निरीक्षण इस संस्थान के वरिष्ठ तकनीकी अधिकारी (राजभाषा) द्वारा किया गया।

दिनांक 28-09-2016 को कायम्कुलम केंद्र में किसान मेला एवं राष्ट्रीय संगोष्ठी के सुअसर पर विमोचित सभी प्रकाशनों और नारियल उपोत्पाद जैसे कल्प क्रन्च का विवरण हिंदी में तैयार किया और लालाताड़ घुन के बृहतक्षेत्र प्रबंधन में सामुदायिक भागीदारी नारियल किसानों के लिए सचित्र पुस्तिका का विमोचन माननीय कृषि एवं किसान कल्याण मंत्री श्री राधा मोहन जी द्वारा

किया गया। किसान मेला के उद्घाटन समारोह में उद्घोषणा हिंदी में की।

### भागीदारी

राजभाषा विभाग की ओर से दिनांक 23-09-2016 को बेंगलूर में आयोजित एकदिवसीय तकनीकी संगोष्ठी में इस संस्थान के वरिष्ठ तकनीकी अधिकारी (राजभाषा) ने भाग लिया।

### नगर राजभाषा कार्यान्वयन समिति, कासरगोड़

कासरगोड़ नगर में स्थित केंद्रीय सरकार के कार्यालय, उपक्रम, बैंक सहित 36 सदस्य कार्यालय सम्मिलित नगर राजभाषा कार्यान्वयन समिति, कासरगोड़ की तीसरी अर्धवार्षिक बैठक दिनांक 26-08-2016 को इस संस्थान के निदेशक महोदय की अध्यक्षता में और उप निदेशक (कार्यान्वयन) राजभाषा विभाग, कोची की उपस्थिति में आयोजित की गई। बैठक में राजभाषा कार्यान्वयन से संबंधित अर्धवार्षिक प्रगति रिपोर्ट की समीक्षा की जाती है और बैठक के चर्चा के अनुसार अनुवर्ती कार्रवाई की जाती है।



नगर राजभाषा कार्यान्वयन समिति, कासरगोड़ की तीसरी अर्धवार्षिक बैठक

### संयुक्त हिंदी समारोह

नगर राजभाषा कार्यान्वयन समिति के सदस्यों के लिए संयुक्त हिंदी समारोह आयोजित किया गया। समारोह के भाग के रूप में उच्च स्तरीय स्कूल के छात्रों के लिए नराकास के तत्वावधान में नेहरू युवा केंद्र, कासरगोड़ की ओर से निबंध लेखन, देशभक्ति गीत और आशुभाषण प्रतियोगिताएं आयोजित की गईं। कासरगोड़ के जिलाधीश के कर कमलों द्वारा पुरस्कार वितरण किया गया। नराकास के सदस्य कार्यालयों के लिए केंद्रीय विद्यालय नं 1 सी पी सी आर आई की ओर से एकल गीता प्रतियोगिता आयोजित की गई। और समापन समारोह में विजेताओं का पुरस्कार वितरण डॉ

पी चौड़प्पा, निदेशक, केंरोफअसं एवं अध्यक्ष नराकास, कासरगोड द्वारा किया गया।

### संस्थान के निम्नलिखित प्रतिवेदनों का सारांश हिंदी में प्रकाशित किया गया

1. केंद्रीय रोपण फसल अनुसंधान संस्थान, वार्षिक रिपोर्ट सारांश (वर्ष 2015-2016)
2. अखिल भारतीय समन्वित ताड़ अनुसंधान परियोजना वार्षिक रिपोर्ट (सारांश एवं प्रस्तावना) (वर्ष 2015-2016) हिंदी में प्रकाशन किया गया

### हिंदी प्रकाशन

1. नारियल कृषकों के लिए सचित्र पुस्तिका-लाल ताड़ घुन के बृहत क्षेत्र प्रबंधन में सामुदायिक भागीदारी (के. श्रीलता, अल्का गुप्ता)

### मुद्रणाधीन (फोल्डर)/तकनीकी बुलेटिन

1. नारियल अवशिष्ट पर खाद्य मशरूम कृषिफोल्डर (अल्का गुप्ता, के. श्रीलता)
2. नारियल पत्ता वर्मीकंपोस्ट उत्पादन का तरीका एवं प्रौद्योगिकियाँ फोल्डर (मुरली गोपाल, अल्का गुप्ता, के. श्रीलता)
3. यूरिया मुक्त कायर गूथा कंपोस्ट बनाने की प्रौद्योगिकी फोल्डर (मुरली गोपाल, अल्का गुप्ता, के. श्रीलता)
4. कें रो फ अ सं - देश की सेवा का शताब्दी वर्ष
5. नारियल खेती - तकनीकी बुलेटिन

मुख्यालय के और अधीनस्थ प्रादेशिक केंद्रों तथा अनुसंधान केंद्रों के सभी वैज्ञानिक, अधिकारी एवं कर्मचारी अपने सरकारी कामकाज में राजभाषा हिंदी के प्रयोग के लिए अपनी प्रतिबद्धता दोहराने का भरपूर प्रयास किया जाता है।

The Budget and Expenditure under Non-Plan and Plan for the financial year 2016-17.

(Figures in lakh ₹)

Budget Head	Non-Plan		Plan	
	Budget	Expenditure	Budget	Expenditure
<b>Revenue</b>				
Estt. Charges	2454.51	2448.16	-	-
OTA	0.10	0.04	-	-
Pension	1973.46	1962.15	-	-
TA	17.00	16.46	25.00	24.90
Research & Operational expenses	298.00	298.00	161.09	161.09
<b>Works Repair &amp; Maintenance</b>				
Office Buildings	60.00	34.55	-	-
Residential Buildings	44.50	32.38	-	-
Minor Work	60.00	49.86	-	-
Other Administrative Charges	431.00	478.48	-	-
Miscellaneous Expenses (including HRD)	33.43	33.41	-	-
Tribal Sub Plan - General	-	-	-	-
<b>Capital</b>				
Equipments	15.00	13.85	11.92	11.93
Information Technology		1.04	0.45	0.44
Library			16.23	16.21
Furniture & Fixtures	10.00	9.95	13.40	13.40
Livestock	1.00	0.99		
Works	-	-	94.91	94.91
Minor Work	-	-	-	-
Tribal Sub Plan - Capital	-	-	-	-
<b>TOTAL</b>	<b>5398.00</b>	<b>5379.31</b>	<b>323.00</b>	<b>322.88</b>

	Budget	Expenditure
Loans & Advances	22.00	10.39

Other Projects	Opening Balance	Receipts	Expenditure	Refund
Other Plan Schemes	10.61	490.43	430.82	64.25
Deposit Schemes (Externally funded)	170.26	225.82	196.09	50.72
<b>KVK, Kasaragod &amp; Alappuzha</b>	0.06	257.42	257.48	0

#### Revenue receipts

Head	Target	Achievement
Income from sales/services	679.88	234.32
Fee/Subscription	6.10	10.95
Income from Royalty, Publication etc.	0.10	0.07
Other Income	-	209.45
STD Interest	-	52.18
Recoveries on Loans & Advances	-	25.62
<b>TOTAL</b>	<b>686.08</b>	<b>532.59</b>

## WEATHER

XXVII.

## ICAR-CPCRI, Kasaragod

Month	Temp.		RH %		Wind velocity (km h <sup>-1</sup> )	Sunshine (h)	Evaporation (mm)	Rainfall (mm)	Rainy days
	Min (°C)	Min (°C)	FN	AN					
April 2016	34.1	27.0	78	62	2.6	8.4	4.8	0.2	Nil
May 2016	33.8	25.3	81	66	2.3	6.9	4.1	150.6	9
June 2016	29.7	21.9	93	84	2.2	2.6	2.3	976.6	25
July 2016	28.7	21.4	96	86	1.8	1.4	1.5	725.4	29
Aug. 2016	29.4	21.8	93	82	1.4	4.0	2.0	470.8	26
Sept. 2016	29.1	21.8	90	79	1.3	4.5	2.3	129.0	16
Oct. 2016	30.1	23.0	85	75	1.5	7.3	2.9	36.2	4
Nov. 2016	32.1	22.9	83	63	1.6	7.9	3.0	24.4	1
Dec. 2016	31.9	21.7	80	59	1.5	7.5	3.0	26.8	1
Jan. 2017	31.9	21.3	81	54	1.5	8.5	3.4	11.2	1
Feb. 2017	32.6	22.9	82	54	1.9	8.5	4.1	—	—
Mar. 2017	32.9	23.8	79	60	2.2	7.8	4.7	—	—

## ICAR-CPCRI, Regional Station, Kayamkulam

Month	Temp.		RH %		Wind velocity (km h <sup>-1</sup> )	Sunshine (h)	Evaporation (mm)	Rainfall (mm)	Rainy days
	Max (°C)	Min (°C)	FN	AN					
April 2016	34.8	26.2	91	65	2.8	8.4	4.5	15.8	2
May 2016	32.2	24.0	92	72	2.4	5.5	3.7	343.2	16
June 2016	30.0	22.8	93	82	2.0	4.0	3.1	505.4	30
July 2016	30.0	24.3	93	81	2.5	4.9	3.4	411.0	22
Aug. 2016	30.3	23.5	92	76	2.8	6.3	3.5	133.7	12
Sept. 2016	30.1	23.0	93	74	2.9	5.7	3.5	81.0	6
Oct. 2016	31.0	23.9	93	66	2.2	8.0	3.8	113.6	4
Nov. 2016	31.8	24.1	93	63	1.4	5.7	3.4	74.4	3
Dec. 2016	32.2	23.3	92	61	1.7	8.1	3.7	41.9	3
Jan. 2017	33.0	22.2	92	52	1.9	8.4	3.9	30.8	2
Feb. 2017	33.4	21.8	92	51	2.1	8.5	4.0	—	—
Mar. 2017	32.8	24.3	92	59	2.2	8.4	3.9	96.9	4

**ICAR-CPCRI, Regional Station, Vittal**

Month	Temp.		RH %		Wind Velocity (Km h <sup>-1</sup> )	Sunshine (h)	Evaporation (mm)	Rainfall (mm)	Rainy days
	Max (°C)	Min (°C)	FN	AN					
April 2016	36.7	24.8	90.9	52.6	3.5	5.4	5.5	0.0	0
May 2016	35.4	24.1	90.1	57.0	3.6	5.3	4.5	94.5	6
June 2016	29.6	22.1	96.7	82.6	2.6	1.7	2.1	776.8	23
July 2016	28.9	21.7	97.6	89.0	2.7	0.9	2.0	811.6	29
Aug. 2016	29.3	22.1	97.3	80.0	3.1	3.2	2.0	442.2	25
Sept. 2016	29.6	21.7	96.5	76.6	2.8	3.2	2.2	196.0	16
Oct. 2016	32.0	21.6	95.4	64.4	2.2	5.7	3.0	36.3	4
Nov. 2016	33.9	19.9	94.1	47.5	1.8	6.1	3.1	15.2	1
Dec. 2016	33.0	18.3	92.7	45.5	1.8	6.3	2.9	14.6	2
Jan. 2017	33.7	17.2	92.5	39.4	2.2	6.7	3.3	16.2	1
Feb. 2017	35.1	19.1	91.3	39.1	2.6	7.1	4.0	0.0	0
Mar. 2017	35.2	20.1	92.5	47.0	3.0	5.2	4.8	6.8	1

**ICAR-CPCRI, Research Centre, Kidu**

Month	Temp.		RH %		Wind velocity (km h <sup>-1</sup> )	Sunshine (h)	Evaporation (mm)	Rainfall (mm)	Rainy days
	Max (°C)	Min (°C)	FN	AN					
April 2016	37.7	23.2	91	43	0.1	8.3	7.1	54	2
May 2016	34.9	23.5	93	59	-	6.9	5.1	245	14
June 2016	28.7	21.2	95	89	-	2.1	2.5	1056	30
July 2016	30.9	21.8	99	87	-	0.8	2.5	1126	31
Aug. 2016	26.7	21.5	97	89.5	-	0.8	2.4	758.4	29
Sept. 2016	39.3	20.5	96	85	-	2.1	2.4	406.8	24
Oct. 2016	33.7	20.8	96	61	-	7.6	3.9	147.1	7
Nov. 2016	33.9	17.3	94	49	-	7.9	4.1	7.6	3
Dec. 2016	33.5	16.5	93	47	-	7.7	3.8	12	5
Jan. 2017	35	16.7	94	42	-	8.5	4.9	14	1
Feb. 2017	36	17.5	91	37	-	8.9	5.6	-	-
Mar. 2017	36.2	20.3	92	42	-	7.7	6	77	2

# Limca

## *Book of Records*

### *National Record*

To celebrate its Centenary (1916-2016), **ICAR-Central Plantation Crops Research Institute (CPCRI)**, Kasaragod, Kerala organised a unique event in which 216 farmers planted 108 coconut seedlings of 18 varieties simultaneously at Centenary Park within the campus on March 12, 2016. During the three-minute programme which started at 10.05 am, farmers from various parts of the country planted one-year old seedlings in previously dug pits of 1.5 cu m in the 0.70 hectare plot.



**Vijaya Ghose**  
*Editor, Limca Book of Records*



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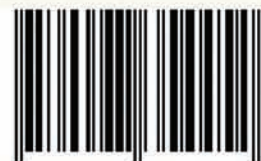


Nethra Centura variety of cocoa



हर कदम, हर डगर  
किसानों का हमसफर  
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