ISSN 0973 – 5445

वार्षिक प्रतिवेदन
ANNUAL REPORT
2021

In the service of nation since 1916

भाकृअनुप-केंद्रीय रोपण फसल अनुसंधान संस्थान, कासरगोड़
ICAR- Central Plantation Crops Research Institute, Kasaragod
(An ISO 9001:2015 Certified Institution)

ISSN 0973 – 5445

वार्षिक प्रतिवेदन
Annual Report
2021

भा.कृ.अ.प.-केन्द्रीय रोपण फसल अनुसंधान संस्थान
कासरगोड़ केरल, भारत
ICAR-CENTRAL PLANTATION CROPS RESEARCH INSTITUTE
KASARAGOD 671 124, KERALA, INDIA

Correct citation: ICAR-CPCRI, 2022. Annual Report 2021,
ICAR-Central Plantation Crops Research Institute
Kasaragod – 671124, Kerala, India, 120 p.

Published by
Dr. Anitha Karun
Director (Acting)
ICAR-Central Plantation Crops Research Institute
KASARAGOD 671 124, Kerala, India
Phone: 04994 – 232893, 232894, 232895 & 232996;
Fax: 04994-232322
Email: directorcpcri@gmail.com
Website: https://cpcri.icar.gov.in/

Compiled and edited by
K. Muralidharan
Murali Gopal
Merin Babu
Sudha R.
Pandiselvam R.
Muralikrishna H.

Coverpage, Photo Credits and Design
K. Shyama Prasad

Hindi Text
Alka Gupta

Digital Layout
Sirigannada Offset Printers
Kasaragod

January, 2022

CONTENTS

Sl.	Particulars	Page
I.	आमुख	i
I.	Preface	ii
II.	कार्य सारांश	iii
III.	Executive Summary	vi
IV.	Vision, Mission and Mandate	x
V.	Institute Profile	xi
	i) Historical Perspective	xi
	ii) Achievements at a Glance	xi
	iii) Organogram	xii
VI.	Research Achievements	
1.	Genetic Resources Management	1
2.	Biotechnological Investigations in Palms and Cocoa	9
3.	Cropping and Farming Systems, Nutrient and Water Management and Bioresources Management in Palms	13
4.	Integrated Management of Diseases in Palms and Cocoa	20
5.	Integrated Management of Pests and Nematodes in Palms and Cocoa	26
6.	Physiology, Biochemistry and Value Chain Management in Palms and Cocoa	34
7.	Technology Transfer, Economics and Statistical Methods	38
8.	All India Co-ordinated Research Project on Palms	47
9.	Krishi Vigyan Kendras	49
VII.	Publications	52
VIII.	Technology Assessed and Transferred	66
IX.	Awards and Recognition	67
X.	Training and Capacity Building	69
XI.	Workshops, Seminars, Summer Institutes, Farmers Days organized	71
XII.	Participation of Scientists in Conferences, Meetings, Workshops and Symposia	73
XIII.	Linkages and Collaborations	85
XIV.	Research Projects	87
XV.	Research and Organisational Management	92
XVI.	Intellectual Property and Technology Management	93
XVII.	Personnel	96
XVIII.	Distinguished Visitors	104
XIX.	Mera Gaon – Mera Gaurav Programme	104
XX.	Swachh Bharat Abhiyan	105
XXI.	Women's Cell Activities	105
XXII.	Major Events and Other Information	106
XXIII.	Budget and Expenditure	113
XXIV.	Weather Data	115
XXV.	राजभाषा कार्यान्वयन	117

आमुख

यह वार्षिक रिपोर्ट वर्ष 2021-22 के लिए भा.कृ.अनु.प.-केंद्रीय रोपण फसल अनुसंधान संस्थान की अनुसंधान गतिविधियों को दर्शाती है, यह अवधि कोविड-19 महामारी के संदर्भ में नई सामान्य स्थिति भी चिह्नित करती है। दोहरे टीकाकरण अभियान को पूरा करने में सफलता और भारतीय अर्थव्यवस्था में तेज सुधार ने जीवन के सभी क्षेत्रों के लोगों में विश्वास जगाया, जिसे संस्थान की गतिविधियों में भी देखा जा सकता है।

वाणिज्य दृष्टि से, पहली बार नारियल निर्यात मूल्य 2,295 करोड़ रुपये का निशान को पार कर गया। वर्ष 2020-21 की तुलना में यह 30% की वृद्धि है। 2021-22 में 1.20 मिलियन टन सुपारी के उत्पादन (अनुमानित) के बावजूद, भारत ने इसी अवधि में केवल 23.98 लाख किलोग्राम निर्यात करते हुए 3.2 करोड़ किलोग्राम सुपारी का आयात किया, जो देश में सुपारी उद्योग के एक समालोचनात्मक विश्लेषण की मांग करता है। 2021-22 में कोको का उत्पादन बढ़कर 27072 टन हो गया। देश ने विश्व को वर्ष 2021-22 के दौरान 25,728 मेट्रिक टन कोको उत्पादों का निर्यात किया है, जिसकी कीमत
रु. 1,108 करोड़ है।

इस वर्ष संस्थान की 22 संस्थान परियोजनाएं और 25 बाह्य वित्तपोषित परियोजनाएं प्रचालन में थीं। इन परियोजनाओं में रिपोर्ट किए गए प्रमुख शोध निष्कर्षों में जड़ (मुर्झा) रोग प्रभावित क्षेत्रों में खेती के लिए लंबी ⁼ लंबी संकर; उच्च उपज देने वाली कोको किस्म VTLCC-2 और संकर VTLCH-6; नारियल में जीन साइलेंसिंग पर पहली रिपोर्ट (SERK और WR1 जीन); अंतर्फसल के तौर पर (i) दालचीनी (पंचकोणीय रोपण और प्रबंधन), (ii) मूंगफली की किस्में गिरनार 2 और गिरनार 3, और (iii) गेंदा; पूर्वोत्तर में सुपारी के तहत गर्मियों और सर्दियों की सब्जियों की अंतर-फसल; मानसून के दौरान प्लास्टिक मल्चिंग पर सुपारी में रोग लक्षणों में कमी; नारियल और सुपारी की पौध में गैनोडर्मा ल्यूसिडम संक्रमण को प्रेरित करने के लिए तीव्र और नवीन टीका तकनीक; ट्राइकोडर्मा हर्जियानम (CPTD 28) के बड़े पैमाने पर उत्पादन के लिए किसान हितैषी प्रौद्योगिकी; यू.ए.वी. द्वारा ली गई छवियों के आधार पर नारियल के शिखर और संक्रमण का पता लगाने के लिए टूलकिट; अनुकार अध्ययन का उपयोग करते हुए अधिदेशित फसलों के लिए देश में भावी फसली क्षेत्र का विश्लेषण; और नारियल डाब काटने की मशीन आदि है। पाथियूर पंचायत (आलप्पुला) में संचालित किसान प्रथम कार्यक्रम के तहत, निम्नलिखित किस्मों की पहचान की गईः तिल (केरल कृषि विश्व विद्यालय की कायमकुलम और तिलक और टीएनएयू की टीएमवी 6); हल्दी (आईसीएआर-आईआईएसआर की प्रगति), बाजरा (टी.एन.ए.यू. की पयूर), मूंगफली (यूएएस, धारवाड़ की जी2 52), और दालें (केरल कृषि विश्व विद्यालय की कनकमणि और हृदया)। हमनें नारियल, सुपारी और कोको की रोपण सामग्री, क्रमशः 111454, 674226, और 48287 इकाइयाँ, और जैव-एजेंटों सहित अन्य सेवाएँ किसानों को प्रदान की हैं। एससीएसपी, एसटीसी और एनईएच जैसे विशेष कार्यक्रमों के तहत देश के विभिन्न हिस्सों में आउटरीच कार्यक्रम आयोजित किए गए। वर्ष 2021-22 में कुल 35 प्रौद्योगिकी हस्तांतरण हुए जिससे 8.44 लाख रुपये की आय प्राप्त हुई।

वर्ष के दौरान ई-ऑफिस और ईआरपी पूरी तरह कार्यात्मक हुए। कागज रहित कार्यालय में अंतरण के लिए सभी कर्मचारियों को अच्छी तरह से प्रशिक्षित किया गया। हमें प्रोत्साहन देने के लिए भा.कृ.अनु.प. मुख्यालय के अधिकारियों का बहुत-बहुत धन्यवाद व्यक्त करते हैं। डॉ. त्रिलोचन महापात्रा, महानिदेशक, भा.कृ.अनु.प. ने हमारा हर तरह से सामर्थ्य बढ़ाने के लिए ऑनलाइन बैठकें बुलाई, हम उनके विशेष आभारी हैं। डॉ. ए.के. सिंह, उप महानिदेशक, उद्यान विज्ञान, डॉ. बी.के. पांडे, एडीजी (एच.एस.-II), डॉ. वी.एस. पांडे, एडीजी (एच.एस.- I), डॉ मनीष दास और डॉ अनूप कुमार भट्टाचार्य, प्रमुख वैज्ञानिक हमारे लिए संपर्क के बिंदु रहे, जिन्हें हम विभिन्न गतिविधियों को अमल में लाने और हर तरह के सहयोग के लिए कोटि - कोटि धन्यवाद देते हैं।

इस वार्षिक रिपोर्ट को तैयार करने के लिए संपादकीय बोर्ड के प्रयासों की अत्यधिक सराहना करते हैं।

अनिता करुण

स्थानः कासरगोड़
दिनांकः 31 जनवरी 2022

अनीता करुण
निदेशक (प्रभारी)

Preface

This annual report depicts the research activities of ICAR-Central Plantation Crops Research Institute for the year 2021, a period characterized by new normalcy referring to the Covid-19 pandemic. The success in the completion of the double dose vaccination drive and the sharp recovery of the Indian economy infused confidence among people from all walks of life, which can also be seen reflected in the Institute's activities. On the commodity front, coconut export value was pegged at Rs. 2295 crore in 2020–21, which is an increase of 30% compared to the previous year. Despite the production of 1.20 million tonnes of arecanut in 2020–21, India imported 23.98 million kg of arecanut while exporting a meagre 3.2 million kg over the same period, which calls for a critical analysis of arecanut industry in the country. In 2020-21, cocoa production was 27072 tonnes. The country has exported cocoa products worth Rs. 1,108 crore to the world during this period.

There were 22 institute projects and 25 externally funded projects in operation. The salient research findings reported in these projects include Tall x Tall hybrid for cultivation in root (wilt) disease affected tract; high yielding cocoa variety VTLCC-2 and hybrid VTLCH-6; first report on gene silencing in coconut (SERK and WR1 genes); intercropping of (i) cinnamon (pentagonal planting and management), (ii) ground nut varieties Girnar 2 and Girnar 3, and (iii) Marigold; intercropping summer and winter vegetable under arecanut in NEH; reduction in YLD symptoms in arecanut on plastic mulching during monsoon; rapid and novel inoculation technique for inducing *Ganoderma lucidum* infection in coconut and arecanut seedlings; Farmer friendly technology for mass production of *Trichoderma harzianum* (CPTD28); toolkit for detection of coconut crown and infestations based on images taken by UAV; analysis of future cropped area in the country for mandate crops using simulation studies; and tender coconut cutting machine. Under Farmer FIRST programme operated in Pathiyur panchayat (Alappuzha), the following varieties were identified: Sesamum (Kayamkulam and Thilak of KAU and TMV 6 of TNAU); turmeric (Pragathi of ICAR-IISR), finger millet (Payur of TNAU), groundnut (G2 52 of UAS, Dharwad), and pulses (Kanakamani and Hridya of KAU).

We could deliver services to the farmers including planting materials of coconut, arecanut and cocoa, 111454, 674226, and 48287 units, respectively and bio-agents. Outreach programmes were conducted at different parts of the country under special programmes like SCSP, STC and NEH. A total of 35 technology transfers took place in the year 2021-22 which generated revenue of Rs. 8.44 lakh.

E-office and ERP became fully functional during the year. All staff were well trained to facilitate the switch over to paperless office.

We immensely thank the authorities at the ICAR headquarters for giving hope and offering support throughout. Dr. Trilochan Mohapatra, Director General, ICAR had called meetings online to give us strength all the way. Dr. A.K. Singh, Deputy Director General, Horticulture Sciences, Dr. B.K. Pandey, ADG (H.S.-II), Dr. Vikramaditya Pandey, ADG (H.S.-I), Dr. Manish Das and Dr. Anup Kumar Bhattacharjee, Principal Scientists were the points of contact for us, whom also we would like to thank for the interventions for various activities to materialize and find a place under this report.

The efforts of the editorial board for the preparation of this annual report are highly appreciated.

Place: Kudlu
Date: 31 January 2022

Anitha Karun
Director (Acting)

III. कार्य सारांश

आनुवंशिक संसाधन प्रबंधन और प्रयोज्यता

भा.कृ.अनु.प.-कें.रो.फ.अ.सं. दुनिया के सबसे बड़े नारियल जर्मप्लाज्म (455 परिग्रहण), सबसे बड़े सुपारी जर्मप्लाज्म (178 परिग्रहण) और कोको के जर्मप्लाज्म (515 परिग्रहण) को रोपण जीन बैंकों में संरक्षित कर रहा है। नेशनल क्रायो जीन बैंक आईसीएआर-एनबीपीजीआर, नई दिल्ली में क्रमशः नारियल परिग्रहणों के 30, पराग 15 जाइगोटिक भ्रूण और 16 डीएनए के रूप में क्रायो-संरक्षण किया गया। आनुवंशिक आधार को विस्तृत करने के लिए, वर्ष के दौरान संग्रह के लिए दक्षिण अंडमान से एक नारियल जर्मप्लाज्म और कर्नाटक से तीन सुपारी जर्मप्लाज्म की पहचान की गई।

2021 के दौरान, कल्प रत्न, एक बहुउद्देश्यीय नारियल किस्म, को केरल, कर्नाटक और तमिलनाडु राज्यों में जारी करने के लिए राजपत्र में अधिसूचित किया गया था। अंडमान हरी बौनी और अंडमान पीली बौनी के लिए विभिन्न प्रकार के रिलीज प्रस्ताव भा.कृ.अनु.प.-कें.रो.फ.अ.सं. से किए गए हैं। पिछले कुछ वर्षों में गहन शोध प्रयासों के परिणामस्वरूप 21 नारियल किस्मों, 11 सुपारी किस्मों और आठ कोको किस्मों को विमोचित किया गया है। नारियल के परिग्रहण की वृद्धि और उपज के लक्षणों का कासरगोड, किदु, मोहितनगर और काहिकुची में मूल्यांकन किया गया। उप-हिमालयी तराई क्षेत्र में मूल्यांकन परीक्षण से पता चला है कि बारी नारिकेल 1 में उच्च वार्षिक नारियल की उपज दर्ज की गई थी।

उत्पाद विविधीकरण के लिए नारियल जर्मप्लाज्म के मूल्यांकन ने वेस्ट कोस्ट टॉल और चंद्र संकर की उपयुक्तता का सुझाव दिया, जिसमें वर्जिन नारियल तेल उत्पादन के लिए बेहतर एंडोस्पर्म गुण और उच्च वसा सामग्री होती है।

सीडीबी फार्म, नेरियामंगलम और भा.कृ.अनु.प.-कें.रो.फ.अ.सं., क्षेत्रीय संस्थान, कायमकुलम में प्रदर्शन मूल्यांकन परीक्षणों ने पहचान की कि डब्ल्यूसीटी ¬ डब्ल्यूसीटी संतानें, जो उच्च उपज और जड़ (मुझा) रोग मुक्त वेस्ट कोस्ट टॉल (डब्ल्यूसीटी) ताड़ों को पार करके उत्पादित होती हैं, ज़्क्र (ग्र) और ज़्क्र (सेल्फ) संततियों की तुलना में अधिक उपज के मामले में बेहतर हैं और कम जड़ (मुर्झा) रोग की घटना दर्ज की गई है। इसे 'कल्प राजा' के रूप में जारी करने की सिफारिश की गई थी, जो कि जड़ (मुर्झा) रोग प्रचलित क्षेत्रों में उपज के लिए उपयुक्त एक लंबी किस्म है। कोको हाइब्रिड वीटीएलसीपी-9 (वीटीएलसी-11 ¬ वीटीएलसी-9) 65-80 फल/पेड़/वर्ष, 40-45 बीज/ फल की औसत 2.5 की उच्चतम सूखी बीन उपज के साथ आशाजनक पाया गया और विट्टल में तुलनात्मक उपज परीक्षण में भी - 3.0 कि.ग्रा./वृक्ष/वर्ष दर्ज की गई ।

कुल 8,33,967 गुणवत्ता रोपण सामग्री जिसमें 72,843 नारियल के बीज/ अंकुर और 38,611 नारियल संकर, 6,74,226 सुपारी के पौधे / बीज और 39,632 कोको के पौधे / ग्राफ्ट और 8,655 कोको बीज का उत्पादन किया गया और 2021 के दौरान किसानों को वितरित भी किया गया।

जैव प्रौद्योगिकी जांच

सिंथेटिक siRNAs ऑलिगोन्यूक्लियोटाइड स को दो चयनित लक्ष्य जीनों के लिए डिज़ाइन और संश्लेषित किया गया था। सोमैटिक एम्ब्रियोजेनेसिस रिसेप्टर किनेज (SERK) और रिंकल्ड (WR1) उनके पूर्ण-लंबाई वाले सीडीएनए अनुक्रम के आधार पर। प्रांकुर और भ्रूणपोष कैली दोनों के लिए वितरण प्रणाली को मानकीकृत किया गया था। क्यूआरटी-पीसीआर विश्लेषण से नारियल में पहली बार रिपोर्ट करने वाले इन दोनों जीनों की साइलेंसिंग का पता चला।

सुपारी के पूर्ण क्लोरोप्लास्ट (सीपी) जीनोम को अनुक्रमित किया गया था। ए. कैटेचू का सीपी जीनोम 158,689 बीपी लंबाई का एक विशिष्ट गोलाकार डीएनए अणु है और 133 जीन, (88 प्रोटीन-कोडिंग जीन), 37 टीआरएनए जीन और आठ आरआरएनए जीन का एक सेट एन्कोड करता है। कुल 70 एसएसआर लोकी का पता चला था, जिनमें से अधिकांश इंटर-जेनिक क्षेत्रों में थे और फ़ाइलोजेनेटिक विश्लेषण से पता चला कि ए. कैटेचु/ ए. वेस्टिरिया से निकट संबंधित था।

फ़सल उत्पादन

नारियल आधारित एकीकृत कृषि प्रणाली (सीबीआईएफएस) जिसमें केला और काली मिर्च के साथ-साथ डेयरी, मुर्गी पालन और बकरी पालन के साथ-साथ रुपये 6,53,853/- एक हेक्टेयर की शुद्ध वापसी प्रति इकाई क्षेत्र से हुई। इस प्रणाली के लिए सी:बी अनुपात 2.08 था जो इसे नारियल किसानों के लिए अपनाने के लिए एक सफल मॉडल के रूप में दर्शाता है।

0.6 मीटर x1.2 की दूरी के साथ दालचीनी (पांच पौधे प्रति गड्ढे) का पेंटागोनल रोपण। मी. नारियल के अंतरक्षेत्रों में 632 किग्रा/हेक्टेयर की उच्च क्विल उपज प्रदान की गई।

मूंगफली (गिरनार 2 और 3) को नारियल में अंतरफसल के रूप में सफलतापूर्वक उगाया गया। जी3 और जी2 किस्म के लिए 50ऽ आरडीएफ अ वर्मीकम्पोस्ट ऋ10 टन/हेक्टेयर के प्रयोग से क्रमशः 2297 और 2092 कि.ग्रा./हे. की उच्च फली उपज दर्ज की गई।

गेंदे की किस्में पूसा बसंती गैंडा (57.9 क्विंटल/हेक्टेयर की उपज) और पेरियाकुलम येलो (57.6 क्विंटल/हैक्टर की उपज) को नारियल के नए लगाए गए बागानों में संभावित अंतर फसल के रूप में उगाया जा सकता है, जिससे रुपये 1.59 लाख और रु। की अतिरिक्त आय प्राप्त होती है। बीसीआर 2.18 और 2.13 के साथ क्रमशः 1.52 लाख।

सुपारी के तहत मौसमी बागवानी फसलों की अंतरफसल जलवायु व्यवहार्यता और स्थानीय उपभोक्ता की पसंद के आधार पर काहिकुची में थी, यह सुझाव देता है कि सर्दी और गर्मी की सब्जियां जैसे गोभी (var अघनी), फूलगोभी (var माधुरी), टमाटर (var वैशाली), बैंगन (var रानी), भिंडी (var गुंजन) और तुरई (var राम) फसलें क्रमशः 7.8 टन / हेक्टेयर, 3.9 टन / हेक्टेयर, 19.3 टन / हेक्टेयर, 6.5 टन / हेक्टेयर, 11.42 टन / हेक्टेयर और 21.9 टन/हेक्टेयर, की उपज के साथ उपयुक्त अंतरफसल हैं।

कर्नाटक के श्रृंगेरी और सुलिया तालुक में किसानों के बगीचों में सुपारी के पीला पत्ता रोग (वाईएलडी) के प्रबंधन ने संकेत दिया कि मानसून (जून-अक्टूबर) के दौरान प्लास्टिक मल्चिंग ने प्रायोगिक अवधि 2017-2021 की तुलना में रोग सूचकांक (1.7 - 3.0%) को कम कर दिया। 2016 में दर्ज किए गए पूर्व-प्रायोगिक डेटा (2.9-5.8%) के अनुसार। महत्वपूर्ण रूप से, गैर-मल्च्ड प्लॉट की तुलना में, मल्च किए गए भूखंडों में उपज 2-14% अधिक (1184 - 2525 किलोग्राम हेक्टेयर -1) थी। यह देखा गया कि, मानसून के दौरान प्लास्टिक मल्चिंग लक्षणों की अभिव्यक्ति में देरी कर सकती है और रोग प्रभावित बगीचे में उपज में वृद्धि कर सकती है (विशेषकर जब प्रारंभिक रोग सूचकांक कम हो)।

ज़्ख़्म स्थानिक रूप से स्वस्थ राइजोस्फीयर मिट्टी (YLD-AHR), ज़्ख़्म स्थानिक रोग गहन राइजोस्फीयर मिट्टी (YLD-DIR), और YLD स्थानिक गैर राइजोस्फीयर मिट्टी (YLD-NR) में राइजोस्फीयर बैक्टीरियल माइक्रोबायोम के शॉटगन मेटागेनोमिक लक्षण वर्णन से पता चला है कि रोगाणुओं के बीच, बैक्टीरिया ने सुपारी ज़्ख़्म स्थानिक राइजोस्फीयर में प्रोटोबैक्टीरिया (70.1% से 75.0%) के प्रमुख बैक्टीरियल फ़ाइला के साथ 96.1% से 96.8% के उच्चतम टैक्सोनॉमिक प्रतिनिधित्व का प्रदर्शन किया। सबसे प्रचुर मात्रा में वर्गीकृत जेनेरा हैं बर्कहोल्डरिया, वेरियोवोरैक्स, पैराबुर्कहोल्डरिया, क्यूप्रियाविडस, स्ब्रिविवैक्स, ब्रैडीरिज़ोबियम, एनारोमाइक्सोबैक्टर, सोरैंगियम, सैंडारासिनस, स्यूडोमोनास, स्फिंगोमोनास, थौएरा, माइक्रोमोनोस्पोरा, रोडोप्लेन, रोडोप्स्यूडोमोनस, मिथाइलोबैक्टीरियम, मायक्सोबैक्टीरियम, मायक्सोबैक्टीरियम।

कोको फल छिल्का बायोचार (सीपीएचबी) ने पीएच 10 और कुल पोटेशियम सामग्री 10-11% दिखाया। इसमें 6.5% पानी में घुलनशील K की प्रशंसनीय मात्रा थी जो कुल पोटेशियम सामग्री का लगभग 60% और लगभग 7.5% विनिमेय ख़, क्ख्त्ए में मौजूद कुल पोटेशियम का लगभग 70% था। इस प्रकार, CPHB का उपयोग मिट्टी में पोटेशियम में सुधार के लिए एक संशोधन के रूप में किया जा सकता है।

ताड और कोको में रोगों का समग्र प्रबंधन

उभरती हुई बीमारियों की एटियलजि जैसे नारियल के पौधों में सूखी स्पिंडिल सड़न *(लासियोडिप्लोडिया थियोब्रोमे और एल. इरेनेंसिस),* नारियल का काला धब्बा रोग *(एक्ससेरोहिलम रोस्ट्रेटम)*, कोको सीडलिंग लीफ स्पॉट *(कोलेटोट्रिकम ग्लियोस्पोरियोइड स)* और सुपारी जड़ क्षय *(फ्यूसैरियम फाल्सीफॉर्म* (एफएसएससी 3 अ) 4)) की स्थापना की गई।

नारियल और सुपारी के पौधों में *गैनोडर्मा ल्यूसिडम* संक्रमण को प्रेरित करने के लिए एक तीव्र और नवीन माइसेलियम इनोक्यूलेशन तकनीक विकसित की गई थी, जिसका उपयोग गैनोडर्मा ल्यूसिडम के लिए नारियल और सुपारी की किस्मों के प्रतिरोध का मूल्यांकन करने के लिए किया जा सकता है।

फंगल कल्चर के दीर्घकालिक भंडारण के लिए फंगल मायसेलिया और कोनिडिया के सोडियम एल्जिनेट आधारित बीड फॉर्मूलेशन विकसित किए गए। *फाइटोफ्थोरा* के खिलाफ प्रभावी बोर्डो पेस्ट और ठोस फॉर्मूलेशन का उपयोग करने के लिए तैयार। 60 दिनों के शेल्फ जीवन के साथ विकसित किया गया था।

पैमाने पर उत्पादन के लिए सुपारी पत्ती शीथ आधारित सूत्रीकरण (1813 ¬ 108) का उपयोग करके किसान अनुकूल तकनीक विकसित की गई थी।

ट्राइकोडर्मा एस्परेलम (आइसोलेट AT172) के आइसोलेट को बढ़ावा देने वाले एक देशी पौधे के विकास की पहचान और विशेषता, जिसमें सुपारी बेसल स्टेम रोट रोगज़नक़ जी. ल्यूसिडम के खिलाफ विरोधी गतिविधि होती है।

मानव रहित हवाई वाहन का उपयोग करके गैंडा के भृंग के संक्रमण की निगरानी के लिए 84.3% की सटीकता के साथ वस्तु का पता लगाने के दृष्टिकोण पर आधारित एक एल्गोरिदम विकसित किया गया।

कीट और नेमाटोड का संघटित प्रबंधन

2021 के दौरान बोंडर्स नेस्टिंग सफ़ेद मक्खी (बीएनडब्ल्यू) द्वारा रगोज स्पाइरलिंग व्हाइटफ्लाई (आरएसडब्ल्यू) का प्रतिस्पर्धात्मक विनियमन देखा गया। एंटोमोपैथोजेनिक फफूंद *सिम्पलिसिलियम लैनोसोनिवम* की आणविक पहचान की पुष्टि मल्टीलोकस सीक्वेंस टाइपिंग द्वारा की गई थी।

गेहूं की भूसी सब्सट्रेट को नारियल पारिस्थितिकी तंत्र में व्हाइटफ्लाई खतरे के पर्यावरण के अनुकूल प्रबंधन के लिए *एस. लैनोसोनिवम* के बड़े पैमाने पर गुणन के लिए उपयुक्त पाया गया।

एफ़ेलिनिड पैरासिटॉइड, एनकार्सिया गुआदेलूपा, न्यूरोप्टेरान प्रीडेटर्स एपर्टोक्रिसा एसपी का उपयोग करते हुए संरक्षण जैविक नियंत्रण। कोकिनेलिड लेडी बीटल और सूटी मोल्ड स्केवेंजर बीटल, लियोक्रिनस नीलगिरिनस ने नारियल पर रगोज सर्पिलिंग व्हाइटफ्लाई *(एलेउरोडिकस रगियोपरकुलैटस)* की आक्रामक क्षमता को कम कर दिया। 1760 करोड़ रुपये के आर्थिक लाभ के साथ पारिस्थितिक तंत्र की जीवन शक्ति और पारिस्थितिक अखंडता को बहाल किया जाता है।

विषाणु ईपीएन, *स्टाइनरनेमा*। CPCRIS0804 को नारियल प्रणाली में उपयोग किए जाने वाले सामान्य कीटनाशकों के लिए अपेक्षाकृत सहनशील पाया गया, जैसे कि IPM कार्यक्रम में इमिडाक्लोप्रिड और हेक्साकोनाज़ोल।

एम्ब्रोसिया बीटल पर पहली रिपोर्ट, *जाइलोसैंड्रस क्रैसियसकुलस* (मोट सचुल्स्की) (कोलोप्टेराः कर्कुलियोनिडे) और कर्नाटक, भारत में सुपारी की गिरी के क्षय से जुड़े इसके कवक सहजीवन एम्ब्रोसिएला रोपेरी।

संक्रमित *एच. थिवोरा* से पृथक एक एंटोमोपैथोजेनिक कवक की पहचान एम. *अनिसोप्लिया टीएमबीएमए* 1 के रूप में की गई और कोको में मिरिड प्रबंधन में प्रभावी पाया गया।

शरीर क्रिया विज्ञान, जीव रसायन और फसलोत्तर प्रौद्योगिकी

'MaxEnt' मॉडल का उपयोग नारियल की खेती के लिए उपयुक्त क्षेत्रों का निर्धारण करने वाले जैव-जलवायु चरों का मूल्यांकन करने और भविष्य की जलवायु परिस्थितियों के तहत संभावित उपयुक्त जलवायु वाले क्षेत्रों की भविष्यवाणी करने के लिए किया गया था।

विभेदक रूप से व्यक्त प्रतिलेखों (डीईटी) के विश्लेषण से पता चला है कि,

486 कोको जल-घाटे तनाव उत्तरदायी प्रतिलेख जीनोटाइप VTLC15 के लिए विशिष्ट हैं जबकि 505 जल-घाटे तनाव उत्तरदायी प्रतिलेख कोको जीनोटाइप VTLC22 में पाए जाते हैं।

एलसी-एमएस विश्लेषण ने नारियल टेस्टा तेल में 18 फेनोलिक एसिड की उपस्थिति का खुलासा किया। विज़-एनआईआर (350-2500 एनएम) स्पेक्ट्रोस्कोपी अ केमोमेट्रिक तकनीकों का उपयोग सूखे नारियल पाउडर (डीसीपी) की शुद्धता का आकलन करने के लिए किया गया है।

विकसित मॉडल डीसीपी में मिलावट के स्तर का अनुमान लगा सकता है यदि मिलावट की मात्रा 10% से अधिक हो।

रोटरी गति को रैखिक गति और हाइड्रोलिक तंत्र में बदलने के सिद्धांत के आधार पर दो प्रकार की अर्ध स्वचालित डाब नारियल काटने की मशीनें विकसित की गईं। डाब नारियल के छिल्का के लिए पोर्टेबल बायोचार इकाई को डिजाइन और विकसित किया गया था।

निम्नलिखित उत्पादों के लिए प्रसंस्करण/पैकेजिंग प्रोटोकॉल को वर्ष 2021 में मानकीकृत किया गया था: (i) नारियल से बनी डार्क चॉकलेट; (ii) नारियल केक और नारियल का हलवा; और (iii) नारियल पुष्पक्रम रस/नीरा और परिपक्व नारियल पानी आधारित सिरका।

प्रसार गतिविधियाँ, सामाजिक- आर्थिक दृष्टिकोण और सांख्यिकीय पहलू

वर्ष के दौरान कुल 168 प्रशिक्षण कार्यक्रम आयोजित किए गए, जिनमें से 57 वीडियो कांफ्रेंसिंग के माध्यम से ऑनलाइन थे। इसमें उद्यमियों के लिए कल्पा ग्रीन चैट ऑनलाइन नामक नई पहल भी शामिल है। किसानों के खेतों में अन्य 249 फ्रंटलाइन प्रदर्शन और 86 नैदानिक दौरे किए गए।

किसान प्रथम पहल के तहत 1287 किसानों और अन्य 376 कृषक परिवारों के लक्ष्य तक पहुंचने के लिए 35 प्रौद्योगिक की हस्तक्षेपों को लोकप्रिय बनाया गया। प्रभाव नारियल के तहत अंतर-फसल में वृद्धि थी। कार्यक्रम के तहत मूंगफली जैसी गैर-पारंपरिक अंतरफसलें किसानों के बीच लोकप्रिय थीं। इन मॉडलों ने किसान उद्यमियों को आय में 216 प्रतिशत तक की वृद्धि प्रदान की।

नारियल क्षेत्र में किसान उत्पादक संगठनों को मजबूत करने के लिए पुनरोद्धार रणनीतियों को अपनाया गया और लंबे समय तक बारिश के मौसम का लाभ पाने के लिए जलवायु लचीली रणनीतियों को लोकप्रिय बनाया गया।

केरल में नारियल के उत्पादन की लागत 9.93 रुपये प्रति फल पाई जाती है। सूखा नारियल पाउडर अंतरराष्ट्रीय बाजार में नारियल का एक महत्वपूर्ण उत्पाद रहा। हालांकि, 70% किसान नारियल को कच्चे फल के रूप में स्थानीय व्यापारियों को बेचते हैं। सामाजिक-आर्थिक पहलुओं के कारण, सहकारी समितियों के माध्यम से केवल 10% सुपारी का व्यापार होता है।

दक्षिण कन्नड़, कर्नाटक में सुपारी कीट और रोग की घटनाओं का आकलन करने के लिए एक क्षेत्र सर्वेक्षण किया गया था। नारियल से जलवायु परिवर्तन और माइक्रोबायोम के लिए अनुकूलित आर स्क्रिप्ट-आधारित कंप्यूटर डेटाबेस प्रोग्राम विकसित किया गया। मेरा गांव-मेरा गौरव के तहत 60 गांवों तक पहुंच नियमित हो गई है। इसके अलावा इन गांवों में किसान संपर्क कार्यक्रम, प्रशिक्षण कार्यक्रम और सब्जी बीज वितरण भी किया गया।

एससीएसपी के तहत अनुसूचित जाति के किसानों और युवाओं के लिए कुल 17 प्रशिक्षण कार्यक्रम आयोजित किए गए। सब्जियों के बीज, छत्ता और सहायक उपकरण, रोपण सामग्री और वित्तीय योजनाओं की जानकारी प्रदान की गई।

एससीएसपी के अनुसूचित जनजाति संघ के तहत भी चार प्रशिक्षण कार्यक्रम आयोजित किए गए और इनपुट वितरित किए गए।

पूर्वोत्तर क्षेत्र घटक के तहत 450 से अधिक किसानों के लिए दस प्रशिक्षण कार्यक्रम आयोजित किए गए। कुल 25,000 सुपारी के पौधे और 5000 नारियल के पौधे वितरित किए गए।

वर्ष 2021-22 में कुल 35 प्रौद्योगिकी हस्तांतरित हुई। प्रौद्योगिकियों की बिक्री से राजस्व रुपये 8.44 लाख का उत्पन्न हुआ ।

जनसंचार माध्यमों के माध्यम से प्रकाशन और जागरूकता के पारंपरिक तरीकों के माध्यम से भी आउटरीच हो रही है। वेबसाइट, सोशल मीडिया, एसएमएस, चैट समूहों के साथ-साथ मोबाइल ऐप 'ई-कल्पा' जैसे आईसीटी टूल का उपयोग हितधारक आवश्यकताओं के साथ-साथ जनता के लिए सूचना के प्रसार के लिए उपयुक्त रूप से किया जाता है।

वर्ष के दौरान, नारियल आधारित प्रौद्योगिकियों के लिए तीन पेटेंट प्राप्त किए गए, अर्थात, कल्परसा संग्रह उपकरण (पेटेंट संख्या 358062), कोको-सैप चिलर (पेटेंट संख्या 373309) और नारियल कर्नेल स्लाइसिंग मशीन (पेटेंट संख्या 382339)।

इस अवधि के दौरान, समीक्षित पत्रिकाओं में उनतालीस (49) शोध प्रकाशन, दो समीक्षा पत्र, संगोष्ठियों / संगोष्ठियों / सम्मेलनों / कार्यशालाओं में 25 पत्र, अर्ध तकनीकी पत्रिकाओं / पत्रिकाओं में 111 लोकप्रिय लेख, दो तकनीकी बुलेटिन, आठ विस्तार पुस्तिकाएं, बारह पुस्तक अध्याय, तीन पुस्तकें, पांच प्रशिक्षण नियमावली और तीन ई-प्रकाशन और 16 वीडियो प्रकाशित किए गए।

भा.कृ.अनु.प.-कें.रो.फ.अ.सं. का एआईसीआरपी पीएचईटी केंद्र लगातार दूसरी बार वर्ष 2020 के सर्वश्रेष्ठ केंद्र के रूप में प्रदर्शन करता रहा। डॉ. (श्रीमती) चंद्रिका मोहन, प्रधान वैज्ञानिक और डॉ. आर. पांडिसेल्वम को उनके शोध प्रदर्शन के लिए सम्मानित किया गया।

IV. EXECUTIVE SUMMARY

Genetic Resources Management and Utilization

ICAR-CPCRI is conserving world's largest coconut germplasm (455 accessions), largest arecanut germpalm (178 accessions) and germplam of cocoa (515 accessions) in the field gene banks. Cryo-preservation in the form of zygotic embryos, pollen and DNA of 30,15 and 16 coconut accessions, respectively were carried out at National Cryo Gene Bank ICAR-NBPGR, New Delhi. Towards broadening the genetic base, one coconut germplasm from South Andaman and three arecanut germpalm from Karnataka were identified for collection during the year.

During 2021, Kalpa Ratna, a multi-purpose coconut variety, was notified in the Gazette for release in the states of Kerala, Karnataka and Tamil Nadu. Variety release proposals for Andaman Green Dwarf and Andaman Yellow Dwarf were developed at ICAR-CIARI.

Intensive research efforts over the years have resulted in the release of twenty one (21) coconut varieties, eleven (11) arecanut varieties and eight (8) cocoa varieties. The growth and yield characters of the coconut accessions were evaluated at Kasaragod, Kidu, Mohitnagar and Kahikuchi. Evaluation trial in the sub Himalayan Terai region revealed that higher annual nut yield was recorded in BARI Narikel 1.

Evaluation of coconut germplasm for product diversification suggested the suitability of West Coast Tall and Chandra Sankara, having better endosperm qualities and high fat content for VCO production.

Performance evaluation trials at CDB Farm, Neriamangalam and ICAR-CPCRI, RS, Kayamkulam, identifed that WCT X WCT progenies, produced by crossing high yielding and root (wilt) disease-free West Coast Tall (WCT) palms, are superior in terms of higher yield and recorded less root (wilt) disease incidence compared to WCT (OP) and WCT (Self) progenies. It was recommended for release for cultivation in root (wilt) disease prevalent tract.

Two cocoa varieties were found to be promising: Cocoa clone VTLCC-2 (1-1.25g single dry bean weight; 2.5-3.0kg dry bean yield/tree) and hybrid VTLCP-9 (VTLC-11 x VTLC-9) (1.1-1.2g single dry bean weight; 2.5-3.0kg dry bean yield/tree).

A total of 8,33,967 quality planting materials comprising 72,843 coconut seed nuts/seedlings and 38,611 coconut hybrids, 6,74,226 arecanut seedlings/seednuts and 39,632 cocoa seedlings/grafts and 8,655 cocoa seed pods were produced and distributed to the farmers during 2021.

Biotechnological Investigations

Synthetic siRNAs oligonucleotides were designed and synthesized for the two selected target genes viz., Somatic Embryogenesis Receptor Kinase (SERK) and Wrinkled (WR1) based on their full-length cDNA sequence. The delivery system was standardized for both plumular and endosperm calli. qRT-PCR analysis revealed silencing of both these genes reporting for the first time in coconut.

The complete chloroplast (cp) genome of arecanut was sequenced. The cp genome of A. catechu is a typical circular DNA molecule of 158,689 bp length and encodes a set of 133 genes, (88 protein-coding genes), 37 tRNA genes, and eight rRNA genes. A total of 70 SSR loci were detected, the majority being in inter-genic regions and phylogenetic analysis revealed that A. catechu was closely related to *A. vestiaria*.

Crop Production

Coconut-based Integrated Farming System (CBIFS) including banana and pepper as intercrops along with dairy, poultry and goatery realized a net return of Rs. 6,53,853/- from a unit area of one hectare. The C:B ratio for this system was 2.08 indicating it as a successful model for coconut farmers to adopt.

Pentagonal planting of cinnamon (five plants per pit) with spacing of 0.6 m x 1.2. m in the interspaces of coconut provided higher quill yield of 632kg/ha.

Groundnut (var. Girnar 2 and 3) was grown successfully as intercrop in coconut. Application of 50 % RDF + vermicompost @ 10 t/ha recorded higher pod yield of 2297 and 2092 kg/ha for G3 and G2 variety, respectively.

Marigold varieties Pusa Basanti Gainda and Periyakulam Yellow can be grown as a potential intercrop in newly planted coconut gardens. It

produced a yield of 57.9 q/ha and 57.6 q/ha fetching an additional income of Rs. 1.59 Lakh and Rs. 1.52 Lakh with BCR 2.18 and 2.13 respectively.

Intercropping of seasonal horticultural crops under arecanut was at Kahikuchi depending upon the climate feasibility and preference of the local consumer suggest that Winter and summer vegetables like cabbage (var. Agheni), cauliflower (var. Madhuri), tomato (Vaishali), brinjal (var. Rani), okra (var. Gunjan) and ridge gourd (var. Rama) crops are suitable intercrops with a yield of 7.8 t/ha, 3.9 t/ha, 19.3 t/ha, 6.5 t/ha, 11.42 t/ha and 21.9 t/ha respectively.

Management of YLD in farmer's gardens in Sringeri and Sullia taluk, Karnataka indicated that plastic mulching during monsoon (June-October) reduced the disease index (1.7 – 3.0%), during the experimental period 2017-2021 compared to the pre-experimental data (2.9-5.8%) recorded in 2016. Importantly, the yield was 2-14% higher (1184 – 2525 kg ha-1) in mulched plots, than non-mulched plot. It was observed that, plastic mulching during monsoon could delay the symptom expression and increase the yield in YLD affected garden (especially when the initial disease index low).

Shotgun metagenomic characterization of rhizosphere bacterial microbiome in the YLD endemic apparently healthy rhizosphere soil (YLD-AHR), YLD endemic disease intensive rhizosphere soil (YLD-DIR), and YLD endemic non rhizosphere soil (YLD-NR) revealed that among the microbes, bacteria exhibited the highest taxonomical representation of 96.1 to 96.8 % with the Proteobacteria (70.1% to 75.0%) s predominant bacterial phyla in arecanut YLD endemic rhizosphere. The most abundant classified genera are *Burkholderia, Variovorax, Paraburkholderia, Cupriavidus, Rubrivivax, Bradyrhizobium, Anaeromyxobacter, Sorangium, Sandaracinus, Pseudomonas, Sphingomonas, Thauera, Micromonospora, Rhodoplane, Rhodopseudomonas, Gemmatirosa, Methylobacterium, Myxooccus, Geobacter* and *Nitrospira.*

Cocoa pod husk biochar (CPHB) showed pH >10 and total potassium content of 10-11%. It contained appreciable amount of 6.5% water soluble K which was about 60% of the total potassium content and around 7.5% exchangeable K, about 70% of the total potassium present in CPHB. CPHB can, thus, be used as an amendment to improve soil potassium.

A thematic map of soil constraints in cocoa cultivation was developed for Tamil Nadu using the available soil map of 1:50000 scale. Soil reaction, which is observed in 68% of the total geographical area of the state, is a major constraint followed by soil drainage (60%), soil texture (46%) and soil depth (40%) and related constraints in terms of their area extent.

Integrated Management of Diseases in Palms and Cocoa

Etiology of emerging diseases such as dry spindle rot in coconut seedlings *(Lasiodiplodia theobromae and L. iranensis)*, black spot disease of coconut *(Exserohilum rostratum)*, cocoa seedling leaf spot *(Colletotrichum gloeosporioides)* and arecanut root decay (Fusarium falciforme (FSSC 3 + 4)) were established.

A rapid and novel mycelium inoculation technique for inducing *Ganoderma lucidum* infection in coconut and arecanut seedlings,which could be used for evaluating the resistance of coconut and arecanut cultivars to *Ganoderma lucidum*, was developed

Sodium alginate based bead formulation of fungal mycelia and conidia for long term storage of fungal cultures were developed. Ready to use Bordeaux paste and solid formulations effective against *Phytophthora* spp. with a shelf life of 60 days was developed.

Farmer's friendly technology for mass production of *T. harzianum* (CPTD28) was developed using arecanut leaf sheath based formulation (1813 x 108).

Identified and characterized a native plant growth promoting isolate of *Trichoderma asperellum* (isolate AT172) having antagonistic activity against arecanut basal stem rot pathogen *G. lucidum*

Developed an algorithm based on object detection approach with an accuracy of 84.3% for surveillance of rhinoceros beetle infestation using unmanned aerial vehicle (UAV).

Integrated management of Pests and Nematodes

Competitive regulation of rugose spiralling whitefly (RSW) by the Bondar's nesting whitefly (BNW) during 2021 was observed. The molecular identity of the entomopathogenic fungus *Simplicillium lanosoniveum* was confirmed by multilocus sequence typing.

Wheat bran substrate was found to be suitable for large scale multiplication of *S. lanosoniveum* for eco - friendly management of whitefly menace in coconut ecosystem.

Conservation biological control using the aphelinid parasitoid, *Encarsia guadeloupae*, neuropteran

predators *Apertochrysa* sp. coccinellid lady beetles and the sooty mould scavenger beetle, *Leiochrinus nilgirianus* reduced the invasive potential of rugose spiralling whitefly *(Aleurodicus rugioperculatus)* on coconut. Ecosystem vitality and ecological integrity are restored with an economic benefit of worth1760 crore rupees.

The virulent EPN, Steinernema sp. CPCRIS0804 was found to be relatively tolerant to the common pesticides used in coconut system viz., imidacloprid and hexaconazole fitting well in IPM programme.

First report on ambrosia beetle, *Xylosandrus crassiusculus* (Motschulsky) (Coleoptera: Curculionidae) and its fungal symbiont *Ambrosiella roeperi* associated with arecanut kernel decay in Karnataka, India.

An entomopathogenic fungus isolated from infected *H. theivora* was identified as *M. anisopliae* TMBMA1 and found to be effective in mirid management in cocoa.

Physiology, Biochemistry and Post Harvest Technology

'MaxEnt' model was used to evaluate the bioclimatic variables determining the regions suitable for coconut cultivation and to predict the regions with potentially suitable climate under future climate conditions.

Analysis of differentially expressed transcripts (DETs) revealed that, 486 cocoa water-deficit stress responsive transcripts are specific to the genotype VTLC15 whereas 505 water-deficit stress responsive transcripts are found in cocoa genotype VTLC22.

LC-MS analysis revealed the presence of 18 phenolic acids in coconut testa oil. vis-NIR (350-2500 nm) spectroscopy + chemometric techniques have been used to assess the purity of desiccated coconut powder (DCP). The developed model could predict the level of adulteration in DCP if the adulterant concentration was more than 10%.

Two types of semiautomatic tender coconut cutting machines were developed based on the principle of conversion of rotary motion to linear motion and hydraulic mechanism. Portable biochar unit for tender coconut husk was designed and developed.

Processing/packaging protocols for the following products were standardized in the year 2021: (i) Coconut infused dark chocolates; (ii) Coconut cake and coconut halwa; and (iii) Coconut inflorescence sap/ neera and mature coconut water based vinegar.

Outreach activities, socio-economic perspectives and statistical aspects

A total of 168 training programmes were conducted during the year, out of which 57 were online through videoconferencing. This also includes novel initiative called Kalpa Green Chat online for entrepreneurs. Another 249 frontline demonstrations in farmers' fields and 86 diagnostic visits were made.

Under Farmer FIRST initiative 35 technology interventions were popularised to reach a target of 1287 farmers and another 376 farm families. The impacts were an increase in intercropping under coconut. Non-traditional intercrops like groundnut were popular among farmers under the programme. These models provided up to a 216 per cent increase in income to farmer entrepreneurs.

Revitalising strategies were adopted for strengthening farmer producer organizations in coconut sector and climate resilience strategies were popularised to get the benefit of a prolonged rainy season.

The cost of production of coconut is found to be Rs 9.93 per nut in Kerala. Desiccated coconut powder was an important product of coconut in the international market. However, 70% of the farmers sell coconut to local traders as raw nut. Due to socio-economic aspects, only 10% of arecanut is traded through cooperatives.

A field survey was conducted to assess arecanut pest and disease incidence in Dakshina Kannada, Karnataka. Customised R script-based computer database programme developed for coconut to climate change and microbiome.

Under the Mera Gaon - Mera Gaurav, outreach to 60 villages has become routine. Apart from this, farmer interface programmes, training programmes and vegetable seed distribution were also carried out in these villages.

Under SCSP, a total of 17 training programmes were conducted for SC farmers and youth. Vegetable seeds, beehives and accessories, planting materials and information on financial schemes were imparted. Under the Scheduled Tribe componenet of SCSP also four training programmes were conducted and inputs were distributed.

Under the NEH componenet, ten training programmes were conducted for more than 450 farmers. A total of

25,000 arecanut seedlings and 5000 coconut seedlings were distributed.

A total of 35 technology transfers took place in the year 2021-22. A revenue of Rs. 8.44 lakh was generated from the sale of technologies.

Outreach is also taking place through conventional modes of publication and awareness through mass media. ICT tools such as website, social media, SMS, chat groups as well as mobile app 'E-Kalpa' are aptly utilized for stakeholder requirements as well as for dissemination of information to the public.

During the period, forty nine (49) research publications in peer reviewed journals, two review papers, 25 papers in seminars/ symposia/ conferences/ workshops, 111 popular articles in semi technical journals/ magazines, two technical bulletins, eight extension pamphlets, twelve book chapters, three books, five number of training manuals and three e-publications and 16 videos were published from the institute.

AICRP on PHET centre at ICAR-CPCRI continued to perform as the Best Centre of the Year 2020 for the second successive year. Dr. (Mrs.) Chandrika Mohan, Principal Scientist and Dr. R. Pandiselvam were honoured for their research performance.

During the year, three patents were obtained for coconut based technologies, viz., Kalparasa® collection device (Patent No. 358062), Coco-sap chiller (Patent No. 373309) and Coconut kernel slicing machine (Patent No. 382339).

IV. VISION, MISSION AND MANDATE

VISION

To develop 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.

V. INSTITUTE PROFILE

ICAR-Central Plantation Crops Research Institute (ICAR-CPCRI), the premier research institution in the National Agricultural Research System of India, is presently mandated to research plantations crops (coconut, arecanut and cocoa). It had a modest beginning as Coconut Research Station in 1916 under the erstwhile Madras Presidency. Since its inception, it has served the farming community with a distinction through exemplary research, generation of appropriate technologies and development of the skilled human resource.

Historical Perspective

The Coconut Research Station at Kudlu (Kasaragod) was taken over by the Indian Central Coconut Committee and established the Central Coconut Research Station (CCRS), Kasaragod in 1947 and 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 the 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 purview of the institute with the formation of dedicated research institutions like Indian Institute of Spices Research, Kozhikode, Directorate of Cashew Research, Puttur and Indian Institute of Oil Palm Research, Pedvegi. 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.

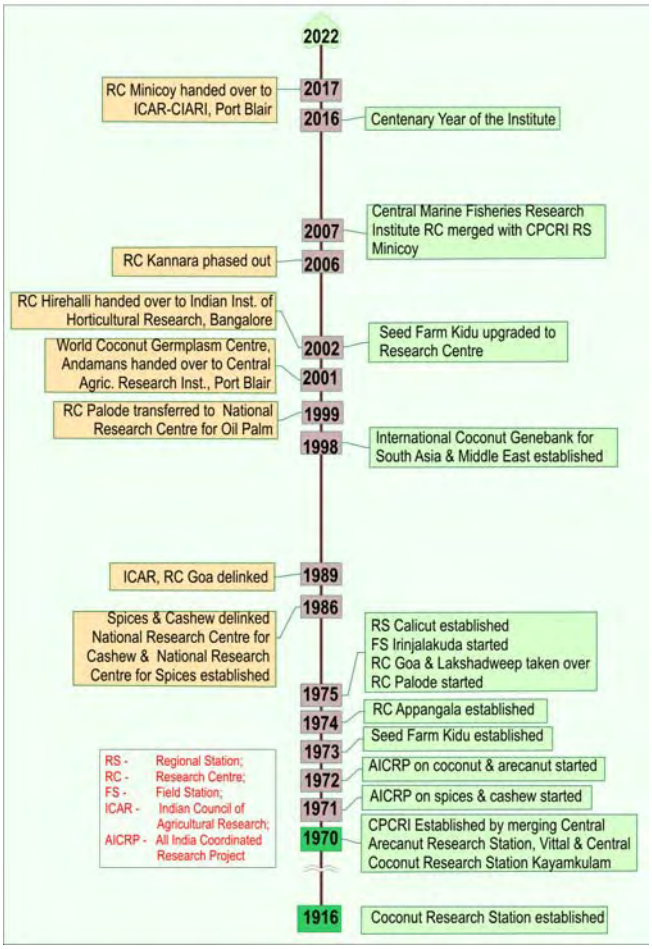
All India Co-ordinated Coconut and Arecanut Improvement Project (AICCAIP) started functioning from 1972 at CPCRI, Kasaragod and was later renamed as All India Coordinated Research Project (AICRP) on Palms in 1986. The AICRPP has 15 centres working on coconut, four on arecanut, six on oil palm, four on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

Achievements at a Glance

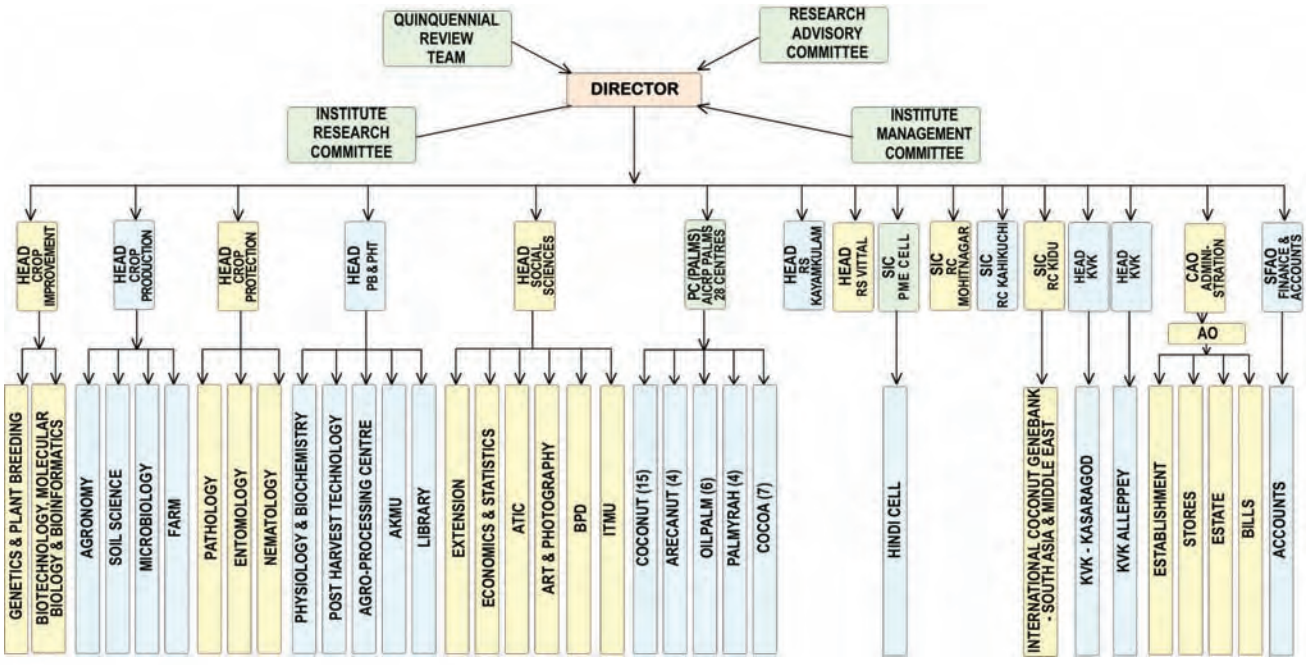
Plant Genetic Resources

ICAR-CPCRI maintains the world's largest repository in coconut with 455 accessions, 178 accessions of arecanut

MILESTONES IN THE TIMELINE OF ICAR-CPCRI



Organogram



and 515 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, 21 improved coconut varieties including six hybrids involving talls and dwarfs 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-1 annually, as compared to 2.96 t copra ha-1 in West Coast Tall local. Kalpa Raja a tall variety of coconut developed by hybridization (WCT x WCT) was recommended specifically for the root (wilt) disease prevalent tract. It has an average yield of 91 nuts/palm/year compared to WCT with a yield of 69 nuts/palm/year in the region. Kalpa Raja is also suitable for tender nut, copra and inflorescence sap production. 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-1 yr-1 and higher dry kernel recovery, in comparison to South Kanara Local (2 kg dry kernel palm-1 yr-1), 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-1 yr-1 with varying processing qualities, as compared to 1.0 kg dry bean tree-1 yr-1 in existing cocoa plantations. High yielding clone VTLCC-11 has been found suitable for high density planting. For Assam, VTLC 19 and VTLC 20 which are high yielding under multi location trials have been recommended for cultivation.

The Institute has been producing quality planting materials annually in coconut, arecanut and cocoa to the tune of 1.2 lakhs, 5 lakhs and 0.5 lakhs respectively, for distribution to farmers and other stakeholders. Seed gardens of improved varieties have been established in the Institute as well as in farmer's fields 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.

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 DNA, 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. In coconut, DNA fingerprint profiles have developed for 25 each of tall and dwarf accessions using polymorphic SSR and EST-SSR markers. 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. New intercrops, viz., sapota and groundnut were introduced in coconut garden grown in littoral soils with promising yields. Compared to coconut mono-cropping, the cropping system can provide more than three times farm income. In the case of arecanut, the income enhancement through intercropping would be 75% to 130%.

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-1 to 0.02 t ha-1 and consequent reduction of nutrient loss due to soil erosion (N from 7.98 to 0.36 kg ha-1, P from 12.52 to 0.9 kg ha-1 and K from 28.5 to 1.1 kg ha-1).

The productivity of coconut in coastal sandy soil, which is made of 99% sand, is very low (30 nuts palm-1 yr-1) 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-1 yr-1. The intercrops generated an additional income of Rs. 2.5 to 3.5 lakh ha-1 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. 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. 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-1 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 P2O5 and 110 g K2O palm-1 yr-1 that has the potential to meet nitrogen and phosphorus requirements of arecanut, which can save the cultivation cost to the extent of Rs. 5,200 ha-1. Arecanut leaf sheath and bunch waste can result in production of 643 kg fresh mushroom. Biochar production units by gasification and pyrolysis has also been developed.

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 vigourous 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.

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 (5g) 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. 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-1) at quarterly interval was found very effective in reducing the disease incidence. Stem bleeding disease of coconut could be effectively controlled using fungicides (Hexaconazole 5EC and Propiconazole 25 EC).

Root (wilt) disease of coconut caused by phytoplasma is another major disease and efforts were made to improve the PCR-based diagnostic techniques for reliable early detection of phytoplasma. A package of practice for the disease affected regions had been recommended.

Spraying of Bordeaux mixture (1%) or mandipropamid (0.5%) was found to be effective in reducing the fruit rot disease of arecanut. 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.

Phytoplasmal etiology of YLD has been established and observed and INM strategies and improved drainage system can sustain yield.

Inflorescence dieback of arecanut could be effectively managed using Propiconazole 25% EC @ 3 ml per litre.

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 @ 250g mixed with equal volume of sand) and aggregation pheromone embedded nanomatrix trap @ 1trap ha-1 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-1 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%.

An acoustics-sensor based red palm weevil detector in coconut was developed with 80% accuracy.

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 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-1), drenching the root zone with chlorpyrifos 20 EC @ 2.5 ml L-1 or imidacloprid 17.8 SL @ 675 ml ha-1 or bifenthrin 10 EC @ 20 litre ha-1 and entomopathogenic nematodes (EPN), *Steinernema carpocapsae* @ 1.5 IJ ha-1 during May-June and September- October reduced the arecanut white grub population significantly. Placement of the neonicotinoid, thiamethoxam (2g) 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 [ECO2] 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 [ECO2]; 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-1 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. A clear contrast was observed between talls and dwarfs in terms of pollen germination at high temperatures, which can be an important selection criterion in evolving varieties with tolerance to high temperature.

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 Chemberi 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. So far the institute could obtain national patents for seven of its technology devices.

Shelflife of coconut gratings can be extended with additives upto 3 week. Coconut milk peda, tender coconut juice, tender coconut dessert and jaggery based coconut chips developed.

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. Mega Expo and Kisans 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 conduct trainings, conferences and interaction workshops with various stakeholders were utilised. Statistical Databases created, technical bulletins, CD ROMs, extension pamphlets, information brochures 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 interfaces. The Institute website (https://cpcri.icar.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 submitted. 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 level/panchayat 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 put forth a restructured sectoral innovation system for the 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 is 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 the semi parametric 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.

Technology Commercialization

The Institute Technology Management Committee is responsible for protection of IP assets and commercialization. Till 31 December 2021, the Institute has commercialized more than 55 technologies, signed 286 MoAs for transfer of technology know-how and realized a revenue of Rs. 76,42,500.

Crops, Area, Altitude and Research Undertaken at Different Locations

Headquarters

KASARAGOD (Estd.: 1916), Crops: Coconut and Cocoa, Area 78 ha; 10.7m MSL

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

Regional Stations

KAYAMKULAM (Estd.: 1947), Crops: Coconut, Area 24.17ha, 3 m MSL

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

VITTAL (Estd.: 1956), Crops: Arecanut and Cocoa, Area 68.34 ha; 58 m MSL

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

Research Centres

KAHIKUCHI (Estd.: 1958), Crops: Arecanut and Cocoa, Area 15.76 ha; 48 m MSL

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

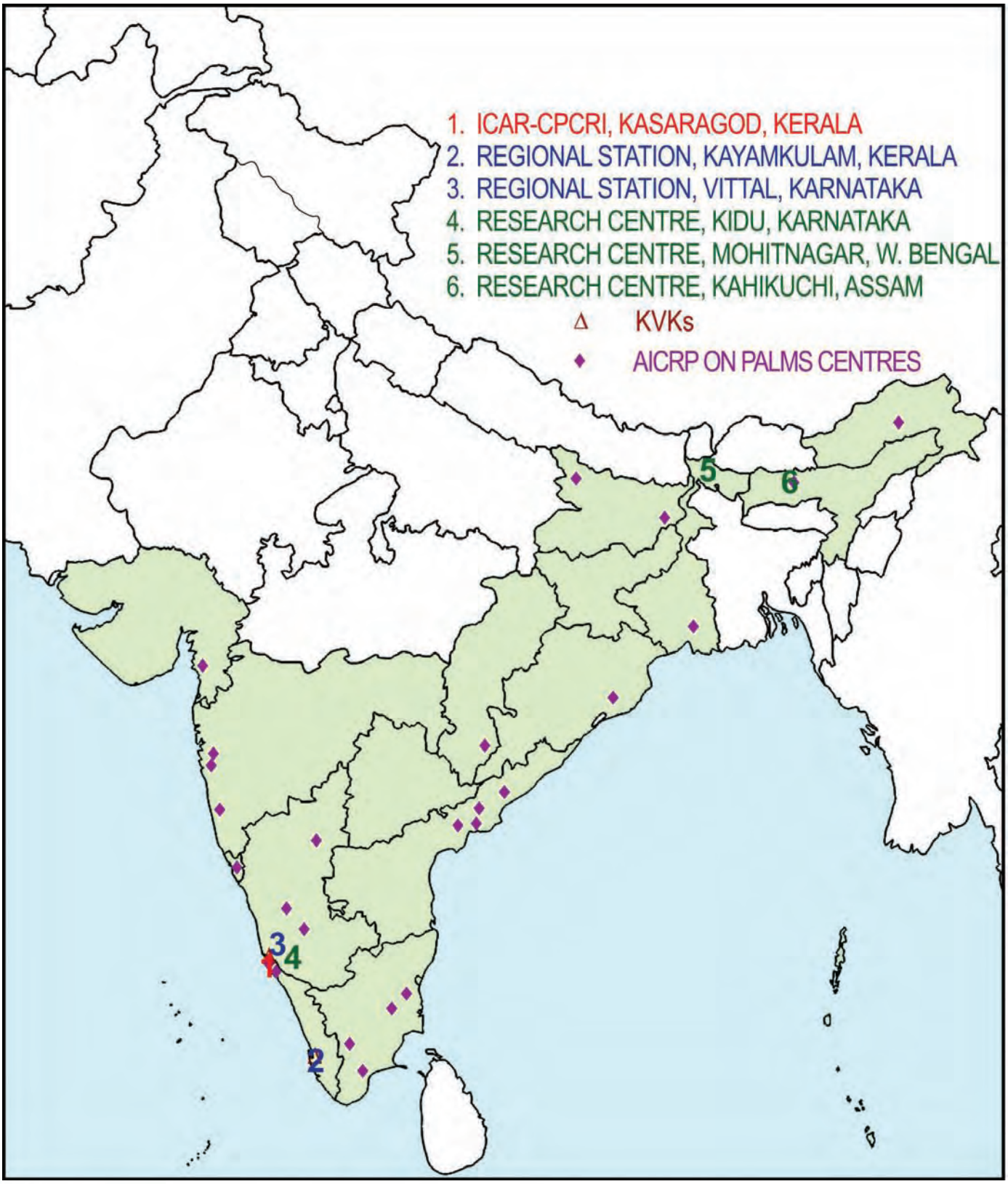
KIDU (Estd.: 1972), Crops: Coconut, Arecanut and Cocoa, Area 120 ha; 281 m MSL

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

MOHITNAGAR (Estd.: 1958), Crops: Coconut and Arecanut, Area 25.99 ha; 91.3 m MSL

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

V. ICAR - CPCRI Locations



Staff Strength as on 31-12-2021

ICAR-CPCRI, KASARAGOD

Category	Sanctioned	In position	Vacant
Scientific	65	65	-
Technical	113	77	-36
Administrative	89	55	-34
Supporting	131	82	-49
Total	398	279	-119

ICAR-KVK, KASARAGOD

Category	Sanctioned	In position	Vacant
Scientific	1	1	-
Technical	11	5	-6
Administrative	2	-	-2
Supporting	2	-	-2
Total	16	6	-10

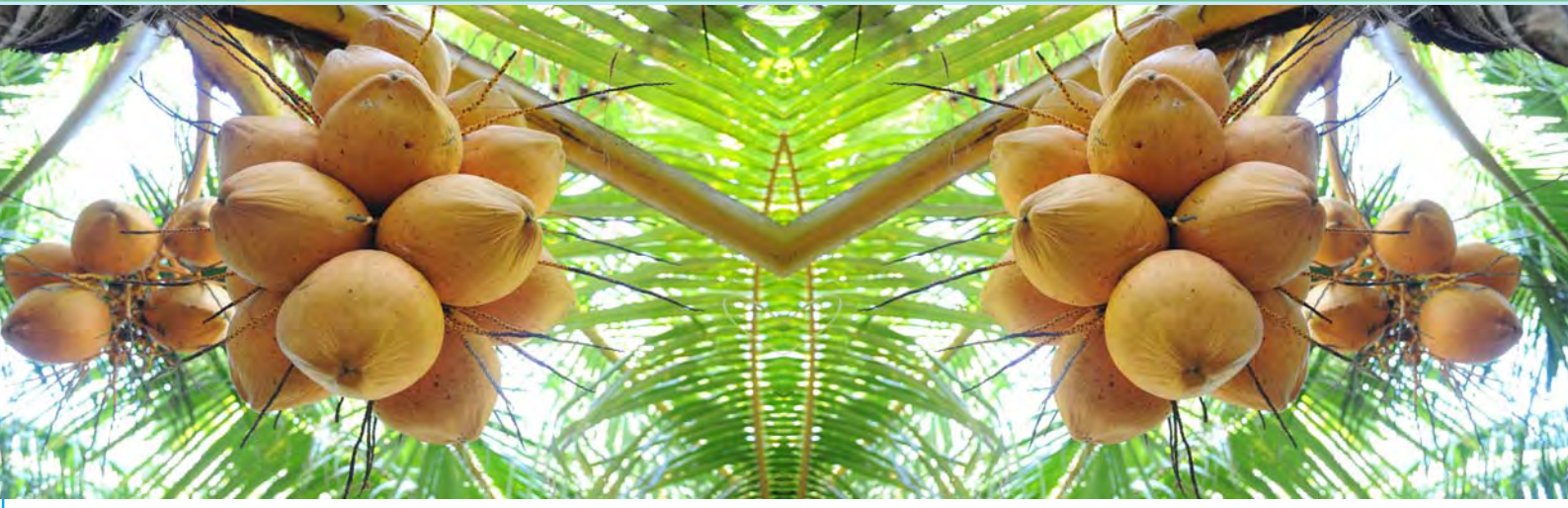
ICAR-KVK, ALAPPUZHA

Category	Sanctioned	In position	Vacant
Scientific	1	1	-
Technical	11	10	-1
Administrative	1	1	-
Supporting	2	-	-2
Total	15	12	-3
Grand Total	429	297	-132

Details in chapter XVII – Personnel

Budget and Expenditure (Rs. in lakhs)

Head	Allocation	Expenditure
Budget	7959.84	7955.65
Revenue Generation	**221.89**	



VI. RESEARCH ACHIEVEMENTS

VI. 1. GENETIC RESOURCES MANAGEMENT AND UTILIZATION

Germplasm Enrichment and Conservation

Field gene banks

At the Institute, a total of 455 coconut accessions, 178 arecanut accessions and 515 cocoa accessions are being conserved in the field gene banks. The coconut gene banks are at Kasaragod and Kidu. Arecanut and cocoa gene banks are at Vittal. In addition, alternate sites of conservation are established at Mohitnagar and Kahikuchi for coconut and at Kidu for cocoa. The Institute also hosts the International Coconut Genebank for South Asia and Middle East-ICG-SAME at CPCRI, Research Centre, Kidu in Karnataka.

Cryopreservation of germplasm

Complementary conservation of core coconut germplasm in collaboration with ICAR-NBPGR, New Delhi was undertaken and during the year, zygotic embryos of 30 accessions, pollen of 15 and DNA of 16 accessions, encompassing South East Asia, South Asia, Africa, Pacific Ocean, Indian Ocean region were cryopreserved at National Cryo Gene Bank ICAR-NBPGR, New Delhi.

Germplasm collection

A coconut accession with green large fruits (> 1.2 Kg), pink mesocarp, dwarf plant habit and green petiole color was identified in South Andamans along with ICAR-CIARI for collection. Two arecanut germplasm accessions were collected. Semi-tall plant habit with putative tolerance to fruit rot disease (collection from Dakshina Kannada, Karnataka); and high yielding and putative tolerance to flooding and less fruit rot disease (collection from Kodagu, Karnataka). Seed nuts of Andaman dwarf arecanut were received from ICAR-CIARI, Port Blair for conservation at field gene bank, Vittal.

Fig. 1. Trait specific arecanut germplasm collected from Dwaraka Estate, Kodagu district, Karnataka

Germplasm Characterization and Evaluation

Coconut

At Kasaragod, accessions viz., Jamaica Tall, Gonthembili Tall, Gangapani Tall, Nigerian Tall, British Solomon Islands Tall, Markham Tall, Lifou Tall, Kappadam Tall, Niu Bulava Tall, Benaulium, Calangute, Verikobbari Tall, Kaithathalli Tall, Guam II Tall, Andaman Ordinary Tall, Palawan Tall, Fiji Tall, Nugli Tall, Goja Tall, Orissa Giant Tall, Dhanei Tall, recorded higher annual nut yield as compared to the local control. While among the dwarfs, Niu Leka Dwarf, Cameroon Red Dwarf, Laccadive Orange Dwarf showed higher fruit yield potential.

Among the exotic and Indian germplasm conserved in ICG-SAME at Kidu, higher production potential, in terms of high annual bunch production and fruit yield were recorded in Philippines Lono Tall, Laccadive Micro Tall, Tiptur Tall, West Coast Tall, Panama Tall, Laccadive Ordinary Tall, Niu Hake Tall, Nadora Tall, Pao Pao Tall, Kayemkola Tall, while amongst dwarfs, Kulashekaram Yellow Dwarf, Chowghat Green Dwarf, Malayan Yellow

Dwarf, Malayan Green Dwarf, Cameroon Red Dwarf recorded higher fruit yield.

Among the conserved indigenous germplasm at Kidu, higher number of bunches, female flower and nut yield were recorded in Chandan Nagar Tall, Mayipadi Tall II, Katchal Micro Tall, Laccadive Micro Tall, Kaveing Tall, Kodiaghat Big Round Tall, Pinarai Tall and Ponnani Yellow Tall. Breeding behaviour studies undertaken in five indigenous and 15 exotic accessions at Kidu, indicated considerable variation in floral biology, pollen biology as well as fruit setting percentage.

At Mohitnagar, among the 31 accessions under evaluation in sub Himalayan Terai region, higher annual nut yield was recorded in BARI Narikel 1, followed by Chinasukhania and Agailjhara Tall. JAMT recorded higher fruit weight followed by BARI Narikel 1 and Agailjhara Tall. Agailjhara Tall recorded high copra content (238 g). Among hybrids, higher yield was recorded in Chandra Laksha followed by Kera Ganga and Laksha Ganga, while among the dwarfs, higher fruit yield was recorded in COD followed by MGD.

At Kahikuchi, fruit yield, fruit component characters and tender nut water content of 15 accessions were studied. Among hybrids, higher annual nut yield was recorded in Kera Sankara and Chandra Sankara and among dwarf accessions, COD recorded higher annual nut yield. Assam Tall recorded higher fruit weight, fresh endosperm content and endosperm thickness. Fiji Tall recorded higher fruit length, husk thickness and husk percentage. Tender nut water content was higher in Assam Tall (485 ml) and COD (428 ml).

Among the 13 local genotypes (KKHC 1-13), KKHC 1 was found to produce higher plant height (4.74 m). However, number of leaves on the crown was found to be higher in KKHC 4 (23.54) followed by KKHC 5 (22.81). KKHC 5 recorded higher annual yield, while KKHC 12 recorded higher fruit weight and fresh endosperm content (320 g). Husk percentage varied from 29% (KKHC 4) to 48% (KKHC 11).

Screening against abiotic/biotic stress and studies on pest dynamics: Among the 15 putative cold tolerant lines at Mohitnagar, annual growth parameters varied significantly. However, during the winter season, none of the palms showed cold injury symptoms.
Fortnightly observations on incidence of rugose spiralling whitefly on selected palms at Kasaragod, indicated higher infestation index in dwarfs viz., COD, MYD, CGD (2.48, 2.38 and 2.21, respectively) while WCT exhibited lower infestation index (0.52).
Population studies: At CIARI, Port Blair, observations on the seed nuts from the high yielding palms of Andaman Ordinary Tall population revealed striking uniformity for fruit morphology, days taken for germination and seedling vigour. Fruit component studies revealed that the kernel content ranged from 410g to 580g and the kernel thickness ranged from 0.95 cm to 1.65 cm. The shell thickness was observed to vary from 0.25 cm to 0.95 cm which is considered a wide range in any coconut population.

Varietal development: During the year, Kalpa Ratna, a multi-purpose coconut variety, was notified in the Gazette for sale in the states of Kerala, Karnataka and Tamil Nadu. Variety release proposals for Andaman Green Dwarf and Andaman Yellow Dwarf are developed at ICAR-CIARI.

Comparative evaluation of dwarf accessions: In comparative evaluation of 28 dwarfs, including indigenous germplasm and selections from dwarfs of South Asian, South East Asia, Pacific, Indian Ocean, African and Atlantic origin resulted significant differences for juvenile growth characteristics. Higher plant height and longer leaves were observed in Andaman Green Dwarf, Malayan Green Dwarf, robust trunk was noted in Niu Leka, Andaman Green Dwarf followed by the Malayan Green Dwarf, shorter and slender trunk in Samoan and Sri Lankan Yellow Dwarf. Significant differences in onset of flowering and inflorescence characters were also recorded. Niu Leka Dwarf was relatively late in flowering while early flowering was recorded in Rangirova Red Dwarf. Longer inflorescences with higher stalk length observed in Malayan Green Dwarf and King Coconut, while higher number of female flowers was recorded in Spicata Yellow Dwarf followed by Rangirova Red Dwarf. Wide variability in tender nut water content (ranging from 37 ml in RRD to 603 ml in IND089S) and copra content (ranging from 44 g in NGOD to 173 g in AOD) was also observed. Variation in total sugars, Na and K content of tender nut water were also observed. Higher initial fruit yield was recorded in Andaman Green Dwarf, Niu Guinea Orange Dwarf, Rangirova Red Dwarf, Laccadive Orange Dwarf, King Coconut, Andaman Orange Dwarf and Andaman Yellow Dwarf.

Evaluation of germplasm for industrial applications/ product diversification: Evaluation of milk yield and milk quality parameters in three talls (Blanchisseus,

Benaulim, West Coast Tall) and two hybrids (Chandra Sankara, Kera Sankara), indicated suitability of West Coast Tall and Chandra Sankara, with better endosperm qualities and higher fat content for VCO production.
Studies on physico-chemical properties of testa oils of six genotypes (WCT, FMST, COD, MYD, CRD x GBGD, MYD x CGD), revealed proportion of testa in de-shelled fruit ranging from 1.3% (COD) to 3.4% (MYD). Proportion of oil in testa varied from 41% (MYD) to 51% (CRD x GBGD). Presence of proxidants Fe (CRD x GBGD: 34.2 ppm to FMST: 62.5 ppm) and Cu (WCT: 1.63 ppm to MYD x CGD: 2.77 ppm) indicated susceptibility of these oils to oxidative damage. Testa oil from COD and MYD x CGD showed relatively high acid values, peroxide values, iodine values and also relatively high levels of Cu content suggesting susceptibility to oxidative rancidity.

Production of planting material for conservation & multi location evaluation: About 1475 seed nuts, including inter se mated/selfed seed nuts of 15 accessions, were sown for generation of planting material for experimental purpose/conservation. There is wide variability observed for time taken for germination and seedling traits. Initiation of germination was relatively late in case of LCOD and COD.

Multiplication of germplasm from WCGC, Andamans: At CIARI, Port Blair, six accessions viz, Rennel Tall, Katchal Tall, Auck Chung Tall, Tahiti Tall, Tamaloo Tall and Pao Pao Tall were identified as potential accessions for utilization in crop improvement programmes for fruit yield, higher recovery of VCO and desirable nut component and palm features. Niu Leka with orange fruits was identified to develop as unique genetic stock from Niu Leka Green dwarf population.

Farmer Participatory evaluation trials: Performance evaluation trial of released selections viz., Kalpa Sreshta, Kalpa Pratibha, Kalpatharu, Kalpa Mitra, Kera Chandra, Kalparaksha, Kalpa Surya, Kalpa Jyothi, COD, Kalpa Ratna and the hybrids viz., COD x WAT, COD x LCT, planted during 2018, is in progress in farmer's field in, Tamil Nadu.

Arecanut

Evaluation of arecanut germplasm at Vittal, Mohitnagar and Kahikuchi: Among the germplasm planted during 1988 (14 accessions), higher chali yield of 3.7 kg was recorded in Mohitnagar. Among the germplasm planted during 1990 (eight accessions), higher chali yield per palm per year was recorded in Sweet Arecanut (1.39 kg) followed by VTL-29 (1.25 kg). Among the germplasm planted during 1991 (12 accessions), maximum chali yield (4.09 kg) was recorded VTL-27. Among the accessions planted during 1992, higher chali/palm (2.77g) was recorded in VTL18(c). Among the 19 NE collection planted during 1994, higher chali yield (3.56 kg) was recorded in Nalbari. At Kahikuchi center, accession Borehat was found to produce higher number of nuts (68.72) and fresh nut yield (4.32 kg).

Estimation of arecoline content from different parts of arecanut palm: Arecoline content was estimated from three different parts viz., leaf sheath, inflorescence and roots of five arecanut varieties. In leaf sheath, arecoline content was found to be ranged from 227.01 µg/g to 329.50 µg/g. Lowest arecoline content was observed in Madhuramangala (227.01 µg/g) and the highest arecoline content was recorded in Swarnamangala (329.50 µg/g). Among the inflorescence samples, lowest arecoline content was recorded in Swarnamangala (170.01 µg/g) and highest arecoline content was observed in Nalbari (462.69 µg/g). Among the root samples, lowest arecoline content was recorded in Sumangala (482.87 µg/g) and the highest was recorded from Sreemangala (8552.86 µg/g).

Cocoa

Morphological characterization and evaluation: Eight local collections were characterized with 20 morphological, quantitative and qualitative traits, passport data was documented and IC numbers were obtained from NBPGR (Table 1).

Table 1. Local cocoa collections along with IC numbers

Vittal Gene Bank No.	Name	Indigenous Collection No.
VTLC- 532	Vittal Criollo	IC 0639775
VTLC- 533	Kallar Criollo	IC 0639776
VTLC- 534	Kulasekharam Criollo	IC 0639777
VTLC- 535	Wayanad Criollo	IC 0639778
VTLC- 536	Vittal Trinitario	IC 0639779
VTLC- 537	Idukki Trinitario	IC 0639780
VTLC- 538	Kulasekharam Trinitario	IC 0639781
VTLC- 539	Shiradi Trinitario	IC 0639782

Cocoa germplasm collections of different age groups from 12 - 25 years were evaluated for their growth and yield performance. Among 14 year old Ghana

collections (15 accessions), VTLC 87 and VTLC 100 recorded higher yields (2 kg dry beans/tree/year). Among 40 Amazon collections, VTLC 145, 156 and 151 had 2 kg dry bean yields/tree/year. Among 12 year old Peruvian collections (30 accessions), VTLC 233, 205 and 210 had 2 kg dry beans yields/tree/year. Among 21 year old cocoa collections at Kahikuchi, dry bean yield ranged from 0.51 to 1.98 kg/tree/year. KHIC-21 recorded bigger pods (720 g), maximum number of beans per pod (40) and high dry bean yield (1.98 kg).

Trait Specific Cocoa Germplasm: IC 565611 was identified with flowers having long pedicel (3-4 cm), IC 565565 with pods showing rounded apex without basal constriction, IC 597837 with 40-45 beans/pod and IC 597838 with larger beans (>1.2 g).

Evaluation of regional cocoa beans for qualitative improvement: In Andhra Pradesh, single dry bean weight varied from 0.80-1.62 g with 34.9-64% fat, in Karnataka, 1-1.56 g bean weight with 51-52% fat, in Kerala, 1-1.66 g bean weight recorded with low fat of 42-47% and in TN beans are of 1- 1.2 g weight with 42-50% fat.

Tolerance to black pod rot disease: Transcriptomes of black pod rot resistant cocoa variety VTLCH 2 and a susceptible variety Forastero were generated. Plant-pathogen interaction and plant hormone signal transduction pathways related to disease resistance were annotated. 165 up-regulated and 63 down-regulated transcripts identified. It is found that important plant stress- responsive genes like WRKY, MYB and cytochrome P450 were up- regulated during disease condition.

Characterization and evaluation of black pepper germplasm

Thirteen black pepper accessions, trained on arecanut standard, were studied for yield and qualitative traits under Assam condition at ICAR-CPCRI, RC, Kahikuchi. Fresh pepper yield varied from 5.13 kg/vine to 10.39 kg/vine. Accession IC-0599145 recorded higher fresh yield (10.39Kg/vine) as well as dry pepper yield (3.84Kg/vine). Descriptor traits were studied in these accessions and shoot tip colour, leaf margin and leaf base shape were observed to be distinctly different in some of the accessions.

Germplasm Utilization

Coconut

Hybrid evaluation trial: Among the D x T hybrid evaluation trials, comprising of 28 D x T hybrid combinations planted at Kasaragod during 2013 & 2014, higher fruit yield was observed in GBGD X CCNT, MGD X SNRT, COD X CCNT, CGD X SNRT, MYD X CCNT. Higher tender nut water content was observed in hybrids with SNRT as one of the parents viz., CGD X SNRT, GBGD X SNRT and MYD X SNRT.

In the D x D evaluation trial planted at Kasaragod in 2016 with 14 hybrid combinations involving seven dwarf parents, the hybrid combinations viz., MYD x CGD, COD x GBGD, CGD x MOD, CRD x GBGD, CGD x MYD, CGD x CRD, GBGD x CRD, CGD x GBGD, MOD x GBGD, GBGD x COD, MYD x NLAD, CRD x CGD, MOD x NLAD, COD x NLAD recorded early flowering, within four years of planting. Preliminary observations on fruit yield indicated higher nut production in CGD x MYD, CGD x CRD and CGD x MOD. The fruit size was larger in MOD x NLAD, CGD X MOD, CGD X GBGD and MYD X NLGD while higher volume of tender nut water was recorded in CGD X GBGD and MYD x NLAD.

In the hybrid evaluation trial planted at Kidu during the 1996, WAT x NAT and WAT x RET performed better in terms of bunch and nut yield. In the hybrid evaluation trial planted at Kidu in 1998, CGD x LCT, CGD x PHOT and LCT x CGD recorded better nut yield. In hybrid evaluation trial planted during 2014 at Kidu, comprising of 26 D x T hybrid combinations, MGD x CCNT, MYD x SNRT and CGD x SNRT recorded superior nut yield. In the D x D trial planted at Kidu in 2003, CGD x GBGD, COD x NLGD, COD x CGD showed better performance in terms of nut production.

At Kidu, pollination work was undertaken for producing eight new cross combinations (Cocobelu x FMST, Cocobelu x ADOT, SUBD x Renell Tall, SUBD x FMST, COD x Renell Tall, MYD x ADOT, MYD x Renell Tall, GBGD x Renell Tall).

In the TxT hybrid evaluation trial planted at Kasaragod, the hybrid PHOT x FJT recorded significantly highest plant girth at base. Total number of leaves were maximum in ADOT which was on par with FJT x WCT and PHOT. WCT x ADOT recorded significantly higher length for 10 internodes and PHOTxWCT recorded maximum number of leaf scars in 1 m. The crosses between FJT x WCT were better female flower producers compared to other crosses in this experiment. Higher nut production was recorded with FJT x WCT followed by WCT. The volume of tender nut water was higher in WCT x FJT compared to other

hybrids and varieties. Significantly the highest fruit weight was recorded with WCT x Pratap. Copra content was higher in AO x WCT followed by WCT x ADOT.

Assessment of drought tolerance in D x T hybrids: The effects of drought on leaf anatomical characteristics were investigated in eight hybrids (CODxWAT, CODxLCT, CODxWCT, CODxADOT, MYDxWCT, MYDxWAT, MYDxLCT, and MYDxADOT) and WCT (control). Thickness of epidermis was associated with drought tolerance; genotypes with higher epidermal thickness had lower water loss rates. Among the hybrids higher thickness of upper and lower epidermis was observed in COD x LCT followed by WCT. Drought tolerance was also associated with thick palisade mesophyll layers. Among the hybrids the thickness of the palisade and spongy mesophyll tissues was more in COD x LCT. Among the hybrids the diameter of the xylem is more in COD x LCT followed by COD x WAT. Among the genotypes, MYDxWCT recorded reduced number of stomata per microscopic field. A comparison of leaf anatomy is made in Fig. 2.

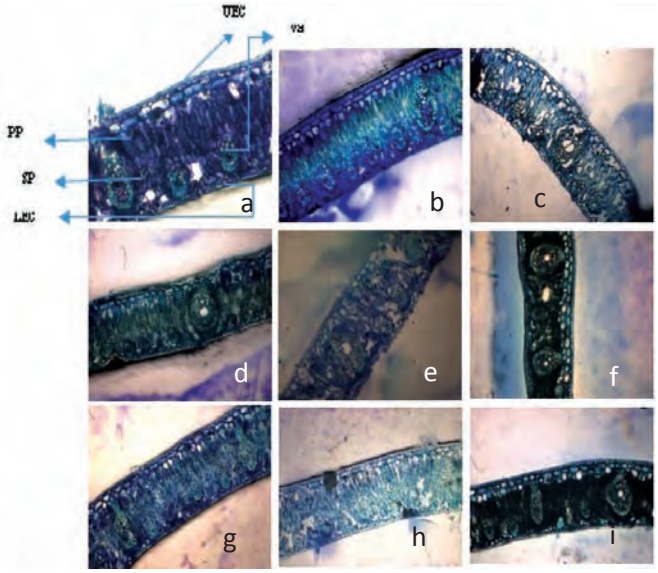


Fig 2. Leaf anatomy of coconut hybrids and WCT. Leaf cross sections showing the upper epidermis cell (UEC), lower epidermis cell (LEC), palisade parenchyma (PP), spongy parenchyma (SP) and vascular bundles (VB) under a light microscope.a) CODxWAT, b) CODxLCT, c) CODxWCT, d) CODxADOT, e) MYDxWCT, f) MYDxWAT, g) MYDxLCT, h) MYDxADOT and, i) WCT

Evaluation of tall accessions of coconut for resistance / tolerance to root (wilt) disease of coconut: In the evaluation trial involving thirteen tall accessions planted during 2014, highest incidence of root (wilt) disease after seven years of planting was recorded in FMST (33.3%) followed by SNRT (12.5%). The accessions, ADOT and PHOT remained disease-free. The average nut yield was highest in St. Vincent Tall (56 nuts/palm/year) followed by Kalpa Haritha (50.76 nuts/pal/year). Significant differences were observed for mature nut characters among the different tall accessions.

Fruit weight was highest in Andaman Giant Tall (2603g) followed by STVT (2206 g). Fruit length was highest for ADOT (28.5 cm) followed by STVT (27.05 cm). Dehusked nut weight was highest for FMST (1211g) followed by SNRT (977 g). Highest husk weight and husk thickness was recorded in AGT (1644 g and 3.17 cm respectively). Highest kernel thickness was recorded in STVT (1.55 cm) and was on par with JVT (1.54 cm). Copra content was highest in FMST (262 g) and was lowest in Kalpa Haritha (133.18g) (Table 2). Among the thirteen accession, volume of tender nut water was highest in Philippines Lono (726 ml) followed by Philippines Laguna (680 ml) and was lowest in JVT (266ml). Significant differences were also observed among coconut varieties in respect of mineral composition in tender nut water. Highest calcium content was recorded in AGT (416.9 ppm) followed by PLNT (334 ppm). Zinc content was highest in Philippines Lono (0.714 ppm) followed by STVT (0.604 ppm). Manganese content was highest in PLNT (4.65 ppm) followed by Guam Tall (4.52 ppm). Copper content was highest in JVT (0.024 ppm) followed by STVT (0.02 ppm).

Evaluation of green dwarf varieties for resistance / tolerance to root (wilt) disease of coconut: In the evaluation trial involving six green dwarfs planted in 2013, the root (wilt) incidence was highest in GBGD (14.8%) followed by Niu Leka Dwarf and Andaman Green Dwarf (7.4%). Kalpasree and Gudanjali Green Dwarf remained disease-free even after seven years of planting. Average yield was highest in Kalpasree (141 nuts/palm/year) followed by Andaman Green Dwarf (128.6 nuts/palm/year). The average yield of Gudanjali Green Dwarf was 105.2 nuts/palm/year. Significant differences were observed among dwarf varieties of coconut varieties in respect of mineral composition in tender nut water. Highest sodium content was recorded in Andaman Green Dwarf (34.6 ppm) followed by King Coconut (19.63 ppm). Highest potassium and Zinc content were recorded in Niu Leka Dwarf (2285 ppm and 0.8095ppm) followed by Andaman Green Dwarf (2182.5 ppm and 0.8065 ppm). Manganese content was highest in Kalpasree (4.0187 ppm) followed by

Andaman Green Dwarf (3.9613 ppm). Boron content was highest in Andaman Green Dwarf (0.8643 ppm) followed by Kalparaksha (0.8147 ppm). Iron content was highest in Gangabondam Green Dwarf (0.2653pm) followed by Niu Leka Dwarf (0.246 ppm).

Evaluation of WCT x WCT palms: WCT x WCT progenies produced by crossing high yielding and root (wilt) disease-free West Coast Tall (WCT) palms. The parental palms for crossing were selected during the period 1993-94 from 'hotspots' of root (wilt) disease after serological testing and crossing were carried out during 1994-96. WCT x WCT progenies planted during 1996-98 are superior in terms of higher yield and recorded less root (wilt) disease incidence compared to WCT (OP) and WCT (Self) progenies. The four years average yield of WCT x WCT progenies was 80.1 nuts/palm/year. The healthy palms gave on an average 158 nuts and the diseased palms gave an average yield of 65 nuts. Performance evaluation trials at CDB Farm, Neriamangalam revealed that the average yield of four years (2015-19) of WCT x WCT was 91.25 nuts/compared to WCT (OP) which yielded 69.44 nuts/palm. It was recommended for release for cultivation in root (wilt) disease prevalent tract.

Developing coconut inbreds: In the inbred development programme, 117 S3 seedlings from six S2 families along with 33 palms of WCT S2, WCT (OP), WCT S2 x GB, WCT S1, GB x WCT S2, and MYD x WCT S2 have established in the field. Difference in growth characters was observed in S3 seedlings. This year 21 palms from six S3 families have started flowering.

On Farm Trial: Performance assessment of newly released hybrids Kalpa Samrudhi and Kalpa Sreshta is in progress at farmer's gardens in Karnataka, Kerala, Andhra Pradesh and Tamil Nadu. A new hybrid evaluation trial involving eight new D x T hybrids is in progress in a farmer's field near Puttur in Karnataka. Another trial of new D x T hybrids is in progress in farmer's field in Erode District, Tamil Nadu.

Unique dwarf character: A unique dwarf coconut was identified among progeny of Lakshadweep population field planted at Kasaragod. There was no fruit set in this dwarf palm so far. Pollen of the dwarf palm was pollinated with COD and 54 seedling progenies were raised. The seedlings were field planted at Kasaragod during 2018 and morphological observations on these seedlings were recorded.

Association mapping for MAS: The phenotypic traits were observed in the 216 palms of 16 genotypes used for association mapping studies. Vegetative, reproductive, yield and fruit component traits displayed quantitative variation among the 16 coconut genotypes. Among the genotypes, stem girth at base ranged from 57.7 cm (GUGD) to 155.5 cm (FJT), length of leaflet bearing portion ranged from 383.7 cm (GUGD) to 595.8 cm (JSBT), length of single inter-node ranged from 3.2 cm (GUGD) to 6.7 cm (LMT), length of spikelet bearing portion ranged from 22.8 cm (GUGD) to 48.8 cm (JSBT), number of spikelets per inflorescence ranged from 19.3 (GUGD) to 38.8 (JSBT), number of bunches/ year ranged from 10.2 (MGD) to 14.8 (PHOT), number of nuts per palm ranged from 34.4 (CRD) to 127 (LMT), fruit weight ranged from 233.8 g (GUGD) to 979 g (SNRT) and copra weight ranged from 77.8 g (CGD) to 260.8 g (SNRT). Principal Component Analysis revealed that the first three principal components (PC1, PC2 and PC3) accounted for 64.09%, 16.93% and 6.2 % of the variation, respectively accumulating to a total of 87.22% of the total variability among the coconut accessions evaluated. The traits viz., stem girth at base, stem girth at 0.5m, stem girth at 1m, length of the leaf, length of the leaflet bearing portion, number of leaflets, length of leaflet, length of inflorescence, length of spikelet bearing portion, length of spikelet, number of spikelets/inflorescence, fruit weight, nut length, nut girth and copra weight had highest loading. The genotypes were screened with 71 SSR markers and among them 32 SSR markers were found to be polymorphic.

Arecanut

Evaluation of arecanut dwarf hybrids at Vittal, Mohitnagar and Kahikuchi: Among the eight arecanut dwarf hybrids and five parents evaluated at Mohitnagar, maximum number of nuts per palm was recorded in the hybrid Mohitnagar x HD (245) followed by HD x Sumangala (242). Maximum chali or dry kernel yield of 2.08 kg/palm/year was recorded in Mohitnagar x HD followed by HD x Mohitnagar (1.84 kg chali/palm/year). In case of parental lines, maximum chali yield was recorded in Mohitnagar (3.81 Kg) followed by Mangala (3.26 Kg).

Multi Location Trial on arecanut consisting of six parents and eight hybrid combinations showed that, maximum fresh nut yield (7.88 Kg/palm) and number of nuts per palm (213.70) was recorded in Mangala. Among the hybrid combinations, Hirehalli Dwarf x Sumangala recorded the maximum fresh nut yield (4.12 Kg/palm)

and number of nuts per palm (124.25).

Cocoa

Comparative Yield Trial (CYT) of Clones and Hybrids of Cocoa: Ten cocoa genotypes evaluated over 12 to 15 years resulted in identification of a promising clone C1-1-63. It is a long fruited, light green type having 50-100 pods/tree/year in 16 m2 canopy. It recorded 43-45 beans/pod having 1-1.25 g single dry bean weight and recorded 2.5-3.0 kg dry bean yield. It showed processing value with 15-18% shelling percentage, 82-85% nib recovery and 50-52% fat content and had good fatty acid profile. They are found to be suitable to grow in high densities under arecanut and coconut.

Fig 3. Promising cocoa clone VTLCC- 2

Promising Cocoa Hybrid VTLCP 9: It is a hybrid between VTLC-11 x VTLC-9 is found to be promising. It is a Forastero type with green smooth pods. This hybrid was found to be precocious, stable and heavy bearer from progeny trials and clonal evaluation carried out for 12 to 15 years and has optimal canopy (16-20 m2) both under arecanut and coconut gardens. It had an average of 65-80 pods/tree/year, 40-45 beans/pod, single bean dry weight of 1.1-1.2 g. It recorded the highest dry bean yield of 2.5-3.0 kg/tree/year. This hybrid recorded processing value of 12-13% shelling percentage, 87-88% nib recovery, 50-55% fat content and with 1% free fatty acids. It can be grown under normal and high density plantings of arecanut and coconut. Exhibited tolerance to black pod rot, tea mosquito bug, low moisture stress.

Evaluation of Exotic Cocoa Hybrids: Among the three Malaysian cocoa hybrids evaluated over 12 years, MH-1 recorded 51-115 pods/tree/year with 2.5-3.0 kg dry bean yield whereas MH-2 recorded 32-51 pods/tree/

Fig 4. Promising cocoa hybrid VTLCH- 6

year with 2.0-2.5 kg dry beans. Among two Philippines hybrids, PH-1 and PH-2 yielded 24-42 pods/tree/year with 1.5 kg dry bean yields.

Multi Location Trial (MLT) of Cocoa Clones and Hybrids: Kasaragod: Two parental clones VTLC-5 and VTLC-30 and two hybrids VTLCH-1 and VTLCH-2 are identified as best performers with 1.02 to 1.22 kg dry bean yield over 12 years of evaluation under coconut.

Kahikuchi: VTLC-19 is identified as best performer over eight years of evaluation as seedlings with 1.76 kg dry bean yield.

Kayamkulam: VTCP-21 recorded the highest pod yield of 100 pods/tree among the 25 promising cocoa clones evaluated under coconut.

Mohitnagar: Pod yield ranged from 48-110 under arecanut and 44-101 under coconut.VTLCH-11 was found to be better performer both under arecanut and coconut followed by VTLCH-1 and VTLCH-4.

Planting Material Production

Production of planting material of mandate crops was undertaken in different centres resulting in revenue

Table 2. Planting material production in Coconut, Arecanut and Cocoa generation to the tune of Rs 236.12 lakhs (Table 2) .

Centre	Coconut			Arecanut			Cocoa		
	Varieties	Hybrids	Total	Seed-nuts	Seedlings	Total	Pods	Seedlings/ grafts	Total
Kasaragod	26483	21459	47942	-	-	-	-	-	-
Vittal	-	-	-	-	101352	101352	8585	39061	47646
Kayamkulam	1635	-	16354	-	-	-	-	-	-
Kidu	28331	17152	45483	470430	44706	515136	70	571	641
Kahikuchi	-	-	-	29738	-	29738	-	-	-
Mohitnagar	1675	-	1675	28000	-	28000	-	-	-
Total	72843	38611	111454	528168	146058	674226	8655	39632	48287

DUS Centre for coconut

DUS characteristics were recorded in candidate variety (REG/2015/415) planted in DUS field with three reference varieties in 4 m x 4 m spacing. Reference variety 1 and 2 recorded earliness in flowering. In addition to the DUS descriptive traits, additional observations on growth parameters and leaf morphology were recorded, and indicated relatively higher palm height, collar girth, total length of leaf, number of leaflets and leaflet length in candidate variety as compared to reference varieties. Along with the candidate and reference varieties, three more example varieties were planted and DUS characteristics were recorded.

Observations on morphological growth characters recorded on varieties under maintenance breeding (planted during 2011) revealed variation both between accessions and spacing. Relatively higher values were recorded for most of the growth characters in 4 m x 4m spacing except for leaf production and leaflet breadth, which were higher under 6 m x 6 m spacing. Among varieties, higher trunk length was recorded in Kalpatharu, longer leaves in Chandra Kalpa and broader leaflets in Kalpa Dhenu.

DUS Centre for Arecanut

Estimated arecoline content from dry kernels of sixteen arecanut DUS reference/ example varieties, namely Mangala, Sumangala, Sreemangala, Mohitnagar, Swarnamangala, Kahikuchi, Madhuramangala, Nalbari, Shatamangala, VTLAH-1, VTLAH-2, Hirehalli Dwarf, S.K. Local, Thirthahalli, Sagar and Sirsi. Lowest arecoline content was recorded from the dry kernel of Sumangala with arecoline content of 796.10 µg/g followed by Sagar (799.80 µg/g). Highest arecoline content was observed in the dry kernel of Hirehalli Dwarf (1295.63 µg/g) followed by Mohitnagar (1264.52 µg/g).

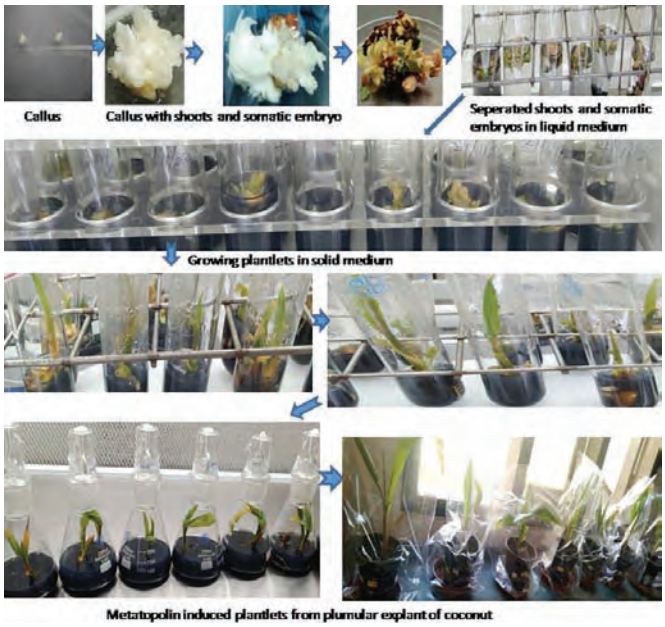
VI. 2. BIOTECHNOLOGICAL INVESTIGATIONS

Coconut Tissue Culture

Experiments with growth regulators on callus induction, formation of embryogenic calli and somatic embryos

Coconut plumular explants were inoculated in M72 medium with picloram as the auxin source. Serial reduction in the auxin concentration and addition of a polyamine (spermine) and an aromatic natural cytokinin (metatopolin) induced somatic embryos and shoots. The shoots, when grown in a solid medium supplemented with BAP, NAA, IAA and IBA followed by transfer to liquid medium, developed into complete plantlets. A maximum of seven plantlets could be obtained from a single plumule following this protocol.

Fig. 5. Use of metatopolin in *in vitro* propagation of coconut from plumular explants.



Initiation of coconut friable callus for suspension culture

Plumular explants of coconut were inoculated in thirteen media combinations with M72 and Y3 as the basal media (full as well as 1/2 macro), with picloram and 2,4-D as the auxin source, together with flurprimidol and adenine sulphate, for induction of friable callus. Limited friable callus was obtained from M72 (1/2 macro) + picloram + flurprimidol. Inoculating the friable calli into suspension culture media [Y3 + picloram + zeatin riboside + ascorbic acid and malt extract] resulted in cell multiplication, though to a limited extent.

Charcoal impregnated calcium alginate spherules in suspension culture

Seventy combinations of calcium alginate spherules (Two sizes; S1: 6 mm and S2: 4 mm diameter), impregnated with sodium alginate (1, 2, 3, 4 and 5%) and calcium chloride (0.025, 0.05, 0.1, 0.2, 0.3, 0.4 and 0.5 M) were prepared to investigate their utility for orbital shaker tolerance and autoclavability. The solution, in which the autoclaved beads were kept for 15 days in orbital shaker, was tested for turbidity and the beads with less nephelometric turbidity unit (S1T20: 3% sodium alginate, 0.4 M calcium chloride; S2T13: 2% sodium alginate, 0.4 M calcium chloride and S2T28: 4% sodium alginate, 0.5 M calcium chloride) were selected. Twelve combinations of the selected beads were prepared with 0, 1, 1.5 and 2g L^{-1} activated charcoal and were tested for phenol adsorption in gallic acid as well as in coconut suspension cultures. The results reveal that S1 beads, with charcoal 2 g L^{-1}, adsorbed more phenols. Among the smaller sized beads, S2T13 adsorbed more phenols than S2T28 . This study thus provides a way forward alternative of incorporating activated charcoal impregnated calcium alginate spherules, in cell suspension cultures, to circumvent the problem of phenolic interference as well as enhancing the visibility and quantifiability of the cultures.

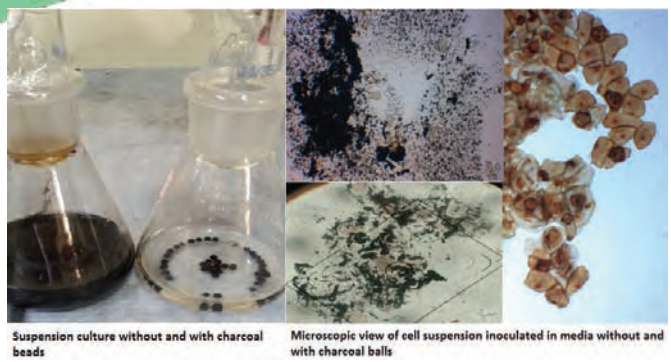


Fig. 6. Use of charcoal beads in cell suspension culture initiated from plumular callus of coconut.

Immature inflorescence culture

For refining the immature inflorescence culture protocol, four media combinations (Y3 with 1 mg/L 2,4-D, Y3 with 100 mgL^{-1} along with 3 mgL^{-1} 2ip, Y3 with 72 mgL^{-1} picloram and Y3 with 36 mgL^{-1} picloram) were evaluated for culture initiation using rachillae bits of 1 mm size collected from West Coast Tall palm. The explants, cultured in picloram supplemented media, turned brown within two weeks after inoculation and cultures in other media combinations enlarged and formed white shoot like outgrowth. However, in subsequent subcultures, the cultures in Y3 media with 2,4-D 100 mgL^{-1} and 2ip also turned brown, indicating that Y3 with 1mgL^{-1} 2,4-D as best suited media for culture initiation using immature inflorescence.

The effect of different culture vessels such as commercial jam bottles with polypropylene caps, Magenta containers, and conical flasks with special glass stoppers and different gelling agents (agar, carrageenan, gellan gum, clerigar) on in vitro culture of coconut were investigated. Among the different gelling agents, gellan gum at 2.5 gL-1 resulted in more multiple shoots (6.2), followed by Clerigar (5gL-1) and no. of vitrified shoots was also more in cultures grown in media containing gellan gum. Among the different culture vessels tested, microbial contamination was minimum in cultures grown in conical flasks with special stoppers (less than 1%) compared to jam bottles (3.5%) with polypropylene lids and magenta containers (6.2%). The subculturing frequency could be reduced during the multiplication phase when cultured in a conical flask with a stopper (once in 2 months). This could be due to the special lid having an inner S-shaped structure plugged with cotton, which allows gas exchange.

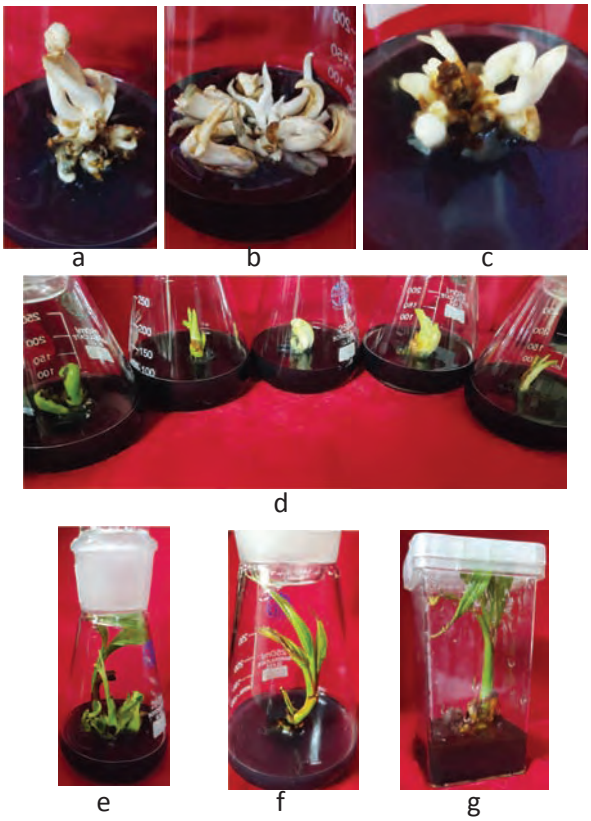


Fig. 7. Effect of different culture vessels and gelling agents on immature inflorescence culture in coconut. A. Cultures in agar; B. Cultures in gellan gum; C. Cultures in clerigar, D. Multiple shoots obtained from single rachillae bit; E. Shoot regeneration in conical flask with special stopper; F. Shoot regeneration in conical flask with special stopper; G. Shoot regeneration in magenta container.

Arecanut Tissue Culture

Immature inflorescence culture

Somatic embryos were produced from immature inflorescence culture initiated from VTLAH2 (HD x Mohitnagar). Plantlets derived from these cultures were in different growth stages. Embryogenic calli obtained from immature inflorescence culture of VTLAH2 were cultured in Y3 medium with 0.5mg L^{-1} of BAP and varying glutamine concentrations, i.e., 0, 200, 400 and 600 mg L^{-1}. Relative increment in callus weight was highest in 200 mg L^{-1} glutamine treatment.

Arecanut callus multiplication media was modified to hasten the callus multiplication rate and somatic embryogenesis. Regular arecanut multiplication media with picloram-2.5µM was replaced with a polyamine compound Spermedine 100 µg/L + Casein Hydrolysate- 200 mg/L. The modified media has shown around 67% and 27.38% increase in callus multiplication rate and somatic embryogenesis over regular media with picloram-2.5µM

Effect of LED lights on arecanut embryogenic calli multiplication

An experiment was taken up to check the influence of different coloured LED lights (5 to 100 PPFD) and their combinations on arecanut embryogenic calli multiplication and plantlet growth. Embryogenic calli multiplication was high, i.e. 0.028±0.001 g g^{-1} d^{-1} under white coloured LED with a PPFD value of 8 µmol m^{-2} s^{-1} followed by dark (0 µmol m^{-2} s^{-1}) and blue coloured LED (5 µmol m^{-2} s^{-1}) lights with Relative Growth Rate (RGR) of 0.026±0.004 g $g^{-1}d^{-1}$ and 0.025±0.003 g $g^{-1}d^{-1}$ successively. While least multiplication rate 0.008±0.001 g $g^{-1}d^{-1}$ was noticed in white-coloured LED with a PPFD of 100 µmol m^{-2} s^{-1}.

Arecanut dwarf hybrid plantlets derived from somatic embryos were tested for their growth and development using different coloured LED lights and their combinations. Among the treatments, survival of plantlets was found to be high in red LED light having PPFD values 9 µmol m^{-2} s^{-1} (75.5±4.4%) and 14 µmol m^{-2} s^{-1} (72.2±20.0%) which was followed by blue LED with PPFD value 5 µmol m^{-2} s^{-1} (72.2±5.5%). Least plantlet survival of 44.4±5.5% was noticed under red LED with a PPFD value of 25 µmol m^{-2} s^{-1}. Per cent increase in rooting was ranged from 1 to 7% under different LED light conditions. Maximum (7%) and minimum (1%) rooting is observed under LED combination of red + yellow (12 µmol m^{-2} s^{-1}) and yellow LED alone. The relative growth rate in terms of plantlet height and weight was found maximum under white LED (8 µmol m^{-2} s^{-1}). Formation of secondary embryogenic calli (83.3%) and maximum somatic embryos (77.77%) from the inoculated cultures were high under combinations of red + yellow LED with 12 and 15 µmol m^{-2} s^{-1}.

Molecular Studies

Validation of long non-coding RNAs (lncRNAs) expressed during somatic embryogenesis

Long non-coding RNAs (lncRNAs) were identified from the transcriptome data of coconut embryogenic calli, derived from plumular explants, of WCT cultivar generated in an Illumina HiSeq 2000 platform. From a total of 6328 transcripts, which were annotated as uncharacterized or with no homology hits with the existing database, 5,110 putative lncRNAs were identified. A total of 10 lncRNA were selected for expression profile validation by qRT-PCR. Their differential expression was verified in different tissues, viz., leaf, plumule, embryo, embryogenic calli (EC), endosperm calli and mature embryo. Tubulin was used as a reference gene and the relative expression were calculated by a comparative CT method (??CT). All the lncRNAs showed the lowest expression in endosperm callus and mature embryos compared to the embryo, EC and plumule. Among the 10 lncRNA studied, three lncRNAs showed the highest expression in the EC. Four lncRNAs displayed the highest expression in the embryo and the expression of three lncRNAs were abundant in plumular tissues. Out of 10 lncRNAs, lncRNA6 showed enhanced expression in all the tissues compared to the other lncRNAs.

Silencing of selected genes using siRNA

Synthetic siRNAs oligonucleotides were designed and synthesized commercially for the two selected target genes, viz., Somatic Embryogenesis Receptor Kinase (SERK) and WRINKLED (WR1) based on the full-length cDNA sequence of these two genes. The delivery system was standardized for both plumular and endosperm calli. qRT-PCR analysis revealed silencing of both these genes.

Mining of AQUAPORINS (AQPs) from coconut genome and their expression patterns studies

A total of 35 CnAQPs were identified from the CGD genome and their structural features were probed. The CnAQPs were classified based on the evolutionary relationship of coconut with oil palm and date palm. Expression studies were performed with selected CnAQPs via quantitative real-time PCR (qRT-PCR) to study the effects of induced osmotic, drought, temperature and hormonal stresses on CnAQPs in zygotic embryos.

DNA fingerprinting in coconut

In coconut, DNA fingerprint profiles have been developed for 25 each of tall and dwarf accessions using polymorphic SSR and EST-SSR markers. Further, 96 coconut genotypes, representing 16 accessions from globally diverse origins, were genotyped using SNPs derived from Genotyping-by-Sequencing (GBS). A total of 10,835 high-quality SNPs were identified for utilization in assessing genetic diversity and population structure. Unweighted neighbour-joining cluster analysis and Bayesian-based model population structure grouped coconut genotypes based on their height (tall or dwarf), with a few accessions clustering based on geographical origin.

Genome analysis of coconut rhinoceros beetle *(Oryctes rhinoceros)*

The draft genome sequence obtained on an Illumina HiSeq x Five platform, was analyzed. The draft genome

assembly was found to be 372 Mb, with 97.6% completeness based on Benchmarking Universal Single-Copy Orthologs (BUSCO) assessment. Functional gene annotation predicted about 16241 genes. In addition, a total of 21,999 putative SSR markers were identified.

Table 3. Draft genome assembly statistic of *Oryctes rhinoceros*

	RAGOO (>= 1Kb)
Total sequences	25242
Total bases	372388193
Min sequence length	1000
Max sequence length	19770802
Average sequence length	14752.72
Median sequence length	1799
N25 length	9393814
N50 length	5428920
N75 length	888259
N90 length	3530
N95 length	1900

Chloroplast genome of arecanut

The cp genome of *A. catechu* was a typical circular DNA molecule of 158,689 bp length. The genome possessed a typical quadripartite structure composed of a pair of inverted repeats (IRa and IRb) of 27,137 bp separated by a large single-copy (LSC) region of 86,814 bp and a small single-copy (SSC) region of 17,601 bp and a GC content of 37.3%. The cp genome of arecanut encodes a set of 133 genes, comprising 88 protein-coding genes, 37 tRNA genes, and eight rRNA genes, among these, 21 contained introns. A total of 70 SSR loci were detected, the majority being in inter-genic regions. Phylogenetic analysis revealed that *A. catechu* was closely related to A. *vestiaria.*

Fig. 8. Circular gene map of the chloroplast genome of A. *catechu.*

Embryo rescue and cryopreservation studies in coconut and arecanut

Pollen from 15 accessions and DNA from 16 accessions were cryostored at National Cryo Gene Bank, ICAR-NBPGR, New Delhi.

Embryos obtained from sweet kernel genotype was inoculated initially inliquid Y3 media with 60 g/l sucrose followed by subculture in liquid Y3 media with 40 g/l sucrose and NAA 1 mg/L. The plantlets developed from the embryo was grown in solid Y3 medium supplemented with BAP, IAA and IBA, followed by liquid Y3 media of the same composition. The plantlets developed are potted in the potting mixture containing coco peat and vermiculite (ratio 3:1).

Fig. 9. Regenerated plantlets of sweet endosperm type coconut through embryo rescue procedure.

Cryopreservation of coconut plumule using V-cryo plate technique

An experiment was designed to investigate the optimal concentration of sucrose in preculture medium, duration of osmoprotection with PVS3 and use of cryo plate for anchoring the explant tissue during cryo conservation and effect of its combinations. A total of 24 treatment combinations were tried to standardize the protocol. Thirty percent post-thaw recovery was observed with cryopreserved plumules in the protocol involves preculture of plumules for 72 h on medium with 0.2 M sucrose, PVS3 treatment for 60 minutes, rapid cooling, rewarming, and unloading in 1.2 M sucrose liquid medium for 30 m.

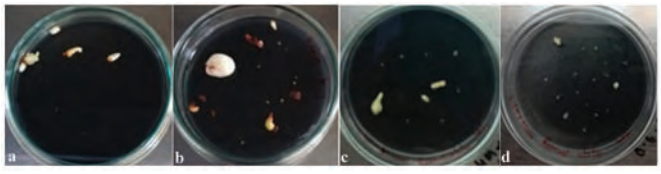


Fig. 10. Post thaw recovery of cryopreserved embryonic shoots / plumular portions of coconut (a). control; (b) 0.2M sucrose with PVS3-60 minutes; (c) 0.4 M sucrose-PVS3-45 minutes; (d) 0.6 M sucrose- PVS3-45 minutes.


VI. 3. CROPPING SYSTEMS AND MANAGEMENT OF RESOURCES

Cropping / Farming Systems

Kasaragod: One hectare of coconut based integrated farming system provided 23800 coconuts, 14940 lit of cow's milk, 372.7 kg live weight of goat, 252.9 kg live weight of poultry birds, 2632.5 kg of banana and 625 kg of pepper for the year 2021. The highest net returns of Rs. 6,53,853/- was realized in the CBIFS which received combined application of 50% RDF and organics (i.e., 25kg/palm FYM/poultry/goat manure + cow dung slurry); the B:C ratio was 2.08. Studies on the effect of grazing on the soil physico chemical properties indicated significantly higher total nitrogen, available P and organic carbon coconut under grazed coconut basin and interspace.

Ground nut varieties viz., Girnar 2 and Girnar 3 were grown as intercrop in the interspace of coconut garden with different nutrient management practices. Application of 50% recommended doze of fertilizers (RDF) and vermicompost @ 10 t/ha provided higher pod yield of 2297 and 2092 kg/ha for Girnar 2 and Girnar 3 respectively.

Experiment on coconut based high density multi species cropping system initiated in 2007 comprising coconut, pepper (trailed on the coconut trunk), banana cv. Kadali, Robusta (inter row space of palms), cinnamon (inter row space of palm) and nutmeg (between 4 coconut palms) under different nutrient management practices indicated that even with reduced to nil chemical fertilizer application (i.e., two-third, one-third and zero percentage of RDF) along with recycling of biomass, biofertilizer application and green manuring resulted in non-significant difference in coconut yield (133-150.5 nuts/palm/year with 3581 to 4222 kg/ha of copra yield). The net returns from the coconut based HDMSCS was Rs. 3,63,486/ha which is 3.7 times more than the coconut monocrop.

Intercropping experiment with sapota (var. DHS 2) in the coastal sandy soil indicated significantly higher yield (93 nuts/palm/year and 47kg per tree of sapota) with the INM treatment consisting application of 150% RDF, green manure, biofertilizers, FYM and organic recycling (Fig. 8). Soil fertility status and microbial load were also higher under this treatment.

Comparison of different spacings for cinnamon (var. Navasree) under coconut (52-year-old plantation; spacing 8x8 m) was made for quill yield after two years of planting. Planting was undertaken in pentagonal method where five seedlings were planted per pit (Fig. 9). Results showed that closer spacing (0.6x1.2m; 3 rows in the interspace of 2 rows of coconut) gave significantly higher quill (Fig. 11) yield of 632kg/ha (from a total of 7290 cinnamon plants).

Sapota as intercrop in coconut under coastal sandy soil

Planting of five cinnamon seedlings

Harvested cinnamon bark (quills)

Fig. 11. Non-conventional intercrops under coconut plantation

Vittal: Arecanut based IFS comprising of arecanut, banan, cocoa, fodder grass (cv. C03), seven milching cows and fishery component (250 m^2) has provided a net return of Rs. 3,90,098. Organic waste recycling potential of the system was 27.0t and dairy alone contributed 89% of it. Total nutrient supply from the system was estimated at 514kg N, 125.5kg P, and 95.3kg K per year.

Kayamkulam: Marigold varieties viz., Pusa Deep (dark red flower), Pusa Basanti Gainda (lemon yellow), Pusa NarangiGainda (deep orange), Pusa Arpita (light orange) and two local types from Tamil Nadu; Periyakulam Yellow, Periyakulam Orange were evaluated during September 2020 to March 2021 and September to December 2021 under Kalpa Sankara palms with wider spacing (8x8m). Results indicated that Pusa Basanti Gainda and Periyakulam Yellow can be grown as a potential intercrop (Fig. 12) in newly planted coconut gardens (25% area). It produced a yield of 57.9 q/ha and 57.6 q/ha fetching an additional income of Rs. 1.59 Lakh and Rs.1.52 Lakh with a BCR of 2.18 and 2.13 respectively.

Kahikuchi: The high density multi specieis cropping systed under the INM treatment of two-third RDF and biomass recycling realised higher yield of 3023kg/ha banana (var. Malbogh); 31,898 fruits/ha citrus (Assam lemon), 2,725 fruits/ha pineapple (Kew type) and 1025 kg fresh rhizome/ha turmeric (var. Megha).

Intercropping of seasonal horticultural crops under arecanut (Fig. 13) indicated that in winter cauliflower (var. Madhuri) and cabbage (var. Rare Ball) and tomato (var. Vaishali) can be cultivated profitably. Yield obtained from these crops is respectively 7.8 t/ha, 3.9 t/ha, and 19.3 t/ha. In the summer season, brinjal (var. Rani), okra (var. Gunjan) and ridge gourd (var. Rama) crops grown as intercrops obtained yield as 6.5 t/ha, 11.42 t/ha and 21.9 t/ha respectively.

Fig. 12. Marigold intercropping under coconut

Fig. 13. Intercropping of winter and summer vegetables under Arecanut

Organic cultivation of coconut under coastal agro-ecosystem: Field experiment was conducted during 2015-2021 to evaluate the performance of coconut palms under different organic cultivation practices in two farmers plots located in Bharanikkav Panchayath, Alappuzha District, Kerala with four treatments and one control with 12 replications. All the treatments included recycling of organic matter in trenches, PGPR consortia and *in situ* green manuring in the basin. Trenches of 1.8m x 60cm x 60cm were opened in opposite directions and filled with the fronds, inflorescence, leaves, husk and other organic wastes from the palm. At the end of experiment, palms supplied with additional dose sulphate of potash recorded higher nut yield (78 nuts/palm/year) with 95% good nuts, and nut characters such as fresh weight (1557.2g), copra content (183.1g), nut water content (176.6ml) and oil recovery (63.5%). The palms which are not supplied with additional dose of potash (T1 and T2) started showing yellowing symptoms of K deficiency from the fourth year onwards.

Nutrient and Water Management

Soil potassium fractions under coconut based integrated farming system: Different nutrient management treatments (chemical, organic and integrated nutrient management) were imposed under a coconut based integrated farming system comprising coconut, banana, fodder grass, dairy unit, poultry, aquaculture and goat unit. Among the different potassium fractions, lattice potassium was found to be the highest (80-88% of total K) which was followed by the exchangeable potassium (5-11% of total K), non-exchangeable potassium (5-7% of total K) and the least content was found to be water soluble potassium fraction (2-6% of total K). Available potassium ranged from 7-15% of total K under various treatments. Total potassium status of soils under fully organic nutrient management was found to be comparatively lower than that of fully inorganic nutrient management and

INM (50% inorganic + 50 % organic). Highest total and available potassium status was observed in the soil under INM practice.

Site specific soil management studies for improving cocoa productivity: Thematic maps of soil constraints to cocoa cultivation were developed for Tamil Nadu using the available soil map of 1:50000 scale. Among the soil properties studied (soil depth, soil texture, drainage and soil reaction), major soil constraint for cocoa cultivation in Tamil Nadu state is soil reaction (68% of the total geographical area of the state) followed by soil drainage (60%), soil texture (46%) and soil depth (40%). The spatial information of these soil constraints is mapped, and the overall constraint map was developed. The soil series of Tamil Nadu state were characterized into different constraints groups *viz*., very severe, severe, moderate and with no constraints (Fig. 14).

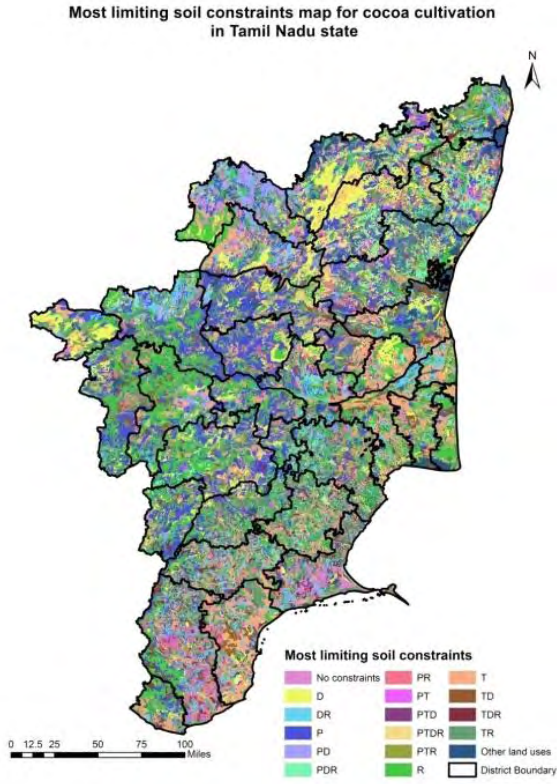


Fig. 14. Overall soil constraint map for cocoa cultivation in Tamil Nadu

Fertigation to enhance yield of hybrid coconut in root (wilt) affected area: A field experiment is in progress with different levels of nutrient application (5 treatments ranging from 50-200% of soil test based nutrient values) through drip fertigation and with basin application of nutrients under drip irrigation, in hybrid coconut (Kalpa sankara). The total quantity of fertilizer as per treatments was applied from July 2020 to May 2021. Though plant height and collar girth were not siginicantly different, number of bunches per palm was significantly higher in 150% fertigation (12.18) compared to surface application (6.2). Application of nutrients @ 150% fertigation recorded higher population of Bacteria ($10.6x10^6$ cfu/g of dry soil), Fungi ($63x10^3$ cfu/g dry soil) and actinomycetes (30 $x10^6$cfu/g of dry soil).

Fertigation schedule for tender nut production in dwarf coconut: A study is taken up since October 2019 for standardizing fertigation schedule for tender nut production in sandy loam soils of root (wilt) disease prone areas. The variety selected for the study is COD. The experiment was laid out during October 2019 in FRBD with nine treatments and one control (C: 100% STBNR (530:150:1200 NPK) as soil application in four splits + 66%PE drip irrigation). The treatments comprised of three levels of irrigation (66%, 100%, 133%) and three levels of nutrition (133%, 166%, 200% STBNR). The nutrients supplied in 20 equal splits at fortnightly intervals during August to May. After I year of experimentation, Treatment 100% irrigation with 166% nutrient application recorded 243.3cm plant height compared to control with 206.6 cm. plant height and flowered at 23 months after planting.

Dynamics of Calcium and Magnesium in laterite soil: Calcium and magensium were supplimenetd through external sources such as lime, dolomite and gypsum. The water soluble and exchangeable fractions of calcium and magnesium was computed from three levels: 0-30cm, 31-60cm and 61-90cm. Water soluble fraction of calcium was greater at 60cm for the treatment containing lime, dolomite and gypsum. The mean exchangeable calcium content in three depths was greatest for the combination treatment with lime, dolomite and gypsum and the values were 432.13, 256.28 and 211 ppm respectively. In the treatment with the dolomite and lime alone, the content of exchanegable calcium was 121, 136.22 and 499 ppm respectively. Displacement of magnesium was evident after treatment with gypsum, as indicated by the higher levels of magnesium at 60cm depth.

Field validation of the efficiency of nutrient mixtures Kalpa Poshak and Kalpa Vardhini: Field validation trials were conducted in the Agro Ecological Unit-3 in Kalpa

Sankara hybrids and West Cost Tall palms. The average annual yield of 79.4 nuts per palm was recorded in Kalpa Sankara hybrid after the application of Kalpa Vardhini @ 250g per palm in two splits. These palms in the juvenile stages were given Kalpa Poshak@ 100g per palm in two splits. In the adult West Cost Tall palms, application of Kalpa Vardhini resulted in 37% improvement over the pre-treatment yield. In the juvenile WCT palms, the per cent improvement in the biometric characters such as height, number of leaves, collar girth and number of split leaves over the control were 30.76, 11.71, 8.07 and 23.91 respectively. Substantial improvement in the soil and leaf nutrient status was also observed. The content of phosphorus, potassium, calcium and magnesium in the index leaf samples of treated palms were 0.17%, 1.45%, 0.282% and 0.151% respectively.

Integrated nutrient management in arecanut at Kahikuchi: A trial was taken up in Kahikuchi, Assam with organic and chemical source of nutrients and their combinations to study the impact of source of nutrients on arecanut. Among the different treatment combinations, application of vermicompost (2/3rd) + fertilizers (1/3rd) recorded the highest number of nuts (243 nuts per palm per year) and maximum chali yield of 2.34 kg per palm per year.

Management of Yellow Leaf Disease in arecanut: Field trial on management of YLD was initiated in two farmer's gardens in Sringeri and three gardens in Sullia taluk in 2015 and 2016, respectively. Plastic mulching during monsoon (June-October) reduced the disease index in all three management trial plots in Sullia during the experimental period (2017-2021) compared to the pre-experimental data (2016). The disease index during 2021 was 1.7 – 3.0%, whereas it was 2.9-5.8% in 2016 in different plots. Importantly, the yield was 1184 – 2525 kg ha^{-1} in mulched plots, which was 2-14% higher than non-mulched plot. It was observed that, plastic mulching during monsoon could delay the symptom expression and increase the yield in YLD affected garden (especially when the initial disease index was low).

Interactive meeting with farmers in Markanja and Kalmakaru villages: A scientist-farmer interaction meeting on YLD was organized in YLD management-cum-demonstration trial plots at Markanja and Kalmakaru villages of Sullia taluk. The farmers opined that, there was no further spread of the disease in plastic mulched plots and yield was higher than non-mulched plot. The 5-years (2016-2021) management-cum-demonstration trial in Sullia taluk of Karnataka indicated that, plastic mulching the YLD affected garden with low disease index could prolong the symptom expression and increase the yield.

Identification of disease free arecanut palms in YLD hotspot area: Field survey was conducted in Sampaje which is a hotspot area for yellow leaf disease of arecanut. A total of 81 arecanut palms having no symptom of yellow leaf disease were identified and marked. Among them, 14 palms were tested for the disease and 9 palms were found to be disease free.

Deciphering rhizosphere bacterial diversity in Yellow Leaf Disease endemic area: The rhizosphere bacterial microbiome in the YLD endemic apparently healthy rhizosphere soil (YLD-AHR), YLD endemic disease intensive rhizosphere soil (YLD-DIR), and YLD endemic non rhizosphere soil (YLD-NR) were characterized through shotgun metagenomics, with a view to study the microbial community structure and functional potentials. The genomic DNA isolated from the soils of arecanut rhizosphere was sequenced on Illumina Hiseq (2 x 150 bp) platform. The respective raw sequence reads (52.4M, 65.3M and 45.1M for YLD-AHR, YLD-DIR and YLD-NR) were processed, following quality filtering and assembled into contigs using Megahit, and were taxonomically classified using Kraken2. The contigs were annotated utilizing BLASTn and used for gene prediction and annotation using Prokka v 1.03. The functional annotation of the predicted proteins in each sample is performed using KEEG Orthologus Groups (KOG) and Cluster of Orthologous Groups (COG) *via* KAAS and WebMGA servers, respectively. The metagenomic data revealed that among the microbes, bacteria exhibited the highest taxonomical representation with 96.1 to 96.8 % with the predominant bacterial phyla as Proteobacteria (70.1% to 75.0%) in arecanut YLD endemic rhizosphere. The most abundant classified bacterial family in YLD endemic arecanut rhizosphere are *Burkholderiaceae, Bradyrhizobiaceae, Anaeromyxobacteriaceae, Comamonadaceae, Streptomycetaceae, Pseudomonadaceae, Sphingomonadaceae, Zoogloeaceae, Micromonosporaceae, Rhodospirillaceae, Xanthomonadaceae, Gemmatimonadaceae, Nitrobacteraceae, Methylobacteriaceae, Myxococcaceae, Geobacteraceae, Acidobacteriaceae* and *Nitrospiraceae*. The most abundant classified genera are *Burkholderia, Variovorax, Paraburkholderia,*

Cupriavidus, Rubrivivax, Bradyrhizobium, Anaeromyxobacter, Sorangium, Sandaracinus, Pseudomonas, Sphingomonas, Thauera, Micromonospora, Rhodoplane, Rhodopseudomonas, Gemmatirosa, Methylobacterium, Myxooccus, Geobacter and Nitrospira. Functional classifications revealed abundant of genes/proteins involved in carbon, nitrogen cycling, inorganic ions transport and metabolism, secondary metabolites, vitamins biosynthesis and metabolism, Xenobiotic degradation and environmental adaptation which are the key functional traits related with rhizosphere microbiome and plant growth and health. The multiple members of these bacterial taxa are known as plant beneûcial microbes, and these microbes help maintain the plant hormone balance, control root development, facilitate nutrition acquisition, and prevent the disease in the plant host. The identiûcation of a core of rhizosphere microbes on arecanut provides a useful starting point for future studies that could exploit synthetic communities to determine the interaction between microbes and in their interactions with arecanut palm to improve health and productivity.

High density planting of cocoa in arecanut: Grafts of cocoa variety Netra Centura were planted in 5 different spacing with planting density ranging from 650 to 3712 plants ha^{-1}. During 5thyear after planting, the dry bean yield per plant was similar among different spacing, however, the dry bean yield per hectare was significantly higher in closely planted grafts (217 – 620 kg ha^{-1}) than grafts under normal spacing (126 kg ha^{-1}) due to higher plant population. Interestingly, the single bean dry weight (g) was also higher in closely planted grafts (1.06-1.13) than grafts under normal spacing (0.94).

Bioresource management in coconut, arecanut and cocoa

Bacillus megaterium in 'Kera Probio' is now Priestia megaterium: Plant growth promoting *Bacillus megaterium,* (Kera Probio®) is recently recognized by McMaster University, Canada as a novel *Bacillaceae* genus with the specific name — *Priestia* gen. nov. — based on phylogenetic and molecular evidence (https://doi.org/10.1099/ijsem.0.004475). The species name is retained and henceforth, the constituent microorganism of 'Kera Probio' bioinoculant will be *Priestia megaterium.*

Kera Probio® induces calcite precipitation: Collaborative research with Amrita School of Engineering, Coimbatore showed induction of calcite precipitation by Kera Probio® in presence of calcium chloride. Formation of extracellular calcium carbonate resulted *via* urea hydrolysis by the bacterium. The property implies its usefulness in self repair of cracks caused in cement due to shrinkage, if the organism forms part of the concrete mixture called biocement. Kera Probio's ability to have optimum growth at alkaline pH is advantageous for its integration in concrete making process as concrete is basic in nature; additionally, its tolerance to a wide range of temperature from 15 to 50^{o}C and ability to produce endospores during adverse conditions offers scope for its enhanced survival in biocement as concrete structures are exposed to thermal and other weathering processes.

Characterization of Cocoa Pod Husk Biochar: Cocoa pod husk biochar (CPHB), prepared in CIAE-developed kiln, was analyzed for its nutrient properties. CPHB was found to have >10 pH and total potassium content of 10-11%. It contained good amount of water-soluble as well as exchangeable potassium; the former accounted for around 6.5% which was about 60% of the total potassium content and the latter was around 7.5% which accounted for about 70% of the total potassium present in CPHB. The water-soluble and exchangeable potassium are the main sources of available potassium in soil and hence, CPHB can be used as an amendment to improve soil potassium. The total Ca content of the CPHB was around 22 g/kg, 45% of which was water soluble as well as exchangeable form. The total Mg content was 13 g/kg, 23% of which was water soluble. CPHB's high ash content (36%) and CEC value indicated its liming potential and increased nutrient retention in soil, respectively.

This nutrient rich CPHB, therefore, has higher agronomic value than coconut biomass biochars for fertilization and enhancing quality of poor tropical acidic soils with low organic matter and low CEC and is an ideal input for incorporation in coconut based cropping systems.

Studies on availability of phosphorus in fertilized and non-fertilized soils when amended with CPHB @ 0, 5, 10, 20 and 40 g kg^{-1} showed an increase in available P and the P activation coefficient in soil at 50% field

capacity. P activation coefficient increased manifold in non-fertilized soil. The increase was also found to be dose-dependent.

To study sorption of phosphorus in acidic soils (fertilized and unfertilized), when cocoa biochar is applied, standard isotherm equations - the Freundlich equation and the Langmuir equation- were employed. Cocoa biochar was used @ 0, 5, 10, 20 and 40 g kg^{-1} (B0, B1, B2, B3, B4, respectively). Soil-biochar complexes were analysed for phosphorus sorption capacity by fitting the equilibrium solution and sorbed concentrations of phosphorus using adsorption isotherms. Results showed that phosphorus sorption increased with higher biochar application rates. Fertilized soils sorbed more phosphorus (323.25 – 995.27 mg kg^{-1}) than non-fertilized soils (347.25 - 805.47 mg kg^{-1}) @ 0–40 g kg^{-1} biochar (Fig. 14-16). Phosphate adsorption on biochar was satisfactorily described by the Langmuir equation (r^2 = 0.96–0.99, P = 0.01) and Freundlich equation (r^2 = 0.87–0.99, P = 0.01).

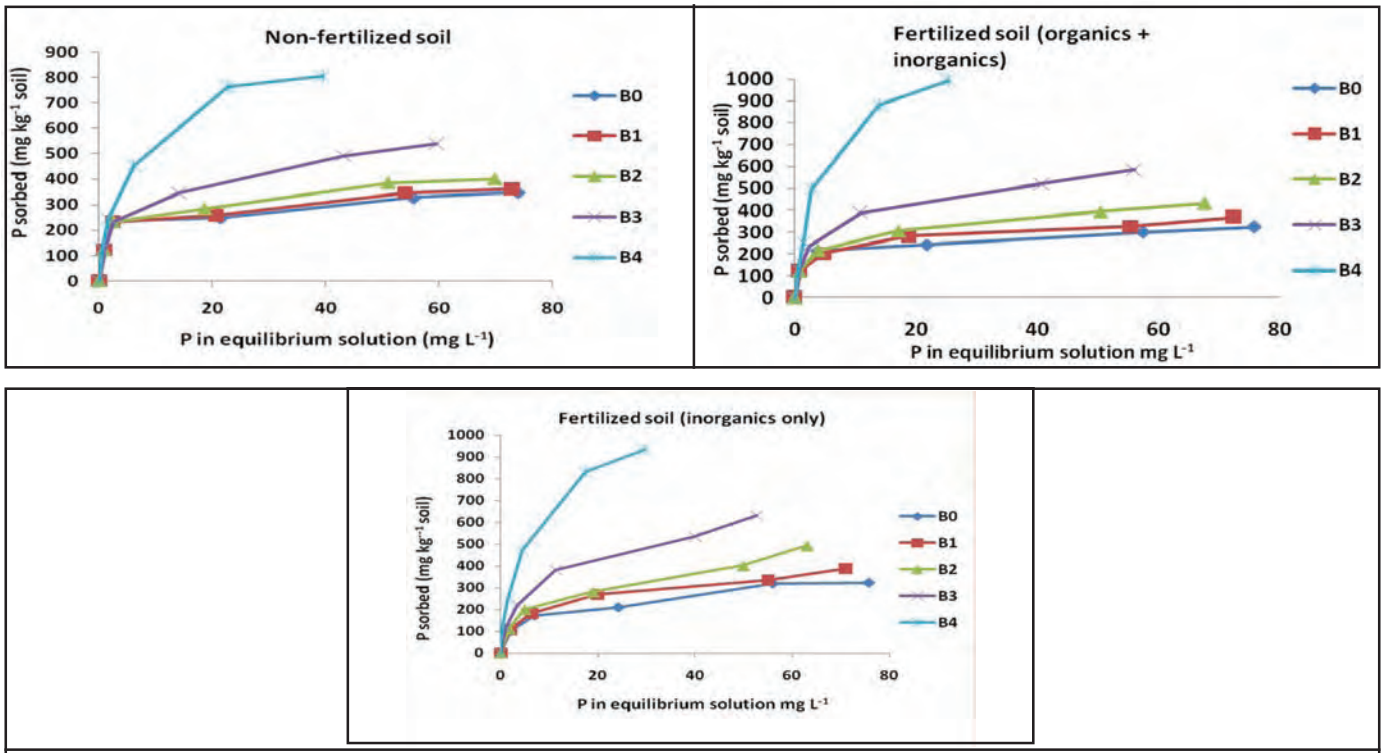


Fig. 15. Phosphorous profiles in different soil treatment.

Small scale composting of cocoa wastes: Cocoa leaves, pod husk and bean shell were composted in plastic drums of 52 cm length and 34 cm width. Drums held 3 kg leaves, 15 kg broken pod husk, 30 kg bean shell and 5 kg cow dung. Six layers each of raw material and slurry were used for composting. It was initiated to get compost from cocoa farm wastes to be used for kitchen gardens.

Nematological studies in coconut residue-based composts: Freshly produced coconut leaf vermicompost and coir pith compost made using the in-house developed composting methods were analysed for presence of nematodes. The composts were processed by Cobb's sieving and decanting followed by Baermann funnel extraction and direct method by concentrating nematode suspension. This suspension was taken in the counting dish and population of both free-living and plant-parasitic nematodes was estimated per kg compost. Both types of composts showed presence of only free-living nematodes and the nematode population was on par. However, the direct method of estimation yielded almost twenty five fold more counts (~1200 kg^{-1}) than Cobb's sieving technique (~46 kg^{-1}). Whereas the direct method gives the total nematode count, the sieving method counts only nematodes less than 1 mm sizes, which are likely to be plant-parasitic. Further microscopic observations revealed total absence of plant-parasitic nematodes in both types of composts.

Absence of any plant-parasitic nematodes is encouraging as these composts can safely be used as substrates for soilless cultivation. Moreover, the free-living nematodes observed in these composts might be performing some role in nutrient cycling based on their feeding behavior.

Biopriming effects of PGPR strains and consortia on coconut seedling: Biopriming treatments of coconut nursery seedlings with phytobeneficial PGPR strains and their consortia were evaluated for growth promotion effects. Seedlings were maintained in poly bags with sand and coir pith (2:1) substrate. Treatments were imposed three times (0,7,11 months after sowing) with bioinoculants @ 50 mL (approximately 1×10^6 CFU/mL) and fungicide (1 mL/L) @50 mL/polybag seedling. Highest shoot height (130.21 cm) and collar girth (11.7cm) were observed in treatment *Bacillus* sp.- CRE-15 (Root endophyte).

Areca husk composting: A trial was carried out at ICAR-CPCRI, Vittal to compost areca husks, in which for each 100 kg of areca husk biomass, 1 kg lime and 1 kg rock phosphate were added in different layers with fresh cow dung made into slurry and mixed thoroughly. Composting was completed within 3 months (75-90 days) with a biomass recovery of 72%. The initial C:N ratio was reduced from 134.7 to 39.4:1 at the end of composting process. The pH of the compost obtained was 6.2-6.7. The total nitrogen increased from 0.72% to 1.28%. The total potassium content increased to 2.4 %, total zinc increased to 0.82 mg /kg.

Evaluation of organic cultivation of coconut-based farming system under coastal agro-ecosystem (Kasaragod)

The experiment was initiated to evaluate the performance of coconut palms under different organic cultivation practices *viz*., T1- In situ organic matter (frond, infloresence waste, husk) recycling in trenches made in the interspace of 6 coconut palms (15m length,1.2m width and 60cm depth) + insitu green manuring in the basin +PGPR consortia in the basin, T2- In situ organic matter (frond, leaf, infloresence waste, husk) recycling in trenches made in the interspace of 6 coconut palms (15m length,1.2m width and 60cm depth) + insitu green manuring in the basin +PGPR consortia in the basin+ cowdung (50% of RD of all crops) T3- T1+ 50% Recommonded K_2O using sulphate of potash, T4-T2+ 50% Recommonded K_2O using sulphate of potash and T5-Conventional method (Chemical fertilizer application). The coconut yield data recorded and analyzed and the results revealed that, the treatment T4 -In situ organic matter (frond, leaf, inflorescence waste, husk) recycling in trenches made in the interspace of 6 coconut palms (15 m length, 1.2 m width and 60 cm depth) + *insitu* green manuring in the basin + PGPR consortia in the basin + cowdung + 50% recommonded K_2O using sulphate of potash recorded significantly higher coconut yield (96 nuts/year) and cocoa dry bean yield (2.22 kg /tree) over other treatments.

VI. 4. INTEGRATED MANAGEMENT OF DISEASES IN PALMS AND COCOA

Fungal diseases of palms and cocoa

Dry spindle rot in coconut seedlings: It was observed in 3 to 5 years old seedlings in Coimbatore, Pollachi and Tirupur districts of Tamil Nadu during 2019 and in Anand district of Gujarat during 2020. Symptoms were characterized as wilting of spear leaf followed by drying and dark brown to black color discoloration near the base of the spindle (Fig. 16). Among the eight isolates purified from spindle rot samples, seven were identified as *Lasiodiplodia theobromae* (Fig. 17a) and one as *L. iranensis* (Fig. 17b) based on morphological characters and by sequencing of ribosomal internal transcribed spacer (ITS) region, Actin (ACT) and beta-tubulin (ß-tub) gene regions.

Fig. 16. Symptoms of dry spindle rot

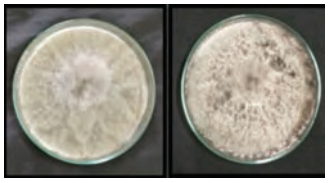


Fig. 17a. *Lasiodiplodia theobromae* colony

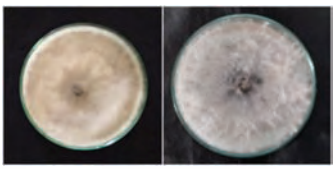


Fig. 17b. *Lasiodiplodia iranensis* colony

Black spot disease of coconut: During late 2020, a black spot disease was noticed in the young coconut palms grown in the coconut gardens of Kidu Research Centre, Karnataka. Disease incidence, percent of fruit with visible lesions, was 15%. Initially, there were tiny water-soaked black spots (2×2mm) on the upper and lower petiole surface of the leaf surfaces that coalesced in later stages to form large spots (Fig. 18a and 18b). Later on these spots appeared on leaves including midribs (Fig. 18c) which lead to drying of leaves from petiole to tips. Mature nuts of 8-10 months old also developed black spots on the surfaces. Based on morphological study results, the fungus was identified as Exserohilum sp. For molecular confirmation, PCR were performed using ITS and ß-tubulin gene specific primers followed by sequencing. ITS (MN890020), and ß-tubulin (MT576064) sequences were deposited at GenBank. BLAST analysis of CK-04 sequences showed that the ITS region showed 100% identity to *E. rostratum* AUMC 14313. Phylogenetic analysis revealed that the isolate was grouped in the same clade sharing similarity with other *E. rostratum* isolates. According to morphology and phylogenetic analysis, the isolate was identified as *E. rostratum*. Pathogenecity tests were subsequently done to fulfill the Koch's Postulates.

(a)

(b)

(c)

Fig. 18a. Symptomatology of Black spot of coconut: 18b. black spot on petiole surface; 18c. large spots; spots appeared on leaves including midribs (in order)

Root decay disease of arecanut, *Areca catechu L.*
During 2018 summer season, several young arecanut seedlings exhibited yellowing, drying, drooping and wilting symptoms (Fig. 19. a-b) in farmer's gardens located in Dakshina Kannada district of Karnataka, India. The longitudinal section of the infected seedlings showed extensive decaying of fibrous roots which extended up to the collar region (Fig. 19. c-e) and ultimately resulted in the death of young seedlings. A series of cultural, morphological, molecular characterization using multi-gene phylogeny, and pathogenicity assays with Koch's postulates confirmed the association of *Fusarium falciforme* (FSSC 3 + 4) as the causal organism of arecanut root decay disease. To the best of our knowledge, the present study confirms the first report of root decay disease caused by *F. falciforme* in arecanut.

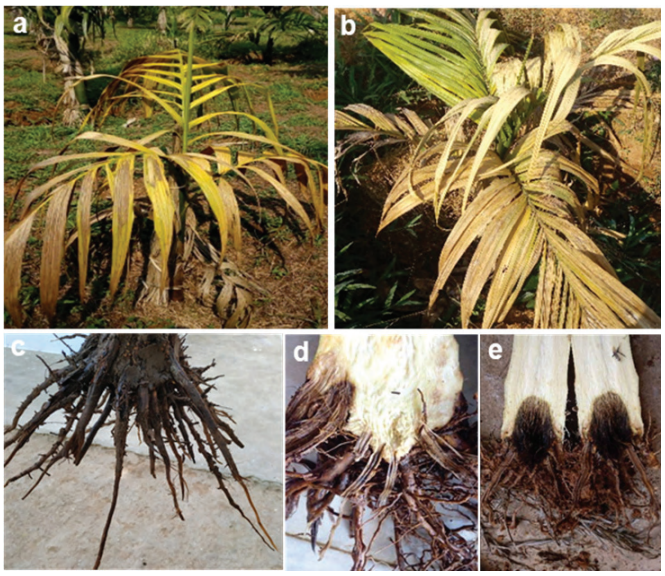


Fig. 19 a to c. Arecanut root decay symptoms caused by *Fusarium falciforme*

Leaf spots on cocoa seedlings: Isolated, morphologically and molecularly characterized SLGC7 isolate of leaf spot pathogen as Colletotrichum gleosporioides isolated from cocoa seedling infected with leaf spot disease and proved pathogenicity by inoculating on detached leaf under in vitro conditions.

Rrapid inoculation technique for inducing *Ganoderma lucidum* infection
Ganoderma lucidum is a soil borne fungi known to cause Basal stem rot (BSR) or Thanjavur wilt or Ganoderma wilt disease in coconut as well as Foot rot or Anabe roga disease in arecanut. Developed the 'mycelium inoculation technique' wherein seedlings were soaked in 4 days old mycelia cultures supplemented with 0.002% Tween 20 for a period of 30 minutes. After 30 minutes, the seedlings were then allowed to dry in room temperature and then planted in potting mixtures that was previously autoclaved and kept ready. Regular watering was provided. The temperature was maintained at 25-30°C and relative humidity at 70-80% by creating a temporary moist chamber made of plastic cover. The initial symptoms could be noticed 15 days after inoculation. The symptom progresses with number of days and the seedlings succumb to death based on the infection severity in a month's time. The pathogen was successfully isolated and confirmed from soil, infected root and shoot girth areas using morphological parameters and molecular tools like PCR. This method is faster and simpler compared to the traditional technique using sorghum seed method or rubberwood block method, wherin in takes more than fifteen months for symptom development.

Farmer's friendly technology for mass production of *T. harzianum* (CPTD28): *T. harzianum* (CPTD28) is a potential native isolate found very effective in the management of major fungal diseases of arecanut, coconut and cocoa. Talc based formulation of *T. harzianum* (CPTD28) is in use at present, but has the limitation of short shelf life. Four cost-effective materials (coconut leaves based, arecanut leaf sheath, sorghum grains and sorghum grain powder) were tried for mass production of *T. harzianum.* Highest colony forming units (cfu/g) was recorded in arecanut leaf sheath based formulation (1813 x 108) and also recorded its virulence even after 12 months of storage.

Sodium alginate based bead formulation of fungal mycelia and conidia for long term storage: Dry mycelial and conidial bead formulations of *Colletotrichum gloeosporioides, Lasiodiplodia theobromae and Trichoderma harzianum* were prepared using sodium alginate solution. The mycelia and conidial mass of fungal cultures were impregnated in sodium alginate by soaking the powdered dry mycelia and conidia in sodium alginate solution (2% w/v) for 30 minutes and made into bead form by gently pouring the solution in calcium chloride solution (3% w/v) with the help of burette at a flow rate of 1 ml/ minute. The beads were washed twice with deionized water and kept for drying in room temperature. Another set was freeze dried to smaller pellets. The beads were later kept at 4°C and room temperature (25°C) desperately for studying the shelf life and conidial viability. The colony forming units (cfu) for the fungal cultures were 104 $\times 10^8$ cfu/gm for

C. gloeosporioides, 125 × 10^8 cfu/gm for *L. theobromae* and 135 × 10^8 cfu/gm of bead for *T. harzianum* in the initial. Further conidial viability was checked at monthly interval for a period of 1 year. The cfu after one year of storage at room temperature was 120 × 107 cfu/gm for *C. gloeosporioides,* 125 × 10^7 cfu/gm for *L. theobromae* and 56 × 10^7 cfu/gm for *T. harzianum.* In case of storage under refrigerated condition, the cfu after one year was 17 × 10^8 cfu/gm for *C. gloeosporioides,* 11 × 10^8 cfu/gm for *L. theobromae* and 53 × 10^7 cfu/gm for *T. harzianum*. The bead formulations were packed in capsule forms for ensuring better storage.

Development of ready to use Bordeaux mixture formulations against *Phytophthora*: Bordeaux mixture (1%) in the form of paste and solid formulation having neutral pH (7.0) was made and found to be effective for 60 days after the preparation.

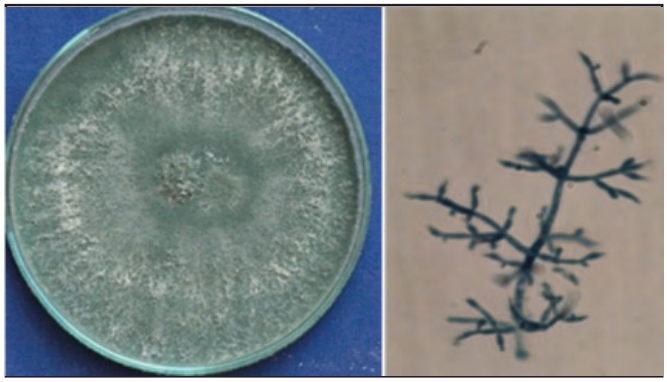
Integrated disease management

Stem bleeding disease of coconut: The field trial conducted in a disease endemic area in Kasaragod indicated that the following control measures are effective and significantly different from the control. While recovery was observed in these treatments, in the control, disease index increased from 21% to 65.5% by third year.

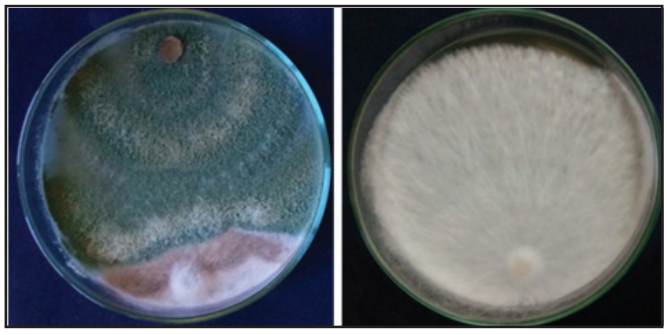
(i) Hexaconazole 5EC @ 2% smearing on bark after removal of bleeding patches and drenching @ 0.1%
(ii) Propiconazole 25EC @ 1% smearing on bark after removal of bleeding patches and drenching 0.01%
(iii) *Trichoderma harzianum* (CPTD 28) enriched areca leaf sheath
(iv) *Trichoderma harzianum* (CPTD 28) talc formulation
(v) *Trichoderma harzianum* (CPTD 28) neem cake formulation.

Inflorescence dieback disease of arecanut: Wider scale demonstration of Propiconazole 25% EC (0.3 %) for the management of arecanut inflorescence dieback disease at ICAR-CPCRI RS, Vittal during February to May 2021 recorded 10.31% disease incidence in comparison with Mancozeb 75% WP (18.2%) and non-sprayed plots (21.34%). Based on three consecutive years trial (2018 to 2020) and wider scale demonstration, Propiconazole 25% EC (0.3%) would be recommended as an alternative fungicide to arecanut inflorescence dieback disease.

Identification of a novel, native biocontrol agent against arecanut basal stem rot pathogen in Assam: An effective fungal biopesticide, *Trichoderma asperellum* strain AT172 was isolated from the soil samples collected from the rhizosphere of arecanut in major arecanut growing areas of Assam (Fig. 20a) Based on growth characteristics and spore morphology, 42 isolates were selected for evaluating antagonistic activity against the arecanut basal stem rot pathogen, *Ganoderma lucidum.* Antagonistic assay resulted in the identification of three effective *Trichoderma* isolates i.e., AT172, AT166 and AT121 with 72.2%, 70.0% and 68.9% inhibition of pathogen respectively. All the isolates showed rapid growth with a mean colony growth rate of 2.3 cm day^{-1}. Growth promotion activity studies under net house condition recorded significantly higher total biomass in arecanut seedlings treated with *T. asperellum* AT172 (49.1 g) as compared to control (45.5 g) (Fig. 20b-d). Holistically, *T. asperellum* strain AT172 was found to be promising with respect to antagonistic activity, mean growth rate and total biomass production.



a



b

Fig. 20 a: *Trichoderma asperellum* strain AT172 mycelium and conidial characteristic; b: Dual plate assay against *Ganoderma lucidum* AGVTL

Demonstration of arecanut fruit rot disease management using Mandipropamid 23.3%SC fungicide: Based on regular occurrence of fruit rot disease, three arecanut gardens were selected: Belvai village, Moodbidri taluk; Kotekar, Mangalore taluk (both in

Dakshina Kannada district); and Kodimoole, Enmakaje, Kasaragod district. Implemented phytosanitory measures and provided Integrated nutrient management followed by prophylactic treatment against fruit rot disease was imposed using Mandipropamid 23.4% SC @ 0.5% during May last week and second round of treatment after 45 days. Fruit rot disease was not recorded in Mandipropamid 23.4% SC sprayed palms while 4% disease incidence was noticed in 1% Bordeaux mixture sprayed plot in Belvai village.

Characterization of storage pathogens associated with arecanut and cocoa: Fourteen culturally different seed storage pathogens were characterized morphologically and molecularly by submitting it in NCBI data base: They are *Talaromyces tratensis* isolate KEB10, *T.tratensis* isolate KEB9, *Aspergillus ruber* isolate KEB7, *Lichtheimia ramosa* isolate K4, *Lichtheimia ramosa* isolate BFB6, *A. amstelodami* isolate BFB3, *Microascus gracilis* isolate BFB1, *Lasiodiplodia theobromae* isolate FASVC6, *Fusarium solani* isolate FASVC7, *Rhizopus arrhizus* isolate FASVC3, *A. flavus* isolate UN1, *A. flavus* isolate CS1, *A. flavus* isolate AF1, and *A. flavus* isolate CS2A0.

Screening of Bacterial biocontrol agents against fungal pathogens: Four bacterial isolates viz., *Bacillus licheniformis* strain PALEB3, *Bacillus megaterium* strain SHIS10, *Bacillus* sp. strain SHIS11 and *Rhizobium* spp. strain S8 were screened following dual plate assay against major fungal pathogens vi.z, *Fusarium solani*, *Ganoderma lucidum* and *Colletotrichum gloeosporioides*. *Bacillus licheniformis* strain PALEB3 recorded maximum inhibition (59.25%) as compared to others showing its bio-control efficacy.

Phytoplasma diseases

An unidentified leafhopper and *Exitianus indicus* from *Cynodon dactylon* and citrus psyllid *Diaphorina citri* from curry leaf plants in RWD endemic regions were collected and subjected to PCR using phytoplasma-specific primers. The DNA samples from the unidentified leafhopper showed positive amplification and the sequences showed more than 99% similarity to '*Candidatus* phytoplasma cynodontis' (16Sr XIV subgroup) causing white leaf disease in *C. dactylon* associated with phytoplasma. The cytochrome c oxidase subunit 1 mitochondrial gene (COI) sequences of the unidentified leafhopper, that inhabited phytoplasma, showed about 92% similarity to Balclutha sp. a common leafhopper feeding on grasses in coconut plantations.

As a part of documentation of phytoplasma diversity in RWD endemic regions, *Catharanthus roseus* plants showing phyllody symptoms were subjected to PCR using phytoplasma-specific primers and the amplicons obtained were sequenced. The 16SrRNA sequences showed 99 percent similarity with aster yellows group phytoplasma. Based on the 16SrRNA sequences and virtual RFLP, the phytoplasma associated with catharanthus phyllody is identified as '*Candidatus* Phytoplasma asteris'- related strain belonging to 16SrI group. This group of phytoplasma is also associated with lethal wilt disease in coconut.

Pest and Disease surveillance on coconut using unmannaed aerial Vehicle (UAV)

ICAR-CPCRI in collaboration with M/s General Aeronautics Pvt Ltd, Bangalore started a project on 'Pest and disease surveillance on coconut using unmanned aerial vehicle' with the financial support from Coconut Development Board during 2019-2021. The salient achievements made during last two years are as follows.

A total of 4320 images of coconut were collected at two different altitudes (40m and 50m) (datasets) during different months of the years (2019-2021) from coconut gardens of ICAR-CPCRI Kasaragod and its regional station Kayamkulam campus in Kerala. Drone was flown at a speed of 3 m/s in square wave pattern; overlap percentage of consecutive images was 75%. Similarly the multispectral images of the coconut palms in the CPCRI farm were captured with GA-03 multicolour drone embedded with 20 megapixel multispectral camera (Micasense Rededge-MX model) which had five imaging sensors for Red, Green, Blue and Near-IR and Rededge bands. For every scenario, this camera captures five images with respect to each band. A total of 500 images were captured using multispectral camera at CPCRI Kasaragod and Kayamkulam.

After capturing the images of coconut from coconut gardens in CPCRI campus using the above mentioned Drone, the images were annotated for healthy and diseases/pest infested coconut and an algorithm was developed for detection of number of coconut palms in the gardens, healthy and diseased palms.

In the process of diagnosis of pest or disease affected coconut palms from the images captured from drone, various image processing methods were followed. The whole process can be divided into two parts, 1) Crown detection and localization and 2) Crown classification as Healthy or Disease/Pest affected. In case of crown detection, two methods viz. image processing based crown detection and object detection based crown detection were developed. In case of crown classification, algorithm was developed using Convolutional Neural Networks (CNN) and Object detection based approach.

Image processing based on geometric features (e.g., triangular or V shaped cuts) was tied, but not found practical because the drone flies at different altitude, zooming and focusing on individual leaf looses pixel information leading to erroneous results.

Alternatively, an image processing method was developed for coconut crown detection and segmentation. To differentiate between coconut crowns from background green images, first the raw input images were converted to LAB and HSV colour spaces for further analysis. The LAB and HSV colour space subtraction gave more information to accurate detection of coconut crowns.

Artificial Intelligence (AI) approach was selected for further classification and detection of pest and disease affected coconut. In deep learning of the images captured or datasets generated, Convolutional Neural Networks (CNN) models were used for features and classification. The CNN model was trained over individual crown images which learn the features for healthy coconut crown and rhinoceros beetle infested coconut crown. The coconut crown was manually identified from the images with “top view” for training the CNN model.

Combining the results from the aforesaid two methods, coconut crown infested by rhinoceros beetle could be counted (Fig. 21). It can be seen that red boxes are for defective crowns and blue boxes for normal healthy crowns. In the brackets along with class prediction, there is probability of class prediction i.e. the probability of crown being defective or normal predicted by the algorithm.

CNN model is trained to classify the object class in a given image while the Region Proposal Network (RPN) is used to localize the object and represent it in bounding boxes.

For crown annotation purpose, the label used was 'crown' and such 5000+ annotations were used in the making of dataset. For training purpose, `Faster R-CNN' model was used which was trained for 3000 iterations. The crown was considered as a single class for this training purpose. While training, the annotation for crown is represented by 1 and all other background with 0. While annotating, coconut crowns near the edge of the image which are opaquely visible or having angular visibility are skipped in this version of training the data. This is done to avoid mis- classification and to focus on top view part of coconut crowns.

The final result of object detection approach was found better than previous approach in terms of detecting coconut crown in cross plantation scenarios. In the image are taken in summer season at an altitude of 40 meter, it can be seen that there is no grass present on the ground, which makes algorithm to identify crowns distinctively. In the object detection approach, it can be seen that the bounding boxes for crowns are more precise as per the shape of the crowns. This same analogy goes for further all object detection results. In intercropping along with the grass terrain images captured in rainy season at an altitude of 50 meters, object detection approach was able to identify coconut crowns from both cases with high mAP, it was able to identify coconut crown in the situation of inter-cropping of banana as well as in grassy terrain where the green intensity of crown and background grass are same.

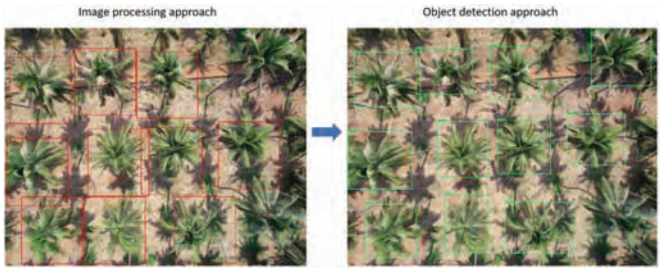


Fig. 21. Comparison of two outputs, Image processing based crown detection vs. Object detection based crown detection.

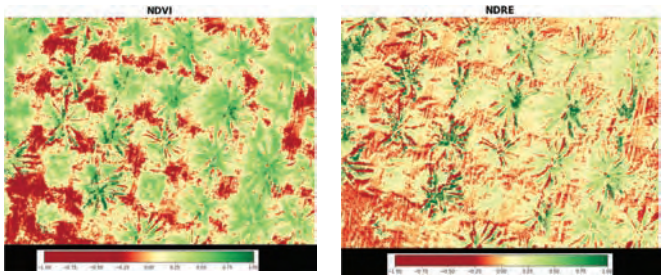
More than 10 object detection models were tested for generating a better object detection model for coconut crown class detection. Empirically following model was chosen for training and validation of proposed method:

Efficient Det D0 512 x 512. The images for whole field were stitched together (Fig. 22), to create panorama of field, on top of which the algorithm was used to identify and classify coconut crowns. The panorama image of field shows the red boxes for defected crowns and blue boxes for healthy crowns. The analysis includes field report which includes the total number of trees in the field, number of healthy trees, number of defected trees, each tree with unique 'tag' and the GPS location tagging to the images which will help in the field to locate the trees in specific areas. For validation of the AI models, field testing was done for two coconut plots in CPCRI Kasaragod campus where images were captured using RGB camera mounted on drone. The plots chosen were having majority of coconut palms heavily infested by rhinoceros beetles. The images captured by the drone were tested using developed AI algorithm in the field. The results delivered by the algorithm were checked and verified manually in the field by observing the coconut trees. For every image, qualitative and quantitative analysis is generated by the algorithm. The output analysis gave GPS location for each individual tree detected by the algorithm. The validation was done by physically going to the GPS location provided by the algorithm. For a given plot, detection of 'Healthy' coconut crowns was having accuracy of 87.5% and detection of rhinoceros beetle infested coconut crowns was the accuracy of 83.4%.

Fig. 22. Stitched image of whole coconut garden at CPCRI, Kasaragod

Root (wilt) Disease Detection: For detection of root wilt disease, the crown classification model was trained for two classes: `Healthy' and 'Root wilt affected". Model was trained with batch size of 64 and learning rate of 0.001 using SGD optimizer for the experiments. The classification model used 3800 `Healthy' cases and 3776 root wilt affected cases of coconut crowns from dataset. The classification model was trained on 80% of data for 120 epochs. The 20% of dataset was used for test where the classification model achieved accuracy 77.81%.

A toolkit to analyze and process multispectral images is being developed. The NDVI, and NDRE images were developed from multispectral images (Fig. 23). Algorithms and software to process and analyze multispectral images were developed. The AI models developed with RGB images and pipeline proposed can be integrated with multispectral imaging for identifying salient features of various pests and diseases in their earlier stages.



a. NDVI image b. NDRE image

Fig. 23. Multispectral images captured using drone and converted to NDVI and NDRE images; a) NDVI image – index used for leaf coverage and plant health; b) NDRE image : Index sensitive to content of leaves against soil background

VI. 5. INTEGRATED MANAGEMENT OF PESTS AND NEMATODES

Rhinoceros beetle, *Oryctes rhinoceros:* Smearing of botanical paste on the spear leaf and covering with fish nets could reduce the pest incidence to more than 72% and area-wide demonstration. In an attempt to detect *Oryctes rhinoceros* nudivirus (OrNV)-resistant haplotype if any in the country, grubs of rhinoceros beetles were collected from the field and inoculated per os with OrNV suspension in the laboratory. During 2021, more than 90% grubs exhibited typical symptoms of loss of appetite, absence of dark gut lining and extroversion of gut indicating the absence of OrNV-resistant haplotype (Guam strain) (Fig. 24). At Kasaragod, no natural infection by OrNV was recorded from field-collected grubs. Upon artificial inoculation of OrNV through per os and food contamination technique, about 90-95% grubs were found infected with typical disintegration of fat body, flaccid cum leathery cuticle and other characteristic symptoms. Molecular characterization of samples is under progress for further confirmation.

Fig. 24. OrNV infected grubs of rhinoceros beetle a) OrNV-infected and healthy grubs b) White and translucent gut contents of OrNV-infected grub c) Extroversion of gut d) Disintegration of fat body e) Different stages of OrNV-infected grubs.

Red palm weevil, *Rhynchophorus ferrugineus*: In collaboration with a Start-up firm M/s Resnova, Kochi, an acoustics-sensor based hardware prototype for early diagnosis of red palm weevil attack was developed based on the feeding cum gnawing sound produced by the grubs. The hardware prototype comprised a sensor, processing unit, display system and power pack as energy source. The sensor is placed on the palm trunk and the embedded hardware records the lower order acoustic feeding signals. The AI model checks for patterns pertaining to the gnawing sound produced by the feeding grubs. In a timeframe of two minutes, the display panel will indicate the presence of grubs as detected or absent. The field efficacy in pest detection was found to be as high as 80%. A cloud-based integration of this prototype through a mobile App is the way forward for easy utility.

In collaboration with KVK Kasaragod, on farm trial (OFT) was conducted to evaluate the efficacy of citriodora oil impregnated calcium alginate beads as prophylactic repellent against red palm weevil infesting coconut palms. The experiment is being continued in 2021 at Panayal Village in Ajanur panchayat Kasaragod. Ten farm units having 3-8 years old coconut palm prone to red palm weevil attack were identified. In each farm units, 50 palms (total 500 palms) were subjected to prophylactic leaf axil placement of citriodora oil impregnated calcium alginate beads @ 5g/ palm. It

provided complete protection for a period of 3 months. On 4th month one palm was found infested by RPW.

Fig. 25. Push-pull mode of RPW management a) RPW infested palm b) Calcium alginate beads c) Beads delivered through perforated polythene packets

Nut crinkler *(Paradasynus rostratus Dist.):* Incidence of the nut crinkling coreid bug, Paradasynus rostratus Dist. on young buttons was found quite severe in South Kerala causing nut drop syndrome. Immature stages of the pest (nymphs) were found in clusters during the inflorescence opening during July-September and their feeding could cause necrotic spindle-shaped lesions on young buttons at meristematic region. Such buttons fall in most cases and those retained, possible feeding impact on the mid or terminal region of the immature nut, exhibit nut crinkling symptoms. Drying of inflorescence could also be observed in certain cases when the nymphs feed on emerging buttons during blooming of inflorescence. Coconut eriophyid mite (*Aceria guerreronis* Keifer) and nut disease (*Lasiodiplodia* sp.) would add more injury and infections to the tender buttons in some cases. All these infestations in synergy with the disease lead to nut drop syndrome. Application of neem oil 1% or thiamethoxam 25%WG (0.2 g per litre) on bunches preferably after pollination and along the dwelling zones of leaf and inflorescence axils could reduce the damage potential significantly. Alternate hosts such as mango, cashew, Malabar tamarind, false mangosteen, guava, passion fruit etc are to be critically monitored for off-season hibernation.

Exotic whiteflies: Five non-native whiteflies (*Aleurodicus dispersus, Aleurodicus rugioperculatus, Paraleyrodes bondari, Paraleyrodes minei and Aleurotrachelus atratus*) were recorded on coconut from different coconut growing regions in the country. Being a quarantine pest of concern, identity of puparium is very important in all species. The palm whitefly, A. atratus was also observed from Pollachi, Tamil Nadu in 2021 after its initial report from Mysuru and Mandya, Karnataka in 2019.

Though, rugose spiralling whitefly, *A. rugioperculatus* was aggressive in all coconut growing regions during the initial phase of introduction, the Bondar's nesting whitefly, *P. bondari* is predominant in all regions at this point of time. Co-occurrence of *P. bondari* with *A. rugioperculatus* is also observed in certain coconut tracts in Kerala. Bondar's nesting whitefly, P. bondari also co-exited with pepper whitefly (*Aleurotrachelus trachoides*), areca whitefly (*Aleurocanthus arecae*), citrus blackfly (*Aleurocanthus woglumi*), woolly whitefly (*Aleurothrixus floccosus*), ornamental Coleus whitefly (*Aleuroclava canangae*) and fig whitefly (*Singhiella simplex*) (Fig. 26).

Fig. 26. Co-existence of whiteflies a) *P. bondari* and *A. rugioperculatus* b) *P. bondari and A. canangae*

Competitive regulation of whiteflies: The modulation of whitefly population during the period is presented In Fig. 27. Rugose spiralling whitefly *(Aleurodicus rugioperculatus)* population was found to be very low (<0.5 colonies /leaflet) during August and October and thereafter shot up slightly to 0.7 colonies by December 2021. The population of Bondar's nesting whitefly (*Paraleyrodes bondari*) was found to be higher recording as high as 2.5 colonies per leaflet in the month of February and got reduced subsequently reaching as low as 1.0 colonies on May 2021. Weather factors especially relative humidity and rainfall supplemented with parasitism by *Encarsia guadeloupae* on *A. rugioperculatus* played a crucial role in whitefly dynamics. Competitive regulation of rugose spiralling whitefly (RSW) by the Bondar's nesting whitefly (BNW) during 2021 was observed with BNW colonies found higher than RSW colonies in most months.

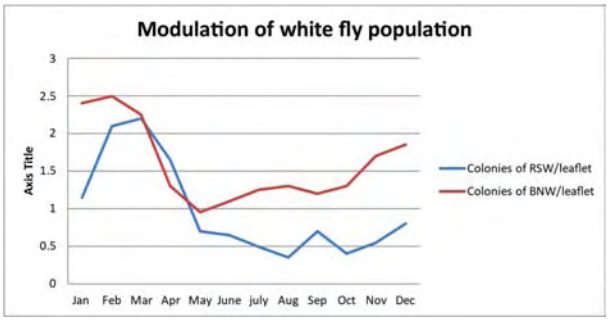


Fig. 27. Modulation of exotic whitefly population on coconut palms

Parasitism of rugose spiralling whitefly by the aphelinid parasitoid, *Encarsia guadeloupae* is presented in Fig 28. Percentage parasitism by *E. guadeloupae* on RSW colonies was found at higher level during January-April 2021. Highest parasitism was observed in Janaury (49%) and the lowest during October (12%). Parasitism increased with increase in RSW population. The population of RSW showed a downward trend after March 2021with a stabilized parasitism.

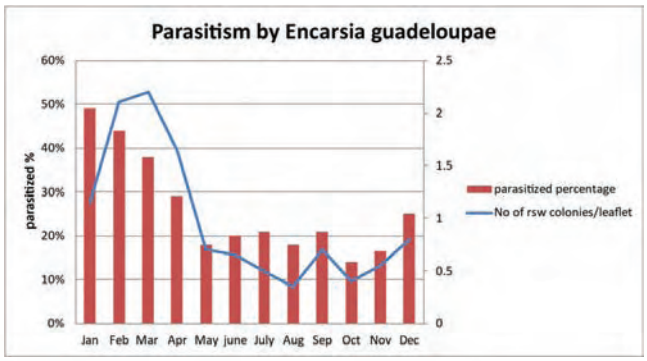


Fig. 28. Parasitism of RSW with *E. guadeloupae*

Population dynamics of whiteflies and parasitism at Kasaragod: Studies on whitefly population indicated that the pest occurrence was found highest during first half of the year (January-June) when compared to second half (July-December) (Fig. 29). Highest RSW population was observed during the month of April (7.9 adullts/ leaflet) and the lowest during October and December (2.4 adults/ leaflet). Similar trend was observed in the population dynamics of nesting whitefly as well during 2021. RSW population outnumbered nesting whitefly in all months except in the month of October. During 2021, per cent parasitism by *Encarsia guadelaupae* ranged between 36.84 (March) to 79.08 (October). Parasitism was found lowest during summer months and showed an increasing trend during second half of the year (Fig. 30).

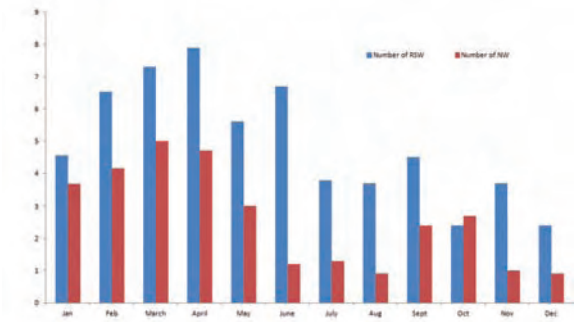


Fig. 29. White fly population in different monts in Kasaragod in 2021

Fig. 30. Percentage parasitism of *E. guadelaupae* on RSW pupae in 2021

In order to enhance the efficiency of trapping RSW on yellow sticky traps (90 x 90 cm), natural (castor oil) and synthetic glues were evaluated. Total numbers of whiteflies entrapped on yellow sticky trap with commercial glue and yellow sticky trap with castor oil were 297.25 ± 47.5 and 396 ± 72.49. respectively over a period of 30 days. The use of castor oil as sticky material

in yellow trap was found better than that of commercial glue.

Bio-suppression of rugose spiralling whitefly: The experiment was initiated during January 2021 on juvenile Kalpasankara palms to evaluate the efficacy of biorationals for the bio-suppression of rugose spiralling whitefly mainly coinciding with the rising phase of the pest. Four treatments (Conservation biological control, Application of *Isaria fumosorosea*, Application of neem oil 0.5%, Water spray) were superimposed with ten palms per treatment and sampling made on four leaflets per palm. Two sprays were undertaken at fortnightly intervals. The least reduction was observed on palms exposed to *Isaria fumosorosea* (36.7%), whereas, neem oil treated palms registered highest pest reduction of 82.4%.

Molecular characterization of the entomopathogenic fungus: The fungal ITS region of *Simplicillium lanosoniveum* was amplified using the primers: ITS4 (5'-TCCTCCGCTTATTGATATGC-3') and ITS6 (5'-GGAAGTAAAAGTCGTAACAAGG-3').
Two more nuclear genes viz., elongation factor-1 alpha (TEF1-a) and RNA polymerase II largest subunit 1 (RPB1) of the ribosomal RNA gene were used in addition to confirm the identification the species level. The DNA was amplified using specific primers of theTEF1-a (983F 5' GCYCCYGGHCAYCGTGAYTTYAT 3' 2218R 5'ATGACACCRACRGCRACRGTYTG and RPB1 (CRPB1 5'CCWGGYTTYATCAAGAARGT3' and CRPB1 A 5'CAYCCWGGYTTYATCAAGAA 3' RPB1Cr 5' CCNGCDATNTCRTTRTCCATRTA 3'. The resultant PCR products were excised and purified using a Qiagen Gel Extraction Kit (Qiagen India) following the standard protocol and were sequenced at Agrigenome, Cochin, India. The generated sequences were submitted to NCBI GenBank (Accession numbers: ITS = MK463992, TEF1—a = MW893683 and RPB1 = MW836952) and used for multi gene phylogenetic analysis. The sequences were used as query to perform BLAST search (http://blast.ncbi.nlm.nih.gov/), and the sequence similarity studies were performed using ClustalX (1.81). The phylogenetic tree of *S.lanosoniveum* was constructed following maximum likelihood (ML) method using MEGA X software. The sequence information of Metarhizium anisopliae (MK532369) was used as an outgroup control in the molecular phylogeny analysis.

Bioassay of the S. lanosoniveum on rugose spiraling whitefly: A gradient of five spore concentrations (1 × 104, 1 × 105, 1 × 106, 1 × 107 and 1 × 108 conidia/mL) of the *S. lanosoniveum* were tested against eggs, initial (first), middle (second – third instars) and later (fourth) instar stages of RSW under laboratory conditions. Results revealed that *S.lanosoniveumis* highly pathogenic to all developmental stages of RSW by causing highest mortality of 95.20 %, 87.33 %, 85.38 % and 72.85 %, in eggs, initial, middle and later instar nymphs of *A. rugioperculatus,* respectively at a high concentration of 1×108 spores/mL at 7 days after exposure. The LC50 and LT50 values recorded for *S. lanosoniveum* were 4.72 × 104, 4.94 × 104, 5.11 × 105, 5.92 × 105 conidia/mL and 4.27, 4.86, 4.56, 5.89 days against eggs, initial, middle and later instar nymphs of RSW, respectively.

Crop pluralism for pest regression and doubling income: In the crop-pluralistic diversified coconut garden (Kalpa Sankara hybrid, n=39) planted in August 2012 with varied intercrops, mean nut yield for six years was found as 156 palm/year. In addition, pest suppression by 80.7%, 100% and 91.5% due to damage by rhinoceros beetle, red palm weevil and rugose spiralling whitefly, respectively could be realized in the crop-pluralistic garden as compared to mono-cropped coconut (Table 4). Soil temperature was low by 5°C and >25 earthworm casts 30cm^{-2} were observed in the diversified garden conserving biodiversity and making it climate smart as well. About 5-7% nut yield enhancement due to establishment of bee colonies was realized.

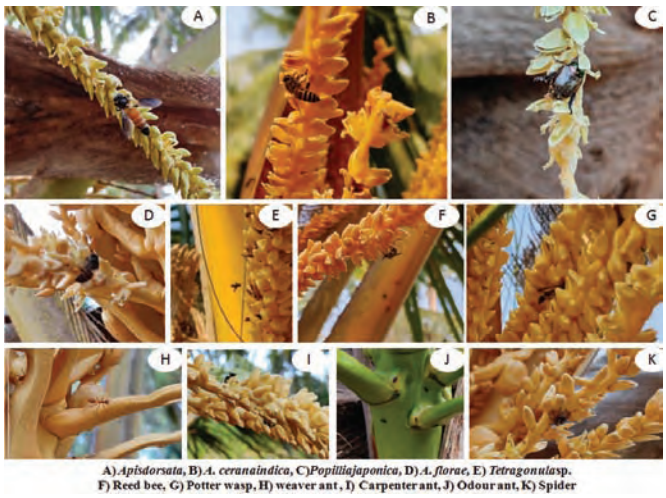
Table 4. Pest incidence in mono-cropping and diversified coconut garden

Pests (%)	Mono-cropping	Crop-pluralism
Rhinoceros beetle	22.9	4.4*
Red palm weevil	1.2	0
Rugose spiralling whitefly	24.8	2.1*

*Significant (t<0.05)

Diversity of inflorescence foraging insects: A preliminary study on inflorescence visitors on coconut palm was taken up at Kasaragod. The different foragers recorded included honey bees (*Apis dorsata, A. cerana indica, A. florea, Tetragonula* sp.), Reed bees (*Braunsapis* sp.), Potter wasp (*Delta* sp.), Carpenter ant (*Camponotus* sp.), weaver ant (*Oecophylla smaragdina)*, Odour ant (*Tapinoma* sp.), Flower beetle (*Popillia japonica*) etc (Fig. 31). Honeybees were found to be the most abundant insect visitors especially

A. cerana indica (20-25%). Aggregation of flower beetle was observed (0-20 beetle/inflorescence) on yellow dwarf palms. Maximum insect diversity was observed during 9.00 am to 11.00 am.



A) *Apisdorsata*, B) *A. ceranaindica*, C) *Popilliajaponica*, D) *A. florae*, E) *Tetragonula* sp. F) Reed bee, G) Potter wasp, H) weaver ant, I) Carpenter ant, J) Odour ant, K) Spider

Fig. 31. Different foraging insects on coconut inflorescence

Compatibility of bioagents and insecticides: Insecticides are one of the key IPM components in the management of white grubs (*Leucopholis spp.*) infesting palms and the antagonistic fungus, *Trichoderma harzianum* is used effectively in the bio-suppression of basal stem rot disease. Hence, a study was undertaken to assess the compatibility of insecticides and *T. harzianum* in the laboratory. Six insecticides viz., Imidacloprid, bifenthrin, chlorpyriphos, fipronil, thiamethoxam and emamectin benzoate were assessed with *T. harzianum* (CPCRI TR 28 isolate) *in vitro* by poison food technique. Among the insecticides evaluated, bifenthrin even at the highest dose of 40 ppm did not affect the growth of *T. harzianum* for the three-time periods studied (24h, 48h & 72h). All other insecticides viz., chlorpyrifos (10 ppm), thiamethoxam (4 ppm), fipronil (1 ppm) and imidacloprid (1 ppm) inhibited the growth of *T. harzianum* by 5.7%, 6.0%, 7.0% and 11%, respectively. The study indicated the relative safety and compatibility of bifenthrin (40 ppm) with *T. harzianum* followed by chlorpyrifos (10 ppm) and thiamethoxam (4ppm).

Mass multiplication of entomopathogenic fungi: In order to mass multiply the entomopathogenic fungi *Simplicillium lanosoniveum* by solid state fermentation, the cost effective substrates such as wheat bran, wheat, rice bran, rice, sorghum, sorghum bran, urad dal bran, soft wood sawdust and coir pith were studied. Highest cfu was recorded in wheat bran (1023) followed by rice (934), rice bran (856) compared to other substrates.

Pest surveillance

Incidence of Cycad blue butterfly *Luthrodes pandava* (formerly *Chilades pandava*) (Lepidoptera: Lycaenidae) on ornamental palm, *Cycas revoluta* at ICAR CPCRI Kasaragod was noticed (Fig. 32). The larvae scrape and feed the chlorophyll of tender fronds of sago palm, Cycasrevolute which give burnt up appearance.

Fig. 32. Cycad blue butterfly a) Initial damage symptoms b) Advanced symptoms c) Butterfly pest

Entomopathogenic Nematodes

Entomopathogenic nematode belonging to the rhabditid group isolated from the Thekkekkara village of Alappuzha district was subjected to molecular characterization by sequencing 28S rRNA gene region of the ribosomal DNA using 28SF and 28SR primers and it showed 98.72% identity with *Metarhabditis* rainai with available sequences in the NCBI data bank. The evaluation on the efficacy of the nematode isolate against 4th instar larvae of *Galleria mellonella* revealed the biocontrol potential of the isolate by inducing 100% larval mortality within 24 hours of treatment application when applied @ 20 IJs/larva.

Effect of pesticides on the survival of EPN: Effect of most frequently used fungicide and insecticide in the coconut system namely Hexaconazole and Imidacloprid was evaluated on the survival of different entomopathogenic nematodes. The infective juveniles of five entomopathogenic nematodes namely *Steinernema* sp. CPCRIS0804 (S0804), *S. hermaphroditum* CPCRIS0905

(SH), *S. abbasi* (SA), *S. carpocapsae* (SC), *Heterorhabdidis indica* CPCRIH12H (HI) were exposed to the recommended doses of the pesticides under laboratory condition and observations on the survival was recorded in 24 hours interval for first three days followed by weekly observation up to one month. Hexaconazole was observed to induce higher level of mortality in all the EPNs as compared to Imidacloprid. Among the species evaluated, *H. indica* was observed to be highly susceptible to both the pesticides followed by *S. hermaphroditum*. However, Steinernema sp. CPCRIS0804 was found to be the most resistant to both the pesticides with maximum of only 22% and 26% mortality after one month of exposure to Imidacloprid and Hexaconazole, respectively.

Demonstrations of EPN for pest management in vegetables: Foliar application of 'Kalpa EPN' (CPCRI – SC1) Aqua formulation of entomopathogenic nematode *Steinernema carpocapsae* @ 75 IJs / ml of water at fortnightly interval against leaf eating caterpillars in vegetables intercropped in coconut system recorded lowest pest incidence in cabbage and cauliflower (10.76%). Reduction of red pumpkin beetle population (79.66%) in cucurbits was recorded during the field demonstrations in farmers field and institute research farm.

Success story of 'Kalpa EPN' in the management of white grubs infesting palms: Application of aqua formulation of 'Kalpa EPN, *Steinernema carpocapsae* (CPCRI-SC1) @1.5 billion IJs/ha and 0.26 billion IJs/ha respectively in the root zone of arecanut and coconut palms, suppressed the white grub population to the tune of 85%-90% and 55%-60% in order. This technology was commercialized and transferred to six entrepreneurs/ farmers groups in and around Kasaragod district of Kerala, Dakshina Kannada, Udupi, Chikamagaluru, Shivamogga and Utttar Kannada district of Karnataka and some of them were able to establish small scale production units and supplied fresh EPN material at local village farmers (Fig. 33).

Plant Parasitic Nematodes

Isolation and molecular characterization of parasitic nematode (CPP1) associated with root knot nematode infesting guava from the ecological engineering garden of ICAR-CPCRI, Regional station, Kayamkulam a potential fungal bioagent against plant parasitic nematode revealed the sequence similarity of the

Kalpa EPN aqua formulation

Bhoomi EPN formulation

Fig. 34 Demonstration of EPN for eco-friendly management of pumpkin beetle in cucurbits

isolate with *Pochonia chlamydosporia* and submitted the sequence data in NCBI GenBank (Acc. No. OM311939). Preliminary study on the biocontrol potential of the isolate revealed significant reduction in the galls induced by root knot nematodes in okra under net house condition.

Chlamydospores

RKN egg mass infested with *P. chlamydospria*

Prevalence of plant parasitic nematodes in coconut intercrops: Studies carried out for the survey and collection of soil and root samples for the characterization of root knot nematodes (RKN) in coconut intercrops in coconut gardens of Alappuzha district. All the locations sampled were found to be infested with RKN with mild to severe infestation in the crops sampled. The crops like amorphophallus and ginger was observed to be most severely affected, whereas comparatively less incidence of RKN was observed in arrowroot and colocasia. The molecular characterization of RKN isolated by the sequenceanalysis of 28S rRNA, revealed the association of *Meloidogyne* incognita and *M. javanica* with the crops sampled.

Integrated management of plant parasitic nematodes in the coconut intercrops: Awareness was created among the farming community in the different villages of Alappuzha district regarding the importance of plant parasitic nematodes as well as the strategies to be followed for their effective management. Integrated nematode management strategies like field sanitation, use of nematode free planting materials, use of *Trichoderma* enriched neem cake and organic manures were demonstrated in three farmers fields. Significant reduction in the nematode infestation was observed in the demonstration plots as compared to the neighboring farmers.

Eco-friendly management of Root-knot nematode in turmeric intercropped with coconut.

Two year field studies indicated that soil application of the fungal bio-agent, *Pochania chlamydosporia* (IISR) and *Trichoderma harzianum* (CPCRI) talc formulation @ 50g / bed (mix with 2kg FYM) at the time of planting pre monsoon (June) and post monsoon (October) period were found promising in the bio-suppression of root-knot nematode, *Meloidogyne incognita* infestation in turmeric (cv Prathibha) intercropped in coconut plantations. Repetitive application of these fungal bio-agents improved the plant health due to the suppression of nematode galls on roots (1.36galls/ plant).

Arecanut kernel decay

Xylosandrus crassiusculus (Coleoptera: Curculionidae: Scolytinae) is reported causing damage to areca palm plantations (*Areca catechu* L. – Arecaceae) in Karnataka. In particular, *X. crassiusculus* has been observed attacking and successfully reproducing on arecanuts; besides the new host plant record, the data provided here represent the first documented case of spermatophagy for this xyleborine beetle. The identity of the scolytid, besides morphologically, was confirmed by its DNA barcoding. Eggs, larvae and pupae were found within the galleries of infested kernels (Fig. 35). All galleries of the infested kernels were characterized by the presence of whitish to greyish fungal growth. The fungus was identified as *Ambrosiella roeperi,* a known symbiont of *Xylosandrus crassiusculus.*

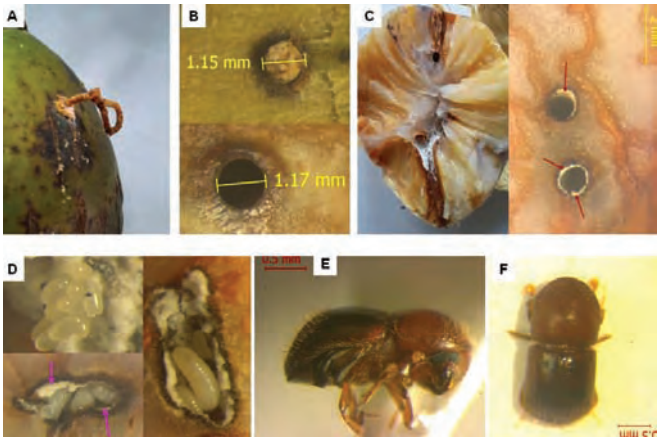


Fig. 35. A-D: Damaging symptoms; D-F; Egg, grub and adult beetles of *Xylosandrus crassiusculus*

Tea mosquito bug, *Helopeltis theivora* infesting cocoa (*Theobroma cacao L.*)

An extensive survey was conducted in Dakshina Kannada district of Karnataka, Peninsular India and H. theivora adults naturally infected with entomopathogenic fungi were collected. Pure culture of the entomopathogenic fungus was isolated from the infected adults. Morphological and molecular characterization confirmed the identity of the fungus isolate (TMBMA1) as *Metarhizium anisopliae* (Metsch.) Sorokin. *In-vitro* efficacy of *M. anisopliae* conidial suspension (1×103 to 1×109 ml-1) against laboratory-reared *H. theivora* confirmed 100% mortality at 1×108 and 1×109 conidial suspensionsafter 6 d of inoculation. Field evaluation conducted for two consecutive years (2019 and 2020) recorded a significantly lower incidence of mirid in *M. anisopliae* TMBMA1 sprayed treatments compared to control. Therefore, *M. anisopliae* based bio-formulation would be an eco-friendly and sustainable alternative for mirid management in cocoa and other plantation in India.

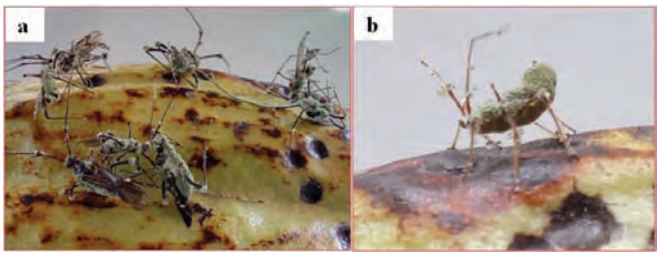


Fig. 36. Entomopathogenicity of *Metarhizium anisopliae* TMBMA1 against *H. theivora.* a Mortality of inoculated adult. b. Mortality of inoculated nymph recovered from field.

Naturally infected wasp (adult) with fungal growth on the body were collected from arecanut gardens located in Moodubidre, Dakshina Kannada district of Karnataka. Pure culture of the fungus was isolated on potato dextrose agar (PDA) media. Cultural and microscopic characteristics were recorded for fungal identification. PCR amplification of internal transcribed spacer (ITS) gene confirmed the identity of fungus as *Cordyceps javanica.* The nucleotide sequences of *Cordyceps* javanica strain (CPCRICJ1) generated in the present study have been deposited in GenBank with accession numbers; MZ396583 and MZ396584. *In-vitro* efficacy of *Cordyceps javanica* against laboratory reared TMB confirmed 100 per cent mortality of subjected adults after 72 h of inoculation. Koch postulate was confirmed by re-isolation of *C. javanica* from the dead cadaver.

VI. 6. PHYSIOLOGY, BIOCHEMISTRY AND VALUE CHAIN MANAGEMENT IN PALMS AND COCOA

Climate Change

Production, vulnerability assessment and adaptation strategies: 'MaxEnt' model was utilized to evaluate the bioclimatic variables determining the regions suitable for coconut cultivation and to predict the regions with potentially suitable climate under future climate conditions. Coconut is expected to witness a contraction in its suitable climate area size and will face a high risk of unfavorable climate in the south interior and eastern regions of India in the wake of global climate change (Fig.37). There is a shift in climate suitability from 'high' to 'moderate', 'moderate' to 'low' and 'low' to 'unsuitable' under future climate (Fig.38). Effective coordination amongst all stakeholders is essential to develop and implement adaptation strategies to ensure sustainable cultivation of coconut at least in presently cultivated areas.

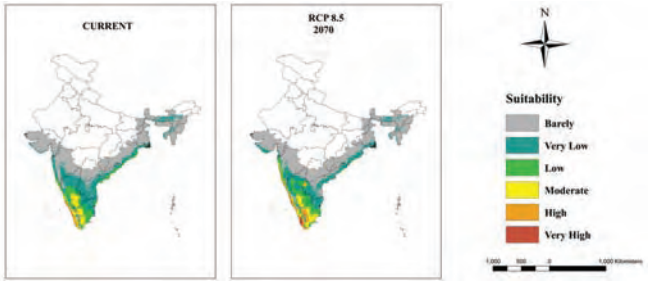


Fig. 37. Climatically suitable areas for coconut production in India under current and future climates of RCP 8.5 2070 as revealed by MaxEnt.

Molecular response of cocoa genotypes to water-deficit stress: The total RNA extracted from the leaves of both the control and treated (water-deficit stress) cocoa genotypes viz., VTLC22 and VTLC15 were sequenced using next generation sequencing (NGS) Illumina platform. Analysis of differentially expressed transcripts revealed that, 486 cocoa water-deficit stress

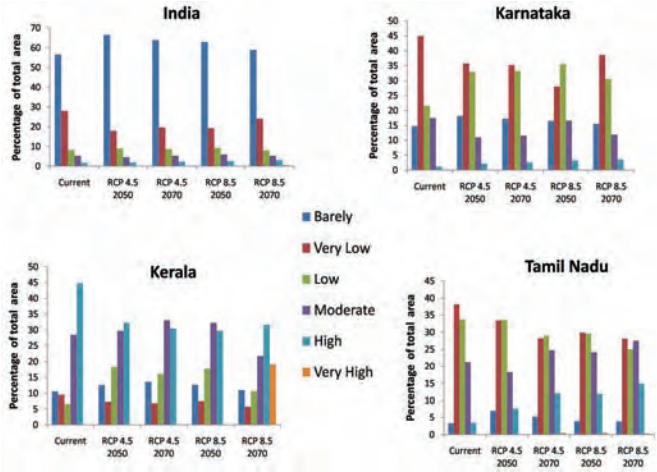


Fig. 38. Percentage of total predicted area under current and future climate of the study area in India and at the regional levels of Karnataka, Kerala and Tamil Nadu.

responsive transcripts are specific to VTLC15 whereas 505 water-deficit stress responsive transcripts belonged to VTLC22. Among this 303 transcripts were shared by both the genotypes (Fig.39a). The differential gene expression pattern in the cocoa genotypes was further corroborated by the variations in the enrichment of KEGG metabolic pathways suggesting differential molecular responses of the genotypes to water deficit stress. Water-deficit stress activates multiple metabolic pathways involved in chalcone synthase, genes involved in cell number regulator, aspartate amino transferases and MYB-related protein among others suggesting the molecular interplay of diverse metabolic pathways (Fig. 39b). Furthermore, conserved pre-miRNA sequences were found to be expressed between the genotypes suggesting the role of non-coding RNAs in response to water-deficit stress in cocoa.

Phenolic acids of coconut testa oil: The phenolic acids of coconut testa oil extracted with 80% methanol were

characterized using LC-MS/MS (Waters UPLC H class system fitted with TQD MS/MS system). It revealed the presence of 18 phenolic acids such as p-coumaric acid (67.40 ± 4.8 µg g^{-1}), caffeic acid (15.14 ± 0.24 µg g^{-1}), vanillic acid (5.32 ± 0.09 µg g^{-1}), ferulic acid (5.05 ± 2.10 µg g^{-1}), trans cinnamic acid (3.75 ± 0.83 µg g^{-1}), gallic acid (3.10 ± 0.59 µg g^{-1}), o-coumaric acid (2.26 ± 0.34 µg g^{-1}), p-hydroxy benzoic acid (1.83 ± 0.12 µg g^{-1}), among others. Phenolic acids such as benzoic acid, syringic acid protocatechuic acid and chlorogenic acid, salicylic acid, 3-hydroxy benzoic acid, 2,4-dihydroxybenzoic acid , sinapic acid and ellagic acid are found in minimal quantities (<1 µg g^{-1}).

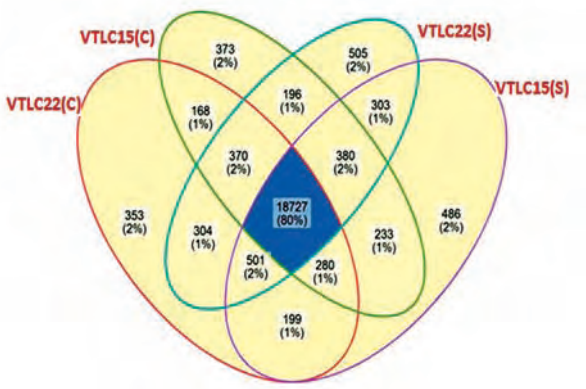


Fig. 39a. Venn diagram of unique and common differentially expressed transcripts of cocoa genotypes VTLC15 and VTLC22 under water deficit stress.

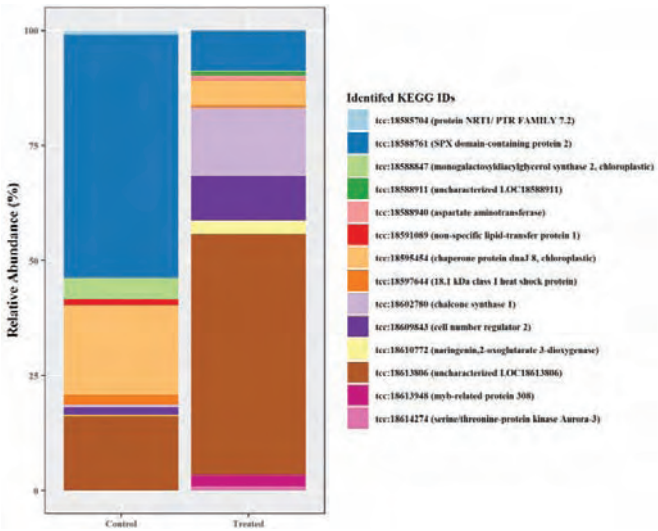


Fig. 39b. Functional categorization of DETs of cocoa genotypes based on KEGG pathway analysis

Value Chain Management

Tender coconut cutting machine: Two tender coconut cutting machines were developed: (i) A semi-automatic tender coconut cutting machine based on the principle of conversion of rotary motion to linear motion operating the knife (Fig. 40a); and (ii)A hydraulic mechanism-based cutting machine (Fig. 40b). The semi-automatic machine can be operated with battery and/or solar power. The cost and capacity of the developed machine is Rs. 25000 and 180 nuts h^{-1}, respectively. This concept has been commercialized to a machine manufacturer. The hydraulic mechanism-based cutting machine consists of SS 304 grade cutting knife, coconut water collection tray and container. Dimension of the developed machine is 1829 mm × 610 mm × 610 mm. It can be easily operated with foot. The limit switchers and sensors were fixed to control the movement of the knife and operator safety. The capacity and cost of the machine is 250-300 nuts/h and Rs. 88000/- respectively. These machines are quite valuable for the tender coconut processing industries.

Fig. 40a. Semiautomatic tender coconut cutting machine

Fig.40b. Hydraulic mechanism based tender coconut cutting machine

Rapid detection of adulteration in desiccated coconut powder: To evaluate the adulteration of desiccated coconut powder (DCP) with coconut milk residue (CMR) vis-NIR (350-2500 nm) spectroscopy along with the chemometric techniques has been used. Partial least square regression (PLSR) models were developed using whole spectral data and selected wavelengths (Fig.41). No statistically significant differences were observed between the PLSR model developed for selected

wavelengths ($R2_P$=0.869; SE_P=11.701; RPD_P=9.381; RER_P=8.595) against PLSR model for whole spectral data. The developed model can be used to predict the level of adulteration in DCP if the adulterant concentration was more than 10%.

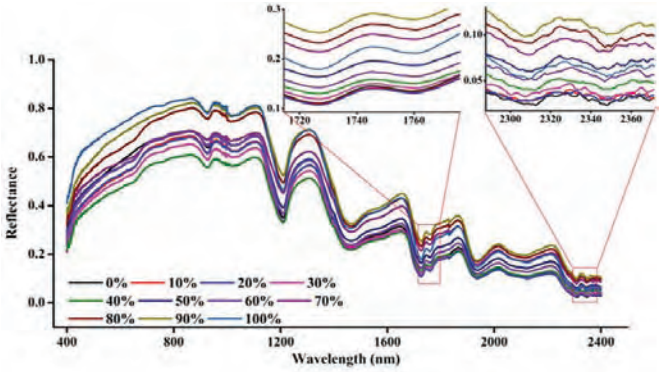


Fig. 41 Spectral signature of desiccated coconut powder adulterated with different levels of coconut milk residue.

Skimmed coconut milk culture-based fermentation for VCO production: Application of aerobic fermented skimmed coconut milk culture (SCMC) at varying concentrations (5-25%) was explored to maximize the yield and quality of virgin coconut oil (VCO) and to minimize the cost, time and energy during the production process. It was observed that 24 h old SCMC at 10% concentration recorded a maximum yield (19.2%) in 19 h fermentation. Individual and interactive effect of type of culture (24 h and 48 h old SCMC) and concentration has significant effect (P<0.001) on yield and non-significant effect on physical (moisture content, viscosity, specific gravity and refractive index) and chemical profile (free fatty acid, peroxide value, acid value, saponification value, iodine value, and total phenolic content) of VCO.

Quality parameters of coconut vinegars and cider apple: A comparative analysis

Natural vinegars produced from coconut inflorescence sap and mature coconut water were compared to that of vinegar from a traditional source, cider apple. The effects of pasteurization and long-term storage (one year) on their quality parameters revealed significant differences (p<0.05). pH of vinegars produced from different substrates varied from 3.033 to 3.31. Titratable acidity was maximum (6.6%) in coconut inflorescence sap-based vinegar particularly in the samples stored for a year wherein no significant influence of pasteurization (p>0.05) was observed. Ascorbic acid content and antioxidant potential were higher in vinegar made of coconut inflorescence sap. However, the total phenolic content of vinegar made from coconut water was comparable to that of vinegar from cider apple. Comparative mineral profiling of fresh and stored coconut vinegar samples, with and without pasteurization and cider apple vinegar revealed that total P, K, Na and Mg content of pasteurized and unpasteurized coconut vinegars were high than that of apple cider vinegar. Total K and Na content were high for vinegar prepared from coconut water compared to inflorescence sap based vinegar and apple cider vinegar. Apple cider vinegar recorded higher sulphur content than coconut vinegars. Both pasteurized and unpasteurized one year old inflorescence sap based vinegar recorded the highest value for total Fe, Mn and B than fresh inflorescence sap vinegar and cider apple. Thus, coconut-based substrates, serve as an excellent source for natural vinegar which can supply fairly a good amount of minerals than cider apple vinegar.

Time course studies on physico-chemical characteristics of coconut oil during continuous and intermittent heating and frying: The physico-chemical qualities of traditional rotary expelled fresh coconut oil under continuous heating and intermittent heating were examined. Continuous heating (coconut oil) with and without sample (papad) was carried out for 1 h and oil was analysed at every 15 min interval. Whereas, intermittent heating with and without sample was performed for 48 h and oil was analyzed at every 24 h interval. Significant effect (P<0.05) was observed for the physical (moisture content, water activity, specific gravity and turbidity) and chemical (free fatty acid, acid value, peroxide value and saponification value) attributes of the oil. Colour of continuously heated sample had changed from cloudy light yellow to brown during 1 h of heating. Parameters namely, moisture content, water activity, specific gravity, free fatty acids, acid value have significantly decreased, whereas turbidity, peroxide value, and saponification value were significantly increased. Moisture, water activity, specific gravity and free fatty acids reduced from 0.19% to 0.13% and 0.16%, 0.796to 0.76 and 0.69, 0.94 g/mL to 0.85 g /mL and 0.89 g/mL, 0.93 % to 0.55% and 0.59% for continuously heated oil without sample and with sample, respectively. The same parameters have changed from 0.19% to 0.12% and 0.1%, 0.796 to 0.449 and 0.397, 0.94 g/mL to 0.93 g/mL and 0.93 g /mL 0.93% to 0.595 and 0.7%, respectively in intermittent heating

without sample and with sample. Both free fatty acids and peroxide values were found on par in intermitted heating of coconut oil (P>0.05). Nonetheless, the values did not exceed the APCC/ICC standards. This experiment suggests heating and frying of coconut oil with and without sample was stable for 1 h.Intermittent heating of oil for 48 h with samples also remained stable for the aforesaid physicochemical quality parameters.

Coconut infused dark chocolates: 'Kalpa bean to bite' dark chocolate comprises 45% cocoa nibs, 30% coconut sugar and 25% cocoa butter. Considering the economic cost of cocoa butter, an effort was made for partial substitution of cocoa butter with different levels of coconut products and by-products such as desiccated coconut, coconut milk powder, coconut milk residue and VCO cake (25 and 50% replacement respectively). The resultant chocolates were compared with that of two control chocolates ('Kalpa bean to bite' and a commercial dark chocolate with 70% nibs and 30% coconut sugar) with respect to sensory attributes and nutritional quality. The raw materials such as raw, roasted beans, nibs showed maximum phenolic content. Among the butter substitutes, chocolate made with 50% of butter replacement with desiccated coconut (703.25 mg GAE/ 100g) showed the maximum phenolic content followed by 50% coconut milk residue (619.56mg GAE/ 100g). Reduction in flavonoids occurred while roasting. Dark chocolate made with 70% nibs and 30% coconut sugar showed high flavonoids comparable with that of raw beans. Cocoa butter replaced with 25 and 50% coconut milk residue was comparable with that of dark chocolate made with the control followed by 50% desiccated coconut. With regard to antioxidant activity, chocolate made with 50% butter replacement with coconut milk residue showed higher antioxidant potential (FRAP) (542.03mg TE /100g) than that of the control (446.82mg per TE/ 100g). With regard to the macro nutrients (P, K, Na, Mg, Ca and S), and micro nutrients (Fe, Mn, Zn and Cu), raw beans and roasted beans showed maximum values followed by chocolate made with 50% butter replacement with VCO cake. Sensory evaluation of the products revealed that the chocolate made with 50% replacement of butter with VCO cake was preferred statistically significant than other treatments. However, there were no significant difference among the chocolate samples in the scores obtained for appearance, colour and mouth feel (P>0.05).

Development of coconut cake and coconut halwa: The common ingredients of cake were replaced with coconut products such as coconut milk, coconut sugar, desiccated coconut powder, coconut milk powder, coconut vinegar and virgin coconut oil. The optimized formulation consists of 38.7% coconut milk, 27.9% wheat flour, 24.8% coconut sugar, 4.6% desiccated coconut powder, 1.5% virgin coconut oil, 0.8% coconut milk powder, 0.4% coconut vinegar with 0.6% baking powder, 0.3% baking soda and 0.4% vanilla essence. The optimized conditions were, preheating and baking at 180°C for 10 min and 40 min respectively. The product showed 25% fat and 2% protein with a moisture content of 20%. The optimized combination of coconut halwa is70% coconut milk (pooled extraction), 25% refined sugar and 5% maida with an overall acceptability score of 8.5. The optimized halwa had 11% moisture, 57.1% carbohydrates, 30.6% fat, 0.7% protein and 0.6% ash.

Portable biochar unit for tender coconut husk

Prototypes of two portable biochar units based on gasification and pyrolysis methods were designed and fabricated to convert tender coconut husk to biochar. Gasification unit comprised of burning chamber with four control valves to control air intake, a lid and a smoke pipe attached to it for enhanced suction. Pyrolysis unit comprised of burning chamber, a lid and a smoke pipe attached to it for enhanced suction. Three pyrolysis chambers were also fabricated to optimize the biochar production.

Gasification unit

Pyrolysis unit

VI. 7. TECHNOLOGY TRANSFER, ECONOMICS AND STATISTICAL METHODS

Frontline extension

As part of disseminating technologies evolved at the institute various technology transfer initiatives with the active participation of farmers, entrepreneurs, Farmer Producer Organisations (FPOs), development/ extension agencies and other stakeholders were organised during 2021.

Capacity development programmes: As part of the technology transfer initiatives of the Institute capacity development programmes including training on various aspects of crop management and value addition of mandate crops were organised during the year 2021 (Table 5).

Table 5 . Training and interface programmes and field visits conducted during 2021

Centre	Institutional		Off-campus	Online	Diagnostic field visits
	Farmers	Others			
Kasaragod	17	8	5	4	25
Kayamkulam	6	2	13	31	18
Vittal	10	2	5	1	37
Mohitnagar	2		8	5	2
Kahikuchi	29		3	16	4
Kidu	1				
Total	65	12	34	57	86

Some of the salient training programmes conductd during the year are

- Agriculture Skill Council of India (ASCI) sponsored training on 'Nursery Worker' (AGR/Q0807) conducted at Vittal during 15 Feb to 11 Mar 2021 upon the request of Directorate of Cashewnut and Cocoa Development, Kochi.
- ICAR-CPCRI Research Centre, Kahikuchi conducted a 21 days
- Training programme on 'Role of farm mechanization in enhancing agricultural production in Assam' in 21 batches that benefited 1050 (635 female) farmers from 6 districts of Assam.
- Training on 'Scientific Cultivation and Production technology of Coconut, Arecanut and Cocoa in Assam' in eight batches for farmers from eight district of Assam.
- Off-campus training in Tripura (two) and Meghalaya (one) on 'Scientific cultivation and management practices of Arecanut, Coconut and cocoa'.
- Entrepreneurship Development Programme (EDP) on coconut cultivation for Gujarat farmers (8-9 Mar 2021) at Kasaragod.
- An online training program 'Gender dimensions for knowledge integration and sustainable food systems through IFS' was conducted from 4-6 January 2022 in collaboration with MANAGE, Hyderabad.
- Second batch of one year Diploma in Agricultural Extension Services for Input Dealers (DAESI) of Alappuzha District in collaboration with ATMA, Alappuzha, SAMETI, Kerala and MANAGE, Hyderabad.
- A Farmers' Meet and training programme on 'Conservation and utilization of coconut genetic diversity in farmers' field', 17November 2021 at Bedadka

- Scientist-FPOs interface programme on 'Effective use oftechnologies for coconut prosperity - Role of Farmer Producer Organizations' 21 Oct 2021 at Kozhikode.
- District level Cocoa seminar on 8 March 2021 sponsored by DCCD as part of International Women's Day.
- Training programme on "Advances in management of pest and diseases in Arecanut", 7 Oct 2021 at Enmakaje, Kasaragod with financial assistance from DASD, Kozhikode.

Fig. 43 a,b Training programmes at Kasaragod and Vittal

Diagnostic field visits: During 2021 a total of 86 diagnostic field visits were conducted by the multi-disciplinary team of scientists (Table 5)

Frontline demonstrations (FLDs): The following FLDs on selected technologies were conducted (Table 6)

Table 6 Frontline Demonstrations in 2021

Demonstrations	Number
Soil and water conservation techniques in coconut gardens in different localities of Kasaragod district	18
Demonstration of Kalpa EPN (CPCRI – SC1) application for the management of white grub in arecanut and coconut	2
Integrated Root (wilt) disease management practices	105
ICAR CPCRI nutrient mixture 'KalpaVardhini'	70
Soil and moisture conservation and INM practices in coconut palms	15
Integrated nematode management of Amorphophallus for planting material production (var: Gajendra) as intercrop in coconut gardens	10
Arecanut based multi-species cropping systems in Assam	2
Arecanut based multispecies cropping system (in Karnataka)	5
Sesamum and pulse varieties	21
Five coconut varieties viz., Kera Chandra, Kalpatharu, KalpaPrathibha, KalpaMithra and Kera Keralam in Palakkad District Jail campus	1

Technology dissemination through mass media

- During the year 2021, 75 popular articles in farm journals and news papers on various aspects of crop management technologies and value addition pertaining to mandate crops were published.
- Three extension publications in Assamese language
- Newspapers in different languages have covered 50 technology transfer programmes and other events organised by ICAR-CPCRI in different stations and localities.
- A total of 40 radio programmes were made during 2021 that including the radio series on scientific arecanut cultivation in Malayalam entitled 'Kamukilninnu karuthilek' was broadcasted duringAugust-September 2021in collaboration with All India Radio, Kannur and the radio series on scientific arecanut cultivation in Kannada was

broadcasted duringAugust-November 2021 in All India Radio, Mangalore.

- Five television programmes were presented.

Farmer Producer Organizations: The Insltitute is the CBBO for formation and promotion of Two Farmer producer Organisations in Thrissur district (Chavakkad and Mullassery blocks) supported by National Cooperative Development Corporation.

ICAR-CPCRI is the POPI (Reg No. U0110KL2019PTC060976; funded by NABARD) for formation of FPO – The Odanadu farmer producer Company Ltd. It has 361 shareholders at present. Towards the value chain activities 14000 coconuts were procured for copra and coconut oil production. During the year 5.7 tons of Kalpa Vardhini and 1.8 tons of Kera Probio® were sold. 'Coconut Care & Cover Program' An innovative farmer service and technology transfer initiative to augment adoption among small and marginal farmers was launched.

Institute facilitated the formation of a farmers' collective located at Bedakam in Kasaragod district and its registration as *Bedakam Thengu Karshaka Samithi* Regd No. KSR/CA/219/2021 Dated 15.12.2021. The collective is having 2500 coconut farmers as its members.

Farm Advisory Services through ATIC

Various farm advisory services were offered to farmers and other stakeholders through Agricultural Technology Information Centre during 2021: 5859 farmers' queries were attended to and seedlings and other farm inputs worth Rs 74,58,608 were sold to farmers and other stakeholders (Kasaragod);and telephone advisory services (1238) (Kayamkulam)

Cyber extension activities: The programmes include webinar series on 'Redefining Agricultural Research and Education Priorities – Way Forward', 9-11 Aug 2021 (Kayamkulam) and the Kalpa Graduate Readiness Programme (2nd edition) (Kasaragod).

Through the E-Kalpa mobile app, 811 advisory services were provided: The app witnessed more than 10000 downloads by users.

Scheduled Caste Sub Plan (SCSP): A total of 17 training programmes were conducted for SC farmers and youths. Topics covered are apiculture (3); computer applications (3); coconut value addition (5); vegetable cultivation (2); and job training on cultivation aspects (4). Number of participants is 180.

Farm Inputs: Vegetable seeds 43.55 kg (280 beneficiaries); Beehives and accessories: 300 (60 beneficiaries); planting material: 5500 coconut seedlings and 3800 arecanutseedlings (285 beneficiaries).

Shri. K. Radhakrishnan, Hon'ble Minister for Welfare of Scheduled Castes, Scheduled Tribes and Backward Classes and Devaswoms, Government of Kerala, was the chief guest on 2 Sept 2022 to provide critical inputs to selected farmers in Thonnakkal village, Pothencode block, Thiruvananthapuram. He also addressed the ST-trainess at Aralam Farm.

Fig. 44a. Shri. K. Radhakrishnan, Hon'bleMinister handing over vegetable seeds.

Fig. 44b. Distribution of certificate to participants of training prorgramme and distribution of inputs for honey cluster farmers under SCSP

Scheduled Tribe Componenet (SCSP): Conducted four training programmes (145 beneficiaries): Coconut based enterprises for income and employment opportunities (Lakshadweep Islands and Aralam Farm); coconut nursery management (Purana Odapada, Odisha); and use of cocosap chiller for collection of Kalparasa® (Kaavarathi, Lakshadweep Islands).

Inputs distributed: In the tribal settlement area of Aralam Farm, 15t turmeric planting material (var. Pratibha of ICAR-IISR) was provided for commercial

cultivation and value addition. Forty cocosap chillers were provided to coconut farmers in Kavarathi and Adnroth, Lakshadweep Islands. A total of 11000 coconut seedlings were distributed to 9900 farmers in three tribal regions: Aralam farm, Dalua (Odisha) and Paderu (Andhra Pradesh). In the Paderu region, 6000 cocoa seedlings, 2000 bush pepper and 600 nutmeg grafts were provided, respectively for 40, 50 and 40 farmers.

Fig. 45a. Distribution of coconut seedlings in Odisha

Fig. 45b. Coconut nurser in Odisha under STC

NEH Component: Training programme for farmers on 'Production and protection technology on arecanut, coconut and cocoa'was conducted at ICAR CPCRI RC, Kahikuchi from 19-27 March 2021 in eight batches in which 320 farmers from Kamrup (Rural), Barpeta, Bongaigaon, Morigaon, Nagaon, West Karbi Anglong, Nalbari and Sonitpur attended.

Training programme on 'Scientific cultivation of Arecanut' was conducted in Umsawnongbri village, Ribhoi district, Meghalaya which was attended by 30 farmers

Training programme on 'Scientific cultivation and management practices of Arecanut, Coconut and cocoa' was conducted in Sepahijala district in Tripura during 2-3 March 2021 in which 110 farmers attended.

Inputs provided: 25000 arecanut seedlings were made available to Mizoram from Kahikuchi and Mohitnagar for distributioin to farmers through the Departiment of Horticulture. From Coconut Development Board, 5000 coconut seedlings were made available for distribution.

Training programme at Kahikuchi and distribution of inputs

Mera Gaon Mera Gaurav: Scientists of ICAR-CPCRI have regularly visited the selected villages under MGMG program and provided advisories on crop production and protection. Specific programmes conducted are:
Kasaragod: Training programme on 'Quality Planting Material Production in Coconut', and 'Cultivation of fruits and vegetables in coconut ecosystem', and distribution of vegetable seeds
Kayamkulam: 'Participatory rejuvenation of coconut homesteads in Bharanikavau, Chunakara and Vallikunnam villages as part of Kera Nanma programme, palm health management in Velanchiraon, distribution of soil health cards, interface programme on safe and approved use of insecticides, and distribution of vegetable seeds
Mohitnagar: Mulitple extension sctivities were conducted in three villages viz., Pradhanpara, Southmatiali and Kudipara
Kahikuchi: World Soil Day was celebrated on the 5th December, 2021 in which 23 farmers from two villages attended and Farmers' meet was organised on 14th December 2021.

Techno-socio-economic evaluation studies: Two studies were conducted: (i) Revitalising Farmer Producer Organisations in coconut sector and (ii) Adaptation deficit analysis and resilience strategies to climate change in coastal coconut agro-ecosystems.

The first study was conducted among 30 selected Coconut Producers Federations (CPFs) from four districts of Kerala viz., Malappuram (7 CPFs), Kozhikode (6 CPFs), Kannur (9 CPFS) and Kasaragod (8 CPFs) facilitated by Coconut Development Board (CDB). The major reason as perceived by the CPFs for the low level of achievements of objectives was lack of support and hand holding by development agencies like CDB and State Agriculture Department. Besides the analysis of performance of CPFs, data were also collected from Coconut Producer Companies (CPCs) facilitated by CDB functioning in Kozhikode district on their perceptions about interventions for revitalising FPOs in coconut sector. Important interventions needed as perceived by CPCs included the following.

- Revitalise the functioning of FPOs in coconut sector through appropriate policies and interventions by Coconut Development Board and State Department of Agriculture, Government of Kerala
- Network of CPSs and CPFs in Kerala may be involved for the effective implementation of coconut development schemes by Coconut Development Board and State Department of Agriculture, Government of Kerala
- Steps may be taken for empowering the CPSs/CPFs to organise community action for managing decentralised coconut nurseries, supply of customised fertilizer inputs for soil health management and facilitate area-wide adoption of integrated pest/disease management.
- Facilitate formation of consortium of FPOs in coconut sector and common branding for the coconut value added products produced and marketed by coconut FPOs
- A corpus fund may be raised with government support for generating sufficient working capital of coconut FPOs
- Procurement of coconut from coconut growers may be facilitated through the network of CPSs/CPFs and primary processing of nuts facilitate the formation of a nodal agency for the collection of copra and central facility for safe storage/ warehousing

In the second study, trend analysis of climatic variables during 2011-2020 revealed an increasing trend in rainfall and rainy days during August-December. Microbial and physico-chemical properties of soil were undertaken. All the soils were non saline in nature. In general, the potassium content was low in all farmers' fields ranging from 5.05 to 33 ppm, except three plots (50-225 ppm), indicating the need for nutrient conservation and slow-release methods like application of coir pith and modified method of husk burial. As part of the resilience strategies, adaptation measures like (a) Selection of ideal intercrops and crop planning for year-round cultivation of inter crops (b) Standardizing planting time, land, soil and water management techniques for water logged areas (c) Shade regulation, moisture conservation techniques and site specific microbial management (d) Soil amelioration for better utilization of nutrients (e) Techniques for enhancing organic resource use efficiency (f) Year-round fodder cultivation with legumes and grass (g) Low cost vertical gardening of vegetables (i) Ideal microbial formulations and nutrient substrate combinations for potting mixture etc. were introduced in 4 AEUs of Alappuzha District.Low-cost vertical gardening using bamboo poles proved as successful during monsoon season in coastal areas prone to water logging and salinity as well as in Kuttanad.

Farmer FIRST Programme (FFP)

ICAR CPCRI's Farmer FIRST Program is being implemented in three panchayaths at present: Pathiyoor and Devikulangara of Alappuzha district and Ochirapanchayath of Kollam district. Total area under the FFP-1647 ha and 1000 farm families of Pathiyur, 12 ha and 43 farm families of Devikulangara and 40 ha 68 farm families from Ochirapanchayaths. The total area where participatory FFP interventions linked with stakeholders including local self-government, Government Departments, farmer producer organizations (FPOs) and women farmers groups, the spread is 1699 ha and 1080 farm families. A summary of interventions carried out in 2021 is provided in the Table 7.

Table.7. Total FFP interventions in Six modules during 2021-2022

Modules	Technologies	No. of farmers benefited
Crop	12	929 farmers
Horticulture	6	205 farmers
Livestock and Poultry	6	153 farmers (303 animals)
Natural Resource Management	4	217 farm families
Value addition and EDP	6	21 units
Integrated Farming Systems (IFS)	1	138 farm families

FFP activities extended to Devikulangarapancahayth since 2021 with decentralized coconut seedling production, demonstration IFS models in farmers gardens, introduction of Ground variety (G2 52 of UAS, Dharwad) and Sesamum in coconut gardens (TMV 6 &7) for suitability assessment for climate resilience in 28 acres involving 43 farm families and to Ochirapanchayath since 2022 April for participatory coconut seedling production and participatory evaluation of millet crops/varieties for the locations. Inputs distributed to farmers are provided in Table 8.

Table 8. Inputs distributed among farmers for multiplication and enabling wider adoption

S.No.	Critical inputs distributed	Quantity
1	Seeds of HYV of various crops (kg)	917.65
2	Tissue culture banana plantlets (no.)	1500
3	Fodder slips of KAU varieties (susthira, super napier, Co 5) (no.)	1250
4	Chemical fertilizers (details) (tons)	16.71
5	Insecticides (kg) / Fungicides (L)	55 & 42
6	Indigenous breeds of poultry (Aseel, Kadaknath, Kairali, Giriraja, Ind bro brown, Gramasree, Gramapriya) (no.)	427

Social Innovations:

- Collective farmer initiatives through Odanadu Farmer Producer Company Ltd., (OFPC): 350 Shareholders, Launched Coconut procurement, primary processing to copra, coconut care and cover program for support and services for coconut management under mutually agreed charges, Participatory community nurseries of WCT seedlings, Value addition of coconut /turmeric, HYV vegetable seedling production.
- Convergence Model /process documentation with MGNREGS enabling rapid spread of improved/HYV of crops and enabling local level nutrition involving women SHG farmers.
- Quality seed/planting material production facilitated by Experts and triangulated by the society ensuring quality and genuinity.
- Decentralized production of poultry birds (9000 per year) as micro units of rural trained youths (chicks and ducklings).
- Participatory evaluation of crops suitability for panchayaths and social level climate resilient initiatives for sesamum, vegetables, paddy.
- Social level Revival and sustainable rejuvenation of Pathiyoor coconut cultivation: the process steps were initiated with Survey and Mapping of healthy WCT mother palms in all 19 wards of Pathiyoor as a participatory activity forming groups of Ward member, coconut farmers, coconut climbers, OFPC directors, SHG women farmers, and FFP team members. All the 19 teams were trained in theory and practical with hands on experience in the actual fields. A total of 363 mother palms selected and geo-tagged and raised a nursery with 3600 seed nuts. Bio priming of coconut seedlings in poly bags with bio agents was carried out.
- Innovative participatory management of root knot nematode in tubers (Amorphophallus): Cultural practices (destruction of stubbles after each harvest, nematode symptom free planting materials, crop rotation) and bio control agents.

- Small machineries unit consisting of coconut tree scooter, coconut pulverizer, copra dryer, drum seeder, fertilizer dispenser rotary tiller machine (2), motorized weeder machine (2), copra dryer (2), manual coconut climbing devise (5), and sprayers (10) was established.

Fig. 47. Sale of coconut seedlings produced through the FPO outlet

Fig. 48. Dr.Venkatasubramanian, Director, ICAR-ATARI, Bengaluru handing over community incubator to Mr. Radhakrishnan, duck-farmer

Impact of FFP interventions: Impact of the interventions are reflected in terms of number of beneficiaries, area spread of technologies, adoption and knowledge improvement, status of crop yield, women empowerment, ecological changes to support sustainability. Data were collected based on survey instrument for each module. The area under intercrops in coconut gardens improved significantly as indicated in Fig. 49. The most suitable varieties and crops were: sesamum (Kayamkulam and Thilak of KAU and TMV 6 of TNAU); turmeric (Pragathi of ICAR-IISR), finger millet (Payur of TNAU), groundnut (G2 52 of UAS, Dharwad), and pulses (Kanakamani and Hridya of KAU) (Fig. 50 and Fig. 51).

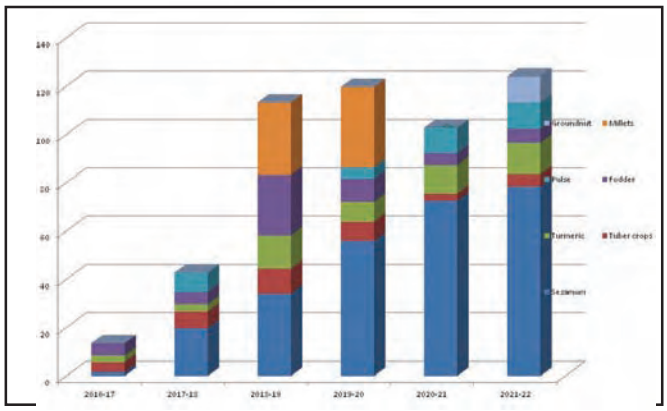


Fig. 49. Increase in area under intercrops in coconut gardens and percentage share

Fig. 50. Pulses in coconut garden (Pathiyur)

Fig. 51. Ground nut in coconut garden (Devkulangara)

Adoption of technologies in coconut cultivation improved in terms of soil testing, lime and organic manure application, and adoption of plant protection measures. The data showed an impressive improvement of 67.67% in adoption of technologies. Lime application increased from 49.33% to 79.64%; organic manure application (56.63 to 98.23%), composting and organic recycling (6.77 to 21.23%), irrigation (30.97 to 53.98%), soil testing (12.83 to 88.49%), mulching (46.31 to 61.06%), basin management (58.63 to72.56%), pest management (32.16 to 55.75%).

Empowering farmers for collection of soil samples for analysis and application of fertilizers accordingly

resulted in 20% increase in soil carbon stock, improved fertility in terms of available potassium and micronutrients.

Economic returns from FFP modules: The average income of FFP poultry farmers improved from Rs.5603.77 to Rs. 17692.00 indicating an average increase of 215.75 percent, besides family consumption. The percentage of farmers improved their poultry income assumes importance since more than 90 % of them are women farmers having very less resources of land, money. Average income improvement per palm/ annum is Rs. 280 @ Rs.20/nut. Climate change was perceived as one of the major reasons for yield reduction. Livestock rearing was the highest income provider in small and marginal land holdings. Women SHG farmers recorded that intercropping in clusters of coconut gardens were the major income provider in convergence with MGNREGS. Enterprises provided the maximum income directly to entrepreneurs.

Agri-Business Incubation (ABI) Center at CPCRI, Kasaragod

A total of 35 technology transfers took place in the year 2021-22: A revenue of Rs. 8.44 lakh was generated from sale of technologies. Four EDPs and eight training programmes and seven technology awareness programmes were conducted. Twelve online programmes were conducted under Kalpa Green Chat.

Intellectual property management and transfer/ commercialization of agricultural technology scheme

The Institute Technology Management Committee (ITMC) held 13 meetings in the year. ITMC has revised the cost of the technologies as when required. National patent was received for Coco sap chiller - 4077/ CHE/2014 (Patent No. 373309) which was granted on 30-07-2021. Kalpa Trademark was renewed. Six varieties' registration with PPV & FRA is in force; registration of two varieties renewed.

Socio-economic dimensions and value chain dynamics in policy perspective

Price and value chain analysis of arecanut: The arecanut prices in India have shown an increasing trend during the post lockdown (COVID-19) regime from April 2020 onwards, and have reached a historical high figure in October 2021 (around Rs 515/kg for old supari). The cyclical price boom and price crash in arecanut is found to be reflected in the 1970s, 1990s and early 2000s, wherein the prices were nosedived and autonomous committees were set in to enquire about the reasons/ suggestions. The recommendations were unequivocal on the prohibition of arecanut expansion on non-traditional arecanut tracts. Nevertheless, the area expansion continued invariable across all possible tracts, whenever the prices were favourable. It is critical that, there has been a reduction in arecanut (chali) production to the tune of 11% in 2021; a 24% reduction in arecanut imports; and a 198% increase in export. These figures imply a huge shortage of arecanut in the domestic market that had influenced then price increase. The primary data sources indicate the increase in the number of middlemen in the arecanut trade (in Kerala and Karnataka) and market hoarding in huge quantities, which eventually resulted in panic sales by the smallholders. The value share of the farmer in the arecanut value chain has come down to 52% in recent times. As of now the share of cooperatives in the arecanut trade is less than 10%. It is of paramount importance to increase the market share of cooperatives at least up to 30% to ensure optimal share for farmers in the value chain.

Trade, price and value chain analysis of coconut: To cope with market fluctuations, there is a need for product diversification and by-product utilization. India, of late, has been making a concerted effort to penetrate its products in the high-value export segments. The desiccated coconut industry in the country is a vibrant sector. The growth rate in exports of DC powder for the last five years stands at a stupendous 26.8%. The Europe and USA together account for 72% import share of the DC and in recent times, due to stringent food safety norms in these countries, the consignment rejections of the products from the Philippines and Indonesia have increased up to 32% and 28% (in last five years) respectively. In this scenario, there exists a huge potential for India to increase the global market share of DC and VCO by ensuring the stipulated quality and safety requirements of the products for the high-value market. Important export destinations of coconut products from India are UAE (fresh coconut 55.5%; coconut oil 50.2%; and desiccated coconut 18.2%), other Middle East countries (fresh coconut 30%; refined oil 27%), Malaysia (dried coconut 43.7%), Sri Lanka (shell charcoal 43.5%) and EU (shell charcoal 39%). Given this, it is imperative to chalk out and implement a plausible export promotion strategy for selected markets with selected commodities where India has a comparative advantage. The potential of products such as VCO as an

export earner is true, and to have premium access in the high-value markets of the EU and USA, we need to take utmost care in positioning the VCO from our country as a super-food complied with all food safety standards.

Price spread analysis of coconut marketing revealed that near about 70% of the farmers sell their produce through the village traders as raw coconuts. Less marketable surplus due to small and marginal holding size is the major reason for the farmers not undertaking copra or oil for sale. The producer share in the consumer rupee was found to be around 64 per cent and the market chain consumes as much as 36 per cent share in the total value chain. Satellite micro-level procurement hubs to be established (that are connected to big hubs at the district/region level) for both raw coconuts and copra utilising the existing three-tier FPO system in the coconuts wherein an autonomous council including representatives from Krishi Bhavan, Cooperatives and CPSs will be responsible/accountable for the efficient procurement. Streamlined tender coconut market chain with a common brand and assured high-tech, hygienic (food safety measures), run by enterprising youths (collectives) should be promoted.

Production economics of mandate crops/systems: The cost of production of coconut in Kerala based on data from a well-managed coconut garden is Rs 9.93 per nut. In this scenario, about 60% of the total cost is incurred due to labour charges. This shows the higher per-unit labour charges prevailing in Kerala, which can be attributed to higher labour demand and higher cost of labour. In addition, the lack of availability of sufficient skilled labourers for harvesting coconut leads to a higher cost of cultivation of coconut. Currently, the wage rate prevailing in Kerala is around Rs 750 per day, which is one of the highest costs prevailing for agricultural labour in India. The total cost of cultivation per hectare is Rs 1,56,380.

Development of Statistical and Computational Techniques for Improving Research Methodology

Analysis of spatio-temporal changes: State-wise and district-wise production statistics of coconut and arecanut for the last 20 years were used to study the spatial and temporal changes in area, production, and yield. The spatio-temporal changes in crop statistics in relation to weather variables were critically analysed. State wise and district wise CAGR of area, production, and yield of coconut and arecanut in different periods were worked out and represented as spatial maps.

Different tests were applied to detect significant changes in climate data and identified the change points.

The spatial patterns and hotspot detection for risk prone areas of Fruit Rot Disease (FRD) in Malnad and coastal tracts of Karnataka were investigated using geo-statistical approaches. Tools such as inverse distance weighting (IDW) and ordinary kriging (OK) are used to interpolate and predict the pattern in terms of the severity distribution across the districts. Moran's I Index (Moran's I) was used to evaluate autocorrelation in FRD spatial distribution and test how taluks were clustered or dispersed in space. Indicator kriging (IK) was used to identify the hotspot and cold spot areas within the study area.

Incidence of diseases/pests: A field survey in Dakshina Kannada district was conducted to assess the incidence of pests and diseases in arecanut. Recent incidence of YLD of arecanut in Puttur, Bantwal and Kadaba Taluks were also studied.

Customized computer programs/database: An R-script has been developed for analysing coconut's vulnerability to climate change in India, based on climate projections for the 2050s and the 2070s under two RCPs: 4.5 and 8.5.

In order to predict functional content of bacterial community over the samples, a software module in R has been implemented using Piphillin algorithm that predicts functional metagenomic content based on the relative abundance of detected 16S rRNA gene sequences corresponding to genomes in regularly updated, functionally annotated genome databases; subsequently, for the retrieval of feature and pathway tables containing predicted KEGG orthologues (KO) occurrence with 95% or 99% cutoff threshold. R-script has also been customized for the construction of microbiome network.

VI. 8. ICAR- ALL INDIA COORDINATED RESEARCH PROJECT (AICRP) ON PALMS

The All India Coordinated Research Project on Palms started in 1972 has coconut, oil palm, arecanut, palmyrah and cocoa as mandate crops and it is implemented in 28 centres. The AICRP (Palms) has 15 centers conducting research on coconut, six on oil palm, four on arecanut, four on palmyrah and seven on cocoa with Headquarters at ICAR-CPCRI, Kasaragod. The coordinating centres are associated with 13 SAUs/SHUs, one CAU and four ICAR institutes spread across 14 states and one union territory.The budget sanctioned from the ICAR for the year 2021 (January-December) was Rs. 669.35 lakh.

Research Achievements

Coconut:

- In the variety evaluation trial at Ambajipetacentre, average annual yield for the period 2014-2020 was significanly higher for Godavari Ganga (144 nuts) followed by VHC-2 (135 nuts) and Kera Ganga (133 nuts).
- Among the Dwarf x Dwarf combinations planted during 2011 at Ratnagiri, hybrid GBGD x MOD and COD X MYD are better performing. Tender nut yield was respectively 68 and 77 nuts, but the former one is relatively early bearing and has highest TSS (5.7 ° Brix); highest volume of tender nut water was forCOD x MYD
- Integration of coconut with pasture crops *(Cumbu Napier hybrid + Desmanthus),* fodder trees *(Sesbania grandiflora + Leucaena leucocephala + Glyricidia)* and Tellicherry breed of goats recorded net income of Rs. 2,54,206/- per ha with BC ratio (3.16) as compared to Rs. 1,51,312/- per ha with BC ratio (2.25) in the monocrop of coconut at Aliyarnagarcentre.
- Site specific nutrient management with 1kg CaSO4. 2H2O and 500g MgSOper palm per year + micronutrient mixture (FeSO4, MnSO4, CuSO4, ZnSO4, Borax and ammonoium molybdate) @ 1 kg per palm per year + coconut frond mulching + *Azospirillum*-100 g + *Phosphobacteria*-100 g + VAM-100 g per palm per year enhanced productivity by 32 % over farmers' practice in Tender nut variety Chowghat Orange Dwarf. Net returns and benefit cost ratio were Rs. 4.38 lakhs per ha and 2.99 in INM package as against Rs. 3.10 lakhs per ha and 2.66 in farmer's practice respectively.
- Thirteen new systemic fungicides were tested against the growth of *Ganoderma* spp. under in vitro conditionwith three concentrations viz., 100, 250 and 500 ppm. The results revealed that, Hexaconazole 4% + Carbendazim 16% SC, Hexaconazole5% + Validamycin 2.5% SC and Azoxystrobin 11% + Tebuconazole-18.3% SC were superior as compared to other fungicides.
- Application of T. *harzianum* and T. *reesei* cake formulation completely cured the stem bleeding disease in coconut when compared to the application of copper oxychloride paste. Disease index of 7.96 and 6.95 was brought down to 0.0 within 50 days with application of *Trichoderma harzianum* cake (CPCRI) and *Trichoderma reesei* cake formulation at Ambajipeta.
- Root feeding with propiconozole @5ml in 100ml of water at three months intervals during Jan, April, July and October reduced the leaf blight incidence by 27% after 36 months of treatment. This treatment also recorded the highest nut yield of 138 nuts/ palm/year (B:C ratio 3.7) as against 97 nuts/ palm/year in the untreated control.
- Following biocontrol agents were made available to farmers of East Godavari, West Godavari, Visakhapatnam and Srikakulam districts of Andhra Pradesh, Bhadradri Kothagudem, Medchal and Khammam districts of Telangana from Ambajipeta centre: 6600 *Bracon hebetor*; 1,77,050G. *nephantidis*, 17100 P. *imbrues*, 242 Tricho cards and 32,61,100 *P. astur* eggs. At Aliyarnagar centre, a total of 12,561 packets of *Encarsia* parasitoid were distributed to about 4000 farmers.
- The IPM strategies (Installation of yellow sticky traps in the garden, three rounds of neem oil spray 0.5% at 15 days interval and three rounds of jet water spray for 10 days after spraying neem oil) for the management of rugose spiralling whitefly was started during the month of November 2018, in the

COD palms (15 years old) at Aliyarnagarcentre. The results revealed that the application of IPM strategies significantly reduced incidence and intensity of rugose spiralling whitefly from 52.2% to 22.5% and 48.2% to 20.5% respectively when compared to the natural control where the percent incidence and pest intensity was increased from 45.2 to 56.2% and 50.5% to 58.5% respectively.

Oil Palm

- Among the 10 hybrids evaluated at Pattukkottai highest bunch weight of 173.25 kg/palm and per ha yield of 24.78 t/ha was recorded in hybrid NRCOP 9.
- Seven different intercrops were evaluated in oil-palm garden at Mulde. The maximum yield of oil palm was recorded in treatment oil palm + red ginger + black pepper with bunch yield of 166.2 kg /palm. The bush pepper recorded maximum yield of 0.726 g per plant and maximum yield of dry berries was 1.05 kg/plot.

Arecanut

- Burmese coriander is a popular herb grown. The herb was grown as an intercrop in bearing to study the profitability of this herb as an intercrops in the warm humid tropical conditions of South Andaman Island. Results suggested that Introduction of Burmese coriander in the interspaces arecanut(var. Samrudhi)in the Andaman and Nicobar Islands could give high net returns of Rs. 13,03,065/- (BC ratio 3.19) as against Rs. 9,59,600/- in the arecanut sole crop.

Fig. 52. Burmese coriander intercropping in arecanut garden

Cocoa

- Evaluation trials at Kasaragod, Ambajipeta and Veppankulam resulted in the identification of best performing varieties under coconut as VTLCH-2, VTLCH-2 and VTLCH-1respectively. In the 8-year-old trial at Aliyarnagar, Ratnagiri and Kahikuchi, respectively VTLCP-16, VTLC-17 and VTLC-20 were found to be best performing. Under oil plam, VTLC-57 was high yielding at Vijayarai.

Palmyrah

- Jaggery powder prepared form fresh neera (collected as per CPCRI method) gives good colour and shelf life up to one year, whereas jaggery from traditional method turns into dark colour and spoil within 3 months under room temperature with normal packing. Palmyrah tender fruit processing machine developed by CIAE was evaluated and it reduces drudgery and time for endosperm separation. It was also observed that the machine is useful for both skilled and unskilled persons at cottage level selling of endosperm. Dehydrated tuber and tuber flour was commercialized and one consignment was sent to UK through an NGO (ASHA Chinturu, AP) and income generated to tribal people.

Annual Group Meeting

The 30th Annual Group Meeting of All India Co-ordinated Research Project on Palms organized by Central Plantation Crops Research Institute, Kasaragod through virtual mode was inaugurated on November 22, 2021. Dr. B.K. Pandey, Assistant Director General (Horticultural Sciences II), ICAR, New Delhi was the Chief Guest of the event. Dr. R. K. Mathur, Director, ICAR-IIOPR, Pedavegi and Dr. Eaknath B. Chakurkar, Director, ICAR- CIARI, Port Blair participated in the Inaugural Session. Dr. Anitha Karun, Director and Project Co-ordinator (Acting), CPCRI, Kasaragod welcomed the dignitaries. The action taken report of the recommendations of the AGM held on 10-11 August 2020 was presented by Dr. Ravi Bhat, Acting Head (Crop Production) and Scientist In charge, PC Cell. The Assistant Director General (Horticultural Sciences) in his inaugural address suggested bringing out a publication on "Fifty Years of AICRP (Palms)" on the occassion of Golden Jubilee Celebrations of the AICRP (Palms). Seventytwoparticipants from different AICRP centres and ICAR-CPCRI were attended.

Fig. 53. 30th Annual Group Meeting of All India Co-ordinated Research Project on Palms

VI. 9. KRISHI VIGYAN KENDRAS

ICAR-Krishi Vigyan Kendra, Kasaragod

OFT on Assessment of Indigenous Functional foods in addressing Anaemia among children (11- 17years) was conducted in four Anganwadi centers (Kadappara-Manjeshwar, Kayyar, Neerchal and Kuttikol). Amylase rich mix (sprouted ragi), Sesame, flaxseeds, minially milled rice and moringa powder were provided in the form of traditionally used laddoos (50 g/day) after conducting nutrition counselling to children and parents, method demonstrations and training. Around 35 kgs of mix using these functional ingredients has been prepared and given as a part of the interventions.

The assessment of high yielding varieties of pepper was initiated in six farmers fields in Parappa and Kuttikol. The varieties being evaluated are Arka Coorg Excel (IIHR), Panniyur-8 and Vijay (KAU).

Frontline Demonstration:

- 'High density planting of cashew' in farmer's plots was initiated. The varieties included are VR 1-3, NRCC selection-2, Ullal 1. The FLD on red palm weevil management was initiated Panayal village in Pallikkara panchayat. The technologies included crop hygiene, chemical pesticide application, mechanical collection and destruction of pests and prophylactic treatment of palms by placing sachets containing essential oil impregnated granules weighing 5 g @ 2 sachets per palm in the emerging leaf axils.
- Banana prop rings devised by KVK, Pathanamthitta was demonstrated in the farmers' plots at Madikai, Periya and Panayal. The rings are intended to provide support to the plants at bearing stages and during heavy winds.
- Pepper special, a micronutrient mixture for pepper devised by ICAR-Indian Institute of Spices Research, Kozhikode was demonstrated to farmers of Sheni, Enmakaje and Madikai. The application of micronutrient mixture @5g/litre of water as foliar spray during October-November months were carried out.
- Manuvarna (Cl 206) a high yielding medium duration (128-138 days) rice variety released from Agricultural Research Station Mannuthy during 2019,was introduced in 25 acre area of 50 farmers at Madivayal, Pilicode grama panchayath.
- The introduced yard long bean variety is a shade tolerant and recommended for intercropping in coconut garden. This demonstration is being conducted in farmers' fields at Panayal village.
- Coconut based cropping system with fodder grass, vegetables and fruit crops was demonstrated in Panayal village.
- The demonstration of small-scale processing of cashew was initiated for 5 FIGs in Nileshwar block.

Capacity development programmes: A total of 68 training programmeswere conducted to benefit 1606 individual of which 1038 were women.

Extension programmes conducted

- Webinar on 'Halt salt salinization and improve soil productivity', 5 December 2021: Dr. Anitha Karun, Acting Director, CPCRI, Kasaragod inauguarated the webinar. Dr. V.V. Prakash, Assistant Director, Soil Conservation, Kannur, Kerala gave the lead lecture.
- World Food Day webinar was conducted on 16 Oct 2021: Dr. Anitha Karun, Director, ICAR-CPCRI inaugurated and Shri Padre, renowned journalist delivered the lead talk in kannada.
- Mahila Kisan Diwas was celebrated on 15 October 2021
- Hon'ble Prime Minister's Interaction on Climate resilient agriculture was organized on 28-09-2021. Besides, live streaming of Prime minister's speech two seminars were also organised on exotic fruit trees and climate resilient agriculture.

- The inauguration of the *Poshan Vatika Abhiyan* was done on 17 September 2021 by Shri Rajmohan Unnithan, Hon'ble M.P from Kasaragod district. The event was presided over by Shri N.A. Nellikkunnu, MLA, Kasaragod. Dr. Anitha Karun Director, ICAR-CPCRI was the chief guest. 40 Officials from ICDS attended the programme at the location and 100 people participated online.
- Orientation programme was conducted on 1 June 2021 in co-ordination with ICDS Manjeshwar including beneficiary children under OFT.
- A webinar was conducted on the topic 'Milk and milk products in human nutrition and rural income'.
- Celebration of International Womens Dayon 8 March 2021 in which fifty farm women participated, apart from KVK and CPCRI officials.
- The building and machinery of FPO handholded by the KVK was inaugurated on 15 February 2021 by Shri Rajmohan Unnithan. Hon'ble M.P. Kasaragod and Shri K. Kunhiraman, MLA presided over the function. Dr. K.B. Hebbar, Director i/c inaugurated the machinery.
- The harvest festival for the FLD on high yielding variety of turmeric, Prathbha was conducted at in Enmakaje panchayat on 9 February 2021.

ICAR-Krishi Vigyan Kendra-Alappuzha

On Farm Testing: Five OFTs were taken up in Puliyur and Mulakuzha panchayaths during the year as listed below

- Assessing the performance of high yielding mosaic resistant cassava variety in laterite belt of Alappuzha.
- Assessment of different amendments on acidity management in paddy in south central laterites of Alappuzha.
- Assessment of NSPPF against the pests of Yard long bean.
- Assessing the performance of IIHR leaf curl virus resistant chilly varieties in Alappuzha district.
- Assessment of essential oil from Pomelo as a flavour enhancement agent in confectionaries.

Frontline Demonstrations: Fourteen front line demonstrations were taken up in Chengannur and Mavelikkara blocks during the year as listed below:

- Demonstration of high yielding non lodging medium duration paddy variety - Pournami.
- Demonstration of integrated management of weedy rice in Upper Kuttanad area.
- Demonstration of cowpea variety PGCP 6 in rice fallows during summer season.
- Micronutrient management for productivity enhancement of turmeric by application of IISR micronutrient mix.
- Demonstration of foliar application of nutrients using UAV in paddy.
- Scientific meliponiculture as additional source of income for rural youth.
- Eco-friendly and economic plant protection practices against banana pseudo stem weevil.
- Demonstration on ecological engineering and bio intensive pest management practices in paddy.
- Management of leaf rot disease in juvenile coconut palms.
- Demonstration on integrated fusarium wilt disease management in cowpea.
- Fodder cafeteria for enhancing profitability of dairy farmers.
- Detection and management of sub clinical ketosis in early lactation of dairy cows.
- Pro beads - EC for productive enhancement in small poultry farm.
- Oral pellet vaccine for the management of Ranikhet disease on homestead poultry units.

Training: Sixtythree training programmes were organized during 2021 for a total of 1174 participants (537 women)

External funded projects:

National Innovations in Climate Resilient Agriculture (NICRA) - Phase II: It is being implemented at Edathua village of Kuttanad Taluk. Climate resilient practices for paddy in Kuttanad region, modified rain shelter for year round vegetable production, short duration cassava variety-Sree Jaya for escaping flood during monsoon season, large scale composting of aquatic weeds using EM solution and use for vegetable cultivation, soil health card for better nutrient and soil health management, recycling of organic residues for energy generation and crop production using portable biogas plants, modified season cultivation of HY ginger for vegetable purpose, improved goat shelters to withstand water logging/flood, climate resilient cages for poultry rearing, stress, disease and nutritional management in dairy animals are being demonstrated in the farmer participant fields. A 'Village Climate Risk Management Committee (VCRMC) is formed with participation of members from the LSG for overseeing and institutionalizing the programme on long term basis in the village.

Onattukara Spices Farmer Producer Company Ltd.

(OSFPCL): FPO promoted by the KVK, Onattukara Spices Farmer Producer Company Limited was registered in December 2016 with grants from NABARD facilitated cultivation, procurement, processing, and marketing of the major spices viz., turmeric, ginger, pepper and garcinia in six panchayaths of Bharanikkavu block. At present it has 350 share holders. A 'Rural Mart cum Farmer Facilitation Centre' with additional funding support from NABARD was establishedat Kattanam of Bharanikkavu Block which was inaugurated by Adv. U. Prathibha, Kayamkulam MLA on 02.02.2021.

Agro Processing Training cum Incubation Centre (APTIC): Formal inauguration of the APTIC funded by Agriculture Development and Farmers Welfare Department, Govt of Kerala was held on 18.11.21by Sri. P. Prasad, Hon. Minister of Agriculture, Govt. of Kerala. The machineries like water immersion retort, pasta production extruder, hot air oven, deep freezer, fruit pulper, RO water unit, sautiner, pulveriser, band sealing machine, dough mixing machine, weighing balances, mini rice huller, pulveriser, and coconut processing machineries like desheller, testa remover and wet pulveriser were installed in the centre. On same day, the newly built training hall cum laboratory building of the KVK funded by ICAR-ATARI was inaugurated by Adv. A. M. Arif, Hon. M. P of Alappuzha. Adv. U. Prathibha, Hon. MLA of Kayamkulam presided over the function in the presence of Dr. V. Venkatasubramanian, Director, ICAR-ATARI, Bengaluru; Dr. Anitha Karun, Director, ICAR-CPCRI; Dr. S. Kalavathi, Acting Head, CPCRI, RS, Kayamkulam and Dr. P. Muralidharan, Head, KVK-Alappuzha.

Value chain in turmeric (VCT): The project was sanctioned under the FSPF of NABARD with a funding of Rs. 18.0 lakhs in 2020. It involves 250 partner farmers from 10 panchayaths of Mavelikkara and Chengannur Blocks of Alappuzha district to be organized in self sustaining groups.

- International Women's Day observed on 8 March 2021 with different programmes in association with ICAR-CPCRI, RS, Kayamkulam.
- World Bee Day was celebrated on 2O May 2021 as part of "Bharat Ka Amrut Mahotsav" with a webinar on "Importance and rearing techniques of honey bees" and a quiz contest for vocational higher secondary students.
- World Milk Day was celebrated on 1June 2021 with the theme "Animal Health and Productivity" as part of "Bharat Ka Amrut Mahotsav.
- Planting materials and inputs distributed to SC families under SCSP: With focus on improving the nutritional security of the socially and economically backward SC families of the society, Mango and Jack grafts, curry leaf seedlings, bush pepper plants, seed rhizomes of ginger and turmeric were distributed along with bio-agents and organic manure to 100 selected SC farmers of Venmony panchayath on 28.06.21 in collaboration with Gramadeepam library, Punthala.
- Tree plantation campaign on 'ICAR Foundation Day' observed on 16 July 2021.
- International year of millets/ Campaign on Nutrigarden and Tree Plantation was organized in two Panchayaths of Chengannur Block of Alappuzha on 17.9.2021.
- Webcasting of the Video conferencing of the PM was held on 28.9.2021 along with a Farmer-Scientist interface programme on "Climate Resilient Agricultural Practices".
- World Soil Day 'Halt soil salinization, boost soil productivity' by following 'good agricultural practices to maintain healthy soil for a healthy society' was conveyed in the programmeorganized at Edathua Grama panchayath. Smt. Mariyamma George, President of the Grama Panchayath inaugurated and distributed soil health cards to 30 farmers.

Revolving fund activities: Different inputs were made available to the farmers of the district (as resource centre) through revolving fund activities viz., vegetable seeds and seedlings, planting materials, bio-agents, Methyl euginol, cue lure and yellow sticky traps, layer chicks, mushroom spawn, mother spawn, multi nutrient mixture for banana and vegetables, azolla, processed products, publications etc. A custom hiring centre is also functioning to provide farm implements like tractor mounted rotavator and transplanter to farmers on hire for land preparation paddy transplanting etc. The progressive closing balance of revolving fund as on 30.11.21 is Rs. 23,42,770.

VII. Publications

Research Articles

Alagar, M., Sivakumar, V., Praneetha, S., Chinnadurai, S., Josephrajkumar, A. and Maheswarappa, H.P. 2021. Eco-friendly management of rugose spiralling whitefly, Aleurodicus *rugioperculatus* Martin infesting coconut. Indian Journal of *Entomology*, DoI.: 10.5958/0974-8172.2021.00153.X (NAAS Score 5.08).

Anithakumari, P., Mahima Mohan and Muralidharan, K. 2021. Impact of training programs for women farmer groups under the Farmer FIRST Program. *Indian Research Journal of Extension Education* **21** (2&3): 8-15 (NAAS Score 5.22).

Anithakumari, P., Sit, A.K. and Mithun, B. 2021. Knowledge integration through e kalpa – a cloud based interactive mobile App for coconut farmers. *International Journal of Economic Plants* **8** (2): 109-112 (NAAS Score 4.37).

Antony, G., Arvind, K., Godwin, J., Sujithra, M., Josephrajkumar, A. and Grace, T., 2021. Draft genome sequence, annotation and SSR mining data of Oryctes rhinoceros Linn. (Coleoptera: Scarabaeidae), the coconut rhinoceros beetle. *Data in Brief*, 38, p. 107424 (NAAS Score --).

Aparna, V., Krishna Prakash, Neema, M., Muralikrishna, K.S., Samsudeen, K., Chandran, K.P., Rajesh, M.K. and Anitha Karun. 2021. Pollen storage of coconut dwarf accession Chowghat Orange Dwarf (COD) at low temperature. *Indian Journal of Agricultural Sciences*, **91** (2): 321-324(NAAS Score 6.21).

Aparna, V., Subramanian, P., Kanwar Pal Singh, Namita, Sapna Panwar, Selvamani, V., Vandita Kumari, Jayasekhar, S., Neema, M. and Ravi Bhat. 2021. Evaluation of indigenous rose varieties as intercrop under coconut plantation in India. *Indian Journal of Horticulture,* **78** (3): 273-279 (NAAS Score 6.16).

Bhalerao, P. P., Maheswarappa, H. P. and Sumitha, S. 2021. Effect of integrated nutrient management in coconut (*Cocos nucifera L.*) based cropping systems in South Gujarat condition. *Current Horticulture*, **9** (2): 52-55.(NAAS 4.53)

Bharath, B. G., Ananda, K. S., Nagaraja, N. R. and Rajesh, M. K. 2021. Microsatellite markers-based assessment of genetic diversity and population structure in arecanut (*Areca catechu L.*). *Indian Journal of Genetics and Plant Breeding.* **81** (4): 601-604. DOI: 10.31742/ISGPB.81.4.16 (NAAS Score 6.55).

Daliyamol, Prathibha, V.H, Vinayaka Hegde and Panjavarnam, G. 2021. First report of *Curvularia eragrostidis* causing fruit rot in Hylocereus *undatus* in India. *Journal of Plant Pathology*, https://doi.org/10.1007/s42161-021-00957-4 (NAAS Score 7.15).

Gangaraj, K.P., Muralikrishna, K.S., Antony, G., Binod, B.S., Hegde, V. and Rajesh, M.K. 2021. A rapid *in vitro* leaf inoculation assay to investigate *Phytophthora palmivora*–coconut interactions. *Journal of Phytopathology,* **169** (5): 316-328. (NAAS Score 7.18).

Hebbar, K.B., Arya Santhosh, Abhin Sukumar, P., Neethu, P., Ramesh, S.V., Selvamani, V. 2021. Effect of sea water substitution on growth, physiological and biochemical processes of coconut (*Cocos nucifera L.*) seedlings - A hydroponic study. Scientia Horticulturae, **280**: 109935. https://doi.org/10.1016/j.scienta.2021.109935 (NAAS Score 8.77).

Hebbar, K.B., Neethu, P., Sukumar, P.A., Sujithra, M., Santhosh, A., Ramesh, S.V., Niral, V., Hareesh, G.S., Nameer, P.O. and Prasad P.V.V. 2020. Understanding physiology and impacts of high temperature stress on the progamic phase of coconut (*Cocos nucifera L.*). Plants **9** (12), 1651.

Hebbar, K.B., Padmanabhan, S., Ramesh S.V., Keshav Bhat, S., Shameena Beegum, P.P., Pandiselvam R., Manikantan, M.R. and Mathew, A.C. 2021. Moisture content and water activity of arecanut samples: A need to revisit storage guidelines. *Journal of Plantation Crops*, **49** (2):136-141(NAAS Score 4.66).

Indhuja, S., Merin Babu, Alka Gupta, Murali Gopal, Jeena Mathew, Regi Jacob Thomas, Haris, A.A. and Krishnakumar, V. 2021. Screening and characterization of nutrient solubilizing phytobeneficial rhizobacteria from healthy coconut palms in root (wilt) diseased tract of Kerala, India. *Journal of Environmental Biology*, **42**: 625–635 (doi.org/10.22438/jeb/42/3/MRN-1489) (NAAS Score 6.78).

Jilu, V. Sajan, Subramanian, S. and Sharma, K. 2021. Attractancy potential of bacterial volatiles from symbiotic bacteria of wild population of *Zeugodacus cucurbitae* Coquillett (Diptera:Tephritidae). *Phytoparasitica.* https://doi.org/10.1007/s12600-021-00966-0. (NAAS Rating: 7.14)

Kambakam, S., Ngaki, M.N., Sahu, B.B., Kandel, D.R., Singh, P., Sumit, R., Swaminathan, S., Muliyar-Krishna, R. and Bhattacharyya, M.K., 2021. Arabidopsis non-host resistance PSS30 gene enhances broad-spectrum disease resistance in the soybean cultivar Williams 82. *The Plant Journal*, **107** (5): 1432-1446 (NAAS Score --).

Kiran Kumar, D. G., Lakshmana, D., Nagaraja, N.R., Sadashiv Nadukeri and Ganapathi, M. 2021. Genetic variability and correlation for nut and yield characters in arecanut (*Areca catechu L.*) germplasm. *Electronic Journal of Plant Breeding*, **12** (4): 1170-1177. DOI: 10.37992/2021.1204.161 (NAAS Score 5.14).

Lekha, G. and Muralidharan, P. 2021. Matchwood (*Ailanthus exelsa*) sawdust as an alternate substrate for oyster mushroom (*Pleurotus florida*) cultivation. *Journal of Krishi Vigyan* **9** (2):134 – 137 (NASS 4.55).

Maheswarappa, H.P., Mathur, R.K., Sumitha, S., Kalpana, M., Gawankar, M.S. and Tamilselvan, M. 2021. New oil palm hybrids. *Current Horticulture*. **9** (2): 70 (NASS 4.53).

Mangrauthia, S.K., Ramesh, S.V., Sahana, N., Praveen, S. 2021. Rhythm of a life within life: role of viral suppressors in hijacking the host cell. *J. Plant Biochem. Biotechnol.* **30**: 636–639. https://doi.org/10.1007/s13562-021-00731-8 (NAAS Score 6.77).

Manikantan, M.R., Pandiselvam, R., Arumuganathan, T., Indurani, C., and Varadharaju, N. 2021. Low-density polyethylene based nanocomposite packaging films for the preservation of sugarcane juice. *Journal of Food Science and Technology,* https://doi.org/10.1007/s13197-021-05174-6. (NAAS Score: 7.95)

Mathew, J., Haris, A.A., Bhat, R., Krishnakumar, V., Muralidharan, K. and Susan John, K. 2021. Comparative assessment of nutrient partitioning in healthy and root (wilt) disease affected coconut palms grown in an Entisol of humid tropical Kerala. *Trees* **35**, 621-635. (NAAS Score --).

Mishra, G., Karna, A.K., Sahoo, S. C., Pattanayak, S. K. and Maheswarappa, H. P. 2021. Effect of Integrated Nutrient Management and Plant Growth Regulator on Generation of Recyclable Biomass in Coconut (*Cocos nucifera L.*) Based Cropping System. *International Journal of Plant & Soil Science,* vol. **33** (17): 236-243. (NAAS Score: 5.07).

Murali Gopal, Sandip Shil, Alka Gupta, Hebbar, K. B. and Arivalagan, M. 2021. Metagenomic investigation uncovers presence of probiotic-type microbiome in Kalparasa® (fresh unfermented coconut inflorescence sap). *Frontiers in Microbiology.* **12**: 662783. doi: 10.3389/fmicb.2021.662783 (NAAS Score: 10.23).

Muralikrishna, K.S., Sajini, K.K., Kavya, P., Prakash, K., Sabana, A.A. and Rajesh, M.K. 2021. Cryopreservation of arecanut (*Areca catechu* L.) embryogenic calli by v cryo-plate method. *Current Journal of Applied Science and Technology,* **40**: 76-82. (NAAS Score: 4.71)

Pandiselvam, R., Khanashyam, A.C., Manikantan, M.R., Balasubramanian, D., Shameena Beegum, P.P., Ramesh, S.V., Kothakota, A., Niral, V., Shil, S. 2021. Textural properties of coconut meat: implication on the design of fiber extraction and coconut processing equipment, *Journal of Natural Fibers*, DOI: 10.1080/15440478.2021.2009401 (NAAS Score 8.62).

Pandiselvam, R., Mahanti, N.K., Manikantan, M.R., Kothakota, A., Chakraborty, S.K., Ramesh, S.V. and Beegum, P.S., 2021. Rapid detection of adulteration in desiccated coconut powder: vis-NIR spectroscopy and chemometric approach. *Food Control*, **133**: 108588. https://doi.org/10.1016/j.foodcont.2021. 108588 (NAAS Score 10.26).

Pandiselvam, R., Manikantan, M. R., Mathew, A.C., Beegum, S., Hebbar, K.B. 2021. Design, development, and evaluation of minimal processing machine for tender coconut. *Agricultural Mechanization in Asia, Africa and Latin America*, **52** (1), 39-43 (NAAS Score 6.17).

Pandiselvam R., Manikantan, M.R., Binu, S.M., Ramesh, S.V., Beegum, S., Gopal, M., Hebbar, K.B., Mathew, A.C., Kothokota, A., Kaavya, R., and Shil, S. 2021. Reaction kinetics of physico-chemical attributes in coconut inflorescence sap during fermentation. *Journal of Food Science and Technology* **58**: 3589-3597 (NAAS Score 7.95).

Pandiselvam, R., Prithviraj, V., Manikantan, M.R., Beegum, P.S., Ramesh, S.V., Padmanabhan, S., and Khaneghah, A.M. 2021. Central composite design, pareto analysis, and artificial neural network for modeling of microwave processing parameters for tender coconut water. *Measurement*: Food, 100015. DOI: https://doi.org/10.1016/j.meafoo.2021.100015 (NAAS Score --).

Paulraj, S., Bhat, R., Rajesh, M.K., Ramesh, S.V., Priya, U.K., Pandian, R.T.P., Hegde, V. and Chowdappa, P., 2021. Data of 16S rRNA gene amplicon-based metagenomic signatures of arecanut rhizosphere soils in Yellow Leaf Disease (YLD) endemic region of India. *Data in Brief,* **38**, p.107443. (NAAS Score --)

Phukon, R. M., Nath, J.C., Sumitha, S., Maheswarappa, H. P. and Elain Apshara. 2021. Early evaluation of cocoa (*Theobroma cacao* L.) clones as intercrop in coconut gardens under red river region of Assam state, India. *Journal of Plantation Crops*, **49** (2): 77-82 (NAAS 4.66).

Pravitha, M., Manikantan, M. R., Kumar, V. A., Beegum, S., & Pandiselvam, R. 2021. Optimization of process parameters for the production of jaggery infused osmo-dehydrated coconut chips. *LWT*, **146**, https://doi.org / 10.1016 / j.lwt . 2021. 111441. (NAAS Score: 10.006).

Preetha, P., Pandiselvam, R., Varadharaju, N., Kennedy, Z. J., Balakrishnan, M. and Kothakota, A. 2021. Effect of pulsed light treatment on inactivation kinetics of *Escherichia coli* (MTCC 433) in fruit juices. *Food Control*, **121**: 107547 (NAAS Rating: 10.26).

Preethi, P., Mangalassery, S., Shradha, K., Pandiselvam, R., Manikantan, M. R., Reddy, S. V. R., Ramyashree Devi, S., and Nayak, M.G. 2021. Cashew apple pomace powder enriched the proximate, mineral, functional and structural properties of cereal based extrudates. *LWT*, **139**, https:// doi. org/ 10.1016/ j.lwt.2020.110539 (NAAS Score 10.006).

Preethi, P., Shafeeq Rahman, Naganeeswaran, S., Sabana, A.A., Gangaraj, K.P., Jerard, B.A., Niral, V. and Rajesh, M.K. 2021. Development of EST-SSR markers for genetic diversity analysis in coconut (*Cocos nucifera* L.) *Molecular Biology Reports* **47**: 9385–9397 (NAAS Score 7.40).

Rajeev, M.S. and Muralidharan, P. 2021. Evaluation of high yielding turmeric varieties for Alappuzha district. *Journal of Krishi Vigyan*, **9** (2): 53 – 56 (NASS 4.55).

Rajesh, M.K., Antony, G., Arvind Kumar, Jeffrey Godwin, Gangaraj, K.P., Sujithra, M, Josephrajkumar, A. and Tony Grace. 2021. Draft genome sequence, annotation and SSR mining data of *Oryctes rhinoceros* Linn. (Coleoptera: Scarabaeidae), the coconut rhinoceros beetle. *Data in Brief 38*. 2021. 107424 https://doi.org/10.1016/ j.dib.2021.107424 (NAAS Score--).

Rajesh, M.K., Chowdappa, P., Behera, S.K., Kasaragod, S., Gangaraj, K.P., Kotimoole C.N., Nekrakalaya, B., Mohanty, V., Sampgod, R.B., Banerjee, G., Das, A.J., Niral, V., Karun, A., Gaikwad, K., Singh, N.K., Prasad, T.S.K. 2020. Assembly and Annotation of the Nuclear and Organellar Genomes of a Dwarf Coconut (Chowghat Green Dwarf) Possessing Enhanced Disease Resistance. *OMICS: A Journal of Integrative Biology* **24** (12): 726-742 (NAAS Score 8.51).

Rajesh, M.K., Gangurde, S.S., Pandey, M.K., Niral, V., Sudha, R., Jerard, B.A., Ganesh Navanath Kadke, Sabana, A.A., Muralikrishna, K.S., Samsudeen, K., Anitha Karun, and Keshava Prasad, T.S. 2021. Insights on genetic diversity, population structure and linkage disequilibrium in globally diverse coconut accessions using genotyping-by-sequencing. *OMICS: A Journal of Integrative Biology,* **25** (12):1-12 (NAAS Score 8.51).

Rajkumar, Pervez Rashid, Maheshwarappa H. P. and Santosh 2020. Occurrence of plant parasitic nematodes associated with Noni (*Morinda citrifolia* L.) intercrop with coconut. *Annals of Plant Protection Sciences* **28** (1):101-102.Article DOI: 10.5958/0974-0163. 2020.00055.5 (NAAS score 5.03)

Ramesh S.V., Hebbar K.B., Rajesh M.K., Abhin S.P., Gangaraj K.P., Athul Bobby 2021. Transcriptome analysis of Cocos *nucifera* L., seedlings having contrasting water use efficiency (WUE) under water-deficit stress: molecular insights and genetic markers for drought tolerance. *Biology and Life Sciences Forum*, **4**: 73 DOI: 10.3390/IECPS2020-08853 (NAAS Score --).

Rani, S., Maheswarappa, H.P. and Sudhalakshmi, C. 2021. Impact of temperature and rainfall on production and productivity of coconut. *Indian Journal of Horticulture*. **78** (3): 287 - 291 (NAAS Score 6.16).

Sahoo, S.C., Sumitha, S., Karna, A.K., Mishra, G. and Maheswarappa, H.P. 2021. Performance of coconut (*Cocos nucifera* L.) hybrids for yield and quality in the Utkal plain region of Odisha state, India. *Journal of Plantation Crops,* 2021, **49** (2): 121-127 (NAAS 4.66).

Santhi, C.K.V., Rajesh, M.K., Ramesh, S.V., Muralikrishna, K.S., Gangaraj, K.P. and Payal, G., 2021. Genome-wide exploration of auxin response factors (ARFs) and their expression dynamics in response to abiotic stresses and growth regulators in coconut (*Cocos nucifera* L.). *Plant Gene*, **28**, p.100344 (NAAS Score--).

Shameena Beegum, P.P., Nair, J. P., Manikantan, M. R., Pandiselvam, R., Shill, S., Neenu, S., Hebbar, K. B. 2021. Effect of coconut milk, tender coconut and coconut sugar on the physico-chemical and sensory attributes in ice cream. *Journal of Food Science and Technology*, https://doi.org/10.1007/s13197-021-05279-y (NAAS Score 7.95).

Shameena Beegum, P.P., Sharma, M., Manikantan, M. R., Pandiselvam, R., & Gupta, R. K. 2021. Incorporation

of coconut milk residue in pasta: Influence on cooking quality, sensory and physical properties. *Journal of Plantation Crops,* **49** (2), 128-135. (NAAS Score 4.66).

Shetty, S.S., Roopashree, P.G., Ramesh, S.V., Ajeet Singh, Arivalagan, M., Manikantan, M.R., Devi, U.H., Sharmila, K.P., Hebbar, K.B. and Suchetha Kumari, N. 2021. Virgin coconut oil (VCO) ameliorates high fat diet (HFD)- induced obesity, dyslipidemia and bestows cardiovascular protection in rats. *Proceedings of the National Academy of Sciences*, India Section B: Biological Sciences, https://doi.org/10.1007/s40011-021-01318-y. (NAAS Score--).

Shinde, V.V., Sumitha, S. and Maheswarappa. H.P. 2021. Soil fertility properties, leaf nutrient status and yield of coconut and intercrops as influenced by integrated nutrient management (INM) and coconut based cropping system in coastal plain of western India. *Bangladesh Journal of Botany*, **50** (4): 1067-1075, 2021 DOI: https://doi.org/10.3329/bjb.v50i4.57074 (NASS Score 6.21).

Singh, L.S., Alpana Das, Niral, V. and Acharya, G.C. 2020. Study on flowering behavior of some local coconut (*Cocos nucifera* L.) genotypes under Assam condition. *Indian Journal Plant Genetic Resources*, **33** (2): 217-223 (NAAS Score 5.54).

Singh, L.S., Anok, U., Acharya, G.C., Elain Apshara and Alpana Das. 2021. Early performance of cocoa genotypes in arecanut under Assam condition of North East Region of India. *Journal of Plantation Crops,* **49** (1): 7-13 (NAAS Score 4.66).

Sudha R., Niral, V. Samsudeen, K. and Hebbar, K.B. 2021. An Investigation of Yield and Quality of Coconut Inflorescence Sap in Different Coconut (*Cocos nucifera* L.) Genotypes under West Coast of India. *International Journal of Current Microbiology and Applied Science* **10** (2): 3030-3041. (NAAS Score--).

Sudha, R., Niral, V., Diwakar, Y. and Samsudeen, K. 2021. Variability and principal component analysis for yield and yield contributing traits in West Coast Tall coconut (*Cocos nucifera* L.) palms. *Indian Journal Genetics,* **81** (3): 469-473 (NAAS Score 6.55).

Sujithra, M.; Prathibha, H.V.; Rajkumar, M.; Guru-Pirasanna-Pandi, G.; Senthil-Nathan, S.; Hegde, V. 2021. Entomopathogenic Potential of Simplicillium *lanosoniveum* Native Strain in Suppressing Invasive Whitefly, *Aleurodicus rugioperculatus* Martin (Hemiptera: Aleyrodidae), Infesting Coconut. *Journal of Fungi* **7** : 964. https://doi.org/10.3390/jof7110964 (NAAS Score 10.62).

Tabassum, A., Ramesh, S.V., Zhai, Y., Iftikhar, R., Olaya, C., and Pappu, H. R. 2021. Viruses without borders: Global analysis of the population structure, haplotype distribution, and evolutionary pattern of iris yellow spot orthotospovirus (Family *Tospoviridae, Genus Orthotospovirus*). *Frontiers in Microbiology,* **12**: 633710. https://doi.org/10.3389/fmicb.2021.633710 (NAAS Score 10.23).

Thava Prakasa Pandian, R., Shivaji Hausrao Thube, Bhavishya, Merin Babu, Chaithra, M., Santhoshkumar, P., Nirmalkumar, B.J. and Vinayaka Hegde. 2021. First report of *Phytophthora palmivora* (E. J. Butler) E. J. Butler, 1919 causing fruit rot disease in *Areca triandra* Roxb. ex Buch.-Ham. from India. *Australasian Plant Pathology.* https://doi.org/10.1007/s13313-021-00802-3 (NAAS Score 7.42).

Thomas, R.J., Shareefa, M., Harsha, H. and Anitha Karun. 2021. Biochemical characterization of pink husked coconut types. *Journal of Plantation Crops* **49** (1): 23-27 (NAAS Score 4.66).

Review Articles

Ramesh, S.V., Krishnan, V., Praveen, S. and Hebbar, K.B. 2021. Dietary prospects of coconut oil for the prevention and treatment of Alzheimer's disease (AD): A review of recent evidences. *Trends in Food Science & Technology* **112**:201-211 https://doi.org/10.1016/j.tifs.2021.03.046 (NAAS Score 17.08).

Ramesh, S.V., Pandiselvam, R., Shameena Beegum, P.P., Saravana Kumar R. M., Manikantan M. R., K. B Hebbar. 2021. Review of *Cocos nucifera* L. testa-derived phytonutrients with special reference to phenolics and its potential for encapsulation. *Journal of Food Science and Technology,* https://doi.org/10.1007/s13197-021-05310-2 (NAAS Score 7.95).

Papers presented in Seminars/Symposia/ Workshops/Webinars

Amala Mohan, Anes, K.M., Merin Babu and Josephrajkumar, A. 2021. Isolation and characterization of entomopathogenic nematodes from coconut intercrops. *In*: Proceedings of National Seminar on Advances in Biological Suppression of Pests, Eds Anes *et al.* September 22, 2021, ICAR-CPCRI, Regional Station, Kayamkulam, 16 p.

Amritha, K.T.K, Muralikrishna, K.S., Anitha Karun and Rajesh, M.K. 2021. 5 Azacytidine (5 azaC) treatment enhances the formation of embryogenic calli and somatic embryos from transverse thin layer cultures

derived from mature coconut zygotic embryos. *In*: Dhanapal, K., Pradip Kumar, K., Shadanaika., Ansar Ali, M.A., John Jo Varghese., Saju, K.A., Manooj Oommen., Thiyagarajan, P. (Eds.). Book of Abstracts, 24th Plantation Crops Symposium, 14-16 December 2021. p. 68.

Aparna Veluru, Subramanian, P., Kanwar Pal Singh, Namita, Sapna Panwar, Selvamani, V., Vandita Kumari and Ravi Bhat. 2021. Transforming coastal zone for sustainable food and income security. *In*: International Symposium on Coastal Agriculture (ISCA Webinar), organized in virtual mode during 16th- 19th March 2021, 80p.

Apshara, S.E. and Subramanian, P. 2020. Performance of selected genotypes of cocoa as clones and seedlings under coconut in Kasaragod condition. *In*: International e-conference 'Advances and future outlook in biotechnology and crop improvement for sustainable productivity'. 24-27 November 2020, UHS, Bagalkot. Fig. 24. OrNV infected grubs of rhinoceros beetle a) OrNV-infected and healthy grubs b) White and translucent gut contents of OrNV-infected grub c) Extroversion of gut d) Disintegration of fat body e) Different stages of OrNV-infected grubs.

Arsha G.M., Anes K.M., Babu, B., Indhuja S., Vidya J. and Josephrajkumar A. 2021. Antagonistic interaction of bacterial symbionts of entomopathogenic nematodes against fungal pathogen associated with coconut leaf rot disease. *In*: Proc. National Seminar on Advances in Biological Suppression of Pests, Eds Anes *et al*. September 22, 2021, ICAR-CPCRI, Regional Station, Kayamkulam 7p.

Bhalerao P. P., Maheswarappa H. P. and S. Sumitha 2021. Impact of integrated nutrient management in coconut based cropping systems under South Gujarat condition. *In*: National Seminar on Horticulture for Next Generation in Eastern India Organized by Bihar Agricultural University, Sabour, Bhagalpur (Bihar) held on 05-06 August, 2021.

Bhavishya, Priya, U.K., Najeeb, N., Thube, S.H., Pandian, R.T.P., Jose, C.T. and Ravi Bhat. 2021. Effect of plastic mulching on disease index and yield of yellow leaf disease affected arecanut (*Areca catechu*). *In*: National seminar on Sustainable plant health management amidst pandemic challenges and strategies, held at ICAR-Central Plantation Crops Research Institute, Kasaragod, Kerala, Indiaduring 1-3 December 2021. p55.

Chandrikamohan. 2021. Advances in bio-suppression of coconut pests (1st K.K. Memorial Lecture-2021). *In*: Proceedings of National Seminar on Advances in Biological Suppression of Pests, Eds Anes *et al*. September 22, 2021, ICAR-CPCRI, Regional Station, Kayamkulam, 3-4p.

Elain Apshara, S. and Senthil Amudhan, M. 2021. Response of cocoa beans to different small scale fermentation methods. *In: 9th* Indian Horticulture Congress from November 18-21, 2021. Chandra Shekhar Azad University of Agriculture and Technology Kanpur, Uttar Pradesh organized by Indian Academy of Horticultural Sciences (IAHS)

Geethu Venugopal, Muralikrishna K.S., Anitha Karun and Rajesh M.K. 2021. Effect of different coloured LED's on cell growth and biochemical parameters of coconut endosperm cultures. *In*: International Symposium on "Advances In Plant Biotechnology And Genome Editing and 42nd Meeting Of Plant Tissue Culture Association (India) held virtually by ICAR-Indian Institute of Agricultural Biotechnology, Ranchi, India during April 8-10, 2021.

Geethu Venugopal, Muralikrishna K.S., Gangaraj K.P., Sugatha P., Anitha Karun and Rajesh M.K. 2021. Transcriptome and biochemical profiling reveal genes involved in oil biosynthesis in endosperm callus of coconut (*Cocos nucifera* L.). *In*: Dhanapal, K., Pradip Kumar, K., Shadanaika., Ansar Ali, M.A., John Jo Varghese., Saju, K.A., Manooj Oommen., Thiyagarajan, P. (Eds.). Book of Abstracts, 24th Plantation Crops Symposium, 14-16 December 2021. p. 70.

Jeena Mathew, Haris, A.A., Anitha Kumari, P. and Ravi Bhat. 2021. Nutrient mixtures – 'Kalpa Poshak' and 'Kalpa Vardhini' for enhancing the productivity of coconut palms. Proc. International Virtual Conference on 'Challenges, Opportunities and Innovations in Agriculture, Plantations and Allied domains posed by the Pandemic', 21.10.2021, Indian Institute of Plantation Management, Bengaluru. p. 7-8.

Josephrajkumar, A. 2021. Advances in pest management in coconut system. *In:* Abstract of the Technical Paper presented during the Technical Session held on September 02, 2021. *Indian Cocon. J.* **64** (3): 7.

Maheswarappa, H.P. and Sumitha, S. 2021. Coconut Based Farming/ Cropping Systems: Recent Developments In System Productivity And Carbon Sequestration. *In*: 9th Indian Horticulture Congress-Horticulture for Health, Livelihoods and Economy, (Eds; Singh, S.K., Singh D.R. and Patel, V.B. *Souvenir cumLead & Oral Paper Abstracts Book)* held at Chandra Shekhar Azad University of Agriculture and Technology, Kanpur,

Uttar Pradesh, India from 18-21, November, 2021, organized by the Indian Academy of Horticultural Sciences, 314 p.

Mohan, A., Anes, K.M., Babu, M. and Josephrajkumar A. 2021. Isolation and characterization of entomopathogenic nematodes from coconut intercrops. *In*: Proc. National Seminar on Advances in Biological Suppression of Pests, Eds Anes et al. September 22, 2021, ICAR-CPCRI, Regional Station, Kayamkulam, 16 p.

Muralikrishna K.S., Rajesh M.K., Nagaraja N.R. and Anitha Karun. 2021. An improved pollen extraction and cryopreservation method for arecanut (*Areca catechu* L.) using Virgin Coconut Oil (VCO). *In*: Dhanapal, K., Pradip Kumar, K., Shadanaika., Ansar Ali, M.A., John Jo Varghese., Saju, K.A., Manooj Oommen., Thiyagarajan, P. (Eds.). Book of Abstracts, 24th Plantation Crops Symposium, 14-16 December 2021. p. 64.

Naganeeswaran, S., Elain Apshara, S., Anitha Karun and R. Manimekalai. 2021. Transcriptome analysis towards pod rot disease resistance in cocoa. In: Abstracts of PLACROSYM XXIV. (Eds. Dhanapal *et al*.), 14-16 December 2021, Spices Board, Kerala. p. 13.

Nagaraja, N. R., Ranjini, T. N., Neenu, S., Niral, V. and Ravi Bhat. 2020. Occurrence and frequency of chlorophyll deficient seedlings in arecanut. *In*: Abstracts - International E-Conference on Advances and Future Outlook in Biotechnology and Crop Improvement for Sustainable Productivity. Fakrudin, B., Halesh, G. K., Shivapriya, M., Lakshmidevamma, T. N., Mohankumar, S., Jayashree Ugalat (Eds.), 24-27 November 2020. Dept. of Biotechnology and Crop Improvement, College of Horticulture, Bengaluru, University of Horticultural Sciences, Bagalkot. pp. 18-19.

Namitha M.S., Amritha K.T.K, Gangaraj K.P., Muralikrishna K.S., Rajesh M.K. and Anitha Karun. 2021. Genome-wide identification and expression analysis of coconut cell cycle transition genes. *In:* Dhanapal, K., Pradip Kumar, K., Shadanaika., Ansar Ali, M.A., John Jo Varghese., Saju, K.A., Manooj Oommen., Thiyagarajan, P. (Eds.). Book of ABstracts, 24th Plantation Crops Symposium, 14-16 December 2021. p. 75.

Nihad, K., Abdul Haris and Ravi Bhat. 2021.Floriculture in coconut plantations- An income generating production system. *In*: International Horticulture Conference - NEXT GEN HORT 2021, Book of Abstracts. pp.156.

Niral V., SamsudeenK., B. Augustine Jerard, R. V. Nair and K.B. Hebbar. Development of multi-purpose variety “Kalpa Ratna”. *In*: Souvenir of Internationa Conference on Recent Advances in Agriculture, Engineering & Biotechnology for food security held on 25-26 September, 2021 organized by Mahima Research Foundation and Social Welfare, Varanasi, UP, India.P?.

Pandian, R. T. P., Thube, S. H., Bhavishya, Nagaraja, N. R., Pratibha, V. H., Merinbabu, Chaithra, M., Santhoshkumar, P., Nirmalkumar, B. J. and Hegde, V. 2021. Identification of an effective isolate of *Trichoderma harzianum* ACT1 for the Management of basal stem rot disease in arecanut. pp. 81-82. *In*: Book of Abstracts- International Symposium on Coastal Agriculture: Transforming Coastal Zone for Sustainable Food and Income Security. Sarangi, S. K., Mahanta, K.K., Raut, S., Bhutia, R. N. and Prakash, N. R. (Eds.), 16th to 19th March, 2021. Indian Society of Coastal Agricultural Research, ICAR-Central Soil Salinity Research Institute, Regional Research Station, Canning Town - 743 329, West Bengal, India, 298 p.

Paulraj, S., Ravi Bhat, Rajesh, M. K., Ramesh, S. V., Priya, U. K., Thava Prakasa Pandian, R., Vinayaka Hegde and Chowdappa, P. 2021. Abundance of *Cand. Patescibacteria:* A novel microbial phylum in arecanut rhizosphere in YLD endemic areas. Virtual National Symposium on “Sustainable Plant Health Management Amidst Covid Pandemic: Challenges and Strategies” 01-03 December 2021. pp. 64-65.

Prathibha, V. H., Rajkumar, Daliya Mol, Rajesh, M. K., Vinayaka Hegde, Monisha, M. and Sushmitha, K. 2021. Phylogeny, identification and pathogenicity of *Lasiodiplodia* associated with coconut-based cropping system. *In*: Virtual National Symposium on ‘Sustainable Plant Health Management Amidst Covid Pandemic: Challenges and Strategies’, 1-3rd December 2021 at ICAR – CPCRI, Kasaragod, Kerala. pp 25-26.

Priya, U. K., Bhavishya, Ravi Bhat, Nagaraja, N. R. and Thava Prakasa Pandian, R. 2021. Carbon dynamics in plantation crops under different cropping systems in ultisols of coastal belt of Karnataka. pp. 208-209. *In*: Book of Abstracts- International Symposium on Coastal Agriculture: Transforming Coastal Zone for Sustainable Food and Income Security. Sarangi, S. K., Mahanta, K.K., Raut, S., Bhutia, R. N. and Prakash, N. R. (Eds.), 16th to 19th March, 2021. Indian Society of Coastal Agricultural Research, ICAR-Central Soil Salinity Research Institute, Regional Research Station, Canning Town - 743 329, West Bengal, India, 298 p.

Rajesh M.K., Sunil S. Gangurde, Manish K Pandey, Niral V., Jerard B.A., Ganesh N. Kadke, Sabana, A.A., Muralikrishna, K.S., Samsudeen, K. and Anitha Karun.

2021. Use of genotyping by-sequencing to determine the genetic structure in coconut and to identify SNP loci associated with height and fruit colour by genome wide association mapping. *In*: Dhanapal, K., Pradip Kumar, K., Shadanaika., Ansar Ali, M.A., John Jo Varghese., Saju, K.A., Manooj Oommen., Thiyagarajan, P. (Eds.). Book of Abstracts, 24th Plantation Crops Symposium, 14-16 December 2021. p. 12.

Rajesh, M.K., Sarika Sahu, Jasmin Habeeb, Amritha K.T.K., Muralikrishna, K.S., Sabana, A.A., Gangaraj K.P., Nagaraja N.R. and Rao A.R. 2021. Mapping and development of novel S.S.R. markers using shallow sequencing data in arecanut (*Areca catechu* L.). *In*: Dhanapal, K., Pradip Kumar, K., Shadanaika., Ansar Ali, M.A., John Jo Varghese., Saju, K.A., Manooj Oommen., Thiyagarajan, P. (Eds.). Book of Abstracts, 24*th* Plantation Crops Symposium, 14-16 December 2021. pp 10.

Rajkumar and Pervez, R. 2021. Evaluation of fungal bioagents against *Meloidogyne incognita infesting* black pepper under coconut cropping system in humid west coast of Kerala. Oral Presentation in National Seminar on 'The facets of innovation and development of plant Nematology, 29th – 30th October 2021 at ICAR – IARI, New Delhi pp 71.

Rajkumar, Sujithra, M., Surekha, Leena, S., Muralidharan, K. and Vinayaka Hegde 2021. Impact of Kalpa EPN liquid formulation on insect pest management in coconut cropping system in Kasaragod district. *In* 24th Plantation Crops Symposium (PLACROSYMXXIV) 14th – 16th December 2021 at Kochi, Kerala. pp180.

Ramesh S.V., Rose Mary, Shameena Beegum P.P., Pandiselvam, R., Sugatha, P., Manikantan, M.R., Niral, V., Hebbar, K.B. 2020. Coconut testa-derived biocolourant and oil: a treasure trove of antioxidants. *In*: International Webinar on Phytochemistry-2020; Proceedings and Abstracts of Papers (Eds. Rameshkumar *et al.*), 28-29 Sep. 2020, Kerala Academy of Sciences, IUCGGT, University of Kerala, Karyavattom, Thiruvananthapuram, Kerala, India (www.kas.org.in) p20. ISBN: 978-81-940888-2-0

Rashid Pervez and Rajkumar 2021. Screening of entomopathogenic nematodes against root grub (*Holotrichia* sp.) infesting ginger (*Zingiber officinale* Rosc.). Poster Presentation in National Seminar on 'The facets of innovation and development of plant Nematology, 29th – 30th October 2021 at ICAR – IARI, New Delhi pp 70.

Santhrupthi B., Kalleshwaraswamy CM and Rajkumar 2021. Diversity of termites (Blottodea) in coconut ecosystem and evaluation of bio-agents against pest termites. Oral Presentation in 'National Seminar – Advances in Biological Suppression of pests 22nd September 2021, ICAR – CPCRI, Regional Station, Kayamkulam. pp13.

Thamban, C., Chandran, K.P., Kalavathi, S., Jayasekhar, S., Rajesh, M.K. and Nimya Mohan. 2021. Geo-spatial variability in coconut productivity in different Agro - Ecological Units in Kerala - An analysis. *In*: Abstracts of PLACROSYM XXIV. (Eds. Dhanapal et al.), 14-16 December 2021, Spices Board, Kerala. pp 101-102.

Thava Prakasa Pandian, R., Shivaji Hausrao Thube, Merin babu, Pratibha, V. H., Rajkumar, Priyank, H. M. and Vinayaka Hegde 2021. First report of *Fusarium falciforme* (FSSC 3 + 4) causing root decay of arecanut, *Areca catechu* L. Oral Presentation in Virtual National Symposium on 'Sustainable Plant Health Management Amidst Covid Pandemic: Challenges and Strategies', 1-3rd December 2021 at ICAR – CPCRI, Kasaragod, Keral. pp43.

Thava Prakasa Pandian, R., Shivaji Hausrao Thube, Merin babu, Pratibha, V. H., Rajkumar, Priyank, H. M. and Vinayaka Hegde 2021. First report of *Fusarium falciforme* (FSSC 3 + 4) causing root decay of arecanut, *Areca catechu* L. from India. Oral Presentation in 24th Plantation Crops Symposium (PLACROSYMXXIV)14th – 16th December 2021 at Kochi, Kerala. pp173.

Thomas, R.J. 2021. Coconut breeding with special emphasis on Eastern India. *In*: Proc. National Seminar on Horticulture for Next Generation in Eastern India - 2021: International Year of Fruits and Vegetables), 5-6 August 2021. Bihar Agricultural University, Sabour.

Vidya, J. and Josephrajkumar, A. 2021. Endophytic bacteria as a potential biocontrol agent against phytopathogens and pests. *In*: Proc. National Seminar on Advances in Biological Suppression of Pests, Eds Anes *et al.* September 22, 2021, ICAR-CPCRI, Regional Station, Kayamkulam, 32p.

Vidya, J. and Josephrajkumar, A. 2021. Endophytic bacteria as a potential biocontrol agent against phytopathogens and pests. *In Proceedings of National Seminar on Advances in Biological Suppression of Pests*, Eds Anes et al. September 22, 2021, ICAR-CPCRI, Regional Station, Kayamkulam, 32p.

Popular Articles

Alka Gupta, Aparna Veluru, Murali Gopal and Maheswarappa, H.P. 2021. Mokkajonna vyardhalato vermi compostu tayaari. *Annadata* **53** (3): 59p.

Anes, K. M., Thava Prakash Pandian, Merin babu, Arha, G.M. and Thamban, C. 2021. Kavungine badhikkunna rogangalum avayude samyojitha niyanthrana reethikalum (in Malayalam). *Kerala Karshakan*. **66** (10): 19-24.

Anes, K.M., Arsha, G.M. and Josephrajkumar, A. 2021. Nematodes as an enemy and friend in coconut based cropping system. *Indian Coconut Journal* **63**(12): 21-25.

Anes, K.M., Chandrika Mohan, Josephrajkumar, A., Merin Babu and Prathibha, P.S. 2021. *Vellechaye thurathaan nadapatikal lalitham (In Malayalam). Indian Nalikera Journal* **12**(10): 23-26.

Anes, K.M., Josephrajkumar, A., Arsha, G.M. and Chandrika Mohan. 2021. *Thenginte Samyojitha Keeda Niyanthranam* (Malayalam). *Kerala Karshakan* **66**(10): 66-71.

Anitha Kumari, P., Shameena Beegum, P.P. and Muralidharan. K. 2021. Ragi - The nutrimillet in coconut gardens, *Indian Coconut Journal*, 21-24.

Anithakumari P., Alka Gupta, S. Indhuja, Merin Babu and Stephin Srambikkal. 2021. *CPCRI ude sanketikvidhya; karshakarude parishodhan shala* (Technology of CPCRI; Farmers' laboratory). *Indian Nalikera Journal*. **12**(9): 16-17 (Malayalam).

Anithakumari, P. 2021. Coconut oil snippets. *Indian Nalikera Journal* **12**(11): 29-30.

Anithakumari, P. 2021. Enabling MGNREGS as a social platform for farm technology transfer. *AESA (Agricultural Extension South East Asia) Network-Good Practices* 52: October 2021.

Anithakumari, P. and Shameena Beegum, P.P. 2021. Combination in cultivation and nutrition for farm families-Coconut and Fingermillet. *Indian Nalikera Journal 12*(11): 10-12.

Anithakumari, P., Alka Gupta, Indhuja, S., Merin Babu and Steffin Srambickal. 2021. Technology of CPCRI and Farmers laboratory for production of KeraProbio. *Indian Nalikera Journal* **12**(9): 16-17.

Anithakumari, P., Alka Gupta, Murali Gopal and Indhuja, S. 2021. FPOs as agricultural technology promoters. I*ndian Coconut Journal.* **64** (4): 22-26.

Anithakumari, P., Jeena Mathew, Alka Gupta and Jithin Shaju. 2021 Odanadu Farmer Producer Company with coconut nutrient mixtures and biofertilizers. *Karshakasree* **27** (11): 36-37.

Anithakumari, P., Jithin Shaju, Kalpanamol, K. and Anju Krishnan. 2021. Mirror flooring with coconut charcoal powder. *Indian Nalikera Journal* **12**(10): 18-20.

Anithakumari, P., Jithin, S., Ijaz, N.M. and Anju Krishnan. 2021. Fruit crops and vegetables in coconut gardens. *Karshakan* **29**(3): 63-64.

Anithakumari, P., Shameena Beegum P.P., and Muralidharan K. 2021. Ragi - the nutrimillet in coconut gardens. *Indian Coconut Journal*. **64**(5) : 21-24.

Aparna Veluru, Shameena Begum P.P., Pandiselvam R., Manikantan M.R., Mathew A.C., Muralidharan, K. and Anitha Karun. 2021. Kobbarito viluva adhaarita utpattulu. Annadata (Telugu), **53**(9): 32-33.

Bhavishya, Pandian, R. T. P., Thube, S. H. and Nagaraja, N. R. 2021. Adikeyalli hechhuttiruva pentatomid tiganeya baadhe, mattu adara nirvahane. *Krishi Bimba*, **19** (9): 30-32.

Bhavishya, R. Thavaprakasa Pandian, Shivaji Hausrao Thube and N. R. Nagaraja. 2021. *Adikeyalli hecchutthiruva pentatomid midthiganeya bhadhe matthu adara nirvahane* (Kannada). *Krishi Bimba Patrike*. **19** (9): 30-32.

Jeena Mathew and Haris, A.A. 2021. Manninum venam oru aarogya card (In Malayalam). *Indian Nalikera Journal,* **12** (12):11-12.

Jerard, B.A., Josephrajkumar, A. Damodaran V., Zamir Ahmed SK., Singh LB. and Jaisankar, I. 2021. Invasive whiteflies infesting on Coconut palms in Andaman, *The Echo of India,* Port Blair, 26 March, 2021.

Jerard, B.A., Josephrajkumar, A., Damodaran, V., Zamir Ahmed, S.K., Singh, L.B. and Jaisankar, I. (2021) Management of invasive whiteflies on coconut palms in Andaman Islands. *Indian Coconut Journal* **63**(12): 5-7.

Jissy George 2021. Viji's Recipes as successful enterprises. *Karshakasree,* **27**(5): 63 (in Malayalam).

Jissy George 2021. Banana provides extra income. *Mathrubhoomi Daily*, Kasaragod Edn. 14th July 2021 (in Malayalam).

Jissy George 2021. Jack products with the taste of Thalassery. *Karshakashree*, **27** (12) : 50-51 (in Malayalam).

Jissy George 2021. Success story of Smitha Matathil with coconut products. *Karshakashree*, **27** (8) : 70 (in Malayalam).

Jissy George 2021. The silent revolution in Karnataka on Banana flour production with KVK's assistance. *Karshakashree*, **27** (9) : 50-51 (in Malayalam).

Jissy George 2021. Value added products from roots and tubers. *Karshakashree*, **27**(1): 69 (in Malayalam).

Jissy George and Muralidharan, P. 2021. Incubation centre of KVK - Alappuzha and its facilities. *Krishiyankanam*, **4**(4): 45-47 (in Malayalam).

Jissy George, Muralidharan P. and Aliya K.M. 2021. Profitable enterprises in coconut value addition with minimum investment. *Indian Nalikera Journal,* **12** (12) : 15-16.

Jissy George, Muralidharan, P. 2021. Jackfruit products in Thalassery taste. *Karshakasree,* **27** (12) : 74.
Jissy George. 14.07.2021. Banana provides extra income. *Mathrubhoomi Daily*, Kasaragod Edn.21.

Jissy George. 2021. New gen Jackfruit products. *Karshakasree,* **27**(6): 68 (in Malayalam).

Jissy George. 2021. Tasty value added products from Tapioca. *Malayala Manorama daily.* **27**th May (in Malayalam).

Jissy George. 2021. New gen Jackfruit products. *Karshakasree,* **27**(6): 68 (in Malayalam).

Jissy George. 2021. Virgin Coconut Oil production- a stable enterprise. *Karshakasree,* **27**(4): 65 (in Malayalam).

Jissy George. 2021. Jackfruit based enterprises started during lockdown turns to success. *Karshakashree*, **27**(10): 65 (in Malayalam).

Josephrajkumar A. 2021. Advances in pest management in coconut system. In: Abstract of the Technical Paper presented during the Technical Session held on September 02, 2021. *Indian Coconut Journal*, **64**(3): 7.

Josephrajkumar A. 2021. Sooty mould scavenger beetle, Leiochrinus nilgirianus Kaszab (Tenebrionidae: Coleoptera) on palms. *Insect Environment*, **24**(3): 402-403.

Josephrajkumar, A., Chandrika Mohan, Jijo Paul, Jayalakshmi, T., Rajendran, K., Hegde, V., Kalavathi, S. and Anitha Karun. 2021. Red palm weevil detector. *Indian Coconut Journal*, **63**(10): 16.

Josephrajkumar, A., Chandrika Mohan, Jijo Paul, Jayalakshmi, T., Rajendran, K., Hegde, V., Kalavathi, S and Anitha Karun. 2021. Red palm weevil detector (Malayalam). *Indian Naalikera Journal,* **12**(1): 26.

Josephrajkumar, A., Chandrika Mohan, Jijo Paul, Jayalakshmi, T., Rajendran, K., Vinayaka Hegde, Kalavathi, S and Anitha Karun 2021. Red palm weevil detector (Malayalam). *Indian Naalikera Journal*, **12** (1): 26.

Josephrajkumar, A., Chandrika Mohan, Jijo Paul, Jayalakshmi, T., Rajendran, K., Vinayaka Hegde, Kalavathi, S. and Anitha Karun 2021. Digital Devise for Diagnosing Red Palm Weevil Infested Palms. *E-Kerala karshakan* **9**(3): 9-12.

Josephrajkumar, A., Mohan, M., Paul, J., Jayalakshmi, T., Rajendran, K., Hegde,V., Kalavathi, S. and Karun, A. 2021. Digital Devise for Diagnosing Red Palm Weevil Infested Palms. *E-Kerala Karshakan*, **9**(3): 9-12.

Kalavathi, S., Haris, A.A., Chandran, A.K. and Jacob, A. 2021. "Varanam Yuvathalamura Thenginu Thangakan" *(In Malayalam) Indian Nalikera Journal,* **12** (3): 13-15.

Kalavathi, S., Haris, A.A., Rajeev, G. and Sunny Thomas. 2021. 'Kalavastha vyathiyanavum anuroopeekaranavum *(In Malayalam). Kerala Karshakan*, **67**(2):22-25.

Kalavathi, S., Rajeev, G. and Abe Jacob. 2021. Coconut farmers to be ready to face Monsoon. *Indian Nalikera Journal,* **12**(7): 11-12.

Kalavathi, S., Rajeev, G., Manikandan, M.R., Shameena Begum, P.P. and Haris, A.A.2021. Anantha sadhyathakalumayi naleekera uthpanna meghala *(In Malayalam). Kerala Karshakan,* **67**(3):17-26.

Maheswarappa H.P. and S. Sumitha. 2021. Fertigation in high value horticultural crops for higher productivity and resource use efficiency. *Indian Journal of Fertilisers,* **17** (11): 12-19.

Maheswarappa, H.P. and Sumitha, S. 2021. ICAR – AICRP on Palms celebrated World Coconut Day across the country. *Indian Coconut Journal*, **65** (3): 33-35.

Maheswarappa, H.P. Mathur R.K, Kalpana M., Madhavi Latha P. and Sumitha. S. New hybrid *tenera* released. *SOPOPRAD e-News*, 2(2) April - June, 2021. Page No 7.

Mathew, A. C. and Thamban, C. 2021. Thottavila gaveshana sthapanathil nalikera dinaghoshavum krishikarkayi sasthreeya pariseelanavum nadathi (in Malayalam). *Indian Nalikera Journal*. **12**(9):10-12

Mathew, J. and Haris, A. A. 2021. Nutrient deficiencies and amelioration in coconut farming *(In Malayalam) Indian Nalikera Journal* **12**(1):18-20.

Murali Gopal, Alka Gupta, Aparna V. 2021. Kobbari pottuto sendreeya eruvu tayaari. *Annadata* **53**(2): 10p.

Nagaraja, N. R., Pandian, R. T. P., Thube, S. H., Chaithra, M., Thanuja, G., Bhavishya, Nayana, H., Khadke, G. N. and Jose, C. T. 2021. *Phytophthora*: Adikeya apariharya shathru (Kannada). *Krishi Bimba Patrike,* **19** (7): 74-77.

Nagaraja, N. R., Priya, U. K., Bhavishya, ThavaPrakasa Pandian, R., ShivajiHausraoThube. 2021. Arecanut cultivation advisory. *Kerala Karshakan*. **8**(11): 16-19.

Neenu, S. 2021.Thenginchottile *mannu paripalanam. Indian Nalikera Journal*, **12**(8):17-18

Neenu, S., Karthika, K.S. and Anilkumar, K.S. 2021. Kuttanad soils: the potential acid sulphate soils of Kerala. *Harit Dhara E Magazine,* **3**(2):19-23.

Neenu, S., Karthika, K.S. and Anilkumar, K.S. 2021. Role of chlorine in coconut cultivation. *Indian Nalikera Journal*, **12**(1):11-13.

Neenu,S., Thamban, C. and Subramanian, P. 2021. Drip irrigation for coconut. *Indian Coconut Journal*, **64**(5): 11-16.

Nihad, K. 2021. Bird of Paradise adds beauty to gardens with ornamental flowers, leaves. *Mathrubhumi* Daily online edition 27 January 2021.

Nihad, K. 2021. Marigold fetches more. Mathrubhoomi Karshikarangam *Mathrubhoomi* Daily 16 October 2021.

Pandiselvam, R., Manikantan, M. R., Ramesh, S. V., Rintu, V. F., Athira, S., Beegum, S., & Mathew, A. C. 2021. Tender Coconut Husk- Various Uses. *Indian Coconut Journal*, Vol?: 8-11.

Pandiselvam, R., Manikantan, M.R., Binu, S.M., Ramesh, S.V., Beegum, S., Gopal, M., Hebbar, K.B., Mathew, A.C., Kothakota, A., Kaavya, R. and Shil, S., 2021. Reaction kinetics of physico-chemical attributes in coconut inflorescence sap during fermentation. *Journal of Food Science and Technology,* pp.1-9.

Patel, R. K., Singh, Beena, Salam, P. K. and Maheswarappa, H. P. 2021. Rugose spiraling whitefly: An invasive pest of coconut in Bastar plateau of Chhattisgarh. *Indian Entomologist.* **2021;2**(2):65-68.

Priya, U. K., Jose, C. T., Bhavishya, Chaithra, M., ShivajiHausraoThube, ThavaPrakasa Pandian, R., Nagaraja, N. R. 2021. High yielding varieties of arecanut for higher profitability (Malayalam). *Kerala Karshakan.* **66**(10): 49-52.

Priya, U.K., Bhavishya, Elain Apshara, S., Jose, C.T., Chaithra, M., Nagaraja, N.R., Shivaji Hausrao Thube, R.Thavaprakasa Pandian, Karthika, K.S. 2021. Nutrient management in cocoa. *Kerala Karshakan* **9**(2): 18-22.

Rajeev, G., Arsha G.M., Jinu S. and Anes K.M. 2021. *'Nimavirakal Shathruvo Mithramo' (In Malayalam). Indian Naalikera Journal,* **12**(3): 20-21.

Rajeev, G., Chandran, A.K. Jeena Mathew and Haris, A.A. 2021. Thenginu kalpa poshakum kalpa vardhiniyum *(In Malayalam). Indian Nalikera Journal* **12**(11):13-14.

Rajeev, G., Chandran, A.K., Mathew, J. and Haris, A.A. 2021. Integrated Nutrient Management in Coconut-Mannarinju Valam Cheyyam *(In Malayalam) Indian Nalikera Journal* **12**(1):16-19.

Rajeev, G., Mohan, B., Narayanan, A., Shareefa, M. and Thomas, R.J. 2021. Geotagging for coconut *(In Malayalam) Indian Nalikera Journal* **12**(9): 21-23.

Rajeev, G., Shareefa, M. and Thomas, R. J. 2020. Keralathinu yyojichcha mikacha thenginangal: evide labhikkum, eppol, engine nedaam. *Indian Nalikera Journal.* **11**(9):13-14.

Rajeev, G., Shareefa, M., Thomas, R.J. 2020. Thengu krishi prashnoththari. Series- 3. *Indian Nalikera Journal* **11**(11):13-14.

Rajeev, M.S. and Muralidharan, P. 2021. Farmer producer companies – Opportunities and Challenges. *Kerala Karshakan.* **67**(3): 13-16 (in Malayalam).

Rajeev, M.S. and Muralidharan, P. 2021. FPOs – Opportunities and Challenges. *Kerala Karshan* **67**(3): 13-16.

Rajeev, M.S. and Muralidharan, P. 2021. Start preparation for summer season sesamum cultivation. *Kerala Karshakan*, **66**(6): 28 – 29 (in Malayalam).

Rajkumar and Sujithra, M. 2021. Scope of entomopathogenic nematodes (EPNs) in coconut pest management. *Indian Coconut Journal*, **63**(12): 30-31.

Rajkumar, Surekha, R., Sujithra M. and Pratibha V. H. 2021.Management of root-knot nematode infestation in coconut cropping system. *Indian Coconut Journal,* **64** (2):33-34.

Ravi, S. 2021. Calf and dairy feeds. *Karshakan*, **29**(1): 18-19 (in Malayalam).

Ravi, S. 2021. Portable Incubator for small poultry farmers. *Kerala Karshakan*. **66**(9): 65-67 (in Malayalam).

Sajnanath, K., Arathy, J. and Muralidharan, P. 2021. Organic manure from aquatic weeds. *Karshakashree*, **27**(3): 57 (in Malayalam).

Shareefa, M., Ganesh, N. K. and Thomas, R.J. 2020. Occurrence of bizarre/freakish inflorescence in coconut palm. *Indian Coconut Journal* **63**(5):19-21.

Shareefa, M., Rajesh, K.S., Nazrin, N. and Thomas, R.J. 2020. Farmers also can produce hybrid seedlings of coconut (In Malayalam). *Krishi Jagaran* **4**(5):12-15.

Shareefa, M., Sreelekshmi, J. S., Thomas, R.J. and Anitha Karun. 2020. Propagation techniques in coconut. *Indian Coconut Journal.* **63**(8): 9-15.

Shareefa, M., Thomas, R.J. and Mayalekshmi. 2021. Cocoa as a potential intercrop in coconut in the root (wilt) disease prevalent tracts. *Indian Coconut Journal* **64**(4): 11-15.

Shareefa, M., Thomas, R.J. and Mayalekshmi. 2021. Cocoa as a potential intercrop in coconut in the root (wilt) disease prevalent tracts (In Malayalam). *Indian Nalikera Journal* **12**(11): 15-17.

Singh L. S., Anok Uchoi, Elain Apshara S. and Alpana Das. 2021. Present Scenario of cocoa cultivation in Assam. *The Cashew and Cocoa Journal*, **9**(1): 12-15.

Singh, L.S., Anok Uchoi and Alpana Das 2021. Current status, constraints and prospects of coconut cultivation in Assam. *Indian Coconut Journal*, **64**(2): 15-18.

Singh, L.S., Anok Uchoi, Elain Apshara, S. and Alpana Das 2021. Present scenario of cocoa cultivation in Assam (Hindi). *The Cashew and Cocoa Journal*, **9**(1): 2-5.

Sivakumar, T. 2021. A new pest on betel vine. *Karshakan*. **29**(4):43-44 (in Malayalam).

Sivakumar, T. 2021. Coconut nursery as a successful enterprise. *Karshakan*. **29** (6):10-12 (in Malayalam).

Sivakumar, T. 2021. How to start a commercial plant nursery. *Karshakan*. **29** (6):14-17 (in Malayalam).

Sujithra M, Subramanian P, Rajkumar and Jillu V Sajan. 2021. Chithal - thenginde nishabdha kolayali. *Indian Naalikera Journal*, **12** (3): 9 - 12.(Malayalam).

Sujithra M, Rajkumar M, Hegde V and Subramanian P. 2021. A novel technique to guard juvenile palms from rhinoceros beetle attack. *Indian Coconut Journal*, **63** (11): 22-23.

Sujithra M, Subramanian P and Rajkumar. 2021. Termites – Silent destroyers of coconut health. *Indian coconut Journal*, **63** (10): 7-10.

Sujithra M., Subramanian P. and Rajkumar 2021. Dimak nariyal pead ke swasthyaeka nishabdh nashak (Hindi language) (Termites silent destroyer of coconut), *Bharthiya Nariyal Patrika* **32**(1):6-9.

Sujithra M., Rajkumar and Sachin Pai. 2021. Strategies to protect coconut palm from rhinoceros beetle attack during monsoon season. *Indian coconut Journal,* Vol. **64** (1): 10-12.

Sumitha, S., H.P. Maheswarappa, R. Siddappa and Balanagouda Patil. 2021. Ball copra. *Indian Coconut Journal.* **64** (4):26-27.

Thamban C., Subramanian, P. and Joseph Rajkumar. 2021. Thengin thoppil September masathe krishippanikal (in Malayalam). *Indian Nalikera Journal.* **12**(8): 33-34.

Thamban C., Subramanian, P. and Joseph Rajkumar. 2021. Thengin thoppil Octoberile krishippanikal (in Malayalam). *Indian Nalikera Journal.* **12**(9):32-34.

Thamban C., Subramanian, P. and Joseph Rajkumar. 2021. Thengin thoppil Novemberile krishippanikal (in Malayalam). *Indian Nalikera Journal.* **12**(10):33-35.

Thamban C., Subramanian, P. and Joseph Rajkumar. 2021. Thengin thoppil Decemberile krishippanikal (in Malayalam). *Indian Nalikera Journal.* **12**(11):33-35.

Thamban C., Subramanian, P. and Joseph Rajkumar. 2021. Thengin thoppil Januariyile krishireethikal (in Malayalam). *Indian Nalikera Journal*. **12**(12):34-35.

Thamban, C. 2021. Kavungine badhikkunna pradhana keetangalum avayude niyanthrana margangalum (in Malayalam). *Kerala Karshakan.* **66** (10): 27-30.

Thamban, C. 2021. Nalikera utpadana mekhalayil Keralathinte pratapam veendedukkanam (in Malayalam). *Kerala Karshakan*. **66** (10): 12-16.

Thamban, C. 2021. Strengthening Farmer Producer Organisations in coconut sector. *Indian Coconut Journal*. **64** (3): 25-29.

Thamban, C. 2021. Thenginte utpadanakshamatha koottan (in Malayalam). *Mathrubhumi Daily.* Page 6. 5th September 2021.

Thamban, C. and Jayasekhar, S. 2021. ICAR-CPCRI celebrated world coconut day. *Indian Coconut Journal*. **64** (3): 30-32.

Thamban, C. and Jose, C.T. 2021. Karuthalode venam kamuku krishi vyapanam (in Malayalam). *Karshakasree*. **27** (8): 38-39.

Thamban, C., Mathew , A. C. and Subramanian, P. 2021. Thonikkadavile keraviseshangal (in Malayalam). *Indian Nalikera Journal*. **12**(12):20-23.

Thamban, C., Mathew, A. C. and Subramanian P. 2021. Thonikkadavile keraviseshangal (in Malayalam). *Indian Nalikera Journal*. **12**(12):20-23.

Thamban, C., Shameena Beegum, Subramanian, P., and Lijo Thomas. 2021. Effective use of technologies for coconut prosperity-Role of FPOs. *Indian Coconut Journal.* **64** (4): 30-31.

Thamban, C., Subramanian, P. and Ashamol, E.P. 2021. Thengin thai nateelum paricharanavum (in Malayalam). *Indian Nalikera Journal*. **12**(7): 05-10.

Thamban, C., Subramanian, P. and Joseph Rajkumar. 2021. Thengin thoppil August masathe krishippanikal (in Malayalam). *Indian Nalikera Journal.* **12**(7): 28-31.

Thamban, C., Subramanian, P. and Joseph Rajkumar. 2021. Thengin thoppil Octoberile krishippanikal (in Malayalam). *Indian Nalikera Journal.* **12**(9):32-34.

Thamban, C., Subramanian, P. and Joseph Rajkumar. 2021. Thengin thoppil Novemberile krishippanikal (in Malayalam). *Indian Nalikera Journal.* **12**(10):33-35.

Thamban, C., Subramanian, P. and Joseph Rajkumar. 2021. Thengin thoppil Decemberile krishippanikal (in Malayalam). *Indian Nalikera Journal*. **12**(11):33-35.

Thamban, C., Subramanian, P. and Joseph Rajkumar. 2021. Thengin thoppil Januariyile krishireethikal (in Malayalam). *Indian Nalikera Journal*. **12**(12):34-35.

Thamban, C., Subramanian, P., and Joseph Rajkumar. 2021. Cultivation practices in coconut garden-September. *Indian Coconut Journal.***64** (2): 34-36.

Thamban, C., Subramanian, P., and Joseph Rajkumar. 2021. Cultivation practices in coconut garden-October. *Indian Coconut Journal.* **64** (3): 37-40.

Thamban, C., Subramanian, P., and Joseph Rajkumar. 2021. Cultivation practices in coconut garden-November. *Indian Coconut Journal*. **64** (4): 33-36.

Thamban, C., Subramanian, P., and Joseph Rajkumar. 2021. Cultivation practices for coconut -December. *Indian Coconut Journal.* **64** (5): 32-36.

Thamban, C., Subramanian, P., and Joseph Rajkumar. 2021. Cultivation practices for coconut -January. *Indian Coconut Journal.* **64** (6): 32-36.

Thomas, R.J. and Shareefa, M. 2021. Caution needed against dwarf varieties of coconut (In Malayalam). *Karshakasree* August Issue: 65.

Thomas, R.J., Shareefa, M. and Ashokan, E.R. 2021. Integrated farming system approach in coconut: A success story from Attappady Hills. *Indian Coconut Journal* **58** (11): 11-14.

Thomas, R.J., Shareefa, M. and Asok, A. 2021. Quick Response (QR) code labeling as a quality assurance mechanism for coconut seedlings *Indian Coconut Journal* **58** (9): 15-17.

Thomas, R.J., Shareefa, M., Harsha, H. and Sreelekshmi, J.S. 2021. Pink husked coconut types and its biochemical properties. *Indian Coconut Journal* **64** (1): 11-12.

Thomas, R.J., Shareefa, M., Harsha, H. And Sreelekshmi, J.S. 2021. Pink husked coconut types and its biochemical properties (In Malayalam). *Indian Nalikera Journal* **12**(8): 12-14.

Book Chapters

Arunachalam, V., Ramesh, S.V., Paulraj, S., Babu, B.K., Muralikrishna, K.S., Rajesh, M.K. 2021. Endosperm Oil Biosynthesis: A Case Study for Trait Related Gene Evolution in Coconut. *In*: Rajesh, M.K., Ramesh, S.V., Perera, L., Kole, C. (eds) The Coconut Genome. Compendium of Plant Genomes. Springer, Cham, pp.145-157. https://doi.org/10.1007/978-3-030-76649-8_10.

Arunachalam, V., Ramesh, S.V., Rajesh, M.K., Muralikrishna, K.S. 2021. Aroma and Fragrance: A Case Study for Trait-Related Gene Evolution in Coconut. *In*: Rajesh, M.K., Ramesh, S.V., Perera, L., Kole, C. (eds) The Coconut Genome. Compendium of Plant Genomes. Springer, Cham. pp. 159-164. https://doi.org/10.1007/978-3-030-76649-8_11.

Jerard, B.A., Niral, V. and Rajesh, M.K., 2021. Breeding Strategies. In *The Coconut Genome* Springer, Cham, pp. 47-76.

Karun, A., Ramesh, S.V., Rajesh, M.K., Niral, V., Sudha, R. and Muralikrishna, K.S., 2022. Conservation and utilization of genetic diversity in coconut (*Cocos nucifera* L.). In cash crops. Springer, Cham, pp. 197-250.

Niral, V., Jerard, B.A. and Rajesh, M.K., 2021. Germplasm Resources: Diversity and Conservation. In *The Coconut Genome*, Springer, Cham. pp. 27-46).

Prathibha, P. S., Jilu V. Sajan and Daliyamol 2021. Mass culturing of biocontrol agents. ***In***: E-Training manual on "Rationalizing the plant health management techniques in palms and cocoa" (Eds. Daliyamol and Jilu V. Sajan). ICAR-CPCRI, Kasaragod – 671124, Kerala. pp. 70-76.

Rajesh, M.K., Ramesh, S.V. and Kole, C., 2021. Coconut: The Tree of Life-Endless Possibilities. In *The Coconut Genome*, pp. 205-207. Springer, Cham.

Rajesh, M.K., Ramesh, S.V., Karun, A., Chowdappa, P. 2021. Genome Sequencing, Transcriptomics, Proteomics and Metabolomics. *In*: Rajesh, M.K., Ramesh, S.V., Perera, L., Kole, C. (eds) The Coconut Genome. Compendium of Plant Genomes. Springer, Cham. https://doi.org/10.1007/978-3-030-76649-8_8.

Rajesh, M.K., Ramesh, S.V., Kole, C. 2021. Coconut: The Tree of Life-Endless Possibilities. In: Rajesh, M.K., Ramesh, S.V., Perera, L., Kole C. (eds) The Coconut Genome. Compendium of Plant Genomes. Springer, Cham. https://doi.org/10.1007/978-3-030-76649-8_15.

Rajesh, M.K., Ramesh, S.V., Perera, L., Manickavelu, A. 2021. Quantitative Trait Loci (QTL) and Association Mapping for Major Agronomic Traits. *In*: Rajesh, M.K., Ramesh, S.V., Perera, L., Kole, C. (eds) The Coconut Genome. Compendium of Plant Genomes. Springer,

Cham, pp. 91-101. https://doi.org/10.1007/978-3-030-76649-8_6.

Ramesh S.V., Mangruthia, S.K. and Praveen, S. 2021. Genetic modifications for disease resistance in crops. *In*: Genetically Modified Crops in Asia Pacific (Eds. Gujar G.T., Trisyono, Y.A., Chen M.) CSIRO Publishing Pp. 273-290. (ISBN: 9781486310920)

Ramesh, S.V., Rajesh, M.K., Singh, A., Hebbar, K.B. 2021. Mitochondrial and Chloroplast Genomes. Rajesh, M.K., Ramesh, S.V., Perera, L., Kole, C. (eds) The Coconut Genome. Compendium of Plant Genomes. Springer, Cham, pp. 133-143. https://doi.org/10.1007/978-3-030-76649-8_9.

Singh, L.S. and Anok Uchoi 2021. Cocoa-an emerging potential plantation crop for Assam. In: Recent approaches in sustainable agriculture development and food security, crop management, forestry, food technology and environmentally balanced production enhancement. Mahima Pub., 194, Karaundi, Banaras Hindu University, Varanasi-221 005 (UP, India). pp 268-275.

Sudha, R., Niral, V. and Samsudeen, K. 2021. Botanical study and cytology. In: Rajesh, M.K., Ramesh, S.V., Perera, L., Kole, C. (eds) The coconut Genome, pp. 13-26.

Book/ Proceedings

Anes, K.M., Josephrajkumar, A., Mohan, C., Babu, M. and Kalavathi S. 2021. *Proc. National Seminar on Advances in Biological Suppression of Pests,* 22 September 2021, ICAR-CPCRI, Regional Station, Kayamkulam, 32p.

Rajesh, M.K., Josephrajkumar, A., Prathibha, V.H., Daliyamol, Sajan, J.V., Merin Babu and Pandian, T.P. 2021. *Abstracts of National Symposium on Sustainable Plant Health Management Amidst Covid Pandemic:* Challenges and Strategies, December 1-3, 2021, ICAR-CPCRI, Kasaragod, 122p.

Rajesh, M.K., Ramesh, S.V., Perera, L. and Kole, C., 2021. The Coconut Genome. Springer, Cham. XXIV, 207. DOI. https://doi.org/10.1007/978-3-030-76649-8.

Extension Folders

Anithakumari, P. and Anju Krishnan. 2021. Pulse crops for nutrition and soil health. Extension Booklet – ICAR CPCRI Famer FIRST Programme. p.24.

Bhavishya, Elain Apshara, S. and Ravi Bhat. 2021. *Cocoa Nutri Card- Cocoa Poshakamsha Card.* Extension Folder No. 297 (Kannada), ICAR- CPCRI, Kasaragod & DCCD, Kochi, p. 2.

Chaithra M., Elain Apshara, Vinayaka Hegde, Harsha Priya. 2021. Cocoa health card (Disease). Extension Folder No: 295 ICAR- CPCRI, Kasaragod & DCCD, Kochi, p.2. (in Kannada).

Elain Apshara, S. and Bhavishya. 2021. Cocoa Nutri Card. Extension Folder No. 296 (English), ICAR- CPCRI, Kasaragod & DCCD, Kochi, p. 2.

Elain Apshara, S., Chaithra, M. and Thava Prakasa Pandian, R. 2021. Cocoa health card (Diseases). Extension Folder No. 294 (English), ICAR- CPCRI, Kasaragod & DCCD, Kochi, p.2.

Jilu, V. S., Prathibha, P. S., Junaid, B. V. and Thamban, C. 2021. Integrated pest management of rhinoceros beetle *(Kombanchelli-samyojitha keeda niyantranam)* Extension folder No. 282, ICAR-CPCRI, Kasaragod. (In Malayalam)

Jilu, V. S., Prathibha, P. S., Junaid, B. V. and Thamban, C. 2021. Integrated pest management of Coreid bug *(Poonkulachazhi- samyojitha keeda niyantranam)* Extension folder No. 285, ICAR-CPCRI, Kasaragod. (In Malayalam)

Jissy George, Muralidharan, P. and Arathy Anil. 2021. Value added products from vegetables. ICAR-KVK-Alappuzha. 40 p.

Nagaraja, N. R. and Ananda, K. S. 2021. Improved high yielding varieties and hybrids of arecanut. Extension folder No. 291. ICAR-CPCRI, Kasaragod, Kerala. p. 2.

Prathibha, P. S., Jilu, V. S., Junaid, B. V. and Thamban, C. 2021. Integrated pest management of coconut whiteflies *(Thengile velleechakal-samyojitha keeda niyantranam)* Extension folder No. 283, ICAR-CPCRI, Kasaragod. *(In Malayalam)*

Prathibha, P. S., Jilu, V. S., Junaid, B. V. and Thamban, C. 2021. Integrated pest management of coconut whitegrub *(Thenginte verutheenippuzhukkalude samyojitha keeda niyantranam)* Extension folder No. 284, ICAR-CPCRI, Kasaragod. *(In Malayalam)*

Prathibha, P. S., Jilu, V. S., Junaid, B. V. and Thamban, C. 2021. Integrated pest management of eriophyid mite *(Mandari- samyojitha keeda niyantranam)* Extension folder No. 286, ICAR-CPCRI, Kasaragod. (In Malayalam) Prathibha, P. S., Jilu, V.S., Junaid, B.V. and Thamban, C. 2021. Integrated pest management of red palm weevil (Chembanchelli-samyojitha keeda niyantranam) Extension folder No. 281, ICAR-CPCRI, Kasaragod. *(In Malayalam)*

Shivaji Hausrao Thube and Elain Apshara, S. 2021. *Cocoa Care Card* (Insect Pests). Extension Folder No. 292 (English), ICAR- CPCRI, Kasaragod & DCCD, Kochi, p. 2.

Shivaji Hausrao Thube and Elain Apshara, S. 2021. *Cocoa Care Card* (Insect Pests). Extension Folder No. 293 (Kannada), ICAR- CPCRI, Kasaragod & DCCD, Kochi, p. 2.

Technical bulletins

Nagaraja, N.R., Jaganathan, D., Jose, C.T., Ananda, K.S., Elain Apshara, S., Thava Prakasa Pandian, R., Shivaji Hausrao Thube and Saneera, E.K. 2021. ICAR- CPCRI, Vittal- In the service of farming community. Technical bulletin No.138, CPCRI, Kasaragod, p.38.

Thube, S. H., Pandian, R. T. P., Nagaraja, N. R., Rajkumar and Saneera, E. K. 2021. Integrated pest and disease management in arecanut. Technical bulletin No. 150. ICAR-CPCRI, Kasaragod, Kerala. 28 pp.

Training manual

Daliyamol and Jilu V. Sajan 2021. E-Training manual on "Rationalizing the plant health management techniques in palms and cocoa". ICAR-CPCRI, Kasaragod – 671124, Kerala. 102p.

Jissy George, Muralidharan, P and Arathy Anil. 2021. Value added products of vegetables. ICAR-KVK-Alappuzha. 40p.

Jacob John, Thamban, C., Subramanian, P.,Sudha, B.,Meera, A.V. and Sajeena, A. 2021. Manual on Integrated Farming. Integrated Farming System Research Station, Karamana, Kerala Agricultural University. pp: 104.

Manikantan, M.R., Muralidharan, K., Shameena Beegum, P.P. and Pandiselvam, R. 2021. Handbook of Spices and Plantation Crops Processing, ICAR-CPCRI, Kasaragod, 221 p. (online).

Nagaraja, N. R. and Khadke, G. N. 2020. Adike thaligalu mattu adikeyalli utthama gunamattada beeja athava sasigala uthpadane. In training manual on Thotada belegalalli sasimadi thanthrikate mattu uthpadana thantragnanagalu (Kannada). Khadke, G. N., Nagaraja, N. R., Niral, V., Samsudeen, K., Dhathri, N. R., Latha, H. K. (Eds.). ICAR-Central Plantation Crops Research Institute, Kasaragod, Kerala, pp. 8-12.

Ravi, S. and Muralidharan, P. 2021. Layer Farming. ICAR-KVK-Alappuzha. 40p.

Thomas, R.J. and Shareefa, M. 2021. Hybridization techniques in coconut including modified ground pollination *(In Malayalam)*. ICAR-CPCRI, Regional Station, Kayamkulam, Kerala. 33p.

e-Publications

Anitha Karun, Thamban C., Rosily Mathew 2020. E – Book on Scientific farming of coconut – Seed to Market in Malayalam **(Ed. Prathibha PS)** ICAR-CPCRI, Kasaragod – 671124, Kerala. 119 P.

CPCRI. 2021. Short videos on different technologies/ activities of KVK (in Malayalam) (i) Farm Machineries; (ii) Mushroom production technology; (iii) Egger nursery; (iv) Aquatic weed management; (v) Biogas production units; (vi) Dairy management; (vii) Poultry rearing; (viii) Functioning of an APTIC in the KVK; (ix) Coconut value addition; (x) Jack fruit processing; and (xi) Fruit and vegetable processing.

CPCRI. 2021. Videos on cocoa nursery and pruning techniques prepared in Kannada, Malayalam, Tamil and Telugu.

CPCRI. 2021. Videos on cocoa nursery techniques- Kannada, Malayalam, Tamil and Telugu.

CPCRI. 2021. Videos on pruning techniques- Kannada, Malayalam, Tamil and Telugu.

CPCRI. 2021. Videos on soil sampling in arecanut and cocoa gardens- English and Kannada.

CPCRI. 2021. Video film on “A decade of interventions in climate resilient farming” (in English).

Daliyamol and Jilu V. Sajan 2021. E-training Manual on "Rationalizing the plant health management techniques in palms and cocoa". ICAR-CPCRI, Kasaragod 101p.

Josephrajkumar, A., Anes, K.M., Nair, C.P.R., Mohan, C., Thajudin, S., Thomas, S., Babu, M. and Kalavathi, S. 2021. Entomology Luminaries @ Kayamkulam, ICAR-CPCRI, Regional Station, Kayamkulam, 9p.

Nihad, K., Anes, K.M. and Kalavathi, S. 2021. E-booklet on Proceedings of Webinar Series on ‘Redefining Agricultural Research and Education Priorities-Way Forward’ ICAR-CPCRI, Regional Station, Kayamkulam 9-11 August, 2021, 62p.

VIII. Technology assessed and transferred

Trichoderma

Mrs. Sreelatha, an ex-school teacher of Kasaragod approached CPCRI and discussed with pathologists on the scope and marketing of bio control agents and its formulations. Kasaragod, delcared as an organic district would be a great platform to start the venture, according to Mrs. Sreelatha. They are having a successful plant growth booster product made out of fish amino acid which is having great market among farming communities. She wanted to include Trichoderma culture in to plant booster in form of a consortia. After thorough discussion with the scientists group, she signed the MoU and purchased the technology of 'Trichoderma talc and coirpith formulation'. The mycelial growth compatibility of '*Trichoderma harzianum* CPTD 28' with their native fish amino acid based product- 'Plant growth booster' was tested in vitro using poison bait technique by CPCRI. This *Trichoderma*- fish amino acid based growth booster is of high performance especially in cardamom, coffee, banana and many vegetable gardens. She has undergone three days hands on training for the same during 20-22 April 2021. Subsequently, she started a private firm 'Sreekrishna Agrofert' in Industrial area of Ananthapuram, Kasaragod on 20th October 2021. The product 'Haritha Plant growth booster' is marketed by All Kerala Southern Phosphates and Minerals Pvt. Ltd in and around Kerala, Tamil Nadu and Karnataka. So far they had marketed around 1000 liters of the product and provided employment to six women.

Entomopathogenic nematode

The 'Kalpa EPN' technology was transferred to Mr. Suhas Mohan of Chikkamagalur district of Karnataka on 08.04.2021. Being a progressive farmer cum entrepreneur, he runs a small unit of mass production of bioagents. Due to enhanced demand for EPN in the management of white grub in arecanut, coconut and cardamom plantation systems, his team visited ICAR-CPCRI Nematology Laboratory and had undergone training on EPN mass production for three days. Now, they started a small production unit of EPN and used in their own garden and also distributing to the needy farmers in the region.

View of exchange of MOA

IX. AWARDS AND RECOGNITION

Awards

- AICRP on PHET Best Centre of the Year 2020: The award was conferred by Dr. K. Alagusundaram, DDG (Engg.), ICAR in the presence of Dr. S.N. Jha, ADG (Process Engineering) and Dr. S.K. Tyagi, Project Co-ordinator, AICRP on PHET on 5 February 2021.
- ICAR-NRC Banana, Tiruchirappalli conferred the Best KVK award to ICAR-CPCRI KVK, Alappuzha In recognition of the outstanding contributions for the transfer of banana related technologies during its 28th Foundation Day.
- Dr. Chandrika Mohan, Principal Scientist (Agricultural Entomology), ICAR-CPCRI, Regional Station, Kayamkulam was awarded the first Dr. K.K. Nirula Memorial Prize-2021 in recognition of her outstanding contributions in Bio-control of Coconut Pests on 22 September 2021.
- Dr. R. Pandiselvam, Scientist (AS&PE), was conferred NAAS Young Scientist Award by Dr. Trilochan Mohapatra, Secretary, DARE & DG, ICAR during XV Agricultural Science Congress, 13-16 November 2021held at Banaras Hindu University, Varanasi.
- Dr. J.S. Pruthi award for the best research paper 2018 by Indian Society of Spices has been conferred to Dr. R. Thava Prakasa Pandian, Scientist, ICAR-CPCRI, Regional Station, Vittal.
- On the occasion of 105th Foundation Day the Institute the following awards were distributed on 5 January 2021
- ICAR-CPCRI Best Scientific Team Research Award for Dr. M.R. Manikantan, Dr. A.C. Mathew, Dr. Shameena Beegum, Dr. R. Pandiselvam, Dr. M. Arivalagan, Dr. S.V. Ramesh, Dr. Murali Gopal, Dr. K.B. Hebbar and Dr. S. Paulraj
- The Best Technical Staff Award was shared among Shri K Krishnan Nair, Technical Officer, CPCRI, Kasaragod and Shri Santhosh Kumar P., Senior Technical Assistant, CPCRI, RS, Vittal.
- The Best Skilled Support Staff award was shared among Shri T.J. Ninan, SSS, CPCRI, Kasaragod and Shri Sudhakara, SSS, CPCRI, RS, Vittal.
- 'Best Oral presentation award' for Dr. R. Thava Prakasa Pandian, Scientist, ICAR-CPCRI, Regional Station, Vittal in the National e-Conference on Plant Health and Food Security: Challenges and Opportunities, 25-27 March 2021 by Indian Phytopathological Society.
- Third best oral presentation award for Arsha G. Madhu, Anes K.M., Merin Babu, Indhuja S., Vidya J. and Josephrajkumar A. in the National Seminar on Advances in Biological Suppression of Pests, 22 September 2021, ICAR-CPCRI, Regional Station, Kayamkulam
- Best oral presentation award for Bhavishya, Priya, U.K., Najeeb, N., Thube, S.H., Pandian, R.T.P., Jose, C.T. and Ravi Bhat in the national seminar on Sustainable plant health management amidst pandemic challenges and strategies, 1-3 December 2021, ICAR-CPCRI, Kasaragod.
- Best oral presentation award for R. T. P. Pandian, S. H. Thube, Merin Babu, V. H. Prathibha, Rajkumar, Priyank, H. M., and Vinayaka Hegde in the national symposium on Sustainable Plant Health Management amidst Covid Pandemic: Challenges and Strategies, 1-3 December 2021, organized by South Zone Chapter of Indian Phytopathological Society at ICAR-CPCRI, Kasaragod.
- Best oral presentation award for Paulraj, S., Ravi Bhat, M. K. Rajesh, S. V. Ramesh, U. K. Priya, R. Thava Prakasa Pandian, Vinayaka Hegde, and P. Chowdappa in the international conference on Global Perspectives in Crop Protection for Food Security, 8-10 December 2021, TNAU, Coimbatore.
- Best oral presentation award for R. Pandiselvam, M.R. Manikantan, A.C. Mathew, and P.P. Shameena Beegum in the International Symposium on Emerging Trends in Agricultural Engineering Education, Research and Extension, 23-25 November 2021, Dr.

Rajendra Prasad Central Agricultural University, Pusa, Bihar.

- Best poster presentation award for Dr. Rajkumar, Scientist, ICAR-CPCRI, Kasaragod in the International symposium on spices and aromatic crops (SYMSAC-X), 9-12 February 2021, ICAR-IISR, Kozhikode.

Recognitions

- Dr. M.K. Rajesh: Fellowship of the Indian Society for Plantation Crops.
- Dr. Nagaraja, N. R.: Recognized as 'PG Teacher/Research Guide' (Genetics and Plant Breeding) by the University of Agricultural Sciences, Bangalore, Karnataka.
- Mr. Ravindran P., Asst. Chief Technical Officer has been awarded with Ph.D. by the Mangalore University under the guidance of Dr. K. Subaharan, Principal Scientist (Entomology), ICAR-NBAIR, Bengaluru.

X. TRAINING AND CAPACITY BUILDING

Inhouse Training Programmes

- Basics in computer and e-office for skilled supporting staff: 22-24 February 2021, Kahikuchi. Dr. Salam Jayachitra Devi, Scientist, Computer Application & IT, ICAR-NRC on Pig was the resource person. Sri. Pankaj Das, Sri. Satish Bhaisya and Sri. Tanka Bahadur Thapa attended.
- Basics in computer, ERP and e-office for administrative, technical and skilled support staff: 18-20 February 2021, Mohitnagar. Dr. Avrajyoti Ghosh, ACTO, Sri. Pratap Kumar Sarkar, STA. Sri. Jagadish Roy, STA Sri. Prakash Barman, TA Sri. Sailen Seal, Sri Krishna Kumar Mandal, Sri. Nipendra Chandra, Sri. Kartik Chandra Biswas, Sri. Sushanta Barman and Sri. Mahade Misra attended.
- Basics of computers and e-Office, 6-8 Feb 2021, Vittal. Sri ChanduNaik, Sri Choma, Sri. Sudhakara, Sri. Dharmapala, Sri. Vinod, Sri. Isubu, Sri. Ibrahim, Sri. Gopala, Sri. Somappa, Sri. Mohana and Sri. M. Ananda attended.
- Basic computer application and E-office, 18-20 March 2021, ICAR-CPCRI, Kasaragod. Sri. M. Shankara, Smt. K. Baby, Sri. A. Mohana, Sri. K. Sukumaran, Sri. P. Kumaran, Sri. V.S Pakeeran, Sri. V. Thambai, Smt. G. Kamala, Sri. K.G. Sureshbabu, Sri. T.J. Ninan, Smt. Chithralekha Kodoth, Sri. B. Chandrahasa, Sri. V.T. Rameshan, Smt. K. Shobhana, Sri. M. Krishnan, Smt. V.A Leela, Smt. U. Sarojini, Sri. V. Krishnankutty, Sri. Chaniya Naik, Sri. B. Ramachandran, Sri. B. Sanjeeva Patali, Smt. N.V. Sasikala, Sri. Laxshmana Naik, Smt. Lalitha Bai, Sri. N. Bhaskaran, Sri. B. Sundara, Sri. K. Sureshan, Sri A. Madhu, Sri K.A. Madhavan, Sri Aneesh E.M., Smt. Vanamalini, Sri Sarath Kumar, Sri. Ashok Kumar R., Sri. Praveen Raj P.R., Sri. Kripesh Kumar, and Sri. Jayaprakash K. attended

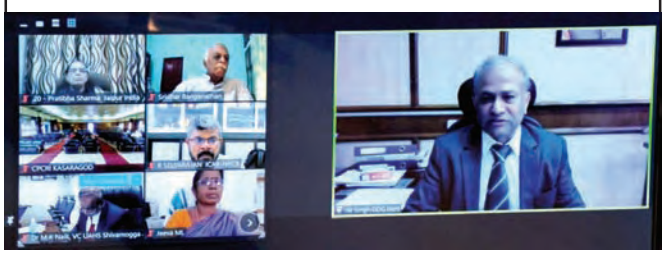
Training within India

Course title	Participant
Scientists	
Online Training Programme on Time Series Data Analysis, 4-9 January 2021, ICAR-NAARM, Hyderabad	Dr. Ravi Bhat Dr. SandipShil
Virtual training programme for the bureau of indian standards technical committee members, 24-25th May 2021, Food and Agriculture Department	Dr. K.B. Hebbar
Online Training on DUS testing, 1 July 2021, PPV & FRA	Dr. V. Niral
Capacity Building in 'Skill Development Management Process for KVKs', 14 July 2021, ASCI & ICAR-ATARI, Bengaluru	Dr. P. Muralidharan
Online training programme on Advances in Extension Research and Evaluation Methodology, 23 Aug-1 Sept, 2021, ICAR-NARM	Dr. Anithakumari P.
'Biosecurity and Biosafety: Policies, Diagnostics, Phytosanitary treatments and Issues' (DBT), 15-24 Sept 2021, ICAR-NBPGR	Dr. Regi Jacob Thomas
Online Training on Transcriptomic Data Analysis, 28-30 Sept, 2021, ICAR-IASRI	Dr. Alka Gupta
Digital Certificate Training Program on Genome Editing(virtual), 15 Oct-15 Dec, MERCK/SIGMA ALDRICH, Bangalore	Dr. M K Rajesh
Online training on Protein Structure Modeling and Dynamics, 27-29 Oct 2021, ICAR-IASRI	Dr. M K Rajesh

Online training programmeon Conservation, Management and Utilization of Horticultural Genetic Resources for Livelihood and Nutritional Security, 22-26 Nov, 2021, ICAR-IIHR	Dr. S. ElainApshara Dr. Shareefa M
Advances in Agricultural Water Management through integrated approach under changing climate (Online), 15-25 Nov 2021, KSCSTE-CWRDM, Kozhikode	Dr. Jeena Mathew
Technical Staff	
Skill Development Management Process for KVKs'(Online), 14 July 2021, ASCI & ICAR-ATARI, Bengaluru	Sri M.S. Rajeev; Dr. S. Ravi; Dr. K. Sajnanath; Smt. Jissy George; & Smt. Lekha, G.
Training on 'Use of statistical tools in agriculture and allied fields' (Online), Society of KrishiVigyan, Punjab during 16-19th July 2021	Sri M.S. Rajeev Dr. T. Sivakumar
E-Governance applications in ICAR, 6-10 September 2021, Recourse Management Unit, ICAR	Sri Hareesh G.S.
Strategies for climate risk management and resilient farming, 20-24 Sept 2021, ICAR-CRIDA & MANAGE	Sri M.S. Rajeev; Dr. S. Ravi & Dr. K. Sajnanath
Social Skills for Extension Approaches Management (Online), 22-24 Sept 2021, MANAGE	Dr. T. Sivakumar
Repair and Maintenance of Office, Residential Building including Guest Houses (online), 22-24 Sept 2021, ICAR-CIAE	Sri V. K. Gopala Krishnan
Competence Enhancement Programme on "Soft Skills and Personality Development, 20-25 Sept 2021, ICAR - NAARM,	Sri Arunji G Sri Bisun Bhasakar
Advances in IPM strategies for important crops of Karnataka, Kerala and Lakshadweep (online), 21-23 Oct 2021, ICAR-ATARI & ICAR-NCIPM	Dr. T. Sivakumar Smt. Lekha G
Statistical Techniques for Data Analysis in Agriculture, 4-13 Oct 2021, ICAR – IASRI.	Dr. Maya Lekshmi, Dr. Murali Krishna K S, Sri. Santhoshkumar P Sri. Bisun Bhaskar
Experimental Data Analysis (Online), 20-29 Oct 2021 ICAR - IASRI National Level Capacity Building Workshop for Agricultural LIS	Dr. Avrajyoti Ghosh
Professionals of SAU and ICAR Institutes, 22-27 Nov 2021, PJTSAU, Hyderabad	Sri Arunji G.
ICAR-IIHR Technologies for dissemination through KVKs (online), 17-18 Dec 2021, ICAR-IIHR	Sri M.S. Rajeev Dr. T. Sivakumar Smt. Lekha G.
Administrative Staff	
Accrual Accounting 26-30 July 2021, ICAR-NRRI	Smt. Roopa Manikandan Sri. Ratan Singh
Accrual Accounting, 20-24 Sept 2021, ICAR-NRRI.	Sri. Pradeepkumar Vasu
Accrual Accounting, 22-26 Nov 2021, ICAR-NRRI.	Sri. Neil Vincer A Sri. Paulson Sam George

XI. WORKSHOPS, SEMINARS, SUMMER INSTITUTES, FARMERS DAYS ORGANIZED

National Symposium on Sustainable Plant Health Management amidst Covid Pandemic: Challenges and Strategies, 1-3 Dec 2021: Organized by ICAR-CPCRI in collaboration with Indian Phytopathological Society (IPS) South Zone chapter in virtual mode. It was inaugurated by Dr. Trilochan Mohapatra, Secretary DARE & DG, ICAR. Dr. A.K.Singh, DDG (Hort.Sci.) presided over the function. Four e-publications from the institute including e-book of abstracts were released. Dr. P. Chowdappa, VC, BESTIU, Andhra Pradesh chaired the technical session having three keynote lectures deliverd by Dr. M.K. Naik, Dr. V.G.Malathi, Dr. Sudisha J and Dr. Vinayaka Hegde. Dr. Anitha Karun, Director, ICAR-CPCRI gave the welcome address. Other important speaker was Dr. Lava Kumar, IITA, Nigeria. More than 130 research papers were presented. Dr. Prathibha Sharma, President, IPS, New Delhi was the chief guest in the validictory.



National Seminar on Advances in Biological Suppression of Pests, 22 Sept 2021 ICAR-CPCRI, Regional Station, Kayamkulam: It was organized as a part of *Azadi ka Amrit Mahotsav.* Dr. Chandish R. Ballal, Former Director, ICAR-NBAIR, Bengaluru inaugurated and Dr. Anitha Karun, Director, ICAR-CPCRI, Kasaragod presided. Dr. Chandrika Mohan, Principal Scientist delivered the first 'Dr. K.K. Nirula Memorial lecture (2021)' on 'Advances in Bio-Suppression of Coconut Pests'. The special guests Dr. Madhu Subramanian, Director of Research, KAU and Dr. M. Nagesh, Director, ICAR-NBAIR, Bengaluru. Two publications viz., Entomology Luminaries @ Kayamkulam and the Seminar Proceedings and a short video on "Ecological engineering for Pest Regression" were released. A panel discussion was held with the participation of Dr. Santhosh J. Eapen, Head, Crop Protection, ICAR-IISR, Kozhikode, Dr. C.A. Jayaprakas, Head Division of Crop Protection, ICAR-CTCRI, Thiruvananthapuram, and Dr. G. Suja, Head, ORARS, Kayamkulam. Dr. C.P.R. Nair, Former Head, ICAR-CPCRI, RS, Kayamkulam was the moderator. Dr. R. Chandramohanan, Former Head, Division of Crop Protection, ICAR-CPCRI, Kasaragod chaired the Technical session on 'Bio-control of pests, nematodes and diseases of crops'. Dr. Rohinilyer, Former Head, Division of Crop Protection, ICAR-CPCRI, Kasaragod and Dr. K. Subaharan, Principal Scientist, ICAR-NBAIR, Bengaluru served as co-chairs of the session. Dr. Vinayaka Hegde, Head, Division of Crop Protection, ICAR-CPCRI chaired the valedictory function and farewell felicitation meeting for Dr. Chandrika Mohan. Dr. A. Joseph Rajkumar, PS outlined the Entomology Luminaries at Kayamkulam from Dr. Nirula to Dr. Chandrika Mohan briefly. The following are the recommendations emerged in the Seminar:

- Virulence validation, smart packaging of entomophaga and quality assessment of entomopathogen formulations used in palm system.
- Ecological intensification through crop pluralism induced conservation biological control for tackling pest outbreaks and conserving pollinators and defenders.
- Promoting one-health approach encouraging animal, plant, human and environmental health for sustainable food production system.
- Ecosystem services of pollinators in plantation crops.

- Deciphering the Functional genomics and evolutionary approaches to unravel the questions to betterment for development of strategies.
- Imaging techniques for non-invasive diagnosis of pest and diseases.
- Impact of climate change in palm pest and disease dynamics and their mitigation measures.

105th Foundation Day celebration of the Institute was held on 5 January 2021 with various programmes. Dr. A. K. Singh, Deputy Director General (Horticultural Science), ICAR, New Delhi delivered the Foundation Day address (via video conferencing). He also released two technologies: (i) an electronic device for early detection of red palm weevil infestation, developed in partnership with M/s Resnova, Kochi with the financial support from Coconut Development Board; and (ii) coconut sap chiller made with the mold developed with the financial support from Coconut Development Board.

Dr. N. M. Nayar, Former Director, ICAR-CPCRI delivered the first Memorial Lecture instituted in memory of Dr. K.V.A. Bavappa, the founder director of ICAR-CPCRI.

Dr. Jelfina C. Alouw, Executive Director, International Coconut Community, Jakarta; Dr. Venkatesh N. Hubballi, Director, Directorate of Cashewnut and Cocoa Development, Kochi, Dr. Homey Cheriyan, Director, Directorate of Arecanut and Spices Development, Kozhikode, Dr. B. K. Pandey, ADG (Hort. Science), ICAR, New Delhi, and Dr. Saradindu Das, CCDO, Coconut Development Board, Kochi offered felicitations.

ICAR-CPCRI signed MoA with Dr. YSR Horticultural University for academic collaborations. Dr. T. Janakiram, Vice Chancellor represented the University.

The on-line programme was attended by Dr. S. P. Ghosh, formerly DDG (Hort. Sci.) and Chairman, RAC of ICAR-CPCRI, members of QRT, past directors and other retired staff, directors of different ICAR institutes and other invitees. Dr. Anitha Karun, Director (Act.), offered welcome address and Dr. K. Muralidharan proposed vote of thanks in the online programme.

A Farmers' meet was organized as part of Foundation Day celebration which was inaugurated by Sri RajmohanUnnithan, Hon'ble MP (LokSabha), Kasaragod. Sri N. A. Nellikunnu, MLA, Kasaragod presided over the function in which Smt. Baby Balakrishnan, President, Kasaragod District Panchayat was the guest of honour. Sri Prashanth, P. V., Programme Executive, AIR, Kannur offered felicitations. Critical inputs to farmers and youths belonging to SC were distributed in the Farmers' Meet. Several extension publications including an audio CD on 'Thengum Thanalum' based on AIR programme, were also released.

Sri Rajmohan Unnithan, M.P., Kasaragod inaugurating the Foundation Day Programme at ICAR-CPCRI Kasaragod

XII. PARTICIPATION OF SCIENTISTS IN CONFERENCES, MEETINGS, WORKSHOPS AND SYMPOSIA

Name & designation	Title of the programme	Organizer & Date
Dr. S. Elain Apshara and Dr. A. Joseph Rajkumar, Principal Scientists Dr. M. Shareefa and Dr. Paulraj, Senior Scientists and Dr. S.V. Ramesh Scientist	Virtual Golden Jubilee ISPC webinar on Plantation Crops genomics: An overview of Current Research"	ICAR-CPCRI, Kasaragod during 18-20 January, 2021
Dr. A. Joseph Rajkumar, Principal Scientist	National Webinar on Coconut Production and Value Addition.	HRS, Ambajipeta (YSRHU) 26.02.2021
Dr. Regi J. Thomas, Principal Scientist	Online Meeting of State Level Award Committee to finalize the State Farmers Award for 2020	Directorate of Agriculture Development & Farmers Welfare, 13.01.2021
Dr. A. Joseph Rajkumar, Pr. Scientist Dr. Merin Babu Senior Scientist	International webinar on Coconut Lethal Yellowing phytoplasmas-Methods of Detection and status of control	ACIAR, Canberra 20-21 Jan, 2021
Dr. A. Joseph Rajkumar, Pr. Scientist	Valedictory function of Kalpa Graduate Readiness Programme	ICAR-CPCRI, 23rd January, 2021
Dr. Regi J. Thomas Principal Scientist	Pre-Conference meeting for Agriculture Session conducted in connection with Session conducted in connection with 'Kerala Looks Ahead'	State Planning Board Govt. of Kerala 27.01.2021
Dr. Ravi Bhat, Head, Dr. Elain Apshara, Principal Scientist, Dr. M. Shareefa Senior Scientist	e- Workshop on 'Coconut based high density multispecies cropping system'	ICAR-CPCRI, Kasaragod 29.01. 2021.
Dr. Abdul Haris A. Principal Scientist Dr. Regi J. Thomas Principal Scientist	'Role of New Technologies in Bridging Yield Gaps' in the online International Conference and Consultation on 'Kerala Looks Ahead'	State Planning Board Govt. of Kerala 02.02.2021
Dr. Abdul Haris A, Principal Scientist	Session on 'Insight with policy makers'	Agri India Hackathon Meet-7 on 05.02.2021
Dr. A. Joseph Rajkumar, Pr. Scientist Dr Merin Babu Senior Scientist	Webinar on Discussion Meeting on the Challenges in management of phytoplasma diseases	IWST, Bengaluru on 05.02.2021

Dr. A. Joseph Rajkumar, Pr. Scientist Dr. Merin Babu Senior Scientist	Webinar on Enigma of Bud rot disease in Oil palm	ICAR-IIOPR, 16.02.2021
Dr. A. Joseph Rajkumar, Pr. Scientist	Webinar on Agricultural Research through Knowledge Delivery	CABI and Telengana Agricultural University on 23.02.2021.
Dr. Regi J. Thomas, Principal Scientist	Online meeting to discuss the availability of coconut seedlings for distribution under Kerala Coconut Development Council Programme	Directorate of Agriculture Development & Farmers Welfare 26.03.2021
Dr. Arun Kumar Sit, PS	Workshop on Rajbhasha	Organized by ICAR-CPCRI, Kasaragod on 15.01.21
Dr. S. Elain Apshara, Principal Scientist (Hort.) and Dr. Sandip Shil, Scientist	3 days open webinar in Plantation Crop Genomics: An Overview of Current Research	Organized by ISPC in collaboration with Bionivid Technology Pvt. Ltd. Held between 18-01-2021 to 20-01-2021
Dr. Sandip Shil, Scientist	Online Training Programme on Time Series Data Analysis	Organized by ICAR-NAARM, Hyderabad during 04-09 January, 2021
Dr. S. Elain Apshara, Principal Scientist (Hort.)	Stakeholders meet on cocoa	DCCD & Dept. of Horticulture, AP, Vijayawada 23 Jan 2021
	Workshop on Coconut based high density multispecies cropping system	CPCRI, Kasaragod 29 Jan 2021
Chaithra M.,	International Conference on “Industrial perspective, challenges and strategies in the development of novel bio-pesticides: Its implication in sustainable pest and disease management (ICBC- 2021)”	TNAU, Coimbatore & Shastri Indo-Canadian Institute 11 to 12 March 2021
Dr. S. Ravi, SMS	Webinar on ‘Critical care and management of diseases in fowls’	TNVASSU, Chennai 7 January 2021
	Webinar on ‘Fluid Homeostasis and Electrolyte Imbalance in Small Animal Critical Care and Emergency’	TNVASSU, Chennai 10 February 2021
	Clinical Workshop online on ‘Stethoscopy in veterinary practice’	TANUVAS – Intas Animal Health 17 February 2021
	webinar on ‘Production of high value products from fish waste’	CIFT 25 February 2021
Dr. V. Niral, Principal Scientist	National online Seminar on Coconut Production and Value Addition	Dr. Y.S.R. Horticultural University, Horticultural Research Station, Ambajipeta on 26.02.2021
Dr. Thava Prakasa Pandian, Scientist	National e-Conference on Plant Health and Food Security: Challenges and Opportunities conducted by Indian Phytopathological Society	ICAR-IARI, New Delhi (25-27 March 2021)

Dr. Thava Prakasa Pandian, Scientist	International Symposium on Coastal Agriculture: Transforming Coastal Zone for Sustainable Food and Income Security conducted by Indian Society of Coastal Agricultural Research, ICAR-Central Soil Salinity Research Institute, Regional Research Station	Canning Town - 743 329, West Bengal 16th to 19th March, 2021
Dr. Nagaraja, N. R., Scientist	Participated as resource person on 05.04.2021 in the fifteen days Horticulture Based Industrial (HBI) placement course for eleven Final B.Sc. (Hort.) students from College of Horticulture, Mudigere, University of Agricultural and Horticultural Sciences, Shivamogga.	Organized by ICAR-CPCRI, Regional Station, Vittal, Dakshina Kannada Dt., Karnataka during 29th March, 2021 to 12th April 2021
Dr. V. Niral, Principal Scientist (Genetics), Crop Improvement and Dr. Nagaraja, N. R., Scientist	International Webinar on Exchange on PVP Post Control Measures	Organized by PPV&FRA, New Delhi on 8.04.2021.
Dr. Regi Jacob Thomas Principal Scientist Dr. Merin Babu Senior Scientist	Annual Review & Action Plan meeting of KVK's in Kerala State	Directorate of Extension, Kerala Agricultural University 20.4.2021 to 23.4.2021
Dr. S. Elain Apshara, Principal Scientist (Hort.)	15th INGENIC Asia-Pacific Breeders Meeting- Virtual	Brisbane, Australia 20-23 April 2021
Dr. Nagaraja, N. R., Scientist	Attended online meeting of the SCSP project	Organized by ICAR-CPCRI, Kasaragod, Kerala on 20.04.2021.
Dr. V. Niral, Principal Scientist	COGENT ITAG1 on In- & Ex-situ online conservation	Alliance of Bioversity and CIAT 22 April 2021
Dr. Rajkumar, Scientist	Webinar on Unmanned aerial vehicles for precision agriculture organized by Bharatiya Engineering Science and Technology innovation University	Andhra Pradesh 12.06.2021
Dr. Regi J. Thomas, Principal Scientist, Dr. S.V. Ramesh and Dr. R. Pandiselvam, Scientists	International Workshop on 'Scientific Writing'	ICAR-NDRI, Karnal under IDP-NAHEP 23th & 24th June 2021
Dr. Nagaraja, N. R., Scientist	Attended online Annual Review Meeting of the project 'DUS Centre for Arecanut' funded by PPV&FRA, New Delhi.	Organized by PPV&FRA, New Delhi on 23rd June 2021
Dr. Sandip Shil, Scientist	Workshop on "Enhancing Agricultural Resilience through Index-based Flood Insurance and Post-flood Management Interventions in India".	ICAR-IIWM & IWMI 29-30 June 2021
Dr. P. Muralidharan, Head, KVK, Dr. S. Ravi, Dr. K. Sajnanath, Dr. T. Sivakumar, Mr. M.S.Rajeev, SMSs	Review cum Action Plan Workshop of NICRA project of KVKs of Zone XI	ICAR-ATARI, Bengaluru on 26.06.2021

Dr. Nagaraja, N. R., Scientist	Attended online Annual Review Meeting of the MIDH (Mission for Integrated Development of Horticulture)/ NHM (National Horticulture Mission) programmes implemented through Directorate of Arecanut and Spices Development, Calicut	Organized by DASD, Calicut during 25th to 26th June 2021
Dr. K. Sajnanath	Sensitization workshop on the network project entitled 'Impact assessment of selected interventions by KVK under DFI for enhancing farmers income'	Organized by ICAR – ATARI Jodhpur on 22.04.2021 (Online)
Dr. S.Ravi, SMS (AH)	Webinar on "Innovative extension strategies for sustainable livestock development"	Organized by Madras Veterinary College, TANUVAS, Chennai on 29.04.2021 (Online).
Mrs. Lekha, G.	National webinar on "Promise of biological control for sustainable pest management"	Organized by MPUAT, Udaipur on 17.05.2021 (Online)
Mrs. Lekha, G.	Online training on "Management of African snail"	Organized by KAU, Thrissur on 02.06.2021 (Online)
Dr. T. Sivakumar Mrs. Lekha, G. Dr. S. Ravi & Dr. K. Sajnanath	Capacity Development Programme on "Virtual Farmers Field School"	Hosted by ICAR – ATARI, Sone VIII, Organized by University of Agricultural and Horticultural Sciences, Shivamoga, Karnataka on 14.6.2021 (Online)
Mrs. Jissy George	Webinar on "Value added products of Banana"	Organized by NRCB, Trichy on 23.06.2021 (Online)
Mrs. Jissy George	Webinar on "New opportunities of food processing"	Organized by KAU- ABI, Thrissur on 26.06.2021 (Online)
Dr. S. Elain Apshara, Principal Scientist (Hort.)	Azadi Ka Amrut Mahotsav (AKAM)-Conservation and utilization of horticultural genetic resources in India	ICAR-DCR Puttur, 13.08.2021
Dr. S. Elain Apshara, Principal Scientist (Hort.)	Swadeshi Science Movement in Kerala (Vijnana Bharati)-Emergence of modern science in India in the Era of Freedom Movement	ICAR-CPCRI, Kasaragod, 15.08.2021
Dr. S. Elain Apshara, Principal Scientist (Hort.)	Introduction to ARMS- Agricultural Research Management System	ICAR-CPCRI, Kasaragod, 18.08.2021
Dr. S. Elain Apshara, Principal Scientist (Hort.)	Post Covid Reforms	ICAR AKAM 19.08.2021
Dr. S. Elain Apshara, Principal Scientist (Hort.)	Coconut nutrients: Role in disease prevention (Food and Nutrition for farmers)	ICAR-CPCRI, Kasaragod, 26.08.2021

Dr. S. Elain Apshara, Principal Scientist (Hort.)	World Coconut Day - Stakeholders meet on coconut	ICAR-CPCRI, Kasaragod, 03.09.2021
Dr. S. Elain Apshara, Principal Scientist (Hort.)	Foundation day lecture ICAR- IIHR- Role of horticulture in Indian Economy	ICAR- IIHR, Bangalore, 07.09.2021
Dr. S. Elain Apshara, Principal Scientist (Hort.)	Cocoponics – A new method of growing vegetables in soilless culture	ICAR-DCR Puttur, 09.09.2021
Dr. S. Elain Apshara, Principal Scientist (Hort.)	International Millets Day- Millets and coconut based products for health and immunity	ICAR-CPCRI, Kasaragod, 17.09.2021
Dr. S. Elain Apshara, Principal Scientist (Hort.)	Kalpa Green Chat- The art and science of chocolate making	ICAR-CPCRI, Kasaragod, 25.09.2021
Dr. A. Joseph Rajkumar, Principal Scientist	Online workshop on the Management of Rodents, mites and Soil Arthropods	ICAR-CAZRI, Jodhpur & ICAR-NCIPM, New Delhi on 01.07.2021
Dr. T.Sivakumar, SMS (Ag.Ent)	Webinar 'World Zoonosis Day'	Organized by ICAR-NIVEDI, Bengaluru on 6th July (online)
Mr. M.S.Rajeev SMS (Agron) Dr.T.Sivakumar Dr.K.Sajnanath SMS (Soil Sci.)	Sustainable integrated cropping and farming system models with special reference to banana for enhanced income for farmers	Organized by ICAR-NRC Banana, Tiruchirapalli on 7th July 2021 (Online)
Dr.S.Ravi SMS (AH)	Webinar on 'Kharif fodder technologies'	Organized by ICAR-Indian Grassland and Fodder Research Institute, Jhansi from Jul 12-14, 2021
Dr. Chandrika Mohan, Dr. A. Joseph Rajkumar, Principal Scientists, Dr. K.M Anes, Scientist	Virtual online Annual Group Meeting of AICRP on Biological Control	ICAR-NBAIR, Bengaluru 14-15 July, 2021
Dr. A. Joseph Rajkumar, Principal Scientist	Brainstorming session on Invasive whitefly complex in plantation crops: Technical Knowledge and Technological Interventions for Management and delivered an invited talk on Diagnosis and molecular lineage of exotic whiteflies on palms	ICAR-IIOPR, Pedavegi on 17.07.2021
Dr. A. Joseph Rajkumar, Principal Scientist	Online meet on Biannual Subcommittee Meeting on National Network of Plant Health Experts	NIPHM, Hyderabad on 22.07.2021
Mr. M.S.Rajeev	Webinar on "Precision Farming with IoTs"	Organized by MANAGE, Hyderabad on July 23, 2021
Dr.S.Ravi	Webinar on Clinical management of metabolic and nutritional diseases in sheep and goat under 'Continuing learning intensive farming'	Organized by Alembic pharmaceutical on 25.07.2021
Dr. P. Muralidharan Mr. M.S. Rajeev Dr. T. Sivakumar	Zonal Workshop-2021 on 'Doubling the Farmer's Income through Strengthening KVKs with Inclusive Technologies and	Organized by ICAR ATARI, Bengaluru on 30-31 July, 2021 (Online).

Dr. S. Ravi Dr. K. Sajnanath Mrs. Lekha G.	Innovative Approaches'	
Dr. Regi Jacob Thomas, Principal Scientist	National seminar on 'Horticulture for Next Generation in Eastern India' and presented a lead paper on 'Coconut breeding with special emphasis on Eastern India'	Bihar Agricultural University, Sabour 05.08.2021
Dr. P. Muralidharan	As moderator of the webinar on "Climate resilient Practices in Dairy Farming"	Organized by ICAR-KVK-Pathanamthitta on 12th August, 21
Dr. A. Joseph Rajkumar, Principal Scientist	Webinar on 'Agricultural Research and Educational Priorities-Way Forward' and delivered a talk on 'Role of ICAR and CPCRI in transforming Agriculture'	ICAR-CPCRI, RS, Kayamkulam 9-11 August, 2021
Dr. T. Sivakumar	Webinar on Tools at workspace for personal Efficiency'	Organized by ICAR-NIAP on 7th August 2021 (online)
Mr. M.S. Rajeev Dr. K. Sajnanath	National webinar on Banana Value Chain and Marketing -New Business Horizons'	Organized by ICAR-NRC Banana, Tiruchirapalli on 21st August 2021 (Online)
Dr. A. Joseph Rajkumar, Principal Scientist	Webinar on Transforming food system under changing climate - Key strategies and Actions	ICAR-CRIDA on 23.08.2021
Dr. Rajkumar, Scientist	National webinar on 'Integrated pest management : A paradigm shift	ICAR – NCIPM, New Delhi 27 - 28 August 2021
Dr. P. Muralidharan Mrs. Lekha, G. Dr. K. Sajnanath	Stakeholders meet (online) in connection with World Coconut Day	Organised by ICAR – CPCRI, Kasaragode on 2.9.21
Dr. K. Sajnanath	Webinar on 'Microbial Management of crop residues for improvement of soil health: Useful methodologies to assess compost maturity and quality'	Organized by ICAR-NBAIM, Uttar Pradesh on 13th September 2021
Dr. S. Kalavathi Dr. P. Muralidharan	ICAR Regional Committee (VIII) meeting	Organized by ICAR-CMFRI on 14.09.21 (online)
Dr. S. Ravi	Application of ICTs in Livestock Management"	Organized by ICAR-NIVEDI - on 15th September 2021
Dr. K. Nihad Senior Scientist	International Horticulture Conference-*NEXTGEN -HORT*	TNAU, Coimbatore 16-19 September,2021
Dr. T. Sivakumar	Webinar on 'Space technologies in Agriculture'	Organized by ICAR-NIAP 18th September 2021(online)
Dr. S. Kalavathi, Head, Dr. Chandrika Mohan, Dr. P. Anitha Kumari, Dr A. Abdul Haris,	National Seminar on Advances in Biological Suppression of Pests and delivered a talk on Entomology Luminaries @ Kayamkulam	ICAR-CPCRI, RS, Kayamkulam on 22.09.2021

Dr. A. Joseph Rajkumar, Dr. P. Muralidharan, Principal Scientists, Dr. K. Nihad, Dr. M. Shareefa, Dr. Merin Babu, Dr. Jeena Mathew, Senior Scientists, Dr. K.M Anes, Dr. S. Indhuja Scientists and Mrs. Lekha G., CTO		
Dr. A. Joseph Rajkumar, Principal Scientist, Dr. K.M. Anes, Scientist	International Webinar on Biological Control-A global sustainable approach for Eco-friendly agriculture and delivered a talk on Biological Pest Suppression in Plantation Crops	NIPHM, Hyderabad on 24.09.2021
Dr. Regi Jacob Thomas, Principal Scientist, Dr. N.R. Nagaraja, Scientist	Awareness programme on 'Germplasm registration in Horticultural Crops'	ICAR-IIHR, Bengaluru 1 October 2021
Dr. A. Joseph Rajkumar, Principal Scientist	*Mera Gaon Mera Gaurav* – Review meeting	ICAR-CPCRI, Kasaragod 7 October 2021
Dr. Shameena Beegum, P.P. , Scientist	International conference on Global Trends in Food Processing and food safty (Food Xplore, 2021)	TNAU, Coimbatore 12 October 2021
Dr. Jeena Mathew, Scientist	International Conference on Challenges, Opportunities and Innovation in Agriculture, Plantations and Allied (APA) Domains Posed by the Pandemic"	Indian Institute of Plantation Management, Bengaluru, 21 October, 2021
Dr. Rajkumar, Scientist	Online seminar on the 'Facets of innovation and Development of plant Nematology	Nematological Society of India held at IARI New Delhi, 29 - 30 October 2021
Dr. A. Joseph Rajkumar, Principal Scientist	International Webinar on Management of Basal Stem Rot in Oil palm and other forest species -present status and future strategies	ICAR-IIOPR, Pedavegi 9-11 November, 2021.
Dr. Regi Jacob Thomas, Principal Scientist	2nd International Agro Biodiversity Congress	Rome, Italy 15-18th November 2021
Dr. S. Elain Apshara, Principal Scientist (Hort.)	9th Indian Horticulture Congress from organized by Indian Academy of Horticultural Sciences (IAHS) (online)	Chandra Shekhar Azad University of Agriculture and Technology Kanpur, Uttar Pradesh, 18-21 November 2021.
Dr. Anitha Karun, Acting Director, Dr. Ravi Bhat, Dr. Vinayaka Hegde, Dr. K.B. Hebbar and Dr. K. Muralidharan, Heads, Dr. S. Kalavathi, and	XXX Annual Group Meet of AICRP on Palms	ICAR-CPCRI, Kasaragod (online) 22- 24 November 2021

Dr. CT Jose, Heads of Stations, Dr. V. Niral, Dr. Regi Jacob Thomas, Dr. P. Subramanian, Dr. Elain Apshara, Dr. Joseph Rajkumar, Pr. Scientist (Agronomy), Dr. C. Thamban, Dr. Murali Gopal, Pr. Scientists, Dr. Merin Babu, Dr. Rajkumar, Dr. Sujitra M., Dr. P S Prathibha, Dr. R Sudha, Dr. VH Prathibha, and Dr. Daliya Mol, Dr. Nagaraja, Dr. Shivaji Hausrao Thube, Dr. Thava Prakasa pandian and Dr. S Sumitha, Scientists		
Dr. M. Shareefa, Sr. Scientist	Conservation, Management and Utilization of Horticultural Genetic Resources	ICAR-IIHR, Bengaluru 22-26th November 2021
Dr. M R Manikantan, Principal Scientist Dr. R. Pandiselvam, Scientist	55th Annual Convention of Indian Society of Agricultural Engineers and International Symposium	Dr Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar, 23-25 November 2021
Dr. A. Joseph Rajkumar, Principal Scientist Dr. Merin Babu, Dr. Paulraj S, Senior Scientist Dr. Rajkumar, Dr. Prathibha V H, Dr. Daliyamol, Dr. K. M. Anes, Sri Bhavishya, Dr. R. Thava Prakasa Pandian, Dr. Jilu V Sajan, Scientists	IPS National symposium on 'Sustainable Plant Health Management Amidst Covid-19 Pandemic Challenges and Strategies'	ICAR-CPCRI, Kasaragod 1-3rd December, 2021
Dr. K B Hebbar, Dr. C Thamban, Dr. V. Niral, Dr. S. Elain Apshara, Dr. A. Joseph Rajkumar, Dr. Rajesh M K, Dr. Chandran K P, Dr. S Jayasekhar Principal Scientists, Dr. Paulraj S, Sr. Scientist Dr. K.S. Muralikrishna, Senior Technical Assistant	PLACROSYM- 24 'Coping with the Pandemic and Beyond-Research and Innovations in Plantation Crops Sector'	Bolgatty Palace 14-16th December, 2021
Dr. S. Elain Apshara, Principal Scientist (Hort.)	International webinar on "Exchange on Biochemical and Molecular Technoques (BMT) guidelines and implementation of BMT in DUS"	Protection of Plant Varieties and Farmers' Rights Authority (PPV & FRA), New Delhi, 16 - 17 December, 2021

Dr. Ramesh S.V.	As a resource person delivered a guest lecture on "Recent advances in plant breeding: Transgenics" via online mode	VIT School of Agricultural Innovations and Advanced Learning [VAIAL], Vellore Institute of Technology, Vellore, Tamil Nadu on 03/June/2021
Dr. Ramesh S.V.	49th International COCOTECH Conference and Exhibition	ICC Secretariat Jakarta – Indonesia, 30-Aug to 2nd Sep-2021 (via online)
Dr. Shameena Beegum, P.P. Scientist	Presented on 'Value addition technologies in coconut" in the State level Package of Practice Workshop, KAU, Thrissur	Online
Dr. Shameena Beegum, P.P. Scientist	Resource person for handing a webinar on Bean to bite chocolate making" organized in connection with the World Chocolate Day for BVoc Food Processing, Department of Home Science, Vimala College, Thrissur, Kerlala held on 7th July, 2021.	Vimala College (autonomous), Thrissur, Kerlala
Dr. Shameena Beegum, P.P	Participated in the technical session on "Entrepreneurship oriented product diversification in Coconut" VAIGA –AGRI HACK	SAMETI, Department of Agriculture Development and farmer's welfare, Kerala held from 10-14 February, 2021 at Thrissur, Kerala Thrissur, Kerala
Dr. Shameena Beegum, P.P.	Handled a session on Millets and Coconut for Health and Immunity on the Curtain Raiser of International Millet Day held on 17.09.2021.	ICAR-CPCRI, Kasaragod
Dr. P. Subramanian Dr. C. Thamban Dr. Shameena Beegum, P.P.	Resource persons for the 'Scientist-FPOs Interface Programme on "Technology transfer and co-learning action research approaches" ON 21st October, 2021	ICAR-IISR, Calicut
Dr. Shameena Beegum, P.P.	Handled two days training for the Subject Matter Specialist of of ICAR-KVK, Kavaratti, Lakshadweep during 23 -24 March 2021.	ICAR-CPCRI
Dr. Shameena Beegum, P.P.	Handled session on Value addition on coconut as part of World Coconut day on 2nd September, 2021 for the trainees of ICAR-KVK, Kavaratti, Lakshadweep	ICAR-KVK, Kavaratti, Lakshadweep
Dr. A.C. Mathew Dr. C. Thamban Dr. P. Subramanian Dr. Samsudeen Dr. Prathibha P.S Dr. Shameena Beegum P.P.	Participated in the Scientist- Farmer Interface programme on "Coconut farming" on 5th January, 2021 on the Foundation day Celebration of ICAR-CPCRI	ICAR-CPCRI

Dr. Shameena Beegum P.P.	Kalpa green chat on "The Art & Science of Chocolate Making" on 25.09.2021	ICAR-CPCRI
Dr. M.R. Manikantan Dr. R. Pandiselvam	55th Annual Convention of Indian Society of Agricultural Engineers & International Symposium on Emerging Trends in Agricultural Engineering Educational, Research and Extension	Dr. Rajendra Prasad Central Agricultural University, Bihar, India during 23-25 November 2021
Dr. R. Pandiselvam	XV Agricultural Science Congress & ASC Expo	BHU, Varanasi during 13-16, November, 2021
Dr. R. Pandiselvam	National Webinar Series on "Nutrition week Celebration-2021"	Department of Food Technology, Faculty of Engineering, Karpagam Academy of Higher Education, Coimbatore, Tamil Nadu during 03 - 07 September, 2021
Dr. Shameena Beegum P.P.	International Symposium on Coastal Agriculture: Transforming Coastal Zone for Sustainable Food and Income Security	Indian Society of Coastal Agricultural Research (Online), 16-19 March 2021
Dr. Shameena Beegum P.P.	International Conference on "Global Trends in Food Processing and safety"	AEC & RI, TNAU on 12th October, 2021 (Online)
Dr. Shameena Beegum P.P.	Indian Horticultural Congress	Kanpur, 18-21 November, 2021 (Online)
Dr. M.R. Manikantan	Online National Conference entitled "Implementing Strategies to achieve Food Security and Food Sustainable Partnership: Progress and Challenges"	AICTE, New Delhi and TNVASU, Chennai (Online), 30.07.2021
Dr. M.R. Manikantan	One District One Product (ODOP) webinar on "Coconut Processing and Value Addition"	IIFPT, Thanjavur, 23.07.2021 (Online)
Dr. M.R. Manikantan	Virtual National level webinar on "Recent Advances in Production Technology and Value Addition of Coconut"	AICRP on Palms, 9th August, 2021 (Online)
Dr. M.R. Manikantan	Kalpataru 2021	Gardens Club, Kolhapur, Maharashtra (Online), 26.08.2021
Dr. M.R. Manikantan	One day webinar on "Value addition in coconut"	EDII Periyakulam Horti Business Incubation Forum, Horticultural College and Research Institute, Periyakulam, TNAU on 22.11.2021
Dr. P. Muralidharan, PS and Head Mr. M.S. Rajeev, CTO Dr. S. Ravi, ACTO Dr. K. Sajnanath, ACTO Mrs. Jissy George, CTO Mrs. Lekha, G, CTO	Capacity Building in 'Skill Development Management Process for KVKs' of ATARI Zone 11' (online)	ASCI and ICAR ATARI, Bengaluru 14th July 2021

Mr. M.S. Rajeev, CTO	Webinar on "Precision Farming with IoTs"	MANAGE, Hyderabad 23th July, 2021
Dr. S. Ravi, ACTO	Webinar on 'Clinical management of metabolic and nutritional diseases in sheep and goat under Continuing learning intensive farming'	Alembic pharmaceutical 25th July,2021
Dr. P. Muralidharan PS and Head Mr. M.S. Rajeev, CTO Dr. S. Ravi, ACTO Dr. K. Sajnanath , ACTO Mrs. Lekha G., CTO	Zonal Workshop-2021 (Online) on 'Doubling the Farmer's Income through Strengthening KVKs with Inclusive Technologies and Innovative Approaches'	ICAR ATARI, Bengaluru 30-31st July, 2021
Dr. T. Sivakumar, ACTO	Webinar on 'Tools at workspace for personal Efficiency'	ICAR-NIAP 7th August 2021
Dr. P. Muralidharan PS and Head	As moderator of the webinar on "Climate resilient Practices in Dairy Farming"	ICAR-KVK-Pathanamthitta 12th August, 21
Mr. M.S. Rajeev, CTO Dr. K. Sajnanath, ACTO	National webinar on 'Banana Value Chain and Marketing -New Business Horizons'	ICAR-NRC Banana, Tiruchirapalli 21st August 2021
Dr. P. Muralidharan PS and Head Mrs. Lekha G., CTO Dr. K. Sajnanath ACTO	Stakeholders meet (online) in connection with World Coconut Day	ICAR – CPCRI, Kasaragod 2nd September,.2021
Dr. K. Sajnanath ACTO	Webinar on 'Microbial Management of crop residues for improvement of soil health: Useful methodologies to assess compost maturity and quality'	ICAR-NBAIM, Uttar Pradesh 13th September 2021
Dr. P. Muralidharan PS and Head	ICAR Regional Committee (VIII) meeting (online)	ICAR-CMFRI 14th September,.2021
Dr. S. Ravi, ACTO	Application of ICTs in Livestock Management	ICAR-NIVEDI 15th September 2021
Dr. T. Sivakumar, ACTO	Webinar on 'Space technologies in Agriculture'	ICAR-NIAP 18th September 2021
Dr. P. Muralidharan PS and Head Mrs. Lekha G.,CTO	National Seminar on " Advances in Biological Suppression of pests"	ICAR - CPCRI 22nd September 2021
Dr. K. Sajnanath, ACTO	National Webinar on Use of Nano technology in Agriculture: Nano fertilizer	ICAR – Research Complex for Eastern region, Patna 23rd September 2021
Mrs. Lekha G., CTO Dr. K. Sajnanath, ACTO	Webinar on " Cleanliness for Healthy life"	ICAR – CPCRI 02nd October, 2021
Dr. P. Muralidharan PS and Head	Meeting (Online) of Working group of Kerala State Planning Board for the preparation of XIVth Plan	KSPB, Govt. of Kerala 13th and 26th October, 2021
Mr. M.S. Rajeev, CTO Dr. K. Sajnanath, ACTO	The role of KVKs in Energy conservation in Agri. sector	PCRA in association with ATARI 29thOctober,2021

Dr. P. Muralidharan PS and Head Mr. M.S. Rajeev, CTO	Zonal Research Extension Advisory Council meeting	RARS, Kumarakom, KAU 19th November, 2021
Dr. P. Muralidharan PS and Head Dr. T. Sivakumar, ACTO Mrs. Lekha G., CTO Dr. K. Sajnanath, ACTO	16th POP workshop of KAU	KAU, 1 – 4th December, 2021

XIII. LINKAGE AND COLLABORATIONS

International

International Coconut Community (ICC), Jakarta, Indonesia	Cooperation between coconut growing countries Coconut genetic resources network, International Coconut Gene Bank for South Asia& Middle East and socio-economic collaboration
Coconut Research Institute, Sri Lanka	Researxh programme againstCoconut Weligama Wilt disease in Sri Lanka

National ICAR Institutes

ICAR-CIARI, Port Blair	Coconut genetic resources collection, conservation and utilization
ICAR- Central Institute of Fisheries Technologies (CIFT), Kochi	Food processing R&D collaboration
ICAR- Directorate of Cashew Research, Puttur, Karnataka	Nematological and entomological programmes
ICAR- Indian Institute of Horticultural Research, Bengaluru	Phytoplasma disease related studies, varietal screening, cropping systems, agricultural tools and machinery and horticultural IP related activities
ICAR- Indian Institute Spices Research, Kozhikode	Cropping system studies, Phytophthora diseases in plantation crops
ICAR-Central Tuber Crop Research Institute, Thiruvananthapuram	Cassava and coconut based value added products, intercropping of tuber crops in coconut gardens
ICAR-CIPHET, Ludhiana	Agricultural pre- and post-harvest machinery
ICAR-CRIDA, Hyderabad	Climate change network and NICRA
ICAR-DMR, Solan	Agricultural pre- and post-harvest technolog development
ICAR-Indian Institute of Oil Palm Research (IIOPR), Pedavegi	Phytoplasma disease related studies and other common activities under plantation crops sector, tissue culture and biotechnological investigations
ICAR-National Bureau of Plant Genetic Resources (NBPGR), New Delhi	Germplasm registration and exchange of PGPR, Cryo-preservation of germplasm
ICAR-NBAII, Bengaluru	Biological control R&D
ICAR-NBAIM, Mau	Microbial research network R&D
ICAR-NRC for Orchids, Pakyong	Technology Mission for the development of North Eastern states, Intercropping of orchids in coconut/ arecanut multispecies based cropping system
ICAR-Sugarcane Breeding Institute (SBI), Coimbatore	Food processing R&D

Others

Agricultural Technology Management Agency (ATMA)	ToT activities
All India Radio (AIR), Kannur, All India Radio (AIR), Thiruvananthapuram, Doordarshan (Prasar Bharati)	Transfer of technology programme through media
Bannari Institute of Technology, Sathyamangalam, Tamil Nadu	Food technology R & D collaboration
Bidhan Chandra Krishi Vishwavidyalaya, Mohanpur, Nadia, West Bengal	Collaborating centre under AICRP
CAMPCO, Mangalore	Arecanut/ cocoa research and development
Central University of Kerala, Kasaragod, Kerala	R & D collaboration in Biotechnology
Coconut Development Board, Kochi	Research and development in coconut
CSIR-NIIST, Trivandrum	Technology programmes
DBT, New Delhi	Advancements in Biotechnology and Bioinformatics
Department of Agricultural Development and Farmers Welfare, Govt. of Kerala	ToT activities, Plating material production
Directorate of Arecanut and Spices Development, Kozhikode	Research and development in arecanut
Directorate of Cashew and Cocoa Research (DCCD), Kochi	Research and development in cocoa
District Panchayath, Alappuzha	ToT activities
District Panchayath, Kasaragod	ICAR-CPCRI, Kasaragod & KVK, Kasaragod ToT activities
DIT, New Delhi	Bioinformatics programmes
DST, New Delhi	Molecular biology research and women empowerment programmes
General Aeronautics Ltd., Bangaluru	Unmanned Aerial Vehicle (UAV- Drone) for palm spraying
IIFPT, Thanjavur, Tamil Nadu	R & D collaboration in PHT
IIPM, Bengaluru	Technology programmes in plantations management
KCAET, KAU, Tavanur	Technology programmes
Kerala State Council for Science, Technology and Environment, Thiruvananthapuram	R & D collaboration
Kerala State Planning Board	R & D collaboration
KSCSTE, Thiruvananthapuram	Research in biotechnology and bioinformatics
KVASU, Wayanad	Technology programmes
National Bank for Agriculture and Rural Development (NABARD), Mumbai	Developing/ demonstrating model coconut clusters in root (wilt) affected areas
Onattukara Regional Agricultural Research Station (ORARS), Kerala Agricultural University	KVK, Alappuzha for NICRA activities
PPV & FRA, New Delhi	DUS Centre on coconut, arecanut and cocoa
M/s Resnova Ltd., Kochi	Red palm weevil detector development
Tamil Nadu Agricultural University, Coimbatore	AICRP Centre collaboration
Tamil Nadu Veterinary and Animal Sciences	AICRP Centre collaboration
University, Chennai	
University of Agricultural Sciences, Bangalore	AICRP Centre collaboration

XIV. RESEARCH PROJECTS

Institute Funded Projects

Project No.	Project Title	Project Leader	Associate (s)
1000761028	Genetic resources management in coconut, arecanut and cocoa	V. Niral	S. Elain Apshara, N.R. Nagaraja, K. Samsudeen, A. K. Sit, L.S. Singh, Alpana Das, Sudha R., Ganesh Khadke, Regi Jacob Thomas, M. Sujithra, K.B. Hebbar, S.V. Ramesh, P. Subramanian, Shameena Begum, C. Thamban, Shivaji Hausrao Thube, Chaithra M., Anok Uchoi and B.A. Jerard ICAR-CIARI, Andamans
1000761029	Genetic investigations and breeding in coconut,	Regi Jacob Thomas	K. Samsudeen, V. Niral, S. Elain Apshara, M. Shareefa, A.K. Sit, N.R. Nagaraja, Merin Babu, arecanut and cocoa A. Josephrajkumar, L.S. Singh, Ganesh Khadke, Sudha R., Alpana Das, Sumitha, S. S. Sendur Kumaran and a scientist from CIARI
1000761031	Development of tissue culture techniques in coconut	Anitha Karun	M. K. Rajesh, Neema M., Aparna V., Regi Jacob Thomas, Shareefa M.
1000761030	Biotechnological applications in palms and cocoa	M.K. Rajesh	Anitha Karun, Neema M., Aparna V., Murali Gopal and Alpana Das
1000761032	Development of double-stranded RNA based food bait for the suppression of red palm weevil	M.K. Rajesh	Josephrajkumar A., Ramesh S.V. and M. Sujithra
1000763057	Cropping/ farming approaches for improving soil health and system productivity in coconut, arecanut and cocoa	P. Subramanian	Ravi Bhat, H. P. Maheshwarappa, V. Selvamani, Alka Gupta, Bhavishya, A. Abdul Haris, K. Nihad, Arun Kumar Sit, S. Neenu, G. Panjavarnam, U. K. Priya and Anok Uchoi
1000763058	Enhancing nutrient and water use efficiency for sustained productivity in coconut, arecanut and cocoa	V. Selvamani	P. Subramanian, H. P. Maheshwarappa, K. Nihad, Ravi Bhat, Neenu S., A. Abdul Haris, Jeena Mathew, U.K. Priya, Alka Gupta, G. Panjavarnam, Indhuja S., A.K. Sit, S. Paul Raj, Anok Uchoi, Merin Babu and P. Anitha Kumari

1000763055	Bioresources management in coconut, arecanut and cocoa	Alka Gupta	Murali Gopal, P. Subramanian, H.P Maheswarappa, Ravi Bhat, Abdul Harris, Elain Apshara, S. Neenu, Selvamani, U.K. Priya, Sandip Shil, S. Indhuja, K. Nihad, Jeena Mathew, Merin Babu, V.H. Prathibha, M. Sujithra and Bhavishya
1000765039	Integrated approaches for management of fungal diseases of palms and cocoa	Vinayaka Hegde	Prathibha V.H. and Thava Prakash Pandian, Chaithra M., Daliyamol, Rajesh M.K., Rajkumar, Ajeet Singh and Dr. L.S. Singh
1000765040	Diagnostics and management of root (wilt) disease (RWD) in coconut and yellow leaf disease (YLD) in arecanut	Vinayaka Hegde	K.B. Hebbar, A. Josephrajkumar, Murali Gopal, Merin Babu, R. Thava Prakash Pandian, S. Indhuja, Daliyamol, M. Chaithra and M.K. Rajesh
1000765041	Integrated management of pests and nematodes in palms and cocoa	Chandrika Mohan	A. Joseph Rajkumar, P.S. Prathibha, Rajkumar, M. Sujithra, Sivaji H. Thube, Jilu V. Sajan, Merin Babu, Anes, K. M, Thava Prakasa Pandian R., Daliyamol, Prathibha V.H. and Ramesh S.V.
1000766014	Phenotyping for climate resilient adaptation and mitigation strategies	K.B. Hebbar	S.V. Ramesh, Elain Apshara, S. Neenu, A.K. Sit, B. Sravanthi and V. Selvaman
1000767018	Mechanization, processing, product diversification and nutraceutical properties	M.R. Manikantan	Shameena Beegum P.P., R. Pandiselvam, Murali Gopal, S. Paul Raj, S.V. Ramesh and K.B. Hebbar
1000767022	Development of continuous type coconut testa removing machine	R. Pandiselvam	M.R. Manikantan, A.C. Mathew and Shameena Beegum P.P.
1000767023	Development of process technology for minimal processing of mature coconut kernel and its value added products	Shameena Beegum P.P.	M.R. Manikantan and R. Pandiselvam
1000767024	Hyper spectral imaging based detection system for identification of adulteration in desiccated coconut powder	M.R. Manikantan	R. Pandiselvam, Shameena Beegum P.P. and Subir Kumar Chakraborty (ICAR-CIAE)
1000767025	Development of linear actuator-based tender coconut punching and cutting machine	R. Pandiselvam	A.C. Mathew, M.R. Manikantan and Shameena Beegum
1000767026	Development of a process technology for the production of coconut infused bean to bite dark chocolates using cocoa beans, coconut and its by-products	Shameena Beegum P.P.	M. R. Manikantan, Ramesh S.V., S. Elain Apshara, and Rajesh G.K from KCAET, KAU, Tavanur

1000769020	Technology transfer and co-learning action research approaches	C. Thamban	S. Kalavathi, P. Anithakumari, C.T. Jose, K. Muralidharan, Chandran K.P., S. Jayasekhar, Alpana Das, N.R. Nagaraja, Abdul Haris, A.K. Sit, P. Subramanian, Sujihtra M. , Rajkumar, S. Paulraj, K. Nihad, Chaitra, M., Elain Apshara, Sandip Shil
1000769013	Socio-economic dimensions and value chain dynamics in policy perspective	S. Jayasekhar	Chandran K.P., Thamban C., Muralidharan K., Jose C.T., Sandip Shil
1000769019	Development of statistical and computational techniques for improving research methodology	Jose C.T.	Muralidharan K., Chandran K.P., Sandip Shil, Shivaji H. Thube, Thavaprakash Pandian and Jayasekhar S.
1000769023	Adaptation deficit analysis and resilience strategies to climate change in coastal coconut agro-ecosystems	Kalavathi S.	Abdul Haris, Chandrika Mohan, C.Thamban, Murali Gopal, Regi Jacob Thomas, Chandran. K.P., Anes, K.M. and Jeena Mathew

Externally Funded Projects

Proj. No.	Proj. Title	Project Leader	Associate (s)
1050761086	DUS Centre for coconut	V. Niral	K. Samsudeen
1050761114	Development of DUS testing criteria and establishment of genebank for arecanut	Nagaraja N.R.	A.K. Sit and L.S. Singh
2010760004	Seed Production in Coconut, Arecanut, Cocoa (Under ICAR Project on Seed Production in Agricultural Crops)	K. Samsudeen	V. Niral, S. Elain Apshara, N.R. Nagaraja, Regi Jacob Thomas, M. Shareefa, Anes K.M., Ganesh N. Khadke, Sudha R., A K Sit and L.S. Singh
1050761127	Commercial production of arecanut – tissue culture of planting material of yellow leaf disease resistant palms and dwarf hybrids	Anitha Karun	M.K. Rajesh, R. Thava Prakasa Pandian, Neema M. and Krishna Prakash
1050761140	Evaluation of stage-specific modulation of specific miRNAs during zygotic and somatic embryogenesis in coconut and their functional validation	M. K. Rajesh	K. Samsudeen and S.V. Ramesh
1050761142	Refinement of in vitro immature inflorescence culture of coconut for multiplication of true-to-type planting materials	Shareefa M.	Anitha Karun, Regi J. Thomas and M. K. Rajesh
1050761138	Participatory Demonstration Plots of Cinnamon intercropping in coconut	Ravi Bhat	P. Subramanian

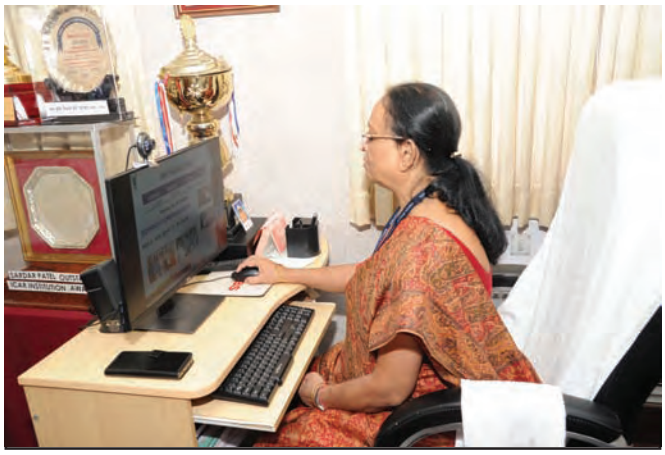
1050761143	Impact of water/ soil moisture conservation to enhancing production of coconut under rainfed and deficit irrigated farms	P. Subramanian	Ravi Bhat, Thamban C., A. C. Mathew and Paulraj, S.
1050761144	Maintenance of multi species cropping in arecanut garden – Assam	Alpana Das	-
1050761146	Establishment of advanced facilities for measuring physiological processes	K. Nihad	-
1050761109	Mass production of plant growth promoting microbes and bio-control agents for sustainability of coconut based farming system	Vinayaka Hegde	Prathibha V.H., Alka Gupta, Murali Gopal, Thamban C., Daliyamol and Prathibha P.S.
1050761128	Pest and disease surveillance on coconut palms by unmanned aerial vehicle	Vinayaka Hegde	A. Josephrajkumar, Chandrika Mohan, Prathibha P.S., Prathibha V.H., Rajkumar, Merin Babu, Daliyamol, Anes K.M., Abhishek Burman
1050761139	Establishment of FLDs on arecanut root diseases management using mandipropamid fungicide	Prathibha V.H.	Vinayaka Hegde, Thava Prakas Pandian and Rajkumar
1050761141	Formulation development of entomopathogenic fungus Simplicillium sp. and its utilization in the management of coconut invasive whiteflies	Sujithra M.	Prathibha V.H.
1050761120	Design, development and field demonstration of an airblast sprayer for coconut	Mathew A.C.	R. Pandiselvam
1050761137	Farmer Producer Organization with ICAR-CPCRI as Producer Organization Promoting Institution (POPI)	P. Anithakumari	-
1050761108	Consortium Research Platform (CRP) on farm mechanization and precision farming	L.S. Singh	Anok Uchoi
2010760007	Intellectual property management and transfer/ commercialization of agricultural technology scheme	K. Muralidharan	M.R. Manikantan and A.C. Mathew

1050761110	Establishment of Agri-Business Incubation (ABI) Center at ICAR-CPCRI, Kasaragod	Muralidharan K.	Mathew A.C., Manikantan M.R., Pandiselvam R., S. Jayasekhar, Murali Gopal, Shameena Beegum
1050761129	Demonstration of Effective and Eco-friendly management of white grubs using Entomopathogenic nematodes in arecanut	Rajkumar	Shivaji H. Thube and Nagaraja N.R.
1050761134	Design, Fabrication and Standardizing The Process Parameters of a Portable Biochar Unit for Tender Coconut Husk	A.C. Mathew	Murali Gopal, M.R. Manikantan, R. Pandiselvam
1050761131	Entrepreneurship Development Through Farmer Led Innovations – Study in Plantation Crops	T.S. Manojkumar	S. Jayasekhar and Sandip Shil
1050761135	Establishing Demonstration Plots on Arecanut Based Multispecies Cropping System	N.R. Nagaraja	C. T. Jose, Rajkumar and U.K. Priya
1050761136	Establishing Demonstration Plots on Arecanut Dwarf Hybrids	N.R. Nagaraja	C. T. Jose
1050761145	Demonstration of integrated management of inflorescence dieback disease in arecanut	R. Thava Prakasa Pandian	-

XV. RESEARCH AND ORGANISATIONAL MANAGEMENT

Research Advisory Committee (RAC) Meeting

The 23rd RAC meeting was held through videoconferencing mode on 11th June 2021 at ICAR-CPCRI Kasaragod. Dr. S.P. Ghosh, former DDG (Hort.), ICAR was the chairman RAC, joined the meeting from The Netherlands. Dr. Abraham Verghese, Former Director, NBAIR, Bengaluru, Dr. B.S. Hansra, Former ADG (Extension), Noida, Uttara Pradesh, Dr. K.V. Bhat, Former Principal Scientist, ICAR-NBPGR, New Delhi and Dr. B.K. Pandey, Principal Scientist, ICAR (Nominee of ADG (HS-II)), were present during the online RAC meeting. Dr Anitha Karun, Director (Acting) presented various activities and achievements made by the Institute in the R&D sector. Dr. Ravi Bhat, Principal Scientist, Member Secretary, RAC and Dr. H.P. Maheswarappa, Project Coordinator (Palms), Heads of Divisions, programme leaders and other scientists of ICAR-CPCRI attended the meeting from different locations online. Project leaders from the Institute have presented their achievements online. It was followed by discussions and recommendations.



Dr. Anitha Karun, Director (Acting), ICAR-CPCRI, Kasaragod at ICAR-CPCRI, Kasaragod presenting research highlights of the Institute

Institute Research Committee (IRC) Meeting

The 49th IRC meeting was held during 22nd - 25th June 2021 through videoconferencing mode under the chairmanship of Dr. Anitha Karun, Director (Acting), ICAR-CPCRI, Kasaragod at ICAR-CPCRI, Kasaragod. She inaugurated the meeting with her opening remarks. Presentation of work done report on various projects under ICAR-CPCRI including externally funded projects was made by the scientists.

The Plenary Session of IRC was held on 25th June 2021. Dr. V. Venkata Subramanian, Director, ICAR-ATARI, Bengaluru was the chief guest on the occasion. The Directors of ICAR-IIOP and ICAR-IISR, Kozhikode have also participated in the Plenary Session. Dr Venkatesh Hubballi, Director, DCCD, Shri Prabhakar Rao, Project Director, ITDP, Vizag, A.P., Shri Krishna Kanta Bora, Organizing Secretary, Bharatiya Kisan Sangh, Assam, Joint Director, of Horticulture, Mizoram, Shri Suresh Kumar Shetty and Shri Sadananda Shetty, IMC Members of the institute and progressive farmers from Kasaragod, Dakshina Kannada and Mizoram have also participated. The session was started with the welcome address of Dr Anitha Karun, Director, ICAR-CPCRI, Kasaragod and ended with vote of thanks from Dr. K. Samsudeen, Principal Scientist and Member Secretary, IRC.

Institute Biosafety Committee (IBSC) Meeting

The first Meeting of the reconstituted Institute Biosafety Committee (IBSC) of ICAR-CPCRI, Kasaragod was held on 4th March/2021 under the Chairmanship of Dr. Anitha Karun, Director (Acting), ICAR-CPCRI and Chairman, IBSC, at ICAR-CPCRI, Kasaragod over video-conferencing mode. The Meeting was attended by Dr. A. Ishwara Bhat, Principal Scientist, ICAR-Indian Institute of Spices Research, Kozhikode, Kerala (DBT Nominee), Dr. Rajendra Pilankatta- Associate Professor, Head of the Department, Central University of Kerala, Periye, Kerala (Outside Expert), Dr. Rekha Rai, Professor (Microbiology), K. S. Hedge Medical Academy, Mangalore (Medical Officer) and all the other members of the Committee.

XVI. INTELLECTUAL PROPERTY AND TECHNOLOGY MANAGEMENT

Patents obtained

Three national patents were granted to the Institute:

Title	Patent No.	Granted date	Inventor's
983/CHE/2009: Manually operated coconut kernel slicing machine	358062	09-02-2021	Dr. Mathew A.C. Dr. Madhavan K.
4077/CHE/2014: Coco sap chiller	373309	30-07-2021	Dr. K.B. Hebbar Sri. Augustine Joseph
2425/CHE/2013: A device for extraction of coconut/ palm sap	382339	23-11-2021	Dr. K.B. Hebbar

Consultancy services

Consultancy service	Client	Amount (Rs.)
Nutrient analysis - Bone meals	Agricultural Office, Krishi Bhavan, Badiyadka	1250.00
Nutrient analysis - Organic meals	Agricultural Office, Krishi Bhavan, Badiyadka	1250.00
Nutrient analysis of - Neem cake	Agricultural Office, Krishi Bhavan, Badiyadka	1250.00
Compatibility test for metarhizium with *Haritha* plant growth booster (2 samples)	Mrs. Sreelatha TK , Durga Lakshmi , Near SDP Temple, Kasaragod	10000.00
Nutrient analysis - Bone meals	Agricultural Office, Krishi Bhavan, Chengala	1250.00
Nutrient analysis - Neem cake	Agricultural Office, Krishi Bhavan, Chengala	1250.00
Organic Manure Sample testing	The City centre Mall, Owners Association, KS Rao Road, mangalore	2750.00
Organic Manure Sample testing	Fernhill Apartments, Nanthoor, Mangalore	2750.00
Analysis N P K Org. Carbon, pH, Ec	M/s. Akshaya Jaivavalam, Mathil Payyannur	2750.00
Analysis N P K Org. Carbon, pH, Ec	M/s. YSM Organic Manuare, Puthukkad, North Trissur	2750.00
TOTAL		27250.00

Commercialization of Technology

During 2021, total 18 technologies were commercialised by the Institute to 30 entrepreneurs through MoAs and an amount of Rs. 6.666 lakhs have been collected as technology transfer fees.

Technology	Date of licensing	Transfer fees (Rs)	Entrepreneurs
virgin coconut oil	02-02-2021	40000	Mr. Rohan Anthony Olegario Nazareth, Residing at Green Glades, Block B, Flat G/1, Opposite Duler Football Ground, Duler, Mapusa, Goa – 403507.
Matured coconut water based value added products	02-02-2021	15000	
Trichoderma Coir Pith Cake	06-03-2021	5000	Mrs. Sreelatha T.K., "Durga Laxmi", Near S.D.P Temple, Kasaragod, Kerala.
Snowball Tender Nut Machine	16-03-2021	2500	Mr. Titto Joseph, Puthumana, Kalathipady, Vijayapuram (PO), Kottayam, Kerala
Knowhow for production of bean to bite chocolate	16-03-2021	10000	Mr. Abhilash K.S, C/o Ushas Dreams, Chowki, Kasaragod, Kerala
Operation of Bean to Bite Chocolate unit at ABI Centre	16-03-2021	2000	-do-
Aqua formulation of EPN Kalpa EPN (CPCRI-SC1)	08-04-2021	5000	Mr. Suhas Mohan, C – 41, Rathnagiri Bore, Chikkamagalur, Karnataka
Preservation of carbonated tender coconut water	05-05-2021	25000	Smt. Livia Thomas, The Director, Scarlet Naturals Pvt. Ltd., 20/353, M.M. Bazar, Aluva Road, Angamaly, Ernakulam.
Knowhow for processing of cocoa nibs	17-06-2021	7000	Smt. Latha Sabbam, C/o CocoaBuzzz, AptC2, 3rd floor, DayalRaj Apartments, Maharanipeta, Visakhapatnam, AP
Kalpa Soil Care (coir pith composting (urea free)	18-06-2021	25000	Poinachi Farmers Welfare Co-Operative Society Ltd., Poinachi, Kasaragod.
Kalpa vardhini	12-07-2021	10000	ICAR-KVK, CARD, Kolabhagom P.O., Thiruvalla, Pathanamthitta
Kalpa Soil Care (coir pith composting (urea free)	22-07-2021	10000	The Secretary, Rajapuram Agricultural Improvement Co-operative Society Ltd., Rajapuram P.O., Kasaragod
Collection of Kalparasa® & production of coconut sugar	29-07-2021	100,000	The Senior Scientist and Head, KVK Lakshadweep, ICAR-CMFRI, Kavaratti
Frozen Coconut Delicacy	29-07-2021	100,000	
Virgin coconut oil	29-07-2021	40,000	
Coconut Chips	29-07-2021	25000	
Preservation of carbonated tender coconut water	29-07-2021	25000	
Matured coconut water based value added products	29-07-2021	15000	
Preservation protocol for trimmed tender coconut	29-07-2021	15000	

Matured coconut water based value added products	11-08-2021	15000	The Director, NAS POOMTHALIR FOODS PVT LTD.(1773), Thalir Building, Payyoli, Kozhikode.
Foam mat dried coconut milk powder	12-08-2021	10000	Mr. Narendran C, Nandanam Agro Food Industries, , Urakam, Thrissur
Operation of Chocolate unit at ABI centre	25-08-2021	2000	Mr. Anmol Gupta, White Mountain Collectives LLP, R21 Second floor, Hauz Khas, Delhi.
Trichoderma Coir Pith Cake.	29-09-2021	5000	ICAR-KVK, Kanhirangad (PO), Taliparamba, Kannur
Preservation protocol for trimmed tender coconut	25-10-2021	15000	Mr. Shajil K.M., C/o Lifeleaf, Sithara complex, 2nd Floor, 4/4361, P.T. Usha Road, Calicut.
Virgin coconut oil	12-11-2021	40000	Yogananda M.P., M.P. Estate, Gowthampura, Anandapuram hobli, Shimoga, Karnataka.
Virgin coconut oil	01-12-2021	40000	Mr. Shahul Hameed C, Chalil house, Perambra P.O., Calicut
Snowball Tender Nut Machine	10-12-2021	2500	M/s. Easy Tender, Vattapparamba, Chaliyam P.O., Kozhikode
Virgin coconut oil	17-12-2021	40000	Miss. Chrysolite, M/s NIVAH, 3/432-A, Near Tekke Kanattu, Makkada Post, Badirur, Kozhikode.
Linear actuator based tender coconut cutting machine	21-12-2021	10000	M/s Stonehat Technologies, No.62C-1, Siruvani Main Road (East), Vadavalli, Coimbatore
Continuous coconut testa removing machine	21-12-2021	10000	

ATIC Sales

Sl. No.	Item	Quantity	Amount (in Rupees)
1	Coconut seedlings-Hybrids	17863 Nos.	4465750
2	Coconut seedlings- Tall varieties	20922 Nos.	2301420
3	Coconut seedlings- Dwarf varieties	2407 Nos.	505470
4	Poly bag coconut seedlings	453 Nos.	101140
5	Coconut leaf vermicompost	2975 kg	53353
6	Earth worms	35720 Nos.	25718
7	Vermi wash	1 litre	100
8	Extension publications	8 Nos.	505
9	Trichoderma	14Kg	1400
10	Kera Probio	40 pkts (250 g)	1000
11	Trichoderma coir pith cake	550 nos	2750
12	Entomopathogenic Nematodes	999 units	18449
13	Arecanut seedlings	169994	1043300
14	Areca Seednuts	641676	11462725
15	Coconut	58958	5699700
16	Cocoa pods	17857	66180
17	Cocoa seedlings	32084	748400
18	Black pepper rooted cuttings	4118	71250
19	Bey leaf rooted layers	1781	53430
20	Acid lime rooted cuttings	53	1060
	Cinnamon	186	5580
		TOTAL	**10524882**

17. PERSONNEL

SCIENTIFIC STAFF

Sl. No.	Name	Designation
KASARAGOD		
1.	Dr. (Mrs.) Anitha Karun	Director (Acting) & I/c PC (Palms)
2.	Dr. H.P. Maheswarappa	Project Coordinator (Palms) (Acting) (On deputation to UAHS, Bagalkot)
3.	Dr. Ravi Bhat	HoD (Crop Production) (Acting) (SIC, AICRP (Palms)
4.	Dr. K.B. Hebbar	HoD (PB & PHT) (Acting)
5.	Dr. Vinayaka Hegde	HoD (Crop Protection) (Acting)
6.	Dr. K. Muralidharan	HoD, (Social Science)(Acting)
7.	Dr. C. Thamban	Principal Scientist (Agril. Extension)
8.	Dr. (Mrs.) Alka Gupta	Principal Scientist (Agril. Microbiology)
9.	Dr. Murali Gopal	Principal Scientist (Agril. Microbiology)
10.	Dr. (Mrs.) V. Niral	Principal Scientist (Genetics)
11.	Dr. P. Subramanian	Principal Scientist (Agronomy)
12.	Dr. A.C. Mathew	Principal Scientist (Soil & Water Conservation Engg.)
13.	Dr. K. Samsudeen	Principal Scientist (Economic Botany)
14.	Dr. M.K. Rajesh	Principal Scientist (Agril. Biotechnology)
15.	Dr. M.R. Manikantan	Principal Scientist (Agril. Structure & Process Engg.)
16.	Dr. K.P. Chandran	Principal Scientist (Agril. Statistics)
17.	Dr. S. Jayasekhar	Senior Scientist (Agril. Economics)
18.	Dr. R. Sudha	Senior Scientist (Fruit Science)
19.	Dr. Selvamani V.	Senior Scientist (Soil Science)
20.	Dr. S. Paulraj	Senior Scientist (Agril. Microbiology)
21.	Dr. (Mrs.) Neenu S.	Senior Scientist (Soil Science)
22.	Dr. (Mrs.) Pratibha P.S.	Scientist (Agril. Entomology)
23.	Dr. Rajkumar	Scientist (Nematology)
24.	Dr. (Mrs.) V.H. Prathibha	Scientist (Plant Pathology)
25.	Mrs. Surekha	Scientist (Agronomy)
26.	Dr. (Mrs.) M. Sujithra	Scientist (Agril. Entomology)
27.	Dr. (Mrs.) Neema M.	Scientist (SPM & AP)
28.	Dr. (Mrs.) Daliyamol	Scientist (Plant Pathology)
29.	Dr. (Mrs.) Sumitha S.	Scientist (SPM & AP)
30.	Mrs. Aparna Veluru	Scientist (SPM & AP)
31.	Dr. (Mrs.) Shameena Beegum P.P.	Scientist (SPM & AP)
32.	Dr. (Mrs.) G. Panjavarnam	Scientist (Fruit Science)

33.	Dr. (Mrs.) Jilu V. Sajan	Scientist (Agril. Entomology)
34.	Dr. R. Pandiselvam	Scientist (Agril. Structure & Process Engg.)
35.	Mrs. Ranjini T.N.	Scientist (SPM & AP)
36.	Dr. Ramesh S.V.	Scientist (Agril. Biotechnology)
37.	Mrs. Bandela Sravanthi	Scientist (SPM & AP)
KVK, CPCRI, KASARAGOD		
38.	Dr. Manojkumar T.S.	Principal Scientist & Head, KVK
KAYAMKULAM		
39.	Dr. (Mrs.) S. Kalavathy	Head (Acting) (Ag. Extension)
40.	Dr. (Mrs.) Chandrika Mohan	Principal Scientist (Ag. Entomology)(up to 01.10.2021)
41.	Dr. (Mrs.). P. Anithakumari	Principal Scientist (Ag. Extension)
42.	Dr. Regi Jacob Thomas	Principal Scientist (Hort.)
43.	Dr. A. Abdul Haris	Principal Scientist (Agronomy)
44.	Dr. Joseph Rajkumar A.	Principal Scientist (Ag. Entomology)
45.	Dr. (Mrs.) Nihad K.	Senior Scientist (Hort.)
46.	Dr. (Mrs.) Shareefa M.	Senior Scientist (Hort.)
47.	Dr. (Mrs.) Merin Babu	Senior Scientist (Plant Pathology)
48.	Dr. (Mrs.) Jeena Mathew	Senior Scientist (Soil Science)
49.	Dr. (Mrs.) Indhuja S.	Scientist (Agril. Microbiology)
50.	Dr. Anes K.M.	Scientist (Agril. Nematology)
KVK, CPCRI, RS, Kayamkulam		
51.	Dr. Muralidharan P.	Principal Scientist & Head, KVK
Vittal		
52.	Dr. C.T. Jose	Head (Acting) (Agril. Stat.)
53.	Dr. S. Elain Apshara	Principal Scientist (Hort-Fruit Science)
54.	Dr. N.R. Nagaraja	Scientist (Plant Breeding)
55.	Dr. Chaithra M.	Scientist (Plant Pathology)
56.	Dr. (Mrs.) Priya U.K.	Scientist (Soil Science)
57.	Sri Bhavishya	Scientist (SPM & AP)
58.	Dr. Shivaji Hausrao Thube	Scientist (Agril. Entomology)
59.	Mrs. Suchithra M.	Scientist (SPM & AP)
60.	Mrs. Saneera E.K.	Scientist (Agril. Entomology)
61.	Dr. Thava Prakasa Pandian R.	Scientist (Plant Pathology)
Kidu		
62.	Sri Diwakar Y.	Scientist (SPM & AP)
63.	Dr. Khadke Ganesh Navanath	Scientist (SPM & AP)
Mohitnagar		
64.	Dr. Arunkumar Sit	Principal Scientist (Hort.)
65.	Dr. Sandip Shil	Scientist (Agril. Stat.)
Kahikuchi		
66.	Dr. (Mrs.) Alpana Das	Senior Scientist (Agril. Biotechnology)
67.	Dr. Anok Uchoi	Scientist (SPM & AP)
68.	Dr. Leichombam Singhajit Singh	Scientist (SPM & AP)

TECHNICAL STAFF

Sl. No.	Name	Designation
1.	Sri H. Muralikrishna	Chief Technical Officer (Tech. Info.)
2.	Smt. K. Shobha	Chief Technical Officer (Library)
3.	Smt. Sugatha Padmanabhan	Assistant Chief Technical Officer
4.	Sri P. Ravindran	Assistant Chief Technical Officer
5.	Smt. K. Sreelatha	Assistant Chief Technical Officer (Hindi) (up to 31.10.2021)
6.	Sri K. Shyama Prasad	Assistant Chief Technical Officer (Field / Farm)
7.	Sri G.S. Hareesh	Technical Officer (Instrumentation Engineering)
8.	Sri M.P. Rajendran Nair	Technical Officer (Mechanical Engineering) (up to 30.06.2021)
9.	Sri K. Ajith Kumar	Technical Officer (Civil Engineering)
10.	Sri K.N. Radhakrishnan Nambiar	Technical Officer
11.	Sri V.K. Gopalakrishnan	Technical Officer (Civil Engineering)
12.	Sri S. Manohara	Technical Officer (Vehicle)
13.	Sri V. Balakrishnan	Technical Officer
14.	Sri K. Krishnan Nair	Technical Officer
15.	Sri K.N. Pankajakshan	Senior Technical Assistant (Vehicle)(up to 31.07.2021)
16.	Sri A.K. Ramadas	Senior Technical Assistant (Vehicle)
17.	Sri M.V. Sreedharan	Technical Officer
18.	Sri Devaraj K.	Senior Technical Assistant (Junior Engineer)
19.	Dr. Muralikrishna K.S.	Senior Technical Assistant
20.	Sri K. Raghavan	Senior Technical Assistant
21.	Sri K. Panduranga	Technical Assistant
22.	Sri A.V. Satheesh Kumar	Technical Assistant (Vehicle)
23.	Sri Bhavani Sankar Naik	Technical Assistant
24.	Sri V. Radhakrishnan	Senior Technician
25.	Sri A.O. Varghese	Senior Technician
26.	Sri A. Divakaran	Senior Technician
27.	Sri K.J. Sebastian	Senior Technician
28.	Sri Sunil S.	Senior Technician (Electrical Engineering)
29.	Smt. M. Vimala	Senior Technician
30.	Sri N. Dinesh Kumar	Senior Technician
31.	Sri A.R. Padmanabha Naik	Senior Technician
32.	Sri Arunji G.	Technical Assistant (Library)
33.	Mrs. Ashamol E.P.	Technician (Field/Farm)
34.	Sri Suvith P.S.	Technician (Field/Farm)
35.	Sri Ajith Kumar R.	Technician (Field/Farm)
36.	Sri Premjith Antony	Technician (Field/Farm)
37.	Sri K. Sukumaran	Technician
38.	Sri M. Krishnan	Technician

39.	Smt. U. Sarojini	Technician
40.	Smt. V. A. Leela	Technician
41.	Smt. Chithralekha Kodoth	Technician
42.	Sri B. Sundara	Technician
43.	Sri B. Chandrahasa	Technician
44.	Sri V.T. Rameshan	Technician
KVK, Kasaragod		
45.	Dr. (Mrs.) Saritha Hegde	Chief Technical Officer (SMS-Home Science)
46.	Dr. (Mrs.) Neelofar Illias Kutty	Chief Technical Officer (Programme Assistant) (Home Science)
47.	Mrs. Jayasree M. P.	Assistant Chief Technical Officer (SMS - Agrl. Extn.)
48.	Sri K. Manikandan	Senior Technical Officer (Programme Assistant) (Agronomy)
49.	Sri Lagesh K.P.	Technician (Vehicle)
Kayamkulam		
50.	Dr. C. Keshavan Nampoothiri	Chief Technical Officer (Statistics)(up to 31.07.2021)
51.	Dr. G. Rajeev	Asst. Chief Technical Officer
52.	Dr. C.G. Narayanan Namboothiri	Asst. Chief Technical Officer
53.	Sri K.K. Sudhanandan	Asst. Chief Technical Officer
54.	Dr. Mayalekshmi	Senior Technical Assistant (w.e.f. 03.05.2021)
55.	Sri K. Rajendran	Technical Officer
56.	Sri B. Anilkumar	Senior Technical Officer
57.	Sri K.P. Udayabhanu	Technical Officer
58.	Sri Sunny Thomas	Technical Officer
59.	Sri Jinu Sivadasan	Senior Technical Assistant
60.	Sri V.P. Joy	Senior Technical Assistant
61.	Mrs. Asha K. Chandran	Technical Assistant (Field/Farm)
KVK, Kayamkulam		
62.	Sri M. S. Rajeev	Chief Technical Officer (SMS-Agronomy)
63.	Smt. Jissy George	Chief Technical Officer (SMS- Home Science)
64.	Smt. Lekha G.	Chief Technical Officer (SMS-Plant Pathology)
65.	Dr. T. Sivakumar	Assistant Chief Technical Officer (SMS- Agricultural Entomology)
66.	Dr. S. Ravi	Assistant Chief Technical Officer (SMS- Animal Husbandry)
67.	Sri Sajnanath K.	Assistant Chief Technical Officer (SMS-Soil Science)
68.	Sri Ansary K.M.	Senior Technical Assistant (Computer)
69.	Smt. Bijila P.V.	Senior Technical Assistant (Horticulture)
70.	Sri Dayanandan Unnithan	Senior Technical Assistant (Vehicle)
71.	Sri Sajin B.J.	Technician (Vehicle)
Vittal		
72.	Smt. Meenakshi Patil	Assistant Chief Technical Officer (Library)
73.	Sri C. Purandhara	Technical Officer
74.	Sri Adolphus Francis Mascarenhas	Technical Officer (Electrician) (up to 31.10.2021)
75.	Sri Abdul Aziz	Technical Officer

76.	Sri V. Chandrasekhara Shetty	Senior Technical Assistant (Vehicle)
77.	Sri Prakash Burman	Senior Technician
78.	Sri Santhosh Kumar P.	Senior Technical Assistant
79.	Sri Tharanatha Naik B.	Technical Assistant (Vehicle)
80.	Sri Bisun Bhaskar	Technical Assistant (Laboratory)
81.	Sri Nirmal Kumar B.J.	Technical Assistant (Field/Farm)
82.	Sri Vinod K.	Technician
Kidu		
83.	Sri M. Manamohan	Technical Officer (Mechanical Engineering)
84.	Sri A.S. Gopalakrishna	Technical Officer
85.	Sri M. Narayana Naika	Technical Officer
86.	Sri Kamal Kumar V.	Technical Assistant (Field/Farm)
87.	Sri Anoop Kumar P.P.	Technical Assistant (Field/Farm)
88.	Sri V. Chennappa	Technician
Mohitnagar		
89.	Sri Avrajyothi Ghosh	Assistant Chief Technical Officer
90.	Sri Jagadish Roy Burman	Senior Technical Assistant (Vehicle)
91.	Sri Pratap Kumar Sarkar	Senior Technical Assistant
92.	Sri Jagadish Roy	Senior Technical Assistant (Vehicle)
Kahikuchi		
93.	Dr. Bikash Chowdhury	Chief Technical Officer
94.	Sri Gopinath Malakar	Senior Technical Assistant (Vehicle)

ADMINISTRATIVE STAFF

Sl. No.	Name	Designation
KASARAGOD		
1.	Sri Hareesh Nair G.S.	Chief Administrative Officer
2.	Sri Ram Avtar Parashar	Senior Finance and Accounts Officer (up to 28.09.2021)
3.	Smt. Jessymol Antony	Finance and Accounts Officer (w.e.f. 06.11.2021)
4.	Sri T.E. Janardhanan	Administrative Officer (up to 23.10.2021)
5.	Smt. Jenny C.M.	Administrative Officer (w.e.f. 15.11.2021)
6.	Sri P. Krishna Kumar	Administrative Officer (w.e.f. 30.12.2021)
7.	Sri K.R. Nithianandan	Assistant Administrative Officer
8.	Sri Pradeep Kumar Vasu	Assistant Administrative Officer
9.	Smt. M. Reetha	Assistant Administrative Officer
10.	Sri A. Neil Vincer	Assistant Administrative Officer
11.	Smt. K. Narayani	Private Secretary
12.	Smt. Girija Chandran	Private Secretary
13.	Smt. Sulochana Nair	Private Secretary

14.	Sri K. Kunhiraman Nair	Private Secretary
15.	Sri T.N. Vidhyadharan	Assistant
16.	Smt. K.S. Vishalakshi	Assistant (up to 31.07.2021)
17.	Sri P.M. Thomas	Assistant
18.	Smt. K.T.K. Sheenakumari	Assistant
19.	Sri P. Narayana Naik	Assistant
20.	Smt. Rupa Manikandan	Assistant
21.	Smt. Jayashree K.	Assistant
22.	Smt. K. Preethi	Assistant
23.	Sri Paulson Sam George	Assistant
24.	Sri T.K. Gangadharan	Upper Division Clerk
25.	Smt. Remya T.R.	Upper Division Clerk (up to 30.09.2021)
26.	Sri Aswin Reghunath	Upper Division Clerk
27.	Sri. N. Udayakumar	Upper Division Clerk
28.	Smt. A.J. Mary	Upper Division Clerk
29.	Smt. Arathi A.R.	Stenographer Gr.III
30.	Sri P.K. Pramodkumar	Lower Division Clerk
31.	Sri Jayarajan V.	Lower Division Clerk
32.	Sri Dinesh	Lower Division Clerk
33.	Sri Ratan Singh	Lower Division Clerk
34.	Sri Satyabrata Moharana	Lower Division Clerk
35.	Sri K.P. Ibrahim	Lower Division Clerk (w.e.f. 10.03.2021)
Kayamkulam		
1.	Sri Babu Raj S.B.	Assistant Finance and Accounts Officer
2.	Sri K.G. Bhageerath	Assistant Administrative Officer
3.	Sri K. Haridas	Assistant
4.	Sri K. Venugopal	Assistant
5.	Smt. K. Sreelatha	Assistant
6.	Smt. V. Madhavikutty	Assistant
7.	Sri C. Ramesh Babu	Personal Assistant (up to 31.07.2021)
8.	Smt. Prasanna Sarngan	Personal Assistant
9.	Smt. Deepa T.	Upper Division Clerk
10.	Sri Arun N.K. Raj	Lower Division Clerk
11.	Sri K.N. Sajeev	Lower Division Clerk
12.	Sri C.R. Babu	Lower Division Clerk
KVK, Kayamkulam		
13.	Smt. Rejitha K.R.	Personal Assistant
Vittal		
14.	Sri P. Krishna Naik	Assistant Administrative Officer
15.	Sri Sasi K.K.	Assistant Finance and Accounts Officer
16.	Sri Mohammed Haneefa P.K.	Upper Division Clerk
17.	Sri T.J. Saji	Upper Division Clerk

18.	Sri Vivek Singh	Stenographer Gr. III
19.	Sri Fawaz C.M.O.	Lower Division Clerk
20.	Sri Choma	Lower Division Clerk
21.	Sri Chandu	Lower Division Clerk
Kidu		
22.	Sri M. Ravindran	Assistant Administrative Officer
23.	Sri Lakshmi Narayana	Lower Division Clerk
24.	Sri Durgesha M.	Lower Division Clerk
Mohitnagar		
25.	Sri Subash Paul	Assistant
Kahikuchi		
26.	Sri Deepak Meena	Lower Division Clerk
27.	Sri Umesh Kumar	Lower Division Clerk

SKILLED SUPPORT STAFF

Sl. No.	Name
KASARAGOD	
1.	Sri M. Shankara
2.	Smt. K. Baby (up to 31.07.2021)
3.	Sri A. Mohana
4.	Sri P.A. Chaniya Naik
5.	Sri P. Kumaran (up to 31.05.2021)
6.	Sri V.S. Pakeeran
7.	Smt. V. Thambai
8.	Smt. G. Kamala
9.	Sri K.G. Sureshbabu
10.	Sri T.J. Ninan
11.	Smt. K. Shobhana
12.	Sri V. Krishnankutty
13.	Sri P.P. Prabhakaran
14.	Sri B. Ramachandran
15.	Sri B. Sanjeeva Patali
16.	Smt. N.V. Sasikala
17.	Sri Lakshmana Naik
18.	Smt. Lalitha Bai
19.	Sri M. Velayudhan
20.	Sri N. Bhaskaran
21.	Sri K. Sureshan
22.	Sri A. Madhu
23.	Sri K.A. Madhavan
24.	Sri Aneesh E.M.
25.	Smt. Vanamalini
26.	Sri Sarath Kumar
27.	Sri Ashok Kumar R.
28.	Sri Praveen Raj P.R.
29.	Sri Jayaprakash K. (Canteen)
30.	Smt. Rohini N. (w.e.f. 21.09.2021)
Kayamkulam	
31.	Sri M.E. Sivan
32.	Sri K.B. Thankachan (up to 31.05.2021)
33.	Sri R. Ravindran
34.	Sri K. Soman
35.	Sri K. Omanakuttan
36.	Sri V.T. Unnikrishnan
37.	Sri T.K. Mani (up to 31.01.2021)
38.	Sri K. Ravi
39.	Sri K.K. Sreedharan (up to 31.07.2021)
40.	Sri C. Sukumaran
41.	Sri K.V. Vijayan (up to 31.09.2021)
42.	Smt. K. Valsala
43.	Sri C. Sundaran
44.	Smt. N. Suma
45.	Sri A.T. Harikuttan
46.	Smt. K. Saseendra (up to 01.10.2021)
47.	Sri Ajith Mattappadan
48.	Sri R. Rajesh
49.	Smt. L. Leena
50.	Sri Ancil Pereira (up to 20.07.2021)
51.	Sri S. Rajesh
52.	Sri N. Reghu (up to 31.05.2021)
53.	Smt. Arathy R. Pillai (w.e.f. 25.06.2021)
Vittal	
54.	Sri Harish Chandra
55.	Sri Sudhakara
56.	Sri A. Gopala
57.	Sri D. Isubu
58.	Sri B. Dharmapala
59.	Sri Ibrahim
60.	Sri Mohana
61.	Sri Somappa K.
62.	Sri M. Ananda
Kidu	
63.	Sri S. Chennappa
64.	Smt. N. Bhavani
65.	Sri S. Janardhana (up to 31.05.2021)
66.	Sri Dasappa Gowda
67.	Smt. T. Susheela
68.	Sri Padmayya Gowda
69.	Smt. B. Bhavani
70.	Smt. S. Rukmini
71.	Sri S. Bhojappa
72.	Smt. Komalangi
73.	Sri V. Jathappa Gowda
74.	Sri S. Sheenappa Gowda
75.	Sri S. Neelappa
76.	Sri S. Regappa
77.	Smt. S. Chandravathi
78.	Smt. Meenakshi K.
Mohitangar	
79.	Sri Sailen Seal
80.	Sri Krishna Kumar Mandal
81.	Sri Nripendra Chandra Roy
82.	Sri Kartick Chandra Biswas
83.	Sri Sushanta Burman
84.	Sri Mahadev Misra
Kahikuchi	
85.	Sri Sathish Baishya
86.	Sri Pankaj Das
87.	Sri Tanka Bahadur Thapa

XVIII. Distinguished Visitors

Due to Covid-19 protocols, there were restrictios during the period for conducting public functions.

Sri K. Somaprasad, MP (Rajya Sabha) visited Agro-Processing Training cum Incubation Centre (APTIC) of KVK - Alappuzha on 28 June 2021.

Shri P. Prasad, Hon'ble Minister for Agriculture Development and Farmers Welfare, Govt. of Kerala, Adv. A.M. Arif, Hon'ble M.P., Alappuzha and Adv. U. Prathibha, Hon'ble MLA, Kayamkulam, visited ICAR-CPCRI, Regional Station, Kayamkulam on 18 November 2021 and interacted with the scientists.

Sl. No.	Visitors	Dates
1	Sri P. Balachandran, Chief General Manager, NABARD, Kerala	24.03.21
2	Sri K.K. Somaprasad, Hon. MP, Rajya Sabha	28.06.21
3	Sri P. Prasad, Hon. Minister of Agriculture, Govt. of Kerala	18.11.21
4	Adv. A. M. Arif, Hon. M P, Alappuzha	18.11.21
5	Adv.U. Prathibha, Hon.MLA, Kayamkulam	18.11.21

XIX. Mera Gaon – Mera Gaurav Programme

Mera Gaon Mera Gaurav: Scientists from all ICAR-CPCRI units regularly visited the selected villages under MGMG and provided advisories on crop production and protection. Specific programmes conducted are:

Kasaragod: Training programme on 'Quality Planting Material Production in Coconut with Special Emphasis on Local Ecotypes' (2-3 Dec 2021), and 'Cultivation of fruits and vegetables in coconut ecosystem' (8 Dec 2021), and distribution of vegetable seeds

Kayamkulam: 'Participatory rejuvenation of coconut homesteads in Bharanikavau, Chunakara and Vallikunnam villages as part of Kera Nanmaprogramme in which 270 mother palms identified and 6000 coconut seedlings were produced; palm health management in Velanchiraon, distribution of soil health cards, interface programme on safe and approved use of insecticides, and distribution of vegetable seeds

Mohitnagar: Activities conducted in three villages viz., Pradhanpara, Southmatiali and Kudipara

Kahikuchi: World Soil Day was celebrated on the 5 December, 2021 in which 23 farmers from two villages attended and Farmers' meet was organised on 14 December 2021.

XX. Swachh Bharat Abhiyan

As a part of Mahatma Gandhi Jayanti there was Swachhata Pledge taking and cleanliness drive activities carried out by the staff of ICAR-CPCRI at headquarters, Regional Stations and Research Centres.
Special Swachhta Campaignorganized by the ICAR-KVK, Alappuzha on 6 October, 2021 in association with Departmentof Agricultural Development andFarmers' Welfare at Puliyur gramapanchayath. Another outreach campaign on 'Fortification of farmresidue and pest management in coconut' was conducted fordairy farmers of Vallikunam panchayat, Alappuza, sensitizingon the potential use of the greenmuscardine fungus, Metarhiziummajus in the management ofcoconut rhinoceros beetle on 12 October 2021 at ICAR-CPCRI, RS,Kayamkulam.
The Swachtha Pakhwada 2021 was celebrated at ICAR-CPCRI, RS Kayamkulam during 16-31 December 2021 involving sanitation drive within campus and the premisesof RVVLP School, Krishnapuram. Asession on organic waste recyclingthrough effective microbes washandled by Dr. N. Chithra, AssistantProfessor, College of Agriculture,Vellayani, during valedictory sessionconducted on 31 December 2021.

XXI. Women's Welfare Committee Activities

The Women's Welfare Committee being chaired by Dr. V. Niral, Principal Scientist convened quarterly meetings of the members to discuss activities for the welfare of women staff of the institute. Two farewell functions were arranged for three of the colleagues on the occasion of their superannuation from ICAR service: Mrs. K. Baby, Skilled Support Staff and Smt. K.S. Vishalakshi, Assistant, retired on 31 July 2021 and Smt. K. Sreelatha, ACTO retired on 31 October 2021.

International Women's Day: It was celebrated at ICAR-CPCRI, Kasaragod on the 8 March 2021 with the theme 'Women leadership in Agriculture: Entrepreneurship, equity and empowerment'. Dr. Anitha Karun, Director presided over the function. Dr. Ashwini Krishna Moorty, Zooligist and an organic farmer-cum-agri-entrepreneur was the chief guest. On the occasion two women entrepreneurs were felicitated viz., Dr. Ashwini Krishna Murthy of VAST Centre, Adyanadka, Dakshina Kannada, Karnataka for her contributions in the field of organic inputs for organic farming and Mrs. G. Gomathi of Gagni Foods, Erode, Tamil Nadu for contribution in the area of value addition in coconut. Other programmes conducted on the day include quiz competition for students, training on 'indigenous food sources for good health and boosting immunity' conducted by Dr. Saritha Hegde, SMS, KVK, Kasaragod.

At ICAR-CPCRI, RS, Vittal, a woman entrepreneur Mrs. Reshma Rajaram, MD and co-owner of Eco-Blizz, successful industry making areca sheath products and exporting was felicitated. Another small entrepreneur Mrs. Sasikala Rajkumar, Vittal who purchased areca plate making machine from Eco-Blizz and started her own unit at home level was also felicitated.

Areca Leaf Sheath Products

At KVK Alapuzha, the day was observed on with different programmes in association with ICAR-CPCRI, RS, Kayamkulam. About 30 women delegate farmers participated, followed by honoring of five women farmers, for their remarkable entrepreneurship, achievements and leadership in the field of Agriculture and allied sectors. Adv. A.K. Rajasree, Coordinator, Human Rights Law Network, Alappuzha delivered the keynote address.

XXII. Major Events and Other Information

World Water Day: Itwas observed in the Institute along with Krishi Vigyan Kendra, Kasaragod on 22nd March 2021. An online workshop, Kisan Ghoshti (on campus) and demonstration (on campus) of water conservation and low cost water harvesting structures developed by the institute for farmers were demonstrated. Dr. Anitha Karun, Director presided over the function. Dr. P. Subramanian, Principal Scientist gave a lecture on the theme topic. Mrs. R. Veena Rani, Principal Agricultural officer, Kasaragod, Dr. Manoj Kumar T.S, ProgrammeCordinator, KVK, Kasaragod and Sri. Ashok Kumar, District Soil Conservation Officer, Kasaragod were the other resource persons. Two progressive farmers, Sri. Chandrasekhara Yethadka and Sri. Radhakrishnan Polakada shared their experience of in implementing water conservation and water harvesting measures in their farm. An essay competition was conducted for high school Students.

In commemoration of the World Water Day celebration an interactive online workshop was organized at RS, Kayamkulam. Dr. S. Kalavathi, Head, RS, welcomed the participants and the webinar was inaugurated by Dr. Manoj P. Samuel, Executive Director, KSCSTE-CWRDM, Kozhikode. A quiz competition was conducted for the staff members.

Shri John D'Souza, Asst.Professor, Govt.College, Vittal talked on the value of water as part of world water day celebration at CPCRI RS Vittal. Micro irrigation trainees arranged exhibits and demonstrated different efficient irrigation systems to conserve water.

Republic Day: Officials and staffs of ICAR-CPCRI HQ, Research Stations, Research centres and KVKs celebrated 72th Republic day on 26January, 2021.

National Science Day: It was celebrated at ICAR-CPCRI, Kasaragod with anonline lecture by Dr. Rajendra, P, Director of Research, Central University of Kerala, Kasaragod on the theme area "Future of STI: Impacts on Education, Skill and Work". Essay writing competition, quiz and extempore speech competition were conducted for the school students and staff members of CPCRI.

As part of the National Science Day celebrations 2021, a Virtual Interactive Workshop on the theme: 'Science, Technology and Innovation for the Empowerment of Students' was conducted from ICAR-CPCRI, Regional Station, Kayamkulam on 1st March 2021. The keynote address for the session was delivered by Dr. G. Byju, Principal Scientist, ICAR-CTCRI.

World Bee Day: It was was celebrated on 20 May 2021as part of "Bharat Ka Amrut Mahotsav" with a webinar on "Importance and rearing techniques of honey bees" and a quiz contest for students was organised by KVK, Alappuzha.

Anti Terrorism Day: It was observed on 21 May 2021 by taking the 'Anti-Terrorism Pledge' by all staff member of ICAR-CPCRI at Headquarters and other units. Dr. Anitha Karun, Director read the pledge in English and Dr. Alka Gupta, Principal Scientist read the pledge in Hindi.

World Milk Day was observed at ICAR KVK Kasaragod: Two programmes conducted on 1 June 2021 - a Webinar on "Milk and Milk products in Human Nutrition and Rural income" and an Orientation Programme on "Milk as a Complete Food".

At KVK, Alappuzha World Milk Day was celebrated with an online training programme on 'Dairy farming as economic enterprise'.

World Environment Day: A Virtual Interactive Workshop on the theme: 'Ecosystem restoration' was conducted at ICAR-CPCRI, Regional Station, Kayamkulam on 7 June 2021. A special lecture on 'Restore ecosystem to save our planet' was delivered by Prof. D. Thankamony, Former Head, Environmental Engineering Division, College of Engineering, Thiruvananthapuram. Elocution competition for students and fruit tree planting campaign were conducted.

International Day of Yoga: The 7th International Yoga Day was celebrated on 21 June 2022 with an online demonstration by Smt. K. Sreelatha, ACTO (Hindi), with the support from Shri Narayana Naik (Assistant). Dr. Anitha Karun, Director inaugurated the programme. The event was attended by all staff members of ICAR-CPCRI and ICAR-DCR, Puttur, Karnataka.

Director and staff performing Yoga excercises as a part of the International Yoga Day

ICAR Foundation Day was celebrated on 16 July 2021 by planting fruit trees in the KVK farm on 16 July 2021.

World Coconut Day: It was celebrated at Kasargtod and Kayamkulam on 2 September 2021. At Kayamkulam, a farmer seminar on 'Coconut for Healthy life' was conducted.

Mahatma Gandhi Jayanti: To commemorate the 152nd birth anniversary of the Father of Nation-Mahatma Gandhi, and 117th birth anniversary of former Prime Minister, Lal Bahadur Shastri, various programmes were conducted at headquarters and other units.

Mahila Kisan Diwas was celebrated at ICAR-CPCRI, Kasaragod on 15 October 2021. A seminar on Bank Micro Credits for Women empowerment was organised in virtual mode with ICAR-KVK, Kasaragod. Dr. Anitha Karun, Director, ICAR-CPCRI presided over the function. Smt. Divya, DDM, NABARD delivered the keynote lecture.
ICAR-KVK, Alappuzha celebrated Mahila Kisan Diwas in collaboration with Santhwanam Cultural and Charitable Trust, Krishnapuram. Krishnapuram Grama Panchayath President, Mr. Shani Kurumpolil inaugurated the programme by handing over vegetable seed kits to progressive woman farmers.

World Food Day was celebrated at ICAR-CPCRI on 16 October 2021. A seminar on Plantation Crops Enterprises for Doubling Farmers' Income was organised in virtual mode and Dr. R. T. Patil, Former Director, ICAR-CIPHET, Ludhiana delivered a lecture.

A webinar was organized by KVK, Kasaragod in which the lead talk was given by renowned Kannada journalist and social activist Shree Padre. Dr. Anitha Karun, Director inaugurated.

At KVK, Alappuzha, orientation programme on "Prospects of value addition of homestead fruits" was conducted.

Vigilance Awareness Week: Inaugural function of the Vigilance Awareness week at ICAR-CPCRI Kasaragod was held on 26 October 2021 under the chairmanship of Dr. Anitha Karun, Director. Dr. Niral V, Vigilance Officer briefed about the activities. Director administered the Integrity Pledge. A quiz programme on the theme was also conducted for the employees of the Institute.

Two 'Grama sabha' programme were organized as part of the vigilance awareness week of 2021 on 2 November 2021 at MogralPuttur Gram panchayath.

Participants attending vigilance awareness 'Gram Sabaha'

Daily wage workers attending vigilance awareness programme

The valedictory function of the Vigilance Awareness Week was held on 2 November 2021 with Mr. K. V. Venugopal, DySP (Vigilance &Anti Corruption Bureau), Kasaragod as the Chief Guest.

At ICAR-CPCRI, Regional Station Kayamkulam the inaugural session commenced with taking integrity pledge by Staff members of the Station. A sensitization workshop 'Awareness Gram Sabha' was also organized for dissemination of awareness in Grama Panchayat. A

lecture on 'Preventive Vigilance' was delivered by Dr. A. Josephrajkumar, Principal Scientist.

Rashtriya Ekta Diwas: To commemorate the 146th birth anniversary of India's iron man Sardar Vallabhbhai Patel, ICAR-CPCRI Kasaragod organized different events on 31 October 2022 as National Unity Day. The programme started with Rangoli competition for the staff members at CPCRI Beach. Celebrations were also held at Regional stations.

Constitution Day: Constitution Day was celebrated at ICAR-CPCRI, Kasaragod on 26 November 2021. Dr. Anitha Karun, Director, CPCRI read the Preamble of the Constitution followed by the staff.

World Soil Day: It was celebrated on 5 December 2021 at Head quarters and other unts. A webinar on the theme 'Halt soil salinization and boost soil productivity' was organised by KVK, Kasaragod. Training programme on 'Soil health management in Palms and Cocoa' was organized at ICAR-CPCRI Regional Station, Vittal. An interactive workshop on 'Halt soil salinisation-boost soil productivity' was conducted at ICAR-CPCRI, RS, Kayamkulam: The keynote address was delivered by Dr. Thomas Mathew, Professor and Head (Retd.), Kerala Agricultural University on the topic 'Management of soil productivity with special emphasis on problem soils'; Dr. S. Kalavathi, Head, RS inaugurated.

Participants attending 'World Soil Day' programme at Vittal

Live streaming of Hon'ble Prime Minister's address during the valedictory function of Pre Vibrant Gujarat summit was arranged at the Institute on 16 December 2021.

National Farmers Day marking the birth anniversary of the fifth Prime Minister of independent India, Sri ChoudhariCharan Singh, was celebrated as awareness cum interactive online workshop on 23 December 2021 at ICAR-CPCRI, RS, Kayamkulam.

Vaccination Against Covid-19: Vaccination camp was arranged at ICAR-CPCRI, Kasaragod for staff during 4-6 March 2021 and for the second doze during 20-21 June 2021 in collaboration with Community Health Centre, MogralPuttur.

Director inaugurating the vaccination camp

Infrastructure Developed

The Central pollen cryo-preservatory at ICAR-CPCRI, Regional Station, Kayamkulam under the scheme 'Large-scale production of elite and hybrid seedlings of coconut for the root (wilt) disease prevalent tract' funded by Department of Agriculture Development & Farmers Welfare, Government of Kerala with Dr. Regi J. Thomas, Principal Scientist as the Principal Investigator (Rs. 9.75 lakhs).

Azadi Ka Amrut Mahotsav

Azadi Ka Amrit Mahotsav is an initiative of the Government of India to celebrate and commemorate 75 years of India's independence. To commemorate the occasion, ICAR-CPCRI is organizing several events including mass awareness campaigns, lectures, documentations etc. from 16 July 2021 (the foundation day of ICAR) onwards. Through these programmes it is aimed to bring awareness on achievements of the Institute in production and value addition of coconut, arecanut and cocoa with an objective to enhance the scope of utilization of these technologies.

Details of the programmes organized under AKAM ()

Sl. No.	Programme	Date
General Lecture series - Online		
1.	Health and Nutritional benefits of coconut: Dr. V. Rajagopal, Former Director, ICAR-CPCRI	
2.	Emergence of modern science in India in the era of freedom movement: Dr. K. Muralidharan, HoD (Social Sciences), ICAR-CPCRI	16.08.2021
3.	Nutritional values of coconut and health: Dr. B. Chembakam, Former Head, Division of Crop Production, ICAR-IISR, Kozhikode	2.09.2021
4.	Body and Mind Management for Peaceful life: Dr. Manivel, Principal Scientist & Head i/c, ICAR-CTRI Research Station, Vedasandur, Tamil Nadu.	16.90.2021
5.	Millets and coconut-based products for health and immunity: Dr. Shameena Beegum, Scientist, ICAR-CPCRI	17.09.2021
6.	Transforming to Organic Agriculture System: Production, Certification and Trade: Dr. Krishnakumar, Former Head, ICAR-CPCRI Regional Station, Kayamkulam	17.09.2021 2.10.2021
7.	Health and hygiene: Dr. B. Padmakumar, Head, Internal Medicine, TD Medical College, Alappuzha	
8.	Vermicomposting for healthy food	12.10.2021
9.	Plantation Crops Enterprises for Doubling Farmers' Income: Dr. R. Patil, Former Director, ICAR-CIPHET, Ludhiana.	12.10.2021
10.	Bank Micro Credits for Women empowerment: Mrs. Divya, NABARD	15.10.2021
11.	How to use GeM portal – a paperless office communication: Shri. Vidhyadharan, Assistant, ICAR- CPCRI	22.10.2021
12.	vertical farming-Technology for the future: Dr.C. Aswath, Head, Division of flower and medicinal ccrops, IIHR	12.11.2021
13.	Advances in Bio-Suppression of Coconut Pests: Dr. Joseph Rajkumar, Principal Scientist, ICAR-CPCRI RS, Kayamkulam	22.11.2021
14.	Potential of handicraft industry and institutional support for artists: Shri. M.P. Shaji, Assistant Director, Handicraft Service Centre, Thrissur.	27.11.2021
15.	The role of science in the development of Indian Agriculture: Challenges and the Future: Prof. R. Ramakumar, Professor and Former Dean, School of Development Studies, TATA Institute of Social Sciences, Mumbai.	28.02.2022
16.	Drones for boosting Agricultural Productivity: Mr. Aakash Sinha, Founder and CEO, Omnipresent Robotics Tech.	04.02.2022
17.	Alzheimer's and female brain: Dr. Sheeja Navakkode Gangadharan, Senior Research Fellow, Nanyang Technological University, Singapore	08.03.2022
18.	GIS solutions for Plantation Activities: Mr. Akhil Krishnan, Assistant Business Manager, ESRI India	30.05.2022
General Lecture series		
19.	Curtain raiser programme of International Year of Millets-Importance of Nutri cereals in alleviating Nutritional Imbalances in children: Neelofar illias kutty, programme assistant, ICAR-KVK, Kasaragod	17.09.2021
20.	Millets and coconut based products for health and immunity: Dr. Saritha Hegde, SMS, ICAR-KVK, Kasaragod	17.09.2021
21.	Gender equality Today for a sustainable Tomorrow" # Break the Bias: Smt. Girija Pathekara, renowned Malayalam poet (RS, Kayamkulam)	08.03.2022

Farm Talks series: ICAR- CPCRI, RC, Kahikuchi (Assamese)		
22.	Scientific management practices of Arecanut under North eastern India	5.08.2021
23.	Quality planting material production in arecanut, coconut and cocoa for North East region of India	7.08.2021
24.	Diseases management of coconut and arecanut for NE region	9.08.2021
25.	Scientific cultivation practices of arecanut, important pest and diseases of arecanut and its value addition	11.08. 2021
26.	Arecanut based high density multispecies cropping system and intercropping of horticultural crops	12.08.2021
27.	Importance of arecanut based cropping system available and its feasibility under North east region	13.08. 2021
Farm Talks series: ICAR- CPCRI, RC, Mohitnagar (Bangla)		
28.	Doubling farm income? Adopt Plantation based cropping system	2.08. 2021
29.	Black pepper -most suitable mixed crop with arecanut and coconut for better livelihood	3.08.2021
30.	Coconut-God's Gift for mankind	5.08.2021
31.	Scientific Arecanut cultivation in Hindi	7.08. 2021
32.	Prospect of Cocoa cultivation in plantation-based cropping system	14.08.2021
Farm Talks series:ICAR-CPCRI, RS, Kayamkulam (Malayalam)		
33-53.	Coconut Advisory Series-2021: Coconut Based Sustainable Agriculture The programme consists of 20 lectures on Sustainability in production and farm income from coconut-based cropping system.	16.07.2021 to 2.09.2021
Farm talk series at ICAR-CPCRI Regional Station, Vittal (Kannada)		
54.	Integtared nutrient management in arecanu	15.09. 2021
55.	Integrated disease management in arecanut	15.09.2021
56.	Integrated pest management in arecanut	15.09. 2021
57.	Advances in management of pest and disease in arecanut"	7.10. 2021
58.	White grub management in coconut using EPN technology	20.10.2021
59.	EPN for management of white grub in arecanut"	26.10.2021
60.	Mushroom Cultivation	20.10.2021
61.	Good Cultivation Practices in Arecanut and Arecanut based Multi-Species Cropping System	25.01.2022
62.	Role of farm mechanization in enhancing agricultural production in NE region	17-31.01.2022
63.	Craft of cocoa bean processing and homemade chocolate preparation from Cocoa: An initiative for women empowerment	05.02.2022
64.	Plant health management in arecanut	04.02.2022
65.	Arecanut based multi species cropping system	28.02.2022
66.	Improved varieties and hybrids of arecanut, quality planting material production, recent advances in arecanut production technologies	28.02.2022
67.	Advances in pest management, recent chemicals/bio-control agents for effective pests control	28.02.2022
68.	Important diseases of arecanut, black pepper and their management	28.02.2022
69.	Establishing demonstration plots on arecanut dwarf hybrids, varieta wealth in arecanut and quality planting material production in arecanut	09.03.2022l

70.	Advances in production technology and pest and disease management in arecanut	09.03.2022
Kalpa Green Chat: Lectures for Entrepreneurs		
71.	Technology Driven Business Ventures in Coconut Secor	1.05.2021
72.	Kalparasa/Neera Technology, Policy,Marketing& Value Additioon	22.05.2021
73.	Enhancing 'Ease of doing Agribusiness' through Empowering FPOs	26.05.2021
74.	Coconut Fresh Gratings, Milk & Powder	5.06.2021
75.	Coconut Novel Products for Micro Enterprises	31.07.2021
76.	EDP on Coconut Value Addition- Curtain Raiser	11.09.2021
77.	The Art & Science of Chocolate Making	25.09.2021
78.	Ventures on Coconut Value Added Products: how to arrive at the bottom figures?	6.09.2021
79.	Export Awareness Session for Exporters & IEC Holders under NiryatBandhu SchemeJointly organised with ICAR - CPCRI ABI, FIEO, NMCC, ECGC and DIC Kasaragod	18.09.2021
Kalpa graduate readiness programme: *Lectures for Students*		
80.	Chronicle of plantation crops research & development	6.10. 2021
81.	Production technology in coconut	13.10.2021
82.	Recycling farm waste	16.10.2021
83.	Coconut nursery –an emerging enterprise	20.10.2021
84.	Disease management in coconut	23.10.2021
85.	Pest management in coconut Part 1	27.10.2021
86.	Pest management in coconut Part 2	30.10.2021
87.	Disease management in arecanut and cocoa	3.11.2021
88.	Pest management in arecanut and cocoa	6.11.2021
89.	Organic certification and labeling	10.11.2021
90.	Cocoa Improvement and production technology	17.11.2021
91.	Biofertilizers- Isolation and utilization of bioinoculants	20.11.2021
92.	Soil and water techniques	24.11.2021
93.	Soil health management for sustained coconut productivity	27.11. 2021
94.	Irrigation and fertigation management in plantation crops	1.12.2021
95.	Climate resilience technology in plantation crops	4.12. 2021
96.	Coconut Improvement	8.12. 2021
97.	*In vitro* propagation techniques in coconut arecanut and cocoa	15.12. 2021
98.	Arecanut Improvement and production technology	18.12. 2021
99.	Bioinformatics and molecular aspects of Coconut Arecanut and Cocoa	22.12.2021
100	Post harvest technology in plantation crop	29.12. 2021
Webinars/seminars		
1	Webinar on "Redefining Agricultural Research and Education Priorities – Way Forward"	9.08.2021 – 11.08.2021
2	Webinar on "Nutri cereals and their role on Human health for Adolescent girls (KANYA)"	17.09.2021
3	National Seminar on Advances in Biological Suppression of Pests	22.9.2021

Library and Information Services

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 e-books/online databases
- Online journals/archives
- Open access resources

CPCRI Digital Repository: The institute digital repository utilizing dspace version 4.2, holding a literature collection to the tune of 7835 is very user friendly with nine communities and provides full text access to its resources through the intranet. 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 450 hits per month.

Research Papers by CPCRI Staff

- Institute Publications
- Mandate Crops-Other than CPCRI
- Deputation Reports
- Reprints
- RPF
- Theses
- Disserttions / Project Reports
- Training Manuals

Library Holdings During the Year 2021

Station	Database/ Journal subscription			Books	Back volumes	Other Publications
	Online data bases	Foreign journals	Indian journals			
Kasaragod	1	2	3	10516	13364	3622
Kayamkulam	-	-	-	3583	6255	3976
Vittal	-	-	3	5312	5801	3052
Mohitnagar	-	-	-	537	-	15
Kahikuchi	-	-	-	134	-	-

XXIII. Budget and Expenditure

The Budget and Expenditure for the period 1 April 2021 to 31 March 2022
(Figures in Rupees Lakhs)

Budget Head	Plan	
	Budget	Expenditure
Revenue		
Estt. Charges	3003.18	2988.60
OTA	-	-
Pension	3787.19	3787.19
TA	7.69	7.69
Research & Operational expenses	328.33	328.33
Works: Repair & Maintenance		
Office Buildings	4.45	4.45
Residential Buildings	2.09	2.09
Minor Works	15.90	15.90
Other Administrative Charges	424.93	424.93
Total	**632.89**	**632.29**
Miscellaneous Expenses (including HRD)	16.61	16.61
Tribal Sub Plan - General	30.00	30.00
Scheduled Cast/ Scheduled Tribe-General	25.00	24.39
NEH	100.00	100.00
Total	**7745.37**	**7730.39**
Capital		
Equipments	167.15	167.15
Information Technology	11.98	11.98
Library	1.0	1.0
Furniture & Fixtures	2.42	2.42
Livestock	-	-
Works	31.92	31.92
Minor Work	-	-
Tribal Sub Plan - Capital	-	-
NEH	-	-
Total	**214.47**	**214.47**
TOTAL	**7959.84**	**7945.26**

Other Projects

	Opening Balance	Receipts	Expenditure	Refund
Other Plan Schemes	46.75	1065.19	1092.49	13.18
Deposit Schemes (Externally funded)	357.20	149.67	183.13	2.06
KVK, Kasaragod	12.74	114.80	141.33	--
KVK, Alappuzha	11.34	199.41	210.70	--

Revenue receipts

Head	Target	Achievement
Income from sales/ services		173.54
Fee/Subscription		-
Income from Royalty, Publication etc.		0.01
Other Income		13.78
STD Interest		31.85
Recoveries on Loans & Advances		2.71
TOTAL		**221.89**

XXIV. Weather Data 2021

ICAR-CPCRI, Kasaragod

Month	Temp. (°C)		RH %		Wind velocity	Sunshine	Evapo ration	Rainfall	Rainy days
	Max	Min	FN	AN	(km/h)	(h)	(litre)	(mm)	
Jan. 2021	33.1	22.3	79	60	1.7	7.9	3.3	132.6	2
Feb. 2021	33.2	20.8	70	56	2.1	8.7	3.8	007.4	1
Mar. 2021	33.8	23.1	71	61	2.1	7.9	4.1	031.4	3
April 2021	33.6	23.5	71	65	2.1	7.1	4.0	079.0	4
May 2021	32.2	23.2	70	72	2.7	4.6	3.0	374.8	16
June 2021	30.8	22.6	74	75	2.6	3.2	2.9	653.9	22
July 2021	29.1	22.7	78	83	1.5	2.7	2.5	804.0	24
Aug. 2021	29.9	22.5	78	79	1.7	3.3	2.5	538.0	19
Sept. 2021	30.1	22.8	75	76	1.6	5.1	3.0	411.4	21
Oct. 2021	32.0	22.6	76	74	1.8	5.1	2.9	395.8	10
Nov. 2021	31.4	22.8	77	73	2.3	3.9	2.7	239.0	11
Dec. 2021	33.1	21.6	74	57	3.5	8.7	3.3	018.8	1

ICAR-CPCRI, Regional Station, Kayamkulam

Month	Temp. (°C)		RH %		Wind velocity	Sunshine	Evapo ration	Rainfall	Rainy days
	Max	Min	FN	AN	(km/h)	(h)	(litre)	(mm)	
Jan. 2021	32.5	22.1	94	63	1.0	7.0	3.8	114.0	9
Feb. 2021	33.6	21.7	92	58	1.8	9.6	4.1	00.0	0
Mar. 2021	34.0	23.4	92	59	1.9	9.2	4.0	76.6	5
April 2021	33.0	24.4	94	69	1.4	7.6	3.8	120.2	7
May 2021	31.2	24.5	94	77	1.4	6.6	3.6	863.1	21
June 2021	31.4	24.5	94	73	1.6	6.8	3.7	294.7	16
July 2021	30.4	24.0	95	76	1.8	6.5	3.6	437.5	18
Aug. 2021	29.9	23.8	95	79	1.4	4.9	3.5	430.4	18
Sept. 2021	30.5	24.1	95	77	1.4	6.8	3.6	411.0	21
Oct. 2021	30.3	24.2	95	79	1.3	4.8	3.4	545.1	24
Nov. 2021	30.2	24.0	96	78	1.1	4.6	3.4	463.7	17
Dec. 2021	33.1	22.6	94	63	1.1	8.4	3.7	30.0	3

ICAR-CPCRI, Regional Station, Vittal

Month	Temp. (°C)		RH %		Wind velocity	Sunshine	Evapo ration	Rainfall	Rainy days
	Max (*C)	Min (*C)	FN	AN	(km/h)	(h)	(litre)	(mm)	
Jan. 2021	33.7	19.7	94	52	1.8	6.7	3.0	42.2	4
Feb. 2021	33.7	18.7	91	47	2.1	7.6	3.6	5.0	2
Mar. 2021	35.7	22.0	93	50	2.4	5.3	4.6	8.2	1
April 2021	34.9	22.8	93	56	2.7	5.8	3.8	41.8	5
May 2021	33.0	23.0	94	70	2.0	5.0	2.5	390.4	21
June 2021	30.1	22.4	96	73	2.1	4.0	2.2	647.2	24
July 2021	28.8	22.4	96	88	2.1	1.8	2.0	1058.4	28
Aug. 2021	29.6	22.3	96	85	2.3	2.5	2.0	422.0	24
Sept. 2021	30.3	22.6	95	78	2.7	3.9	2.5	344.4	22
Oct. 2021	31.1	22.6	94	77	1.7	1.9	2.2	389.8	19
Nov. 2021	31.9	21.0	94	71	1.3	2.4	2.4	224.0	15
Dec. 2021	33.3	20.1	91	52	1.5	2.0	3.5	6.6	1

ICAR-CPCRI, Research Centre, Kidu

Month	Temp. (°C)		RH %		Wind velocity	Sunshine	Evapo ration	Rainfall	Rainy days
	Max (*C)	Min (*C)	FN	AN	(km/h)	(h)	(litre)	(mm)	
Jan. 2021	34.9	20.7	93	52	0.71	6.50	4.14	152.3	5
Feb. 2021	35.4	19.4	90	41	1.09	8.51	4.80	43	2
Mar. 2021	37.9	22.8	92	40	1.33	7.36	4.97	9	2
April 2021	35.7	24.0	92	55	1.53	5.99	4.55	213.7	9
May 2021	33.5	23.6	93	69	0.71	3.87	4.28	458.2	24
June 2021	30.3	23.1	93	78	0.69	1.29	3.57	836	23
July 2021	28.9	23.1	94	85	0.80	1.48	2.30	1078	24
Aug. 2021	29.0	22.4	94	89	0.52	0.93	1.95	962.4	28
Sept. 2021	30.3	23.4	95	75	0.74	2.47	2.59	427.6	19
Oct. 2021	32.6	23.0	95	73	0.35	3.99	3.30	441	17
Nov. 2021	31.4	22.6	94	74	0.25	2.48	1.93	332.8	21
Dec. 2021	34.0	20.0	87	49	0.41	7.38	3.87	30.2	3

XXV. राजभाषा कार्यान्वयन

हिंदी पखवाड़ा समारोह

हिंदी पखवाड़ा समारोह का उद्घाटन डॉ. के. मुरलिधरन, प्रमुख(सामाजिक विज्ञान), केंरोफअसं , कासरगोड़ की अध्यक्षता में हुआ । भारत माता की वंदना करते हुए श्रीमती जयश्री, सहायक मुख्य तकनीकी अधिकारी, कृषि विज्ञान केंद्र, ने सभाके मन में मातृभूमि के प्रति प्रेम की भावना जगायी । श्रीमती श्रीलता, सहायक मुख्य तकनीकी अधिकारी (राजभाषा) ने समारोह के मुख्य अतिथि डॉ तारु एस पवार , एसोसिएट प्रोफसर, केरल केंद्रीय विश्वविद्यालय, कासरगोड़ का परिचय कराया और कोविड -19 महामारी के परिप्रेक्ष्य में केंद्र सरकार द्वारा जारी दिशा-निर्देशों एवं मानक प्रचालन प्रक्रिया एसओपी का अनुपालन करते हुए उत्साहपूर्वक प्रत्यक्ष और परोक्ष रूप से समारोह में उपस्थित काजू निदेशालय, पुत्तूर, कर्नाटक सहित मुख्यालय कासरगोड़ एवं अधीनस्थ केंद्र, मोहित नगर के सभी अधिकारियों एवं कर्मचारियों का स्वागत किया । अध्यक्ष महोदय ने 14 सितंप्रार की विशेषता पर प्रकाश डाला और सभी अधिकारियों एवं कर्मचारियों से एकसाथ सहायोग की भावना से अधिकाधिक हिंदी शप्रब्दों का प्रयोग करने की अपील की। डॉ त्रिलोचन महापात्र, महानिदेशक, भाकृअनुप, नई दिल्ली की अपील पढ़कर श्रीमती श्रीलता के, सहायक मुख्य तकनीकी अधिकारी (राजभाषा) ने सभी स्टाफ सदस्यों से अधिकाधिक कार्य हिंदी में करने की प्रार्थना की ।

डॉ तारु एस पवार, एसोसिएट प्रोफसर, केरल केंद्रीय विश्वविद्यालय, कासरगोड़ ने हिंदी भाषा का विकास और विश्व में प्रथम स्थान की ओर अग्रसर हिंदी भाषा के महत्व पर प्रकाश डाला । श्री अश्विन रघुनाथ, श्री प्रदीप कुमार वासु, सहायक प्रशासनिक अधिकारी ने मुख्य अतिथि और अध्यक्ष महोदया सहित सभा में उपस्थित सप्रभाके प्रति धन्यवाद ज्ञापन किया।

डॉ तारु एस पवार , एसोसिएट प्रोफसर, केरल केंद्रीय विश्वविद्याल, कासरगोड़ भाषण देते हुए

हिंदी पखवाड़ा समापन समारोह डॉ अनिता करुण, निदेशक महोदय की अध्यक्षता में हिंदी पखवाड़ा समारोह का समापन मनाया गया। डॉ सीमा चोपड़ा, निदेशक (राजभाषा) भारतीय कृषि अनुसंधान परिषद, नई दिल्ली इस समारोह की मुख्य अतिथि रही। निदेशक महोदय ने अपने अध्यक्षीय भाषण में हिंदी समारोह की सफलता पर खुशी प्रकट की कि अधिकांश स्टाफ सदस्यों ने एक साथ जुड़कर हिंदी समारोह के विभिन्न कार्यक्रमों के आयोजन में सहयोग दिया, प्रतियोगिताओं में भाग लिया और अपनी अपनी रुची प्रकट की । उन्होंने अपील की कि इसी प्रकार राजभाषा के कार्यान्वयन में, प्रयोग में सहयोग देकर हिंदी के प्रयोग को उत्तरोत्तर प्राढ़ावा दें और इस संस्थान का मान प्राढ़ाएँ।

डॉ सीमा चोपड़ा, निदेशक (राजभाषा), भारतीय कृषि अनुसंधान परिषद ने हिंदी भाषा के महत्व पर प्रकाश डाला कि इन विशेष गुणों के कारण ही संविधान निर्माता ओं ने हिंदी भाषा को राजभाषा का दर्जा दिया है। इस संवैधानिक कर्तव्यों के अनुपालन हेतु प्रत्येक सदस्यों की मानसिकता और प्रतिप्राद्धता प्राढ़ाने की आवश्यकता की ओर ध्यान आकर्षित किया। प्रधान मंत्री जी जी के मार्गदर्शन से राजभाषा विभाग की ओर से कार्यान्वित 12 'प्र' कार्यक्रमों जैसे प्रेरणा, प्रोत्साहन,

प्रशिक्षण, प्रेम, प्रतिप्रश्रद्धता पर भी विवरण दिया । संसदीय राजभाषा समिति के निरीक्षण की गंभीरता और हिंदी पदों के सृजन और खाली पदों को जल्दी ही भरने की आवश्यकता पर जोर दिया। राजभाषा के प्रयोग प्रगढ़ाने के लिए हिंदी वातावरण सृजित करने हेतु आयोजित संस्थान की गतिविधियों और राजभाषा कार्यान्वयन की सराहना की।

श्री रामअवतार पाराशर, वरिष्ठ वित्त एवं लेखा अधिकारी ने सभा में उपस्थित स्टाफ सदस्यों का स्वागत किया और मुख्य अतिथि डॉ सीमा चोपड़ा का परिचय कराया। हिंदी पखवाडा समारोह की अवधि पर आयोजित विभिन्न प्रतियोगिताओं के विजेताओं को नकद पुरस्कार डॉ अनिता करुण, निदेशक महोदय और श्री रामअवतार पाराशर, वरिष्ठ वित्त एवं लेखा अधिकारी ने वितरित किए। श्रीमती जयश्री, सहायक मुख्य तकनीकी अधिकारी एवं विषय मामला विशेषज्ञ, कृषि विज्ञान केंद्र की मुधुर वाणी ने वातावरण प्रगदला और श्रीमती श्रीलता के, सहायक मुख्य तकनीकी अधिकारी (राजभाषा) ने अपने धन्यवाद प्रस्ताव में अपनी 33 वर्षों की सेवा में सभी स्टाफ सदस्य और परिषद से प्राप्त हुए सहयोग और मार्गदर्शन के प्रति आभार प्रकट किया।

डॉ सीमा चोपड़ा, निदेशक (राजभाषा), भारतीय कृषि अनुसंधान परिषद, ऑनलाइन पर भाषण देते हुए

भाकृअनुप
ICAR

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

Agrisearch with a human touch