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Companion of coconut community Since 1916

वार्षिक प्रतिवेदन
ANNUAL REPORT
2015-16

भाकृअनुप-केन्द्रीय रोपण फसल अनुसंधान संस्थान
कासरगोड़, केरल - 671124, भारत
ICAR-CENTRAL PLANTATION CROPS RESEARCH INSTITUTE
KASARAGOD - 671124, KERALA, INDIA

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के.रो.फ.अ.सं CPCRI


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Planting of coconut seedlings in ‘Centenary Coconut Park’ by farmers

PREFACE

The year 2016 marks the 100 glorious years of coconut research in India. Coconut exerts a profound influence on rural economy of the country by supporting the livelihoods of 12 million people. India has produced 20,440 million nuts in the year 2015 from an area of 1.97 million ha with a productivity of 10,345 nuts per hectare. In the recent times, coconut is confronted with unprecedented crises on account of various macro and micro level factors. The productivity of the crop is constrained by the low input use efficiency in conjunction with other biotic and abiotic stresses, which are priority areas of research. The aspect of mechanization also deserves adequate attention, considering the scarcity of skilled labour. Above all, the most important facet is value addition, which should be strengthened to mitigate the issue of low profitability of the sector. For brightening the future prospects of a sustainable coconut sector, it is imperative to delink the sector from the dependency on coconut oil and enhance the production of diversified value added products. It is noteworthy that post World Trade Agreement and ASEAN Treaty regime has witnessed integration of coconut economies across the globe that resulted in fierce competition among producing countries. The relevance of retrospection and introspection of 100 years of research in the coconut sector arises exactly in this context, wherein the institutions strive for technology generation and dissemination to address the challenges and to convert the weaknesses to opportunities, in a concerted and synergized fashion.

The coconut sector in India has evolved in a unique fashion by imbibing scientific excellence for the past 100 years. The country has rich coconut genetic resources to provide breeders with required genetic stock to tackle future challenges. The International Coconut Genebank for South Asia has been established in the country under a tripartite agreement among ICAR-FAO-ITPGRFA. We have a National Coconut Genebank that serves as the National Active Germplasm Site for coconut. The focused research efforts to improve productivity and overall profitability have resulted in the development and release of eighteen improved high yielding varieties including twelve selections and six hybrids. Three varieties- Kalpa Shatabdi (coconut), Shatamangala (arecanut) and Netra Centura (cocoa) - have been released this year to commemorate the centenary celebrations. There is tremendous potential for the released varieties as they are capable of yielding two to six times more than the average yield in different growing regions. Coconut based cropping system (CBCS) with pepper, banana, nutmeg, pineapple, ginger, turmeric and elephant foot yam generated a net income which is 150% higher than that of coconut monocrop, while the coconut based mixed farming system (CMFS) with pepper, banana, crossbred cows, poultry birds, goat, and pisciculture generated a net return which is 288% higher than that of coconut monocrop.

Two organic products *viz*., Kalpa Organic Gold and Kalpa Soil Care have been released for sustainable, clean and green cultivation of coconut. Integrated disease management strategies developed for root (wilt) and leaf rot disease affected coconut gardens could increase yield by 25-83% depending on severity of the disease. The coconut climbing model developed with the safety attachment has become an effective solution, since it can be operated even by women with proper training.

There exists a huge scope for coconut based agri-business in India by increasing the present 8% level of value addition to at least 25%, and thereby ensuring a fair, reasonable and steady price to coconut farmers. In view of this, ICAR-CPCRI has developed a bouquet of technologies for the production of virgin coconut oil, coconut chips, coconut honey, jaggery and sugar. The institute has developed an exclusive technology for collecting coconut inflorescence sap by using a scientifically designed technique. The sap thus collected is called Kalparasa, which can be preserved up to 45 days under cold condition without adding any preservatives and additives. It is an indubitable fact that Kaplarasa is a high potential breakthrough product, which may bring in a paradigm shift in commercialization of domestic coconut sector.

The research system has been producing quality planting materials in coconut for distribution to farmers. Seed gardens of improved varieties have been established at the institute level as well as in farmers' gardens to augment planting material production. It is worthwhile to note that coconut-based microenterprises run by women SHGs have increased their income by 3-5 times compared to their previous income from copra, securing a steady source of additional income. Equally important, the intervention provided employment opportunities to formerly unemployed and under employed rural women resulting in enhanced self esteem, and economic and social empowerment. It is heartening that, trained women serve as 'skilled coconut pollinators' for coconut hybrid seed production, transcending all gender barriers prevailing hitherto.

To commemorate the 100 years of scientific excellence of the institute, year-long celebrations have been planned and a series of activities are being conducted. The uniqueness in launching of the centenary celebrations by simultaneously planting 100 coconut seedlings of ICAR-CPCRI released varieties by farmers from various regions of the country reflects utmost reverence and the priority that the Institute accords to the farmers. The celebrations will be culminated with an "International Symposium on Coconut Research and Development" that provides the most appropriate platform for the researchers and other stakeholders at both national and international arena to come together, discuss and plan the future actions to safeguard the sector. Inclusive growth and sustainability of coconut economy could be achieved through integrated development of cultivation and industry coupled with a stable market. The programmes which has taken a shift in strategy like aggregation of farmers for group activities, collaborative research for production of high yielding and hybrid seedlings, creating more skilled labourers for farming, harvesting and processing operations along with the objective of triggering production, processing and value addition will hopefully place our coconut sector at forefront in the world.

In the case of arecanut, the improved varieties developed by the institute have increased the nut yield up to three times higher than that of local varieties. Arecanut based cropping system with cocoa, banana and black pepper as component crops generated 132% higher net returns than that of arecanut monocrop. It is a matter of pride that arecanut nurseries of the institute at Vittal and Kidu are graded as 'four-star' nurseries by National Horticultural Board. At present, the demand for cocoa beans outstrips the domestic production, necessitating large scale imports to meet the national requirement. The cocoa production in the country should increase at an annual growth rate of 7.68 per cent to meet the future demand of the sector. The elite clones and hybrids developed by the institute yield up to 2.5 kg dry bean tree^{-1} with varying processing qualities. The institute is committed to develop a rejuvenated, empowered and economically viable cocoa sector through holistic multi-stakeholder efforts across the cocoa sector.

In this backdrop, I am greatly privileged to present the Annual Report 2015-16 of ICAR-CPCRI, showcasing the research activities and achievements of this institute for the year 2015-16, presented in a thematic mode. I am grateful to Dr. T. Mohapatra, Secretary, DARE and Director General, ICAR for the encouragement and guidance that we are fortunate to receive. I remember with gratitude, the guidance and support extended by Dr. S. Ayyappan, the former Director General, ICAR. I place on record my sincere gratitude to Dr. N.K. Krishna Kumar, Deputy Director General (Hort. Science) for his support and guidance in the activities and progress of the institute. I thank Dr. T. Janakiram, ADG (Hort. Science) for the unstinting support received from the Horticulture division of ICAR. I thank the scientists, officers and all staff members of this institute for the significant contributions made in fulfilling the mandate of the institute.

07-06-2016

(P. Chowdappa)
Director

कार्य सारांश

भारत में रोपण क्षेत्र की भूमिका महत्वपूर्ण मानी जाती है क्योंकि यह करोड़ों लघु एवं सीमांत किसानों की आजीविका की सहायता तथा पारिस्थितिक सेवाओं का समर्थन करता है। इसके अतिरिक्त यह क्षेत्र मज़दूर समस्याओं और उसके द्वारा प्रोत्साहित किए जा रहे समावेशी विकास सुसाध्य बनाने के कारण रोज़गार प्रदान करने में योगदान देता है।

भा.कृ.अनु.प.-केंद्रीय रोपण फसल अनुसंधान संस्थान को भारत में नारियल, सुपारी और कोको पर अनुसंधान करना और समन्वयन करने का अधिदेश दिया गया है। रिपोर्टाधीन वर्ष 2015-16 की अवधि में 10 भिन्न विषयक क्षेत्रों के अधीन मुख्य फसलों से संगत आधारी और अनुप्रयुक्त शोध करने में संस्थान द्वारा जारी किए गए अनुसंधान कार्य की प्रगति इस रिपोर्ट में प्रस्तुत की गई है।

पादप आनुवंशिक संसाधन

भाकृअनुप-कें.रो.फ.अ.सं. में नारियल (455 प्रजातियाँ) और सुपारी (173 प्रजातियाँ) के जननद्रव्य का सबसे बड़ा संग्रहण का अनुरक्षण किया जाता है। इसके अलावा कोको की 352 प्रजातियों का बड़ा संग्रहण है। जीन बैंक को अधिक समृद्ध बनाने के लिए कार निकोबर द्वीप से 16 और दक्षिण अण्डमान से 1 गुण विशेष जैसे बौनेपन, बड़ा फल आकार, उच्च खोपड़ा, हृष्ट पुष्ट तना, उच्च गुठली उत्पादन, फल रंग, मृदुल और आसानी से छीलने योग्य छिल्का, मीठी अष्टी और उच्च डाब पानी मात्रा, जननद्रव्य संग्रहण किए गए जिनका संरक्षण जीन बैंक में किया जाता है। सुपारी में पाँच विशेष जातियाँ, कर्नाटक से तीन और अण्डमान निकोबर द्वीप से एक बौनी प्रजाती और एक वन्यप्ररुप का संगहण किया गया।

कल्प समृद्धि (सुधारित बौनी x लंबी नारियल संकर) और कल्प तरु (सुधारित उच्च उपज देने वाली, बढ़ौती बॉल खोपड़ा, नारियल प्रजाति) संस्थान में विकसित की गईं और क्रमशः केरल और कर्नाटक तथा केरल, कर्नाटक और तमिलनाडु के लिए भारत सरकार के राजपत्र में अधिसूचित किया गया है। नारियल की उच्च उपज देनेवाली प्रजातियाँ आई एन डी 010 एस, आई एन डी 042 एस और आई एन डी 034 एस 24 कि.ग्रा./ ताड़/ वर्ष से अधिक खोपड़ा उपज और नारियल संकर जैसे आई एन डी 058 x एस आई एन डी 042 एस, आई एन डी 007 एस x आई एन डी 008 एस और आई एन डी 007 एस x आई एन डी 091 एस, संस्थान स्तर पर विमोचन के लिए सिफारिश की गई हैं। रोपाई सामग्री के उत्पादन बढ़ाने और जेल निवासियों को सशक्त बनाने के लिए नेदुकलतेरी खुली जेल, तिरुवनन्तपुरम, केरल में जड़ मुर्झा सक्षम कल्पश्री प्रजाति की एक प्रदर्शनी एवं मातृ बाग के रूप में स्थापित किया गया।

सुपारी में 124 स्वदेशी प्रजातियों में उपज एवं उसका संघटक गुण का रिकार्ड किया गया है जो आर्थिक गुण के लिए मूल्यांकन के अधीन है। वी टी एन 146 की उच्च उपज 3.91 कि.ग्रा./ताड़/वर्ष की सूखी अष्टी उपज और 3.26 कि.ग्रा./ताड़/वर्ष मृदु फल उपज देने वाली सुपारी जातियाँ संस्थान स्तर पर विमोचन के लिए पहचानी गयी हैं। 24 जातियों में किए गए डाब प्रक्रमण के तुलनात्मक अध्ययन से दुदिना, महुआ, मालन, टुरा, बोकुल और कलिरहट जातियों में उच्च डाब 68 प्रतिशत से अधिक संसाधित प्रथम गुण का डाब पाया गया।

कोको में वायनाड से स्थानीय संग्रहण से पंद्रह वर्ष का क्लोनल मूल्यांकन का और कर्नाटक और केरल राज्य में नाइजीरिया के विदेशी संग्रहण से तीन क्लोन वी टी एल सी-13, वी टी एल सी-20, वी टी

एल सी-120 उच्च उत्पादन क्षमता (औसत सूखा बीन उपज 2.5 - 2.8 कि.ग्रा.) सुपारी और नारियल छाया के नीचे इष्टतम वितान उच्च बीन सूचकांक (1.2) औद्योगिक मूल्य, और जैविक और अजैविक तनाव का सक्षम 3.2 कि.ग्रा. /ताड़/वर्ष औसत सूखा बीन उपज पहचानी गयी। प्रजातीय के साथ कोको संकर वी टी सी पी आई विमोचन के लिए सिफारिश किया गया। कोको पौधों की आकारिकी शरीरक्रिया विज्ञान प्रतिक्रिया पर निरीक्षण प्रेरित जल कमी तनाव से वी टी एल सी पी-22, वी टी एल सी पी-24 और वी टी एल सी एच-4 को नमी तनाव सक्षम क्लोन के रुप में पहचाना गया।

भाकृअनुप-केरोफअसं, अनुसंधान केंद्र मोहितनगर में जननद्रव्य का सुरक्षित द्विगुणन के लिए 21 नारियल प्रजातियों का रोपण किया गया। इसके अलावा प्रादेशिक केंद्र / अनुसंधान केंद्र, अखिल भारतीय समन्वित ताड़ अनुसंधान परियोजना के अनुसंधान केंद्रों में विभिन्न सस्य पारिस्थितिक अंचलों में नारियल (16), सुपारी (9) और कोको (16) के चुने गए लाइन का बहुस्थानीय मूल्यांकन स्थापित किया गया। जननद्रव्य वर्गक संग्रह के विकास के लिए कोको (40) सुपारी (12) और नारियल (11) की प्रजातियों का वर्णन रिकार्ड किया गया। नारियल में 1.397 लाख, सुपारी में 7.40 लाख और कोको में 0.539 लाख कुल 9.339 लाख रोपाई सामग्री का उत्पादन किया गया और कृषकों और हितधारकों को वितरण किया गया।

जैव प्रौद्योगिकी और जैव सूचना

सुपारी में हिरेहल्ली बौनी और बौनी संकर (वी टी एल ए एच-1 और वी टी एल ए एच-2) के फूल कर्त्तोतक से कायिक भ्रूणोद्भव और पादपक पुनरुत्पादन और विकास के विभिन्न अवस्था में 100 पादपक प्राप्त किया गया। मृदुल भ्रूणपोष नारियल के भ्रूण उद्धार, जो प्राकृतिक स्वभाव में अंकुरण संभव नहीं है, अंकुरित हो जाता है। नारियल भ्रूण प्रशीत परिरक्षण नयाचार विकास किया गया। पाँच जातियों में अनुसमर्थन किया गया। तीन नारियल जातियों (फिलीपीन्स आर्डिनरी लंबी, लकाडीव आर्डिनरी लंबी और मलयन हरा बौनी) और दो नारियल जातियों का परागण तरल नाइट्रोजन में शुष्कण नयाचार का उपयोग कर लंबी अवधि भण्डारण के लिए भण्डार किया गया।

नारियल पत्ता ट्रान्स्क्रिप्टोम ऑकडे से निकाला गया इ एस टी-एस एस आर मार्केर्स, लंबी और बौनी सम्मिलित 18 संकर से 103 संन्ततियों के संकर प्रमाणीकरण के लिए उपयोग किया गया। पूरी लंबी टी आई आर-एन बी एस-एल आर आर (लंबी/इन्टरलेयुकिन-1 रिसेप्टर-लाइक डोमाइन-न्यूक्लियोटिड -बैन्डिंग साइट लेयुसिन-रिच रिपीट) रोग प्रतिरोध जीन एनालॉगस और नारियल में कायिक भ्रूणोंद्भव के समय जीन प्रेरित (बेबी बूम, डब्ल्यु यु एस सीएच इ एल, एस इ आर के और ए पी 2) का कृन्तकी-करण और गुणावगुण किया गया।

डब्ल्यु सी टी और सी ओ डी में कृत्रिम वातावरण में (कांच के अंदर) पुनरुत्पादन की विभिन्न अवस्थाओं में RT-qPCR का उपयोग कर आठ जीन का जीन एक्सप्रेशन विन्यास का तुलनात्मक अध्ययन किया गया। पुनरुत्पादन क्षमता और जीन एक्सप्रेशन विन्यास में महत्वपूर्ण भिन्नताआँ पायी गयी। यह कृत्रिम वातावरण में संवर्द्धन का जीन प्ररुपी भिन्नताओं का सुझाव देता है। नारियल में युग्मनज और कायिक भ्रूणोद्भव के तुलनात्मक प्रोटियोमिक विश्लेषण से 10 प्रोटिन पाये गये जो कायिक भ्रूण की तुलना में युग्मनज भ्रूण में उच्च निचोड़ स्तर पाया गया।

गैनोडेरमा लूसिडम और लाल ताड़ घुन के ESTs में संरक्षित miRNAs की जांच की गई। *गैनोडेरमा लूसिडम* में प्रेडिक्टड सूक्ष्म आर एन ए द्वारा लक्षित अधिकांश जीन रोगजनक कवक में अत्यंत संरक्षित और ट्रान्स्क्रिप्शन रेगुलेशन, डी एन ए बंधन, ए टी पी बन्धन और प्रोटीन बन्धन में संबद्ध पाया गया। लाल ताड़ घुन में आयन ट्रान्सपोर्ट रेगुलेशन, जीन रुपान्तर आदि में कार्यक्षम miRNAs का मुख्य

योगदान है। यह कीट शरीर क्रियाविज्ञान नियंत्रण में और लाल ताड़ घुन में जीन एक्सप्रेशन के धमन के लिए कार्यक्षम लक्ष्य की पहचान में miRNAs की प्रधानता दिखाता है।

फसलन और कृषि पद्धति

नारियल, काली मिर्च, चारा, मत्स्य, मुर्गीखाना और बकरी सम्मिलित नारियल आधारित मिश्रित कृषि पद्धति से उच्च सकल आय प्रति हेक्टर से 7,17, 955/ रुपए प्राप्त किए गए। संघटक फसलों के बीच दुग्धशाला, नारियल और कालीमिर्च से कुल आय का 80 प्रतिशत प्राप्त किया गया। चारा फली वाली फसल और जैविक पूरक आदि मृदा उर्वरता और उत्पादन क्षमता अनुरक्षण में सहायक पाये गये। संकर नेपियर जाति की कृषि के लिए जैविक पोषण प्रबंधन मानकीकृत किया गया। नारियल रोपण में द्विवार्षिक अंतराल में गोबर, वर्मीकम्पोस्ट, *एजोस्पिरिल्लम* और फोसफोबैक्टीरिया के प्रयोग के साथ Co3 चारा अंतरफसल से उच्च चारा उपज 139 टन/हेक्टर प्राप्त की गयी।

जैवभार (वर्मीकम्पोस्ट) का पुनः चक्रमण, हराखाद प्रयोग, जैव उर्वरकों का प्रयोग वर्मीवाश प्रयोग, छिल्का डालना और पलवारने (नारियल अलवाल में) से समीकृत पोषण प्रबंधन के समान नारियल आधारित उच्च घनता बहुजातिय फसलन पद्धित में उच्च नारियल उत्पादन क्षमता प्राप्त किया जा सकता है।

केरोफअसं, अनुसंधान केंद्र, मोहितनगर में सुपारी और नारियल आधारित पद्धति के अधीन औषधीय पौधों, एस्परागस और एलोवेरा, सुधारित पद्धति उत्पादन क्षमता है। सुपारी, कालीमिर्च, नींबू और हल्दी सम्मिलित सुपारी आधारित फसलन पद्धति मॉडल उच्च उत्पादन क्षमता रिकार्ड की गयी। काली मिर्च से 67-70 प्रतिशत और मुख्य फसल सुपारी से कुल उत्पादन क्षमता का 22-26 प्रतिशत अंशदान प्राप्त किया गया।

नारियल रोपण में तटीय बलुआर मृदा में मृदा नमी संरक्षण सबस्ट्रेट्स का उपयोग कर फूल फसल जैसे ग्लाडियोलस जाति, अरका केसर और मेरीगोल्ड जाति बंगार सफलतापूर्वक प्रदर्शित किया गया और नारियल पत्तों के छोटे छोटे टुकड़े सबस्ट्रेट से उच्च उपज रिकार्ड किया गया और गुणी फूल भी प्राप्त किये गये। हेलिकोनिया एक लाभदायक अन्तरफसल है। *एच करिबइया* x *एच बिहाई* जाक्विनी और करिब्बीयन रेड की तुलना में *हेलिकोनिया स्ट्रिक्टा* 'आईरिस' *एच बिहाई*, *एच करिबाइए* कवौची, *हेलिकोनिया स्ट्रिक्टा* 'सनराइस' और *एच ओरथोट्रोपिका* 'शी' अन्तरफसलन के लिए नारियल रोपण में अधिक उचित पाया गया। फूलों के उत्पादन वर्ष तक प्रजातियों का संकरण 'शी' और 'सनराइस' 1:1 अनुपात में अन्तरफसलन किया जा सकता है।

मिनिकॉय, लक्षद्वीप में उच्च उपज प्रदत्त विभिन्न वनस्पतियों की सुधारित प्रजातियाँ जैसे मिर्च, बैंगन, लोबिया और सजनाफली, भिण्डी, फूलगोभी और गोभी और फल फसल केला, पपीता, चीकू और अमरुद सफलतापूर्वक द्वीप निवासियों के बीच प्रतिपादन करने के लिए प्रदर्शित किया जाता है। सब्जी की स्थानीय आवश्यकताओं के संवर्धन करने की दृष्टि में व्यापक कार्यवाई योजना तैयार की गयी है और परिकल्पित गतिविधियों का कार्यान्वयन किया गया। कृषकों के बागों में छादित जाल/जाल हाउस से सब्जी की संरक्षित कृषि प्रारंभ की गयी है।

जैव संसाधन उपयोग

दो जैविक उत्पाद 'कल्प ऑरगेनिक गोल्ड' (स्वदेशी *यूड्रिलस* जाति के केंचुए का उपयोग कर नारियल पत्तों से वर्मीकंपोस्ट उत्पादन) और 'कल्प सोयल केयर' (यूरिया मुक्त कॉयर पिथ कंपोस्ट) का उत्पादन

शुरु किया गया। मृदा विहीन सबस्ट्रेट्स, नारियल जैवभार अवशेष और उसका मिश्रण जैसे नारियल पत्ता वर्मीकंपोस्ट और यूरियामुक्त कॉयर पिथ कंपोस्ट पुनःचक्रमण उपयोग का निर्धारण किया गया और सुपारी और कोको पौध उगाने के लिए उचित पायी गयी। राईजोस्पियर माइक्रोफ्लोरा बढ़ाने के अलावा मृदाविहीन मीडिया में पीजीपीआर और ट्राईकोडरमा के प्रयोग से सुपारी और कोको पौधों की वृद्धि मापदण्ड में सुधार पाया गया। बायो श्रेडर का उपयोग कर चूर चूर किया गया नारियल ताल पत्रों (कठोर पर्णवृंत सहित) के उपयोग द्वारा प्राप्त सक्षम नारियल पत्ता वर्मीकंपोस्ट में एक चक्र में 80-85 प्रतिशत परिवर्तन क्षमता पायी गयी। विभिन्न जैव संसाधनों जैसे यूड्रिलस जाति (नारियल पत्ता वर्मीकंपोस्ट बनाने वाले केंचुएँ) 1,50,00 'कल्प ऑरगोनिक गोल्ड' (नारियल पत्ता वर्मीकंपोस्ट 28 टन) 'कल्प सॉयल केयर' (यूरिया मुक्त कॉयर पिथ कंपोस्ट) 6 टन, 'केरा प्रोबायो' (पीजीपीआर बायोइनोकुलेंट 120 कि.ग्रा.), नारियल पत्ता वर्मीवाश (200 लीटर) और मशरूम स्पॉन (20 कि.ग्रा.) का उत्पादन किया गया और कृषकों और अन्य अंत उपयोगकर्ताओं को वितरण किया गया।

फसल नाश कम करना

नारियल, कोको और सुपारी संक्रमित छह फाईटाफ्थोरा जाति *पी. पाल्मिवोरा*, *पी. निकोटियानेइ*, *पी. काप्सिसि*, *पी. मीडियाई*, *पी. सिट्रोफ्थोरा* और *पी. कोलोकेसियाए* की द्रुत पहचान के लिए जातिय विशेष प्राइमर्स का उपयोग कर विशेष और संवेदनशील पी.सी.आर. एस्सेइस का विकास किया गया है। कली सड़न रोग प्रबंधन पर प्रक्षेत्र परीक्षण से यह देखा गया कि 1 प्रतिशत बोर्डो मिश्रण या कॉपर हाइड्रोक्साइड या ट्राइकोडेरमा कॉयर पिथ केक का छिद्रित कवकानी थैली के साथ रोगनिरोधी उपचार कली सड़न रोग लक्षण कम कराने में प्रभावी पाया गया। सुपारी फल सड़न रोग प्रबंधन परीक्षण में 23.3 प्रतिशत फसल सड़न लक्षण कम पाया गया जहाँ मन्डिप्रोपिमड फुहार किया जाता है। तिमाही अंतराल में नीम केक 5 कि.ग्रा. प्रति ताड़ समृद्ध *ट्राइकोडेरमा हरज़ियानम* (सीपीटीडी 28) का मृदा प्रयोग नारियल का गैनोडेरमा मुर्झा रोग प्रबंधन में प्रभावी पायी गयी।

प्राईमर्स जैसे p1/p6-R16F2n/R16R2,F3-B3,P4/P7 SecA for/rev और tuf F/rev का उपयोग कर तर्कु पत्ते, धड़ वेधन, जड़ मुर्झा रोग प्रभावित नारियल ताड़ के मूल एवं फूल रोचिल्ले से कुल एकलित डी.एन.ए. के साथ नारियल जड़ मुर्झा रोग के साथ संबंद्ध फाइटोप्लाज़्मा की पी.सी.आर. आधारित पहचान की गयी।

नारियल बाग में घासपात के साथ संबद्धित फाईटोप्लाज़्मा की पी. सी. आर पहचान और गुणावगुणन किया गया जैसे वेरनोनिया सिनेरिया फिलोडी, बरमुडा घास सफेद पत्ता और मोल्लुगो डिस्टिचा फिल्लोडी। वी. सिनेरिया और एम. डिस्टिचा में फाइटोप्लाज़्मा कारक फिल्लोडी कान्डिडाटस फाईटोप्लाज़्मा ऑस्ट्रालिसिए ने उपसमूह 16SrII से समजातता दिखायी लेकिन बरमुडा घास सफेद पत्ता फाइटोप्लाज़्मा कान्डिडाटस फाइटोप्लाज़्मा सिनोडोन्टिस ने 16SrXIV उपसमूह के साथ समानता दिखायी।

जैविक नियंत्रण, कृषक प्रतिभागिता पहुँच तथा वानस्पतिक तैयारियों पर बल के साथ ताड़ों और कोको के मुख्य कीटों के धमन के लिए एकीकृत कीट प्रबंधन रणनीतियाँ सही की गयीं।

क्लियोडेन्ड्रोन इनफोरटुनाटम और *क्रोमोलेइना ओडोराटा* के वनस्पतिक सत्व के साथ टाल्क लेपित केक का उपयोग कर नारियल के राईनोसेरस भृंग के विरुद्ध रोग निरोधी उपचार से राईनोसेरस भृंग प्रेरित पत्ता क्षति में 54 प्रतिशत कमी पायी गयी। नारियल तेल (200 मि.ली.) और सल्फर (5 ग्रा. प्रति लीटर) संयुक्त तरुण गुच्छों पर फुहारना, संविलयन या स्पिरोमेसिफेन (1 मि.ली. प्रति लीटर) या नीम तेल (2%) या नमक (2%) एपीएसए (2%) नारियल एरियोफिड़ कीट धमन में प्रभावी पायी गयी। क्लोरान्ट्रानिलिप्रोल (0.018%) और नीम तेल (0.5%) के उपचार से नारियल में कोरिड बग के लक्षण में 73-75 प्रतिशत कमी रिकार्ड की गयी।

समय पर भृंगों का संग्रहण, कीटनाशिनी का प्रयोग (बैफेन्त्रिन 2 कि.ग्रा./ हेक्टर), इमिडाक्लोप्रिड (0.045% दर में) और कीट रोगजनक सूत्रकृमि (*स्टेइनेरनेमा कारपोकासिए*) (1.55 अरब आई जे/ हेक्टर) प्रयोग से सुपारी बाग में मूल ग्रब के प्रबंधन के लिए एकीकृत कीट प्रबंधन का मापांक का विकास किया गया। 60-80 माइक्रोन आकार का निम्न घनत्व पॉलिथिलीन के साथ पैक करने से कीट रोगजनक सूत्रकृमि (*स्टेइनेरनेमा कारपोकासिए*) 25-27 डिग्री सेंटिग्रेड के तापमान में 30 दिनों तक जीवित पाया गया।

जलवायु लचनशील प्रौद्योगिकियाँ

खुला टॉप चैम्बर में वर्द्धित नारियल पौध का जैवभार और पौध वृद्धि उन्नत कार्बनडायऑक्साइड के अनुक्रिया में उच्च पायी गयी लेकिन बढ़ते तापमान (3 डिग्री सेंटिग्रेड परिवेशी) के अधीन महत्वपूर्ण रुप से घटाव पाया गया। इसी प्रकार जल कमी तनाव के अधीन वृद्धि में घटाव पाया गया। सूखा सह्यता उपाय के रुप में जल उपयोग क्षमता के लिए विस्तार परिवर्तन नारियल जीनोटाइप दिखाया जाता है। लंबा पौध गुण अर्थात फेडरेटड मलाय स्टेट्स लंबे का जीनोटाइप, साधारण सिंचाई के अधीन उच्च जल उपयोग क्षमता प्रदर्शित किया लेकिन नमी तनाव के अधीन बौनी, चौघाट ग्रीन बौनी में जल उपयोग क्षमता उच्च था। सूखा सह्यता व्यवस्था के रूप में रंध्र रेगुलेशन के साथ उत्तम मूल पद्धति सक्षम जीनोटाइप में पायी गयी। उच्च तापमान सह्यता के लिए जीनोटाइप के छानबीन का पराग अंकुरण तकनीक परिष्कृत किया गया। अल्पीकरण कार्यक्षमता के रुप में नारियल 31 टन कार्बन डायऑक्साइड/ हेक्टर/ वर्ष अलग किया जाएगा जो अन्य रोपण फसल की तुलना में उच्च है।

उत्पाद विविधीकरण, मूल्य वर्द्धन और मशीनीकरण

नारियल अष्टी और कल्परस से मूल्य वर्द्धित उत्पाद तैयार किये जाते हैं। कल्परस एक मूल्य वर्द्धित पेय है और विभिन्न मूल्य उत्पाद का वाणिज्यिकीकरण केरल, गोवा और पश्चिम बंगाल में किया जाता है। नारियल शक्कर उपयोग कर तैयार किया गया अदीप्त चोकलेट सुगंधित और रुचीपूर्ण है। कल्परस का उपयोग कर परिष्कृत शक्कर रहित बंगाली मिठाई भी तैयार की गई। द्रव पाश्चरीकरण प्रौद्योगिकी का उपयोग कर नारियल रस का परिरक्षण मानकीकृत किया गया है। और पाश्चरीकृत नारियल रस के लिए बोतलीकरण प्रौद्योगिकी का विकास किया गया है। नमी मात्रा, जैवरसायन मापदण्ड, वयन और संवेदी मापदण्ड के अनुसरण में परिष्कृत शक्कर या नारियल रस के साथ नारियल चिप्स का रसाकर्षी निर्जलीभवन के लिए भिगोने का समय, 15 मिनिट इष्टतमीकृत किया गया। नारियल दूध अवशेष और वरजिन नारियल तेल केक आधारित मिश्रित उत्स्वेद (30 प्रतिशत स्तर तक का संयोजन) और वरजिन नारियल तेल केक आधारित मफिन केक (40 प्रतिशत स्तर तक का संयोजन) का मानकीकरण किया गया।

छिल्का निकालने के पहले आकार के अनुसार सुपारी का वर्गीकरण इकाई और सुपारी का छिल्का निकालने के यंत्र की कार्यक्षमता बढ़ाने के लिए सुपारी का स्वचलित फीडिंग के लिए स्वयं लादने की व्यवस्था का विकास किया गया।

आर्थिक, सॉख्यिकीय और प्रौद्योगिकी वितरण मॉडल

नारियल लाल ताड़ घुन के प्रबंधन के लिए क्षेत्र व्यापक सामुदायिक विस्तार पद्धति वर्ष 2014-15 में आलप्पुष़ा जिले में भरणिकाव ग्राम पंचायत में 2000 हेक्टर में शुरु की गई और फलस्वरुप लाल ताड़ घुन लक्षण में 2.93 प्रतिशत से 0.38 प्रतिशत तक कमी पायी गयी। नारियल आधारित कृषि

पद्धति के अन्दर सामुदायिक आधारित जैव संसाधन प्रबंधन आलप्पुष़ा जिला के कन्जिकुष़ी ब्लॉक में लागू किया गया और वहाँ 16 प्रतिशत तक उपज में वृद्धि पायी गयी।

उत्तर केरल में नारियल के मुख्य रोग एवं कीटों का लक्षण और तीक्ष्णता के आँकलन से यह देखा गया कि पादप संरक्षण विधियों की स्वीकृति का स्तर बहुत कम है और नारियल कृषकों को अधिकांश कीट के विरुद्ध एकीकृत कीट प्रबंधन के बारे में आवश्यक ज्ञान नहीं है। कासरगोड जिले को एक जैविक जिले के रुप में घोषणा करने के संदर्भ में प्रक्षेत्र स्तर परिदृश्य और हितधारक परिप्रेक्ष्य पर किए गए अध्ययन से यह देखा गया कि जैविक कृषि में परिवर्तन पर प्रचलन की संदिग्धता और निर्णय और दृढ़ विश्वास में अभिसरण की कमी है।

सुपारी उर्वरण परीक्षण से आंकडे का उपयोग कर बहिर्वासियों के प्रभाव नियंत्रण के लिए एक प्रबल नॉनपारामेट्रिक कोवेरियन्स तकनीक प्रस्तावित और सत्यापित की गयी।

लीनियर और नॉनपारामेट्रिक कोवेरियन्स तकनीक की तुलना में आकलन की मानक त्रुटियाँ और आकलित मूल्य प्रस्तावित प्रबल विधि में कम था। सुपारी का पीला पत्ता रोग और नारियल का जड़ मुर्झा रोग लक्षण में क्षेत्रीय और अस्थायी भिन्नताओं और उपज के साथ उसका संबंध सम्मिलित करने के लिए रोग तीव्रता सूचकांक परिष्कृत किया गया। सुपारी का पीला पत्ता रोग और नारियल का जड़ मुर्झा रोग के लिए उचित रोग सूचकांक प्राप्त करने के लिए प्राथमिक और अन्य संबंधित लक्षण और उपज के साथ एक बहुलीकरण लक्षणों की पुनरावृत्ति होने का एक मॉडल उपयोग किया गया। कर्नाटक में पीला पत्ता रोग के स्थानिक स्वत सहसंबंध और अर्ध वारियोग्राम विश्लेषण से महत्वपूर्ण अनुकूल स्थानिक स्वतः सहसंबंध देखा गया कि रोग लक्षण एक समूह के रुप में है। जलपाईगुड़ी (पश्चिम बंगाल) में सुपारी का गैनोडरमा रोग का फैलाव विन्यास के विश्लेषण से बाग के अन्दर रोग लक्षण एक समूह के रुप में पाया गया।

मुख्य नारियल निर्यात देश जैसे फिलीपीन, इंडोनेशिया और श्रीलंका की अपेक्षा भारत का स्पर्धी लाभ कम है। नारियल, नारियल तेल और खोपड़ा का मूल्य उतार - चढ़ाव अगस्त 2014 से तीनों के मूल्य गिरने की तरफ झुकाव देखने में आया।

मासिक मूल्य भिन्नताओं के परीक्षण करते समय उतार-चढ़ाव खोपड़े की अपेक्षा नारियल में अधिक पाया गया। हम अन्त प्रज्ञता से अनुमान करें कि नारियल तेल क्षेत्र में प्राप्त उच्च मूल्य का असली लाभ नारियल कृषकों को आनुपातिक रुप से हस्तांतरण नहीं किया जाता है जो नारियल कृषकों का अवधारणीयता को सिद्ध करता है। अच्छी तरह प्रबंधित नारियल बाग में नारियल उत्पादन का खर्च 8.21 रुपए प्रति गुठली है। इस परिदृश्य में कुल खर्च का 58 प्रतिशत मज़दूरी के लिए खर्च किया जाता है जो राज्य में उच्च मज़दूर की मांग एवं मज़दूरी के उच्च खर्च पर आरोपित किया जाता है।

क्षमता निर्माण कार्यक्रम

विभिन्न राज्य प्रतिनिधित्व करने वाले 20 अधिकारियों के लिए रोपण फसल के लिए भागीदारी प्रौद्योगिकी पहुँच पर मॉडल प्रशिक्षण पाठ्यक्रम आयोजित किया गया। विभिन्न राज्यों के हितधारकों के लिए कुल 118 प्रशिक्षण एवं खुला संदर्शन, कृषक प्रक्षेत्र स्कूल तथा अभिमुख कार्यक्रम आयोजित किया गया। केरल के सात जिलों में नारियल का जड़ मुर्झा रोग के समीकृत प्रबंधन पर प्रमुख प्रदर्शनी, मूल ग्रब के समीकृत प्रबंधन पर कर्नाटक में और नारियल का गैनोडरमा मुर्झा रोग पर कासरगोड में आयोजित किया गया। 'मेरा गॉव मेरा गौरव' कार्यक्रम संस्थान के 62 वैज्ञानिकों द्वारा 70 गॉवों में सफलतापूर्वक कार्यान्वित किया गया। विश्व मृदा दिवस मनाया गया और 500 कृषकों को मृदा कार्ड

वितरण किया गया। विश्व नारियल दिवस पर विभिन्न कार्यक्रम जैसे प्रशिक्षण, प्रश्नोत्तरी और निबंध लेखन-तुमकूर और कायम्कुलम में आयोजित किया गया। 'जय किसान, जय विज्ञान' कैंप चेरुताष़म कृषि भवन में छात्रों के लिए निबंध लेखन, प्रश्नोत्तरी प्रतियोगिता, प्रदर्शनी एवं प्रशिक्षण विधियाँ सम्मिलित विभिन्न कार्यक्रमों के साथ आयोजित किया गया। नाबार्ड के सहयोग के साथ चुनी गयी प्रौद्योगिकियों पर सात वीडियो फिल्म जैसे स्नोबॉल मृदुफल नारियल, वरजिन नारियल तेल, नारियल चिप्स, नारियल शक्कर, समीकृत कीट एवं रोग प्रबंधन और जैविक कृषि तकनीक तैयार की गयीं। नारियल विकास बोर्ड, कृषि विभाग और भाकृअनुप-केंरोफअसं के साथ साइबर विस्तार कार्यक्रम, वीडियो सम्मेलन आधारित अभिमुख कार्यक्रम आयोजित किया गया।

एक पहल के रुप में अनुसंधान गतिविधियों की दृश्यता बढ़ाने में और संस्थान द्वारा विकसित प्रौद्योगिकियों को विख्यात बनाने में कासरगोड में एक संस्थान उद्योग अभिमुख आयोजित किया गया और 1,20,000 रुपए मूल्य की प्रौद्योगिकियाँ हस्तांतरित की गयी।

कृषि विज्ञान केंद्र

कृषि विज्ञान केंद्र, कासरगोड द्वारा 7 फार्म पर और 18 प्रक्षेत्र प्रशिक्षण कार्यक्रम आयोजित किये गये इसके अतिरिक्त 2809 कृषकों के हित के लिए 146 प्रशिक्षण कार्यक्रम का आयोजन किया गया। कृषि विज्ञान केंद्र आलप्पुष़ा द्वारा सात और 10 प्रक्षेत्र प्रशिक्षण कार्यक्रम 2248 कृषकों के हित के लिए 93 प्रशिक्षण कार्यक्रम आयोजित किये गये। इसके अतिरिक्त विस्तार कार्यक्रम जैसे फसलोत्तर समारोह कैंप, सहायक सेवाएँ, सस्य क्लिनिक प्रदर्शनियाँ, तकनीकी बैठक और प्रक्षेत्र दिवस आयोजित किया गया। केरल कृषि विश्वविद्यालय के कृषि पद्धति सिफारिशों में सम्मिलित करने के लिए नारियल के तना स्त्रवण रोग के प्रबंधन के लिए कृविके, आलप्पुष़ा द्वारा विकसित प्रौद्योगिकियाँ स्वीकृत की गयीं।

अठाईसवीं अनुसंधान सलाहकार समिति की बैठक 18 फरवरी 2016 को आयोजित की गयी और जारी अनुसंधान कार्यक्रमों में सिफारिशें सम्मिलित की गयीं।

भाकृअनुप-केरोफअसं के प्रतिबद्ध और लगातार प्रयास आधारित और प्रायोगिक अनुसंधान प्रधान अनुसंधान उपलब्धियाँ वाणिज्यिकीकृत प्रौद्योगिकियों (21) और गुणी प्रकाशनों (65) में रूप में परिणत हुआ।

Centenary Commemorative Varieties

Kalpa Shatabdi

Shata Mangala

Netra Centura

EXECUTIVE SUMMARY

Plantation sector in India assumes a crucial role by supporting the livelihood of the millions of marginal and small land holders as well as environmental services. Besides, the sector contributes towards employment generation, on account of its labour intensity, and thereby facilitates the inclusive development being upheld today. ICAR-Central Plantation Crops Research Institute is mandated to conduct and coordinate research on coconut, arecanut and cocoa in India. The institute has continued its momentum in conducting basic and applied research relevant to the mandate crops and the progress of research work during the year 2015-16 is reported under 10 thematic areas.

Plant Genetic Resources

ICAR-CPCRI maintains the largest collection of coconut (455 accessions) and arecanut (173 accessions) germplasm in the world. Further, the institute has 352 cocoa accessions conserved in the field gene bank. During the year, the coconut germplasm collection was enriched with 17 trait specific accessions, 16 from Car Nicobar Island and one from South Andaman, for traits *viz.,* dwarfness, large fruit size, high copra, robust stem, high nut production, fruit colour, soft cum easy peel husk, sweet kernel and high tender nut water content. In arecanut, five distinct accessions were collected, three from Karnataka and one dwarf accession and a wild type from Andaman and Nicobar Islands.

Kalpa Samrudhi (an improved D x T coconut hybrid) and Kalpatharu (an improved, high yielding, premium ball copra, coconut variety), developed at the Institute, have been notified in the Gazette of India for the states of Kerala and Karnataka and Kerala, Karnataka and Tamil Nadu, respectively. High yielding selections of coconut, namely, IND010S, IND042S and IND034S, with copra output of more than 24 kg copra $palm^{-1}yr^{-1}$ and coconut hybrids *viz.*, IND058S x IND042S, IND007S x IND008S and IND007S x IND091S, were recommended for release at the institute level. A demonstration plot cum mother garden of root (wilt) tolerant Kalpasree variety was established in Nettukaltheri Open Prison in Thiruvananthapuram, Kerala, for enhancing the planting material production and empowering the prison inmates.

In arecanut, yield and its component traits have been recorded in 124 indigenous accessions which are under evaluation for economic traits. High yielding arecanut selection of VTL146, with dry kernel yield of 3.91 kg $palm^{-1}yr^{-1}$ and tender nut yield of 3.26 kg $palm^{-1}yr^{-1}$, was identified for release at the institute level. Comparative study of tender nut processing in 24 accessions indicated high tender nut recovery, more than 68% first quality processed tender nut, in the accessions Dudina, Mahuva, Malan, Tura, Bokul and Kalirhat.

In cocoa, fifteen years of clonal evaluation of local collections from Wayanad and exotic collections from Nigeria in the states of Karnataka and Kerala has resulted in identification of three clones, VTLC-13, VTLC-20, VTLC-120 with higher yield potential (average dry bean yield of 2.5-2.8 kg $tree^{-1}yr^{-1}$), optimal canopy both

under arecanut and coconut shades, high bean index (1.2), industrial value and tolerance to biotic and abiotic stress. Cocoa hybrid VTCP1, with average dry bean yield of 3.2 kg $tree^{-1}yr^{-1}$, was recommended for varietal release. Observation on morpho-physiological responses of cocoa seedlings to induced water deficit stress resulted in identification of VTLCP-22, VTLCP-24 and VTLCH-4, as moisture-stress tolerant clones.

Nine coconut accessions were conserved at ICAR-CPCRI, Research Centre, Kidu and 21 accessions planted at ICAR-CPCRI Research Centre, Mohitnagar for safety duplication. Further, multi-location evaluation of selected lines of coconut (16), arecanut (9) and cocoa (16) were established in different agro-ecological zones in regional stations/centers and research centers of AICRP on Palms. Descriptors for accessions of cocoa (40), arecanut (12) and coconut (11) have been recorded for development of germplasm catalogue. A total of 9.339 lakh planting material units, including 1.397 lakh in coconut, 7.40 lakh in arecanut and 0.539 lakh in cocoa, were produced and distributed to farmers and other stakeholders.

Biotechnology and Bioinformatics

Somatic embryogenesis and plantlet regeneration was achieved in arecanut, from inflorescence explants of Hirehalli Dwarf and dwarf hybrids (VTLAH1 and VTALH-2), and about 100 plantlets are in different stages of development. Embryo rescue of soft endosperm coconut, which do not germinate in nature, could be achieved. Coconut embryo cryopreservation protocol developed was validated in five accessions. Pollen of three coconut accessions (Philippines Ordinary Tall, Laccadive Ordinary Tall and Malayan Green Dwarf) and two arecanut accessions (Hirehalli Dwarf and Sumangala) was stored in liquid nitrogen for long term storage using simple desiccation protocol.

EST-SSR markers, mined from coconut leaf transcriptome data, were utilized in hybrid authentication of 103 progenies derived from 18 crosses involving tall and dwarf parents. Cloning and characterization of full-length TIR-NBS-LRR (Toll/interleukin-1 receptor-like domain-nucleotide-binding site leucine-rich repeat) disease resistance gene analogues and genes induced during somatic embryogenesis in coconut (*BABY BOOM*, *WUSCHEL*, *SERK* and *AP2*) was carried out. A comparative study of gene expression patterns of eight genes, during different stages of *in vitro* regeneration in WCT and COD, using RT-qPCR revealed significant differences in regeneration potential and gene expression patterns, suggesting genotypic differences to *in vitro* culture. Comparative proteomic analysis of zygotic and somatic embryogenesis in coconut revealed 10 proteins, which showed higher expression levels in zygotic embryos in comparison to somatic embryos.

Detection of conserved miRNAs was carried out in ESTs of *Ganoderma lucidum* and red palm weevil. Most of the genes targeted by predicted microRNA in *Ganoderma lucidum* were found to be highly conserved in pathogenic fungi and were involved in transcription regulation, DNA binding, ATP binding and protein binding. The existence of potential miRNAs having major role in ion transport regulation, gene modification etc. signifies importance of miRNAs in regulating insect physiology and in identification of a potential targets for suppression of gene expression in red palm weevil.

Cropping and Farming Systems

Coconut based mixed farming system involving, coconut, black pepper, fodder, fishery, poultry and goats, was found to give high a per hectare net return of ₹ 7,17,955/-. Among the components, dairy, coconut and black pepper contributed 80% of the total returns. Inclusion of fodder legumes and organic supplements was found to help in maintaining the soil fertility and productivity. Organic nutrient management was standardized for cultivation of Hybrid Napier var. Co3 fodder intercrop in coconut plantations, with application of cow dung slurry, vermicompost, *Azospirillum* and *Phosphobacteria* at bimonthly interval resulting in high fodder yield of 139 t ha^{-1}.

It was demonstrated that in coconut based high density multi species cropping system, higher coconut productivity, on par with integrated nutrient management, can be sustained through fully organic treatments including recycling of biomass (vermicompost), green manuring, application of biofertilisers, vermiwash application, husk burial and mulching in coconut basin. Cultivation of medicinal plants, asparagus and *Aloe vera,* improved system productivity under arecanut and coconut based cropping system at CPCRI Research Centre, Mohitnagar. Arecanut based cropping system model involving arecanut, black pepper, acid lime and turmeric continued to record higher system productivity with black pepper contributing 67-70% and the main crop arecanut contributing only 22-26% to total system productivity.

Intercropping of flower crops*, viz. gladiolus* var. Arka Kesar and marigold var. Bangar in coconut plantation, under coastal sandy soil, utilizing soil moisture conservation substrates was successfully demonstrated, and shredded coconut leaf substrate recorded significantly higher yield and quality of flowers. *Heliconia* is a profitable intercrop, with the varieties, *Heliconia stricta* 'Iris', *H. bihai* x *H. caribaea* 'Kawauchi', *Heliconia stricta* 'Sunrise' and *H. orthotropica* 'She' being more suited for intercropping in coconut plantations, than *H. caribaea* x *H. bihai* 'Jacquini' and 'Caribbean Red'. A combination of varieties, namely 'She' and 'Sunrise', can be intercropped in 1:1 ratio for year round production of inflorescences.

Cultivation of high yielding and improved varieties of different vegetables (chillies, brinjal, amarnathus, drumstick, bhendi, cauliflower and cabbage) and fruit crops (banana, papaya, sapota and guava) was successfully demonstrated in Minicoy, Lakshadweep Islands and popularized among the Islanders. With a view to augmenting local requirement of vegetables, a comprehensive action plan been drawn up and the envisaged activities are being implemented. Demonstration of protected cultivation of vegetables with shade net/net house in farmers' gardens has also been initiated.

Bioresource utilization

Two organic products, Kalpa Organic Gold (vermicompost produced from coconut leaves using indigenous *Eudrilus* sp.) and Kalpa Soil Care (urea-free coir pith compost) were launched. Soilless substrates, utilizing recycled coconut biomass residues and their mixtures, such as coconut leaf vermicompost and urea-free coir-pith compost, were assessed and found suitable for raising arecanut and cocoa

seedlings. Application of PGPRs and *Trichoderma* to soilless media, in addition to enhancing the rhizosphere microflora, improved the growth parameters of the arecanut and cocoa seedlings. Efficient coconut leaf vermicomposting with 80-85% conversion efficiency in one cycle (90 days) was achieved by use of coconut fronds (including the hard petiole) pulverized using bio-shredder. Different bioresources *viz.*, *Eudrilus* sp. (coconut leaf vermicomposting earthworms; 1,50,000 nos.), Kalpa Organic Gold (28 tonnes), Kalpa Soil Care (6 tonnes), Kera Probio (PGPR bioinoculant; 120 kg), coconut leaf vermiwash (200 L) and mushroom spawn (20 kg) were produced and supplied to farmers and other end users.

Reducing crop losses

Specific and sensitive PCR assays using species-specific primers were developed for rapid detection of six *Phytophthora* spp. *viz.*, *P. palmivora, P. nicotianae, P. capsici, P. meadii*, *P. citrophthora* and *P. colocasiae* infecting coconut, cocoa and arecanut. The field trial on bud rot disease management indicated that prophylactic treatment with 1% Bordeaux mixture or placement of perforated fungicidal sachets of copper hydroxide or *Trichoderma* coir pith cake was effective in reducing the bud rot incidence. In arecanut disease management trial, less fruit rot disease incidence was recorded in mandipropamid (23.3% SC) sprayed plots. Soil application of *Trichoderma harzianum* (CPTD 28) enriched neem cake @ 5 kg per palm at quarterly intervals was found effective in managing *Ganoderma* wilt disease of coconut.

PCR-based detection of phytoplasma associated with coconut root (wilt) disease was undertaken, with total DNA isolated from spindle leaves, trunk borings, root and inflorescence rachillae of root (wilt) affected coconut palms, using the primers *viz.*, P1/P6-R16F2n/R16R2, F3-B3, P4/P7, SecA for/rev and tuf F/rev. The primer combination P1/P6-R16F2n/R16R2 showed amplification at desired base pair level (1250 bp). Further, PCR detection and characterization of phytoplasmas associated with weeds in coconut gardens *viz., Vernonia cinerea* phyllody, Bermuda grass white leaf and *Mollugo disticha* phyllody, was undertaken. The phytoplasma causing phyllody in *V. cinerea* and *M. disticha* showed homology to *Candidatus* Phytoplasma *australasiae*, belonging to subgroup 16SrII, while the Bermuda grass white leaf phytoplasma showed similarity with *Candidatus* Phytoplasma *cynodontis* belonging to subgroup 16SrXIV.

Integrated pest management (IPM) strategies were fine tuned for suppression of key pests of palms and cocoa with emphasis on biological control, farmer-participatory approaches as well as botanical preparations. Prophylactic treatment against rhinoceros beetle of coconut utilizing talc-coated cake with botanical extracts of *Clerodendrum infortunatum* and *Chromolaena odorata* was observed to reduce rhinoceros beetle induced leaf damage by 54%. Spraying young bunches with combination of coconut oil (200 ml) and sulphur (5 g L^{-1}) emulsion or spiromesifen (1 ml L^{-1}) or neem oil (2%) or common salt (2%) plus APSA (0.2%) were found effective in the suppression of coconut eriophyid mite. Palms treated with chlorantraniliprole (0.018%) and neem oil (0.5%) recorded 73-75% reduction of coreid bug incidence in coconut.

IPM module was developed for the management of root grubs in arecanut garden by timely collection of beetles, application of insecticide (bifenthrin 2 kg ai ha^{-1}), imidacloprid @ 0.045%) and entomopathogenic nematode (*Steinernema carpocapsae* @ 1.5 billion IJ ha^{-1}). Packaging with low density polyethylene (LDPE) of 60-80 micron size resulted in sustained higher survival (69.9%) of EPN, *Steinernema carpocapsae,* up to 30 days in temperature regime of 25-27°C.

Climate Resilient Technologies

Coconut seedlings grown in open top chamber (OTC) had high biomass and seedling growth in response to elevated CO_2 (700 ppm), while it significantly declined under increased temperature (3°C above ambient). Similar decline in growth was also observed under water deficit stress. Coconut genotypes showed wide variability for water use efficiency as a measure of drought tolerance. Genotypes with tall plant habit *viz*., Federated Malay States Tall exhibited higher water use efficiency under normal irrigation while, under moisture stress, water use efficiency was higher in dwarfs, namely Chowghat Green Dwarf. Tolerant genotypes were observed to have better root systems, with stomata regulation as a drought tolerance mechanism. Pollen germination technique was refined to screen the genotypes for high temperature tolerance. As a mitigation potential, coconut could sequester 31 tonnes CO_2 $ha^{-1}yr^{-1}$, which is higher as compared to other plantation crops.

Product diversification, value addition and mechanization

Value added products were prepared from coconut kernel and Kalparasa. Kalparasa, as a value added drink, and different value products were commercialized in Kerala, Goa and West Bengal. Dark chocolate prepared using coconut sugar is of good aroma and taste. Bengali sweets were prepared using Kalparasa, devoid of refined sugar. Preservation of coconut sap using double pasteurization technology was standardized, and bottling technology for pasteurized coconut sap was developed. Soaking time for osmotic dehydration of coconut chips, either with refined sugar or coconut sap, was optimized at 15 minutes with respect to moisture content, biochemical parameters, textural and sensory parameters. Process technology for coconut milk residue and VCO cake based composite extrudates (up to 30% level of incorporation) and VCO cake based muffin cakes (up to 40% level of incorporation) has been standardized.

A grading unit to sort arecanuts as per the size before de-husking and a self loading mechanism for automatic feeding of arecanut were developed in order to improve the efficiency of the arecanut de-husking machine.

Economic, statistical and technology delivery models

Area wide community extension approach for management of coconut red palm weevil in Bharanikkavu grama panchayath, Alappuzha district in 2000 ha during 2014 and 2015, resulted in reduction of of red palm weevil incidence from 2.93 per cent to 0.38 per cent. Community based bio-resource management with in coconut based farming system, implemented in Kanjikuzhy Block of Alappuzha district indicated overall yield improvement to the tune of 16%.

Assessment of incidence and intensity of major diseases and pests of coconut in North Kerala revealed that the level of adoption of plant protection measures was very low and vast majority of coconut farmers do not have adequate knowledge about the IPM measures against the pest. The study on field level scenario and stakeholder perspective in the context of declaring Kasaragod as an organic distract revealed the prevalence of ambiguity and lack of convergence in opinion and conviction on transition to organic farming.

A robust nonparametric covariance technique for controlling the effect of outliers was proposed and verified using the data from arecanut fertigation experiment. The standard errors of the estimates and the estimated value of were lesser in the proposed robust method than the linear and nonparametric covariance technique. The disease severity index of yellow leaf disease (YLD) of arecanut and root (wilt) disease (RWD) of coconut was refined to incorporate the regional and temporal variations in the symptoms and its relationship with the yield. A multiplicative regression model with the primary and other related symptoms and yield were used to obtain a suitable disease index (DI) for RWD of coconut and YLD of arecanut. Spatial autocorrelation and semi-variogram analysis of the data of YLD in Karnataka showed a significant positive spatial auto correlation and indicated that the disease incidence is in cluster form. Analysis of the spreading pattern of *Ganoderma* disease of arecanut in Jalpaiguri (West Bengal) showed that the disease incidence within the gardens are in cluster form.

It was revealed that competitive advantage of India is lower than major coconut exporting countries like the Philippines, Indonesia and Sri Lanka. The price movement of coconut, coconut oil and copra clearly indicates the declining trend of all three items from August 2014 onwards. While examining the monthly price differences, the fluctuations are more in the case of coconuts than copra. We may intuitively infer that the real benefit of higher prices in the coconut oil sector is not proportionally getting transferred to the coconuts, and this in turn proves detrimental to the coconut farmers. Cost of production of coconut in a well-managed coconut garden is ₹ 8.21 per nut. In this scenario, about 58 percent of the total cost is incurred on labour charges, which can be attributed to higher labour demand and higher cost of labour in the states.

Capacity building programmes

Model training course on participatory technology approaches for plantation crops was conducted for 20 officers representing various states. A total of 118 training cum exposure visits, farmer field schools and interface programmes were organized for stakeholders of different states. FLDs on integrated management of coconut root (wilt) disease in seven districts of Kerala, integrated management of root grub in Karnataka and *Ganoderma* wilt of coconut in Kasaragod were conducted. *Mera Gaon - Mera Gaurav* programme was successfully implemented in 70 villages by 62 scientists. World Soil Day was celebrated, wherein soil health cards were distributed to 500 farmers. World Coconut Day was commemorated with various programmes like training, quiz and essay competition at Tumkur and Kayamkulam. *Jai Kisan - Jai Vigyan* campaign was organized at Cheruthazham Krishi Bhavan

with programmes including essay writing for students, quiz competition, method demonstrations and trainings. Seven video films on selected technologies *viz.*, snow ball tender coconut, virgin coconut oil, coconut chips, coconut sugar, integrated pest and disease management and organic farming techniques were produced in collaboration with NABARD. Cyber extension programmes including video conferencing based interface programme with Coconut Development Board, Department of Agriculture and ICAR-CPCRI was conducted.

As an initiative in enhancing the visibility of research activities and popularizing the technologies developed by the institute, an Institute-Industry interface was organized at Kasaragod and technologies were transferred to the tune of ₹ 1,20,000/-.

Krishi Vigyan Kendra

KVK Kasaragod undertook seven OFTs and 18 FLDs, besides 146 training programme benefitting 2809 farmers. KVK Alappuzha organized seven OFTs, 10 FLDs and 93 training programmes benefitting 2248 farmers. In addition, extension activities like harvest festival, campaigns, helpline services, agro clinics, exhibitions, technology meets, and field days were conducted. Technology for management of stem bleeding disease of coconut using organics developed by KVK Alappuzha was accepted for inclusion in Package of Practice recommendations of Kerala Agricultural University.

The XVIII Research Advisory Committee meeting of the institute was conducted on 18th February 2016 and its recommendations were incorporated in the ongoing research programme.

The committed and sustained efforts of ICAR-CPCRI in conducting basic and applied research have culminated in important research achievements, which are aptly reflected by technologies commercialized (21) and quality publications (65).

VISION, MISSION AND MANDATE

Vision

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

Mission

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

Mandate

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

INSTITUTE PROFILE

ICAR-Central Plantation Crops Research Institute is a premier agricultural research institute on coconut, arecanut and cocoa.

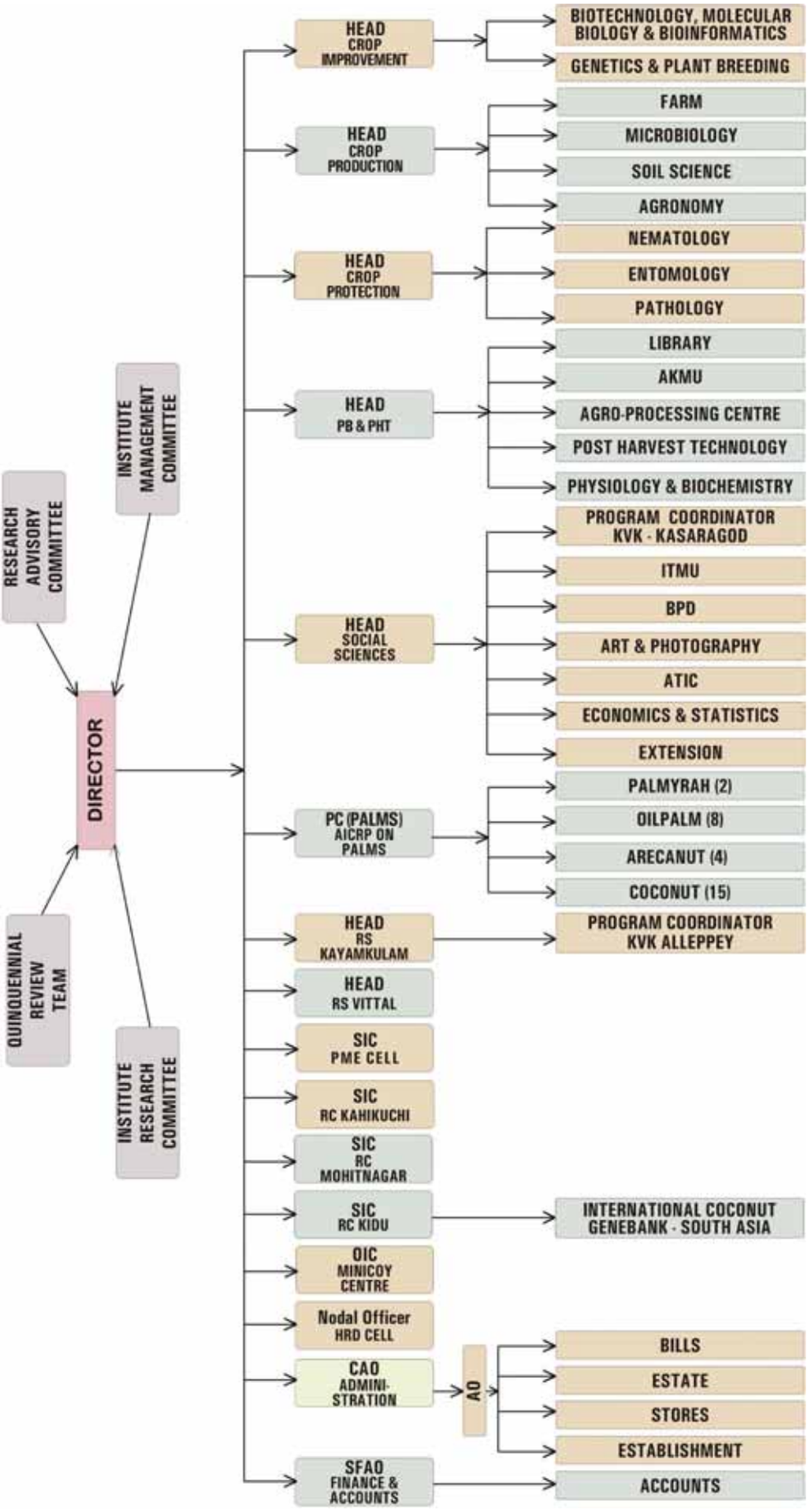
Historical perspective

The Central Plantation Crops Research Institute was established in 1916 as Central Coconut Research Station by the Presidency of Madras and taken over by the Indian Central Coconut Committee in 1948. It was later taken over by the Indian Council of Agricultural Research. The ICAR established CPCRI in 1970 by merging Central Coconut Research Stations at Kasaragod and Kayamkulam as well as Central Arecanut Research Station, Vittal and its five substations at Palode, Kannara, Hirehalli, Mohitnagar and Kahikuchi, with the mandate to work on plantation and spices crops. The research centers of CPCRI for spices, oil palm, coastal agriculture and cashew were subsequently upgraded to independent institutes; Indian Institute of Spices Research, Kozhikode; Indian Institute of Oil Palm Research, Pedavegi; Central Coastal Agricultural Research Institute, Goa and Directorate of Cashew Research, Puttur, respectively.

Currently, ICAR-CPCRI focuses on research in coconut, arecanut and cocoa. The headquarters of the institute is situated at Kasaragod, Kerala and the two regional stations are at Kayamkulam (Kerala) and Vittal (Karnataka). There are four research centres under the institute *viz.*, Mohitnagar (West Bengal), Kahikuchi (Assam), Kidu (Karnataka) and Minicoy (Lakshadweep).

Besides, there are two KVKs (Kasaragod and Kayamkulam) under the institute. All India Co-ordinated Coconut and Arecanut Improvement Project started functioning from 1972 at CPCRI, Kasaragod and was later renamed as All India Coordinated Research Project (AICRP) on Palms in 1986. The AICRP on Palms presently has 15 centres on coconut, four on arecanut, eight on oil palm and two on palmyrah.

Organogram


RESEARCH ADVISORY COMMITTEE
INSTITUTE MANAGEMENT COMMITTEE
DIRECTOR
QUINQUENNIAL REVIEW TEAM
INSTITUTE RESEARCH COMMITTEE
HEAD CROP IMPROVEMENT
BIOTECHNOLOGY, MOLECULAR BIOLOGY & BIOINFORMATICS
GENETICS & PLANT BREEDING
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FARM
MICROBIOLOGY
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AGRONOMY
HEAD CROP PROTECTION
NEMATOLOGY
ENTOMOLOGY
PATHOLOGY
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AKMU
AGRO-PROCESSING CENTRE
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PHYSIOLOGY & BIOCHEMISTRY
HEAD SOCIAL SCIENCES
PROGRAM COORDINATOR KVK - KASARAGOD
ITMU
BPD
ART & PHOTOGRAPHY
ATIC
ECONOMICS & STATISTICS
EXTENSION
PC (PALMS) AICRP ON PALMS
PALMYRAH (2)
OILPALM (8)
ARECANUT (4)
COCONUT (15)
HEAD RS KAYAMKULAM
PROGRAM COORDINATOR KVK ALLEPPEY
HEAD RS VITTAL
SIC PME CELL
SIC RC KAHIKUCHI
SIC RC MOHITNAGAR
SIC RC KIDU
INTERNATIONAL COCONUT GENEBANK - SOUTH ASIA
OIC MINICOY CENTRE
Nodal Officer HRD CELL
CAO ADMINI-STRATION
AO
BILLS
ESTATE
STORES
ESTABLISHMENT
SFAO FINANCE & ACCOUNTS
ACCOUNTS

Achievements at a Glance

Plant Genetic Resources

ICAR-CPCRI maintains the world's largest repository in coconut with 455 accessions (323 indigenous and 132 exotic genotypes) from 28 countries, 173 germplasm collections in arecanut of which 23 are exotic and 141 indigenous and 352 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, 19 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. Ten improved varieties of arecanut, including eight 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 Kannara Local (2 kg dry kernel $palm^{-1}$ yr^{-1}), have significantly improved arecanut productivity in the country. In cocoa, seven high yielding varieties have been released from the institute, three elite clones and four hybrids, which yield up to 2.5 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.

The institute has been producing quality planting materials in coconut, arecanut and cocoa for distribution to farmers and other stakeholders. Seed gardens of improved varieties have been established in the Institute as well as in farmer's garden to augment planting material production. ICAR-CPCRI nurseries at Kasaragod, Kidu, Kayamkulam and Vittal were graded with 'four-star' status in the five star scale by National Horticultural Board. Quality planting materials are produced to an extent of 1.2 lakh coconut seed nuts including 40,000 hybrids, 5 lakh arecanut seed nuts including one lakh seedlings and 1.1 lakh cocoa seedlings annually.

Biotechnology and Bioinformatics

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

Sequence characterized amplified regions (SCAR) markers have been developed for confirming the hybridity at seedling level in both coconut and arecanut. A panel

of SSR markers has been identified for confirming the hybridity of D x T hybrids (CGD x WCT) which will ensure supply of genuine hybrid material to farmers. Transcriptome analysis of response of coconut to root (wilt) disease and somatic embryogenesis have been undertaken using RNA-Seq and transcripts up/ down-regulated have been identified. Many of transcripts down-regulated in root (wilt) diseased palms were primarily involved in defense responses, signaling pathways, cellular transport and other metabolic processes. Transcriptome analysis of coconut embryogenic calli, derived from plumular explants of West Coast Tall, resulted in the identification of 14 genes with important roles in somatic embryogenesis.

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 centres which include MAPS (Microsatellite Analysis and Prediction Software), stand alone EST-SSR analysis pipeline (SEMAT), prediction tools for resistant gene analogues and enzymes in gibberellic acid biosynthesis using machine learning algorithms, prediction of miRNAs in date palm, coconut and *Phytophthora* spp. and transcriptome based reconstruction of carotenoid biosynthetic pathway in cocoa and gibberellic acid biosynthetic pathway in coconut.

Cropping and farming systems

Coconut or arecanut based inter/ mixed, multi-storied multi-species cropping as well as mixed farming systems have been developed by integrating livestock to increase total productivity. The coconut based cropping system using multi-species cropping of coconut with black pepper, banana, nutmeg, pineapple, ginger, turmeric and elephant foot yam generated a net income of ₹ 3.7 lakhs ha^{-1}, which is 164% higher than that of coconut monocrop (₹ 1.4 lakhs), while the coconut based mixed farming system (CMFS) comprising coconut, black pepper, banana, cross bred cows, poultry birds, goat, and pisciculture generated a net return of ` 5.5 lakhs ha^{-1}, reflecting 293% higher return than coconut monocrop.

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

Drip irrigation in arecanut, coconut and cocoa has reduced the use of water to the extent of 35-40 per cent, with increase in yield by 30-40 per cent. Drip fertigation in these crops has reduced the use of chemical fertilizer from 50 to 75 per cent, with increase in yield by 35-40 per cent. *In situ* soil and water conservation techniques such as, half-moon bund reinforced with pineapple planting, trench filled with coconut husk and bund reinforced with pineapple planting and providing catch

pits helps in augmenting the soil moisture availability in coconut plantations having mild slope and could enhance coconut yield up to 60%. This could reduce soil erosion from 2.73 t ha^{-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 ₹ 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 8 tonnes of leaf residues, 3-4 tonnes of vermicompost can be produced annually using the local isolate of *Eudrilus* sp. or 1,660 kg of fresh mushroom can be generated that adds more than ₹ 50,000 per year to the farmer's income. The coconut leaf vermicompost can also meet 50% of the nitrogen requirement of coconut palms grown in one hectare area saving expenditure on inorganic fertilizer. 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 soilless medium for production of quality planting material.

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 P_2O_5 and 110 g K_2O $palm^{-1}$ yr^{-1} that has the potential to meet nitrogen and phosphorus requirements of arecanut which can save the cultivation cost to the extent of ₹ 5,200 ha^{-1}. The yield of arecanut can be sustained at 26 q ha^{-1} by recycling waste as vermicompost. A net income of about ₹ 30,000 could be generated from vermicompost production from wastes of one hectare arecanut garden, while arecanut leaf sheath and bunch waste can result in production of 643 kg fresh mushroom with a net income of about ₹ 30,000.

In the area of microbial bioresources, plant growth promoting rhizobacteria (PGPR) based bioinoculant products, 'Kera Probio' containing *Bacillus megaterium* and 'Cocoa Probio' containing *Pseudomonas putida* have been released for production of healthy and 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 were identified by whole genome sequencing and analysis.

Reducing crop losses

Root (wilt), bud rot, basal stem rot and stem bleeding of coconut; fruit rot and yellow leaf disease of arecanut and black pod and stem canker in cocoa are major diseases that cause substantial crop losses.

Integrated disease management strategies involving farm and palm hygiene, application of soil test based nutrients NPK (N: 500 g, P: 300 g K: 1250 g palm^{-1} yr^{-1} in two splits in May – June and August – September), 250 g $MgSO_4$ palm^{-1} yr^{-1}, irrigating the palms (250 L water palm^{-1} week^{-1}) during summer months, basin management with green manure crops like cowpea and control of leaf rot by application of hexaconazole 5 EC @ 2ml in 300 ml water, which have been developed for root (wilt) and leaf rot affected coconut gardens, could increase the yield by 25-83%, depending on severity of the disease.

Prophylactic treatments of Bordeaux mixture (1%) or placement of two perforated sachets containing mancozeb (5 g) or *Trichoderma* coir pith cakes in the inner most leaf axil of the coconut, just before onset of monsoon, has saved thousands of coconut palms in the bud rot endemic areas. The soil application of *Trichoderma* enriched neem cake (5 kg palm^{-1}) has been able to revive several coconut gardens affected with basal stem rot and stem bleeding disease.

Phytoplasmal etiology of YLD has been established and management of the affected gardens with soil test based application of NPK (N:100 g, P:40 g, K:140 g per palm^{-1} yr^{-1} application of FYM @ 12 kg per palm^{-1} yr^{-1} with summer irrigation (20 L water palm^{-1} day^{-1}) and improving drainage during rainy season has been advocated. Prophylactic spraying Bordeaux mixture (1%) to arecanut bunches just before the onset of monsoon and one more spray after 35-40 days or covering the bunches with polythene bags (200 gauge thickness, 24 x 30 inches size) just before onset of monsoon has reduced the loss to the extent of 90 to 100 % due to fruit rot in arecanut.

Adoption of integrated disease management involving phyto-sanitation and application of Bordeaux mixture (1%) has helped the farmers to harvest healthy cocoa pods free from black pod disease and reduced the crop loss to the extent of 90 % and increased the income on an average of 20-25%. '*Trichoderma* coir pith cake', a new eco-friendly bioformulation, has shown great potential to save the cocoa trees from stem canker disease.

Clean and green innovative pest management technologies have been developed and field validated for the bio-suppression of rhinoceros beetle, red palm weevil, leaf eating caterpillar and eriophyid mite infesting coconut. IPM module for the management of rhinoceros beetle through integration of biocontrol agents *viz*., *Oryctes rhinoceros* nudivirus (OrNV), Green Muscardine Fungus (GMF), *Metarhizium anisopliae*, botanicals (leaf axil filling with neem/ marotti/ pongamia cake @ 250 g mixed with equal volume of sand) and aggregation pheromone embedded nanomatrix trap @ 1 trap 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) have significantly reduced the spear leaf and inflorescence damage to an extent of 81.2%.

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%.

For the bio-suppression of leaf eating caterpillar, augmentative release of stage-specific parasitoids *viz., Goniozus nephantidis* and *Bracon brevicornis* @ 20 parasitoids per palm, removal of heavily damaged outer three leaves and improving soil and palm health of infested palms reduced the leaf damage to 95.3% in a period of 12-15 months. Area-wide field validation and demonstration experiments conducted at Vechoor 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 20EC @ 2.5 ml L^{-1} or imidacloprid 17.8 SL @ 675 ml ha^{-1} or bifenthrin 10 EC @ 20 L ha^{-1} and entomopathogenic nematodes (EPN), *Steinernema carpocapsae* @ 1.5 IJ ha^{-1} during May-June and September-October reduced the areacanut white grub population significantly. Placement of the neonicotinoid, thiamethoxam (2 g) in perforated poly sachets on the innermost two leaf axils of areca palms during April-May safeguarded arecanut palms from spindle bug damage. IPM strategies, developed for phytophagous mites and pentatomid bugs, involving 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 found to be 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.

To study the climate change impact, a simulation model Infocrop-coconut was developed. The model project that coconut productivity will be reduced in East Coast due to dry weather and increased in West Coast due to increased precipitation. Overall, the model project an increase in coconut productivity by 4.3% in 2030 and

1.9-6.8% in 2080. 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. The following coconut varieties *viz*. Chandra Laksha, Kera Sankara, and Chandra Kalpa have been identified as tolerant to water deficit stress. In cocoa, five cocoa accessions (NC23; NC29; NC 31; NC39; NC42) and two hybrids (II-67xNC 42/94, II-67xNC29/66) were identified as tolerant to moisture stress. Coconut pollen germination was very sensitive to high temperature. It was 63% at 30°C and reduced to 14% at 45°C. Across all the temperatures, WCT (58%) had high pollen germination while it was the least in MYD (37%). Management strategies in the farmers field such as husk burial, coir pith compost and mulching with coconut leaves or farm bio-waste increased nut yield by 20 to 75% and increased farmers income. Compared to any other plantation crop, coconut had the highest C-sequestration potential of 20 to 35 t ha^{-1} yr^{-1}. Areca-cocoa system has a standing biomass of 23.5, 54.9 and 87.10 t ha^{-1} in 5^{th}, 8^{th} and 15^{th} years of growth, respectively. Annual increments in biomass or net primary productivity ranged from 1.38 - 2.66 t ha^{-1} in cocoa and 3.34 - 7.11 t ha^{-1} in arecanut.

As a measure of water conservation, the 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 checkdam, sub surface dam, vented cross bars, storage structures using ferro-cement technology could augment surface as well as sub surface water resources.

Product diversification, value addition and mechanization

Value addition is the need of the hour to stabilize the price fluctuation and the institute aims at increasing the present 8% level of value addition to at least 15% by 2020. In that context the recently developed 'Coco-sap Chiller' technology for collecting fresh, hygienic and unfermented coconut inflorescence sap called Kalparasa is very promising. Its adoption by the farmers or producer companies demonstrated that either selling it as health drink or processing into coconut sugar and marketing is highly profitable. A farmer tapping 15 coconut palms for Kalparasa could earn on an average net profit of ₹ 45,000 a month, while a tapping technician can earn about ₹ 20,000 a month. Other value added products, like virgin coconut oil, coconut chips etc and their adoption improved the income of farmers and also generated employment in coconut sector. VCO was also observed to have medicinal properties and effective on Alzheimer's disease. A micro-enterprise venture for production of arecanut leaf sheath plates and cups could accrue income of ₹ 27,000 ha^{-1}.

Farm mechanization and various processing machineries developed at the institute reduced the production cost, increased labor 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 inexperienced women with proper training. This gives much required confidence to the climbers, especially the beginners. Apart from those, other machineries and gadgets have been 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, copra moisture meter.

Capacity building

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.

Applications of ICT tools like videoconferencing to develop linkages with various stakeholders were implemented. Statistical databases have been created, website regularly updated and technical bulletins, CD ROMs, extension pamphlets, information brochures were published. Krishi Vigyan Kendras under CPCRI–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 utilised for facilitating the Research-Extension-Farmer interface. Research-Farmer-Extension interface programmes facilitated through video conferencing were conducted. The Institute website (http://www.cpcri.gov.in) is being updated regularly with 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.

Statistical models to improve field experiments

Spatial (bivariate) smoothing technique was developed to estimate / eliminate the positional effect in field experiments non-parametrically. The method is very much useful when the direction of soil fertility or other location effects influencing the parameter under study to make homogeneous blocks is not known in advance. 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 semiparametric regression technique. A data driven technique was developed to estimate the trend and relative growth rate of time series data. The method was extended for handling sudden shifts or changes in the trend or growth rate functions by adding dummy variables for the jumps. It has been applied to estimate trend and growth rate of area, production and yield of

major crops in India. Robust spatial smoothing technique was developed to estimate the spatial effect of a field in the presence of outliers or extreme observations. It is based on fitting M-type robust non-parametric spatial regression following iterative kernel weighted local regression surface technique. Yield prediction in cocoa was done using biometrical/ partial harvest data.

Business planning and development unit

The Business Planning and Development Unit (BPD) at CPCRI, Kasaragod was established as a sub-project of National Agricultural Innovation Project with the objectives of promoting entrepreneurship in coconut value added products and providing training and consultancy in the area of coconut production and processing technologies.

Impact of CPCRI technologies

Analysis of coconut sector in India in the light of recent policy issues, especially the ASEAN free trade agreement was attempted. Studies on household level consumption of coconut for culinary purpose among the major states of India has been carried out. A general decline in consumption has been observed. A Sectoral System of Innovation (SSI) methodology was developed and applied to analyse the tender coconut market scenario and the results underscore the paramount importance to restructure the chain governance from middleman driven to producer driven, thereby improving the value share of the producer in the chain. In the case of coconut, the results on rate of adoption of the selected technology showed that about 12 per cent of farmers in Kerala adopted coconut hybrids and improved varieties. After three years of intervention with compatible intercrops the coconut yield was increased to 112 nuts palm^{-1} (which is 80% more than yield reported from the base line survey) in farmer fields of northern Kerala. The impact study of improved arecanut varieties revealed that 13.6 per cent of total area in Karnataka is under released arecanut varieties. The economic impact of released arecanut varieties in monetary terms was found to be ₹ 421 million yr^{-1}. The impact assessment of arecanut based cropping systems in coastal region of Karnataka revealed that, total economic impact in monetary terms due to adoption of cropping systems in the region was found to be ₹ 1022 million yr^{-1}. Domestic value chain study in coconut shows that the producers share in consumer rupee is around 64 per cent and the market chain consumes as much as 36 per cent share in the total value chain which reflects the low marketing efficiency of the market channel. Four different marketing channels were observed in the case of arecanut trade. Regarding the consumer's share in the final price, cooperative marketing channel was found to be the most efficient which could provide the farmer with 68.1 per cent of the final price. The analysis on impact of yearly planting materials supplied from ICAR-CPCRI, revealed that there would be an economic impact to the tune of ₹ 1604 lakhs yr^{-1}, considering the economic life span of the coconut palms.

THEMATIC ACHIEVEMENTS

PLANT GENETIC RESOURCES

Exploration and Collection of Germplasm

Coconut

Fig. 1. Natural coconut groves of Car Nicobar Island, explored for germplasm collection

Germplasm exploration undertaken in Andaman and Nicobar Islands resulted in collection of 17 accessions, 16 from Car Nicobar Island and one accession from South Andaman, for specific traits *viz*., dwarfness, large fruit size, high copra, robust stem, high nut production, fruit colour, soft cum easy peel husk, sweet kernel and high tender nut water content (Fig. 1 - 3). A total of 843 seed nuts of germplasm were collected and sown for generation of seedlings for conservation. Observations also revealed presence of a green dwarf population in Goa, a thick shell population from Karnataka and a population with higher tender nut water content and soft tender endosperm from Andaman Islands, and these have been identified for collection. A survey of the coconut populations of Kamrup district of Assam resulted in identification of a distinct green tall population with three whorls of tepals in female flowers (Fig. 4), with potential for utilization in the breeding programme.

Fig. 2. Dwarf coconut germplasm of Car Nicobar Island

Fig. 3. Diverse germplasm collected from Car Nicobar Island

Fig. 4. Germplasm with three whorls of tepals in female flowers

Arecanut

Five distinct accessions were collected, three from Karnataka and one dwarf accession (from ICAR-CIARI, Port Blair) and a semi tall from Andaman and Nicobar Islands (Fig. 5 & 6), enhancing the total arecanut germplasm collection to 173 accessions.

Fig. 5. Arecanut germplasm of Car Nicobar Island

Fig. 6. Dwarf arecanut accession from Andaman and Nicobar Islands

Germplasm Conservation

Coconut

A total of 455 accessions are under different stages of conservation, at different locations, including Kasargod, Kidu (Fig. 7), Mohitnagar, Minicoy, Kahikuchi and WCGC Andamans, with majority of the collections being conserved at Kasargod and Kidu. During this year, 21 coconut lines, including elite germplasm, released

varieties and local control, were planted at Mohitnagar, for safety duplication at sub Himalayan Terai region. Nine accessions, comprising new collections from Lakshadweep and Andaman and Nicobar Islands, selections from conserved germplasm, genetic stock deposited by ICAR-CCARI, were conserved at Kidu, along with WCT and COD. Seedlings of coconut germplasm collected from Andaman and Nicobar Islands, genetic stocks developed from conserved germplasm and registered germplasm, namely Gangabondam (GBGD), Kidu Green Dwarf, Yellow Spicata, INGR13061, INGR13062, INGR13063, and INGR13065 were produced. Seed nuts of INGR13064 were collected and provided for embryo culture.

Assisted pollination for planting material production to facilitate germplasm conservation and multi-location evaluation was undertaken in selected accessions. At Kasaragod, about 9191 female flowers were pollinated in 30 accessions, 2983 *inter se* seed nuts of 20 accessions were produced and sown for generation of seedlings for conservation and evaluation. At Kidu, controlled pollination was undertaken in selected parental palms of Chowghat Yellow Dwarf for evaluation/conservation of the genetic stock developed. Further, 2068 seed nuts in 51 accessions were sown for generation of planting material for regeneration and evaluation. Gap filling with about 376 seedlings in 37 accessions was undertaken in the conservation plots of ICG-SA and National Gene Bank. *Inter se* mating was carried out in 17 WCGC accessions, including Pacific Ocean accessions at World Coconut Germplasm Centre (WCGC), ICAR-CIARI Port Blair, and a total of 8500 female flowers were pollinated and an overall setting percentage of 14.4% was recorded. Relatively higher setting percentage was recorded in Acc 4 (66.4%) followed by Acc 30 (55.2%). A total of 600 *inter se* mated seed nuts of 10 accessions from Pacific Ocean region were received from WCGC for conservation and evaluation. In addition, 363 seed nuts of three were also received from WCGC for conservation and evaluation.

Planting material of five coconut varieties proposed for release were received from the centres of AICRP on Palms for conservation in National Active Germplasm Site (NAGS) and facilitating issue of national identity numbers from ICAR-NBPGR (Table 1).

Fig. 7. Gene bank at CPCRI Research Centre, Kidu

Table 1: Coconut varieties received from AICRP on Palms centres for conservation in NAGS

Name of variety	Depositor	Planting material deposited
GBGD x PHOT	AICRPP, Ambajipeta	15 seedlings (6 month old)
GBGD x LCT	AICRPP, Ambajipeta	15 seedlings (6 month old)
GBGD x FJT	AICRPP, Arsikere	15 seedlings (6 month old)
LCT x CCNT	AICRPP, Veppankulam	15 seedlings (6 month old)
Kamrupa	AICRPP, Kahikuchi	30 seed nuts

Planting material of germplasm/ released varieties were provided to CPCRI Regional Station Kayamkulam for gap filling and RWD screening; CPCRI Research Centre Kidu for conservation and gap filling and to CPCRI Research Centre Mohitnagar for conservation. In addition, seedlings/ tissue samples of germplasm/varieties were provided to facilitate biotechnological investigations, nutrient studies, physiological screening for drought, high temperature and climate change studies. Planting material of germplasm/released varieties were also provided to centres of AICRP on Palms for conservation and evaluation (Table 2).

Table 2: Planting material of germplasm/ varieties provided to AICRP on Palms for evaluation

Germplasm/Variety	Centres of AICRPP
Kalpa Samrudhi	Navsari
Kalparaksha	Navsari
Kalpa Dhenu	Navsari
Kalpar Pratibha	Navsari
Kalpa Mitra	Navsari
INGR 13065	Aliyarnagar, Ratnagiri
Straits Settlement Green Tall	Aliyarnagar

Arecanut

A total of 173 accessions of arecanut are under various stages of conservation at Vittal, Mohitnagar and Kahikuchi. During the year, a total of 2680 female flowers were pollinated in 12 NE batch II accessions for regeneration and conservation, as well as screening against Yellow Leaf Disease (YLD). Planting material of two arecanut varieties proposed for release were received from the University of Agricultural and Horticultural Sciences (UAHS), Shimoga for conservation in the NAGS, a pre-requirement for issue of national identity numbers from ICAR-NBPGR (Table 3).

Table 3: Arecanut varieties received for conservation in NAGS at CPCRI, Regional Station, Vittal

Name of variety	Depositor	Planting material deposited
SAS 1	UAHS, Shimoga	15 sprouts (6 month old)
SAS 2	UAHS, Shimoga	15 sprouts (6 month old)

Cocoa

Fifty seven new plantings were made during the year, with seven local collections and hybrids. A total of 352 accessions are being maintained in field gene banks under coconut and arecanut canopies at CPCRI Regional Station, Vittal. Besides,

30 genotypes were multiplied as clones for planting in the alternate gene bank at CPCRI Research Centre, Kidu.

Characterization and Evaluation

Coconut

Characterization and evaluation of conserved germplasm was undertaken in the National Gene Banks at Kasaragod and Kidu and ICG-SA at Kidu. Under the Consortium Research Platform on Agrobiodiversity, characterization data was recorded in WCT, seven Odisha and four Pacific Ocean coconut accessions for development of germplasm descriptors.

Among the germplasm in stabilized bearing phase, accessions Federated Malay States Tall (FMST), Kenya Tall (EAT32), San Ramon Tall (SNRT), Palawan Tall (PALT), Laguna Tall (LAGT), Philippines Lono Tall (PLNT), Kappadam Tall (KPDT), New Guinea Tall (NGT)I, Niu Leka Dwarf (NLAD), Guam Tall II (GUBT), Jamaica Tall (JAMT), Surinam Tall (SUT), Kongthieyong Tall (KONT), Nigerian Green Dwarf (NIGD), Fiji Tall (FJT), Zanzibar Tall (ZAT), Jamaican San Blas Tall (SBLT), Cameroon Red Dwarf (CRD) and Laccadive Orange Dwarf (LCOD), continued to show higher potential for yield and yield component traits. Among the Pacific Ocean germplasm, higher nut yield was recorded in Niu Bulavu (TVT), Solomon Tall (SIT), Niu Hako (NUH), Tutiala Tall (SMOT02), Rennell Tall (RIT) and Nikkore Dwarf (NGOD). Parental lines from selected accessions *viz.*, SUBD, RTB04, KTOD, KYD, SLYD, AYD, LCOD, FMST, RIT, ADOT, WAT were identified for development of new cross combinations for evaluation.

In the germplasm evaluation trial laid out in 1990 involving 10 accessions, SNRT, EAT32, FMST, PLNT, PALT and FJT were found to record significantly higher yield than West Coast Tall (local control), with more than 24 kg copra palm^{-1} yr^{-1}. Among these, SNRT, EAT32, FMST were also observed to give consistently higher yield (>23 kg copra palm^{-1} yr^{-1}) in the AICRPP centre at Aliyarnagar in Tamil Nadu. Hence, high yielding selections of FMST (IND010S), EAT32 (IND042S), SNRT (IND034S) were recommended for varietal release at the institute level (Table 4).

In the comparative dwarf evaluation trial, including 33 accessions, significant variation was recorded for plant height, girth, leaf length and leaf production. Early flowering was recorded in NGOD and GBGD, followed by MOD, MYD, MGD and AYD.

Among the indigenous collections in pre-stabilized phase at CPCRI Research Centre Kidu, Kurmadera Tall, Burmanella Tall, Aliyarnagar Tall, Chandan Nagar

Table 4: Promising coconut selections identified for varietal development and release

Varietal Identity	Breeding method	Copra content (g nut^{-1})	Nut vield (nuts palm yr^{-1})	Copra yield (kg palm yr^{-1})
IND034S	Selection from San Ramon Tall	272.9	105	28.65
IND042S	Selection from Kenya Tall	189.0	130	24.18
IND010S	Selection from Federated Malay States Tall	201.0	128	25.29

Tall, Mayipadi Tall, Achamthuruty Tall, Sendagan Tall, Malaca Tall, Barajaguli Tall, Chappadam Tall, Pinarai Tall, Mullasery Tall, Pallisery Tall, Arasampatti Tall, Champin Micro Tall, Kodiaghat Tall, Laccadive Micro Tall, Katchal Micro Tall, Bionliton Green Tall, Manjery Tall and Nicobar Beak Tall, exhibited early bearing and high yield potential.

Fig. 8. Local coconut germplasm at CPCRI Research Centre, Kahikuchi

At CPCRI Research Centre Mohitnagar, evaluation of accessions in sub Himalayan Terai region indicated significant variation for trunk height and girth. At CPCRI Research Centre Kahikuchi (Fig. 8.), among the 13 local accessions under evaluation, there was no significant difference in plant height and girth. Among the 15 conserved germplasm under evaluation, Chandra Sankara recorded higher nut yield.

In the ICG-SA at Kidu, higher bunch and nut yield was recorded in Panama Tall (PNT), Strait Settlement Apricot Tall (SSAT), SNRT, Sakhigopal Tall (SKGT), Benaulim Tall (BENT), Rotuma Tall (ROT), NGT, Andaman Ordinary Tall (ADOT), Laccadive Ordinary Tall (LCT), Kulasekaram Yellow Dwarf (KYD), Kar Kar Tall (KKT), Guam Tall (GUAT), Blanchissuse Tall (BLIT), Cochin China Tall (CCNT), Borneo Tall (BONT), Car Nicobar Tall (CART), FMST, Laccadive Micro Tall (LMT), Lifou Tall (LFT), Malayan Yellow Dwarf (MYD), Tiptur Tall (TPT), West African Tall (WAT), West Coast Tall (WCT) and CRD among Indian accessions; Sambava Green Tall, Sambava Green Tall, Coco Bleu Tall, Comoros Tall and Pemba Red Dwarf among Indian Ocean accessions (Fig. 9); Kayemkola Tall, Rupdia Tall, Khairtala Tall, BARI Narikel-II

Fig. 9. Pemba Orange Dwarf from Mauritius

Fig. 10. Bagharpara Tall accession from Bangladesh

and Bagharpara Tall among Bangladesh accessions (Fig. 10) and Gontembili Tall, Sri Lanka Red Dwarf and Sri Lanka Yellow Dwarf among Sri Lankan accessions.

Fig. 11. Comparative fruit component traits among select coconut accessions

Fruit component analysis undertaken in 12 accessions, including South East Asian, African, South American, South Asian and Indian Ocean accessions, indicated higher copra content (comparable to SNRT) in the Nicobar Tall population, Aukchung Tall (Fig. 11). Evaluation of tender nut water quality in selected accessions at Kidu, indicated good tender nut water quality with higher tender nut water content in Rennell Island Tall (RIT), British Solomon Islands Tall (BSIT), SSAT and Yellow Spicata (Fig. 12).

Fig. 12. Tender fruits of RIT and BSIT in comparison to COD: a) tender fruits, b) CS of RIT tender fruit

Comparative evaluation of six dwarfs, *viz.* Chowghat Orange Dwarf (COD), MYD, Malayan Orange Dwarf (MOD), Chowghat Green Dwarf (CGD), Gangabondam Dwarf (GBGD), CRD, for tender nut purpose, indicated higher tender nut water content and tender nut water yield in CRD, followed by MOD. Studies on coconut milk and VCO recovery in eight accessions *viz.*, PALT, Gangapani Tall (GPT), PNT, Nicobar Beak Tall (NIBT), JAMT, CRD, ADOT, FMST, indicated higher VCO recovery in FMST, JAMT and NIBT. Further, in addition to quantitative differences in coconut milk and oil yield, qualitative differences in oil quality, with respect to aroma and colour was observed among the accessions.

Screening against abiotic stress - moisture deficit, cold and high temperature

Among the 15 cold tolerant selections under evaluation at Mohitnagar, higher plant height and girth was recorded in Lataguri-II followed by Mohitnagar-III, with higher leaf production in Mohitnagar-III followed by Malbazar-II. In the 15 accessions studied for cold tolerance at Kahikuchi, COD, WCT, Assam Green Tall, Chandra Laksha were found to produce inflorescences continuously during winter period. More number of female flowers was recorded in Chandra Sankara, but flowering was not seen during all the months. Among dwarfs, COD was found to perform better than MYD.

Among the 12 accessions under physiological screening for moisture deficit stress tolerance and adaptation at Kasaragod, which includes six dwarfs, significant differences were observed for growth and adaptation. CGD showed higher water use efficiency and better adaptation to water deficit stress.

Response to inflorescence sap production and quality

Observations on inflorescence sap yield and quality in 14 accessions *viz.*, WCT, LCT, FJT, JAMT, GPT, NIGD, FMST, Hazari Tall (HAZT), Nu Quawen Tall (NUQT), MYD, CRD, GBGD, CGD, COD, indicated variation in sap yield and quality. Sap yield varied between accessions as well as between palms and in general was lesser in dwarfs. Among the six dwarf accessions studied, sap yield was very low in CGD, followed by GBGD, while MYD and CRD were observed to produce higher quantity of sap. Highest sap yield was observed in LCT followed by NIGD, FMST, WCT and FJT.

In situ characterization of new ecotypes

In situ characterization was undertaken in a coconut population in Palakkad district of Kerala (Table 5). Biochemical characterization (total protein content, poly phenol oxidase and peroxidase activity) of a pink husked coconut accession was carried out. Selfing was done in one inflorescence and *inter se* mating in four inflorescences in one selected pink husked accession.

Table 5: *In situ* characterization of a coconut population in Palakkad district

Variable	Minimum	Maximum	Mean+SD
Plant height (cm)	920	2015	1559.0±217.3
Girth of trunk at base (cm)	74	200	126.5±27.8
Trunk girth (cm)	68	144	99.0±15.0
No. of leaf scars metre $^{-1}$	9	28	14.8±3.1
Length of internode (cm)	4	11	7.1±1.4
No. of leaves on crown	22	36	27.6±2.7
Length of petiole (cm)	73	131	102.1±11.9
Length of leaflet bearing portion (cm)	236	417	304.2±29.8
Leaf length (cm)	315	538	406.3±37.8
No. of leaflets (one side)	87	123	108.3±7.5
Length of leaflet (cm)	80	145	106.8±12.5
Breadth of leaflet (cm)	4	7	5.8±0.6
Length of inflorescence (cm)	72	133	106.3±12.5
Length of spikelet bearing portion (cm)	16	51	34.3±6.5
Length of stalk (cm)	13	61	40.8±7.0
Girth of stalk (cm)	4	16	8.5±1.7
Length of spikelet (cm)	25	57	39.4±5.8
No. of spikelets inflorescence^{-1}	22	48	33.0±5.2
No. of female flowers	4	71	20.5±11.3
Total bunches on the crown	8	18	12.2±1.5
Tender nut water quantity (ml nut^{-1})	130	600	309.6±88.0
TSS (°Brix)	5	7	6.1±0.6

Arecanut

Yield and its component traits have been recorded in 124 indigenous accessions which are under evaluation for economic traits. Accessions, Rongron, Darangiri, Cal-33, Kodinar and Nalbari recorded high dry kernel yield of 3.58, 3.86, 3.90, 3.98 and 4.10 kg palm^{-1} yr^{-1}, respectively (Fig. 13 & 14).

Fig. 13. Arecanut accession – Kodinar

Fig. 14. Arecanut accession – Cal - 33

At Kahikuchi, among the 17 local germplasm under evaluation, Borehat recorded higher vigour with greater plant height, more number of leaves and higher circumference (four years after planting).

A total of 40 arecanut genotypes including 12 released varieties, two dwarf hybrids, a natural dwarf mutant and a promising variety were characterized using nine SSR markers (AC01, AC06, AC07, AC08, AC14, AC23, AC28, AC29 and AC30). The genotypes clustered at 43% similarity. The dendrogram formed two major clusters, with the first cluster containing only three accessions with greater diversity *viz.*, VTL 81, VTL 41 and VTL 66 (Fig. 15). The second cluster was subdivided into five sub clusters, comprising 37 genotypes (Cluster IIa - 22, IIb - 1, IIc - 9, IId - 3, IIe - 2 genotypes). Hirehalli Dwarf (VTL 56) clustered with Swarnamangala (VTL 12) in Cluster IIe, while dwarf hybrids, VTLAH 1 and VTLAH 2, clustered along with seven tall genotypes in Cluster IIc.

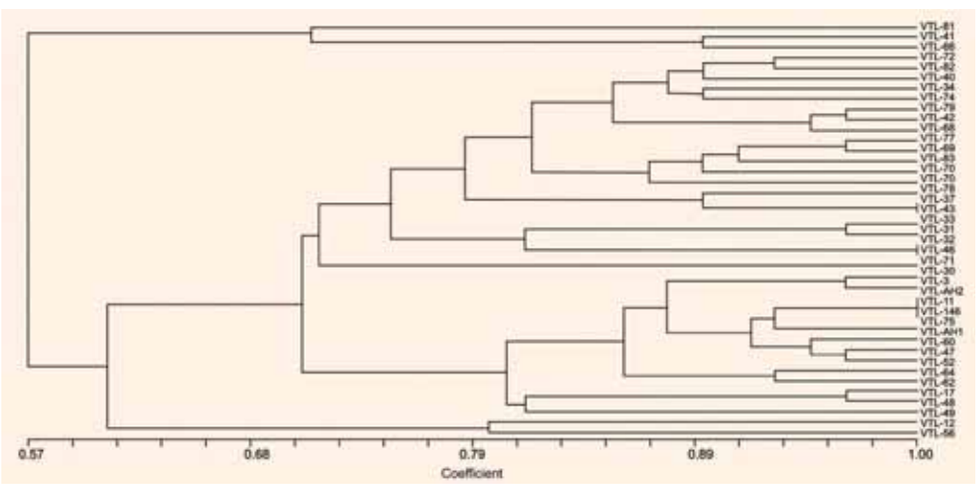


Fig. 15. Cluster analysis of arecanut genotypes – SSR data

Based on 14 morphological and 17 yield and fruit components, 12 North East batch II collections were described. Tender nut processing study was undertaken in nine accessions of Gujarat and 17 accessions of North East batch I collections. Accessions Dudina, Mahuva and Malan among Gujarat collections and Tura, Bokul and Kalirhat of North East collection recovered more than 68% first quality processed tender nut.

Cocoa

For development of cocoa catalogue, 20 clones were characterized with morphological descriptors. Fifteen years of clonal evaluation of local collections from Wayanad and exotic collections from Nigeria at Karnataka and Kerala resulted in identification of three selections VTLC-120, VTLC-13, VTLC-20 as promising with 2.5 to 2.8 kg annual dry bean yield, optimal canopy (15-20 m^2), both under arecanut and coconut shades, high bean index, processing value and tolerance to biotic and abiotic stress. The selections were released as varieties for commercial exploitation at the institute level (Fig. 16 & 17).

Fig. 16. Cocoa selection – VTLC-13

Fig. 17. Cocoa selection – VTLC-20

In the other evaluation trials, different promising clones were identified for further exploitation: four Malaysian, seven Nigerian, five Trinidad and two Wayanad collections with >50 pods and 2 kg dry bean yield $tree^{-1}\ yr^{-1}$ and optimal canopy (15-20 m^2); 12 clones with >1.5 g single bean dry weight, with the highest being 1.92 g in NC-57; 32 clones with >50% fat content in nibs. Further, higher range of 50-65% fat was observed in 52 new Amazon collections (introduced during 2007).

Screening for black pod rot, tea mosquito bug and low moisture stress

Infection due to pod rot, during the main harvest season (June-August), was observed to be lesser among some of the collections: 2% in Nigerian, 3.3% in Malaysian, 5% in Amazon, 7.8% in Kew and 8.5% in Ghana clones. The clones VTLC 7, VTLC 4, VTLC 2, VTLC 11, VTLC 6 were observed to be free of tea mosquito bug damage during May, while 11 genotypes with red color smooth surfaced pods were observed to be free of tea mosquito bug damage during October.

Fig. 18. Cocoa hybrid - VTLCH-4

Morpho-physiological responses of cocoa seedlings

to induced water deficit stress resulted in identification of VTLCP-22, VTLCP-24 and VTLCH-4 (Fig. 18) as tolerant types, with low stomatal conductance and low transpiration rate. Screening with biochemical markers, lipid peroxidation and antioxidant enzymes revealed that VTLCH-4, VTLCP-26 and VTLCP-22 had high catalase and superoxide dismutase activity under water deficit stress. Threshold levels for moisture stress were standardized (Table 6).

Table 6: Threshold levels for low moisture stress traits in cocoa seedlings

Soil moisture content (%)	20% FC
Physiological traits	
Stomatal resistance (s cm^{-1})	≥ 10.77
Conductance (mole m^{-2} s^{-1})	≤ 0.36
Transpiration rate (mmol m^{-2} s^{-1})	≤ 0.99
Leaf water potential (bar)	≥ -19
Photo (µmol m^{-2} s^{-1})	≥ 9.62
$CO_{2\ int}$ (ppm)	≥ 300
WUE (Pn E^{-1})	≥ 10.49
Pn/C_{int}	≥ 0.032
Chlorophyll fluorescence (Fv/Fm)	≥ 0.31
Epicuticular wax (µg cm^{-2})	≥ 20.58
Biochemical metabolites	
Total soluble sugar (µg g^{-1} MF)	≥ 16.86
Total amino acid (µg g^{-1} MF)	≥ 2.05
Proline (µg g^{-1} MF)	≥ 0.048
Protein (µg BSA mg^{-1} MF)	≥ 0.84
Antioxidant enzymes	
Superoxide dismutase (Specific activity min^{-1} $protein^{-1}$)	≥ 0.5
Catalase (Specific activity min^{-1} $protein^{-1}$)	≥ 0.07
Peroxidase (Specific activity min^{-1} $protein^{-1}$)	≥ 0.83
Polyphenol oxidase (Specific activity min^{-1} $protein^{-1}$)	≥ 0.147

DUS Centre for Coconut

Information on provisions of PPV & FR Act and registration of varieties was disseminated to farmers, students and other stakeholders. One application has been received for on-site DUS testing. At the DUS centre under the PPV & FR Authority, juvenile growth characters, such as seedling height, petiole length, girth, number of leaves in crown, leaflet count, leaflet length, leaflet breadth were recorded in 11 extant/ reference varieties (planted in 2013) for generation of DUS test data. Early flower initiation, 26 months after planting, was recorded in COD and Chandra Sankara. On-site DUS characters with respect to inflorescence and fruit characters were recorded on seven released/extant varieties for development of database. About 40 seed nuts each of selected reference/ released/ extant varieties were sown in polybags for generation of seedlings for DUS testing. Time taken for germination and seedling growth characters were recorded.

Germplasm Utilization

Coconut

Characterization for tender nut traits and VCO recovery was undertaken in D x T hybrids, including COD x WAT and COD x LCT which were released at institute level by the Institute Research Committee on the basis of their better performance over other hybrids and WCT for copra and tender nut traits. Preliminary observations showed higher VCO recovery in COD x WAT followed by COD x WCT. Morphological traits recorded in the newly planted (during 2013 and 2014 at Kasaragod and Kidu, respectively) Dwarf x Tall hybrid evaluation trials comprising 28 hybrid combinations (seven dwarf parents crossed with four tall parents), indicated that the hybrids exhibited vigorous growth compared to tall and dwarf parental accessions. Morphological observations in the technology evaluation trial (with 10 lines planted, during 2012 in farmer's garden at Tamil Nadu) revealed differences in growth, with better leaf production and plant height in FMST, Kera Chandra and Kalpa Pratibha. Dwarf x Dwarf trials at Kidu were observed for bunch production and tender nut quality. Hybrids, MYD x CGD, COD x GBGD, MYD x NLGD and MYD x GBGD continued to be better for bunch production and tender nut traits. Fruit component analysis in MYD x NLGD indicated copra content ranging from 224-356 g.

Flowering observations in the trial involving selfed progenies of coconut planted at Kidu, with S_1 and open pollinated progenies of five accessions, indicated early flowering among selfed progenies of MYD and GBGD. Forty five selfed progenies of MYD, GBGD and MOD and 18 open pollinated progenies of WCT, MOD and LCT were gap filled in the trial. A total of 181 S_3 progenies produced from selfing of S_2 palms at KAU were field planted at Kidu along with COD, WCT and LMT. Evaluation of progenies of six dwarf accessions viz., MOD, MYD, COD, CGD, GBGD and CRD, indicated wide variation for annual nut yield ranging up to 232 nuts per palm. Tender nut studies in four hybrids *viz.*, WAT x RIT, WAT x RGT, WAT x NAT and PHOT x GBGD, indicated wide variability in volume of tender nut water (Fig. 19 & 20), ranging from 257 ml (WAT x RGT) to 526 ml (PHOT x GBGD). PHOT x GBGD also recorded higher annual nut yield of 70 nuts palm^{-1}, on par with WAT x RGT

Fig. 19. Tender fruits (6 months stage) of experimental hybrids

Fig. 20. PHOT x GBGD tender fruits with large cavity

Fig. 21. CGD x LCT hybrid with bright green fruits

(64 nuts) and COD x WCT (63 nuts). Among the nine hybrids (including D x T and T x D hybrids) under evaluation at Kidu, three hybrids were found better performing for annual nut yield (four years average) and were on par, namely CGD x LCT (102 nuts palm^{-1}, Fig. 21, CGD x PHOT (94 nuts palm^{-1}) and PHOT x CGD (90.5 nuts palm^{-1}). About 30 selected hybrid/parental palms were removed and planted for assessing feasibility of successfully replanting adult coconut palms. Among the seven T x T hybrids and four parents evaluated at Kasaragod, FJT x WCT showed positive heterosis (25.14%) over WCT for nut yield.

Production of new hybrid combinations

Pollination programme was continued at Kasaragod and WCGC, Andaman for production of experimental hybrids. Pollen of HPOD and NLGD was received from WCGC for pollination and production of experimental crosses at Kasaragod and 347 female flowers were pollinated in three Dwarf x Dwarf combinations from April 2015 to February 2016. Besides, 1188 female flowers were pollinated in four different Dwarf x Dwarf combinations at Kasaragod and 4067 female flowers pollinated in 19 D x T hybrids including five newly released/ identified hybrids Kalpa Samrudhi, Kalpa Sreshta, MYD x EAT32, COD x LCT, COD x WAT and 14 new D x T combinations involving FMST and ADOT as male parents and LCOD, AYD, RTB04, KYD, MOD, CRD, SUBD, SLYD and KTOD as female parents. Pollen of CCNT and SNRT were processed and despatched from Kasaragod to ICAR-CIARI, Port Blair for production of experimental crosses. At WCGC, Andamans a total of 1633 female flowers were pollinated in nine different D x T cross combinations and overall setting percentage 28.4% was recorded. A total of 82 seed nuts of experimental hybrids, including the parents were received for sowing.

Pollination for new cross combinations *viz.*, CGD x FMST, CGD x ADOT, COD x FMST, COD x ADOT, MYD x FMST, MYD x ADOT, SUBD x FMST, SUBD x ADOT, SUBD x RIT, Coco Bleu x FMST, Coco Bleu x ADOT, Coco Bleu x RIT, GDD x FMST, GDD x ADOT and GDD x RIT was initiated during the year at Kidu, aiming for dwarfness, higher copra, good tender nut qualities, and earliness in flowering. A total of 535 female flowers were pollinated during January 2016. A total of 829 and 1211 female flowers were pollinated for production of COD x LCT and COD x WAT combinations, respectively, at Kidu during January 2015 to January 2016. A total of 2951 and 2454 female flowers were pollinated for production of the newly released hybrids Kalpa Samrudhi and Kalpa Sreshta at Kidu during the same period. A total of 68 COD x LCT and COD x WAT and a total of 233 hybrid seed nuts of Kalpa Samrudhi and Kalpa Sreshta were harvested from the first harvest during January 2016 and sown at Kidu. At Kasaragod, 244 nuts of Kalpa Sreshta, 58 nuts of Kalpa Samrudhi and 151 nuts of MYD x Kenya were produced and sown. In addition, at Kasaragod 1652 seed nuts of 18 Dwarf x Dwarf combinations were produced and sown for experimental planting. Germination and seedling observations were recorded in about 3500 crossed progenies of different combinations that are established in poly bag nursery for experimental purpose.

Technology evaluation trials

Technology evaluation trial in farmers' fields has been established in Kerala and Tamil Nadu with released dwarf varieties Kalpa Surya, Kalpa Jyothi and a promising dwarf line IND 092S. In Karnataka, evaluation trial of three dwarf tender nut varieties,

Fig. 22. Trial for moisture stress tolerance in farmer's field (withering old palms of local population seen adjacent to experimental seedlings)

Kalpa Surya, Kalpa Jyothi and Chowghat Orange Dwarf, released from the institute, were established at three seed farms of State Department of Horticulture, Dakshina Kannada District. Seedlings of the released hybrid, Kalpa Samrudhi, were planted in farmer's field at Tamil Nadu and seedlings are produced for planting in Andhra Pradesh, Karnataka and Kerala. Technology evaluation is in progress for drought tolerance in Tamil Nadu (Fig. 22). Seedlings of Kalpa Samrudhi were also provided to AICRP on Palms, Navsari Centre for technology evaluation. Hybrid seedlings of identified crosses such as MYD x CGD, MYD x EAT32, MYD x WCT, COD x LCT and COD x WAT were produced for establishment of multilocation trials. Seedlings of MYD x CGD were provided to AICRP on Palms centre, Veppankulam, Tamil Nadu for planting in the ongoing trial.

Population improvement and trait - specific genetic investigations

Fig. 23. Five bulbil plantlets from single inflorescence of coconut

Forty *inter se* mated LMT seedlings were selected and planted at farmer's field at Tamil Nadu and 14 seedlings planted at Kidu for further evaluation along with dwarf and tall selections. A cross of LMT x COD was initiated for use as mapping population and 110 female flowers were pollinated. Bulbil shoots obtained from the bulbiferous coconut palm were successfully rooted and a total of five secondary bulbil shoots are under vegetative growth (Fig. 23).

Preliminary observations on stem traits of 36 hybrids involving eight tall

and one dwarf parents planted in 1972 showed the possibility of exploiting SNRT among the talls for higher degree of dwarfness in terms of leaf scars spacing. Selfing of MYD x CGD and MYD x NLGD hybrid palms was commenced for studying the segregation pattern.

Varieties notified

Dwarf x Tall coconut hybrid Kalpa Samrudhi, suitable for copra and tender nut purpose and tolerant to moisture deficit stress, was notified in the gazette of Govt. of India for cultivation in the states of Kerala and Assam (Fig. 24). Another variety Kalpatharu, with higher moisture stress tolerance potential and suitable for production of premium grade ball copra, in addition to coconut oil, was notified in the Gazette of Govt. of India for the states of Karnataka, Tamil Nadu and Kerala.

Besides, the release proposal on a Dwarf x Tall coconut hybrid Kalpa Sreshta (Fig. 25), involving IND058S as female parent and IND125S as male parent, was recommended by Central Sub Committee on Crop Standards and Release of Varieties of Horticultural Crops for release and notification during its 23rd meeting held on 7th April 2015 at ICAR-IIHR, Bengaluru.

Fig. 24. Coconut hybrid Kalpa Samrudhi (MYD x WCT)

Fig. 25. Coconut hybrid Kalpa Sreshta (MYD x TPT)

Development of superior genetic stock

A dwarf population bearing bright apricot coloured fruits (having shades of red, orange and pale yellow) at the tender fruit stage, large fruits with lesser husk and higher volume (870 ml) of good quality tender nut water (TSS 5.7° Brix) was developed through selection and controlled pollination from SSAT (a tall accession bearing orange coloured, small to medium in size fruits). The attractive colour and fruit characteristics of this genetic stock has immense potential for exploitation in ornamental horticulture and tender coconut production (Fig. 26).

Fig. 26. Apricot coloured dwarf genetic stock: a - Crown, b - Tender fruit with apricot colour, c - Husked fruits

A robust, early flowering dwarf selection was developed from the Surinam Brown Dwarf (SUBD) accession. At Kidu, this selection started bearing 4-5 years after planting. The inflorescences are long with higher number of fruits (10-15 fruits bunch^{-1}). The fruits are medium in size, oval in shape and brownish green in colour. The husk content of the fruits is lower and the tender nut water is around 775 ml. (Fig. 27). Planting material of this selection has been generated and efforts to evaluate this selection for its reaction against abiotic/ biotic stress, especially tolerance to cold and moisture stress, is underway.

Fig. 27. High yielding dwarf selection from SUBD: a - Crown, b – Inflorescence

Fruit component analysis was undertaken in Yellow Spicata, and desirable fruit characters of higher copra content (ranging from 208 to 399 g) and with low proportion of husk in comparison to the conserved tall spicata accession (WCT01), WCT and COD was recorded (Fig. 28). Development of a brown dwarf genetic stock from Tiptur coconut population, with very good tender nut water quality and containing up to 380 ml of tender nut water is in progress.

Fig. 28. Dwarf yellow spicata: a - Crown, b – Fruit traits

Breeding for resistance/tolerance to coconut root (wilt) disease

Surveys were undertaken in 'hotspots' of root (wilt) disease and characterization of 200 Chowghat Green Dwarf (CGD) mother palms was completed with GPS tagging. Sero-diagnosis of 134 CGD mother palms based on ELISA test was completed and 78 palms were found with negative reaction. Crossing was carried out on 101 Chowghat Green Dwarf palms involving 474 bunches and 13,142 female flowers. Observations recorded (30 months after planting) from the trial involving six different green dwarfs revealed that 93% of GDD have started flowering followed by GBGD (60%) and CGD (50%). The initial inflorescence production in GDD was significantly superior compared to other dwarfs. In the experiment on evaluation of dwarfs and hybrids (planted during 2009), CGD x WCT and CGD x MGD continued

to record less root (wilt) disease incidence (8.8% and 11.1%, respectively), with nut yield of 40 nuts palm^{-1} yr^{-1}. Higher root (wilt) disease incidence was recorded in MOD (30%) followed by MYD x WCT (28.6%). In the new evaluation trial (started during November 2014) involving 13 promising tall accessions, CCNT recorded the highest plant height and number of leaves while FMST recorded highest collar girth followed by CCNT. The juvenile growth characters of self and *inter se* mated progenies of WCT (raised from S_1 WCT population), continued to be on par (three and half years after planting).

Pollination biology studies

The population of floral visitors was significantly higher in MOD compared to MYD, MGD and CGD. Bee population (*Trigona iridipennis*, *Apis cerana indica*, *Apis dorsata*) was found to be the maximum (10 bees inflorescence^{-1}) during August - September. Population of different flies was higher (8 flies inflorescence^{-1}) during September. Weevils (*Amorphoidea coimbatorensis)* and other insect visitors were found maximum (22-25 weevils and 48-50 other insect visitors inflorescence^{-1}) during July. In general, insect population and diversity was higher during July (81 insects inflorescence^{-1}).

Seedling selection standards

The selection criteria for six month old seedlings were fixed based on the best 70 % among the 400 coconut seedlings. Accordingly, the recommended selection criteria for Kalpasree seedlings are as follows: collar girth of ≥ 7.1 cm and 4-6 leaves and for Kalparaksha: collar girth of ≥ 8 cm and 5-8 leaves for six month old seedlings. Similarly, the criteria for nine month old Kalpasree seedlings are: collar girth of ≥ 9.7 cm and 6-8 leaves and for nine month old Kalparaksha seedlings: collar girth of ≥ 12 cm, 7-10 leaves and early splitting. The selection criteria for one year old Kalpasree seedlings are: collar girth of ≥ 11 cm, 7-10 leaves and early splitting in one leaf and for one year old Kalparaksha seedlings: collar girth of ≥ 12.7 cm, 8-12 leaves and early splitting in 1-2 leaves.

Arecanut

Studies were undertaken on yield components in dwarf and tall hybrids at Vittal, Mohitnagar and Kahikuchi. High yielding selection of arecanut *viz*., VTL146 was recommended for varietal release. Significant difference among the hybrids and parents for chali (dry kernel) yield were observed in the dwarf hybrid trial. Higher dry kernel yield was recorded in HD x Mohitnagar (2.66 kg palm^{-1} yr^{-1}) followed by Mohitnagar x HD (2.50 kg palm^{-1} yr^{-1}) and HD x Sumangala (2.52 kg palm^{-1} yr^{-1}), while tall parents showed superiority in dry kernel yield as compared to dwarf hybrids.

In the MLT at Kahikuchi and Mohitnagar, growth parameters *viz*., total palm height, stem height, stem girth, number of nodes, leaf production and internodal length were recorded in eight dwarf hybrid combinations. Hybrids and parents varied significantly for the morphological parameters studied, except leaf production. Significant reduction in height, crown length and crown size were observed in the eight hybrids while tall parents showed more vigorous growth (Fig. 29).

Fig. 29. Multilocation trial of arecanut at CPCRI Research Centre, Kahikuchi

Fig. 30. Mohitnagar x Mangala arecanut hybrid

In the tall hybrid trial, Mangala x Shriwardhan, Shriwardhan x Sumangala and Mohitnagar x Mangala (Fig. 30) combinations continued to record higher dry kernel yield of 3.46, 3.68 and 3.92 kg palm^{-1} yr^{-1}, respectively.

Planting of MLT of released varieties and promising cultivars, comprising of Mangala, Sumangala, Sreemangala, Swarnamangala, Mohitnagar, Madhuramangala, Shriwardhana and VTL-146, was undertaken in centres of AICRP on Palms at Wakawali (Maharashtra) and Navile (Shimoga, Karnataka). Mother blocks of Hirehalli Dwarf were established with 25 seedlings each at Shimoga and Wakawali.

Screening for Yellow Leaf Disease

Growth traits were recorded in tissue culture material in two farmers' gardens at YLD endemic Sampaje. Indexing for disease incidence was carried out and no symptoms of YLD were observed. Recording of growth traits and disease indexing

Fig. 31. *Areca microcalyx* in YLD endemic area at Sampaje

Fig. 32. Dwarf arecanut hybrids in YLD endemic area

were undertaken in YLD screening trial comprising of three *Areca* species and one related genera, and so far no symptoms of YLD have been observed. Among the *Areca* species, *Areca triandra* and *Areca microcalyx* have started bearing (Fig. 31). Screening of six dwarf hybrids along with parents for YLD tolerance/resistance is in progress in the farmers' garden at Sampaje and so far has not exhibited symptoms of yellowing of leaves (Fig. 32).

Production of new hybrid combinations

For developing inter-specific hybrids for screening against YLD and fruit rot of arecanut, crossing between *Areca catechu*, *A. concinna*, *A. triandra* and *Normanbya normanbyii* was initiated. Besides, production of new/promising hybrids involving Hirehalli Dwarf and tall cultivars/released varieties was continued and a total of 4376 female flowers were pollinated in six combinations.

Cocoa

From the cocoa progeny evaluation trials over a period of 11-13 years, a hybrid between Upper Amazon Forastero and Trinitario, VTLCP-1 has been identified as a promising variety with 2.5 to 3 kg dry bean yield tree^{-1} yr^{-1} under arecanut and coconut. Among the cocoa hybrid combinations evaluated at Vittal and Kidu, VTLCH-2 and VTLCH-3 recorded higher yield under arecanut and coconut canopies, respectively (Table 7). Among 14 cocoa genotypes, VTLC-36 and VTLC-9 showed higher vigour, optimal canopy spread and early bearing at four years, under oil palm canopy.

At Vittal, under arecanut canopy, significant differences were observed for yield traits between clonal and seedling progenies. Hybrid varieties exhibited high yield as clones and parental clones had high yield as seedlings. At Kasaragod under coconut, two parental clones recorded higher yield both as clones as well as seedlings.

Table 7: Promising cocoa varieties evaluated under arecanut and coconut canopies in Karnataka and Kerala

Varietal identity	Breeding method	Dry bean yield range (kg tree^{-1} yr^{-1})	No. of beans pod^{-1}	Single dry bean weight (g)	Shell %	Nib recovery %	Fat %
VTLCS 3	Selection from VTLC 120 (IC 565609)	2.0-2.5	40	1.0	15	91	50
VTLCS 4	Selection from VTLC 13 (EC 631541)	2.4-2.5	43	1.0	11	88	55
VTLCS 5	Selection from VTLC 20 (EC 631547)	2.5-2.8	44	1.1	13	87	55
VTLCH 5	Hybrid progeny - VTLCP 1 (IC 565554 x IC 565559)	2.5-3.0	43	1.1	11	88	52

Fig. 33. Multilocation trial of cocoa clones at CPCRI Research Centre, Kahikuchi

At Mohitnagar, under arecanut canopy, VTLCC-1 yielded 50 pods tree^{-1} yr^{-1} and under coconut canopy VTLC-5 yielded 68 pods tree^{-1} yr^{-1}. At Kahikuchi, clones were rejuvenated with systematic pruning and training measures and early bearing was recorded in three clones (Fig. 33). In Andhra Pradesh and Tamil Nadu, VTLCH-2 recorded higher yield. Multi-location Research cum Demonstration trials were established at CPCRI Research Centres at Mohitnagar and Kahikuchi and AICRP on Palms HRS, Kahikuchi, with additional 16 genotypes, under DCCD funding.

Planting Material Production

At Kasaragod, 39,797 hybrid seed nuts of coconut were produced and sown (Fig. 34a). About 30,314 seed nuts of other coconut varieties were produced and sown for seedling production. Mother palms of coconut varieties planted in farmer's field for developing seed gardens in a participatory mode established well and are in second year of growth. Work on developing soilless media for coconut planting material production has been initiated. Soil amendment with PGPR (Kera Probio) was initiated to study the effect on the quality of the seedlings. About 1,80,000 female flowers from 650 WCT palms were pollinated during the current year. Rainy season pollination for increasing production of hybrids was initiated on an experimental basis. Different types of bags were tried for bagging the bunches: 25 bunches (631 female flowers) in 10 palms with plastic bag, 35 bunches (925 female flowers) in 10 palms with denim cloth and 30 bunches (1,151 female flowers) in 10 palms with kora cloth were pollinated. Preliminary analysis showed 22.8% setting with denim bag, 16.9% setting with kora cloth bag and 12.4% setting in plastic bag.

At CPCRI Research Centre, Kidu, 10,678 hybrid coconut seed nuts were produced and sown. About 42806 seed nuts of different coconut varieties were produced. During the current year, 20,000 female flowers from 200 WCT palms were pollinated and assisted pollination was carried out in 800 COD palms. In arecanut, about 4,78,585 seed nuts and 1,15,997 seedlings were produced and distributed. At CPCRI Regional Station, Vittal, about 81,000 arecanut seed nuts were produced and sown (Fig. 34b). Further, 64,661 arecanut seedlings were distributed during the

period. In cocoa, 53,948 seedlings were produced and sold (Fig. 34c). About 16,113 seed nuts including 895 hybrid nuts of coconut were produced in participatory mode and sown in the nursery at CPCRI Regional Station, Kayamkulam. At CPCRI Research Centre, Kahikuchi, 26,500 arecanut seedlings of five varieties *viz.*, Kahikuchi, Mohitnagar, Mangala, Sreemangala and Sumangala and 500 coconut seed nuts of Assam Tall were produced. At CPCRI Minicoy Centre, 213 seed nuts and 627 seedlings of coconut were produced and made available.

Revenue of about ₹.106.81 lakhs was generated from planting material production and distribution at the Institute.

Fig. 34. Planting material for sale at the institute:
a- coconut, b- arecanut, c- cocoa seedlings

BIOTECHNOLOGY AND BIOINFORMATICS

Tissue Culture

Enhancement of production of embryogenic calli, meristemoids and somatic embryos from plumular explants of coconut

Effect of different amino acids and organic supplements

In order to enhance embryogenic callus production from plumular explants of cv. West Coast Tall (WCT), three types of basal media (Y3, MS and ½MS), three amino acids (glutamine: 200 mg L^{-1}, L-asparagine: 100 mg L^{-1} and proline: 100 mg L^{-1}) and one organic additive compound (casein hydrolysate: 250 mg L^{-1}) were supplemented to the media along with an auxin (2,4-D: 16.5 mg L^{-1}). Out of 18 combinations tested, four treatments *i.e.* MS + 2, 4-D (16.5 mg L^{-1}) + glutamine (200 mg L^{-1}), Y3 + 2, 4- D (16.5 mg L^{-1}) + glutamine (200 mg L^{-1}) + casein hydrolysate (250 mg L^{-1}), Y3 + 2, 4- D (16.5 mg L^{-1}) + L-asparagine (100 mg L^{-1}) + proline (100 mg L^{-1}) and ½MS + 2, 4- D (16.5 mg L^{-1}) + glutamine (200 mg L^{-1}) were found to give better embryogenic calli (Fig. 35) compared to the existing media combinations *i.e.,* Y3 + 2, 4-D (16.5 mg L^{-1}). Among the three basal media, Y3 and MS were found to be better compared to ½MS and among amino acids tested, glutamine was found to exert a positive influence on multiplication of embryogenic calli.

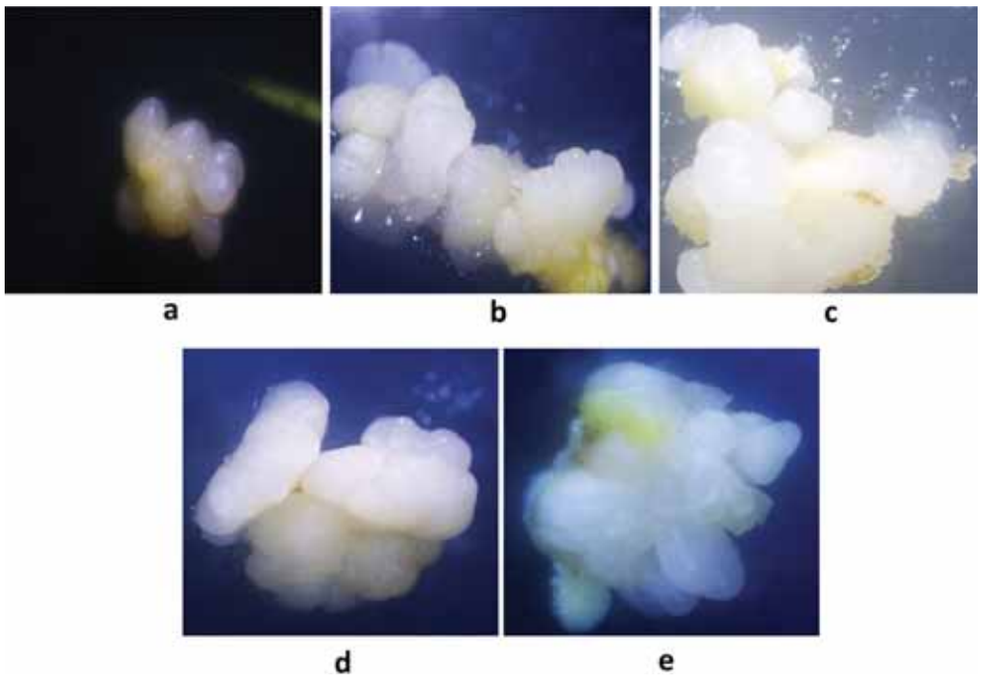


Fig. 35. Production of embryogenic calli (60 days old) using different basal media:

a) Control, b) MS + 2, 4-D + glutamine, c) Y3 + 2, 4-D + glutamine + casein hydrolysate, d) Y3 + 2, 4-D + L-asparagine + proline, and e) ½ MS + 2, 4-D + glutamine.

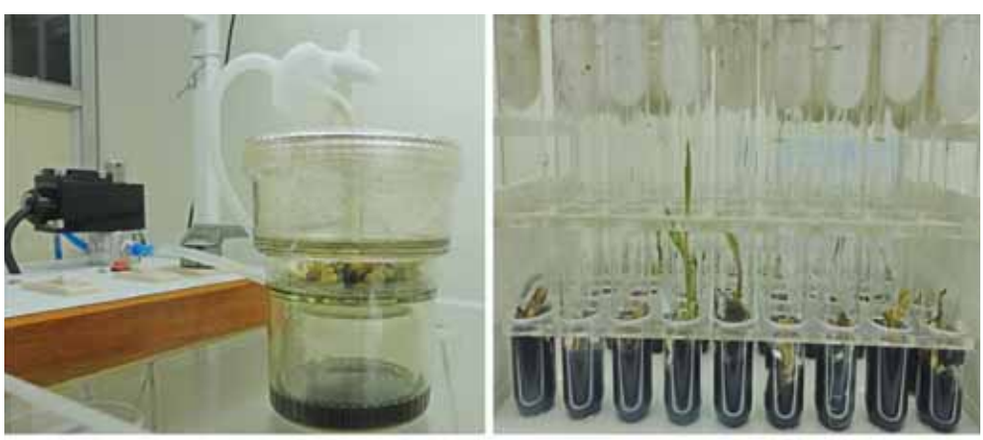
Effect of different cytokinins

Plumular explants of WCT were inoculated into Y3 basal media containing three cytokinins (BAP, TDZ and 2-i,P) at three different levels (0.5, 1 and 1.5 mg L^{-1}) in addition to four different concentrations of picloram (72, 96, 120 and 144 mg L^{-1}).

Response of the explants *viz.* browning, days taken for callus initiation, nature of callus, number of meristemoids and plantlet formation from the meristemoids were recorded. Callus initiation from the explants was noticed in media supplemented with lower concentrations of picloram (72 and 96 mg L^{-1}) and picloram in combinations with the three cytokinins. Initial browning of the explants was noticed in media supplemented with higher concentrations of picloram (120 and 144 mg L^{-1}). With the addition of cytokinins in media supplemented with higher concentrations of picloram, browning of explants was reduced, but bulging of plumular region and callusing were found to be delayed. Enhanced callusing was observed in plumular explants inoculated into 2-i,P (1 mg L^{-1}) + picloram (72 mg L^{-1}) followed by BAP (1 mg L^{-1}) + picloram (72 mg L^{-1}). However, after a month, the calli were transformed, instead of somatic embryos, into non-embryogenic hard milky white structures resembling meristemoids.

Shoot initiation from meristemoids

Meristemoid-like structures, which are formed out of milky white, non-embryogenic callus types derived from coconut plumular explants, were subjected to different culture conditions for shoot initiation. RITA® temporary immersion bioreactor system, 'Growtek' chamber and normal culture bottle with Y3 liquid containing three concentrations of BAP. (20, 40 and 60 mg L^{-1}) were used for the experiment (Fig. 36). Shoot initiation from the meristemoids was observed from each growth container at each level of BAP. More number of shoots were observed in temporary immersion system (84.4% meristemoid to shoot transformation), followed by 'Growtek' chamber (66.66%). Significant differences were not noticed for shoot initiation between the three concentrations of BAP.



a b

Fig. 36. Shoot initiation from coconut meristemoids: a) RITA® temporary immersion system b) Plantlets obtained from coconut meristemoids

Effect of different basal media

Experiment was conducted to study the effect of different basal media *viz*. MS, Y3, B5, M72 and WPM in enhancing the embryogenic calli production from plumular explants of coconut. The basal media were supplemented with picloram at concentrations of 24, 60 and 96 mg L^{-1}. The maximum number of embryogenic callus was observed in Y3, MS and M72 supplemented with 24 and 60 mg L^{-1} picloram (Fig. 37).

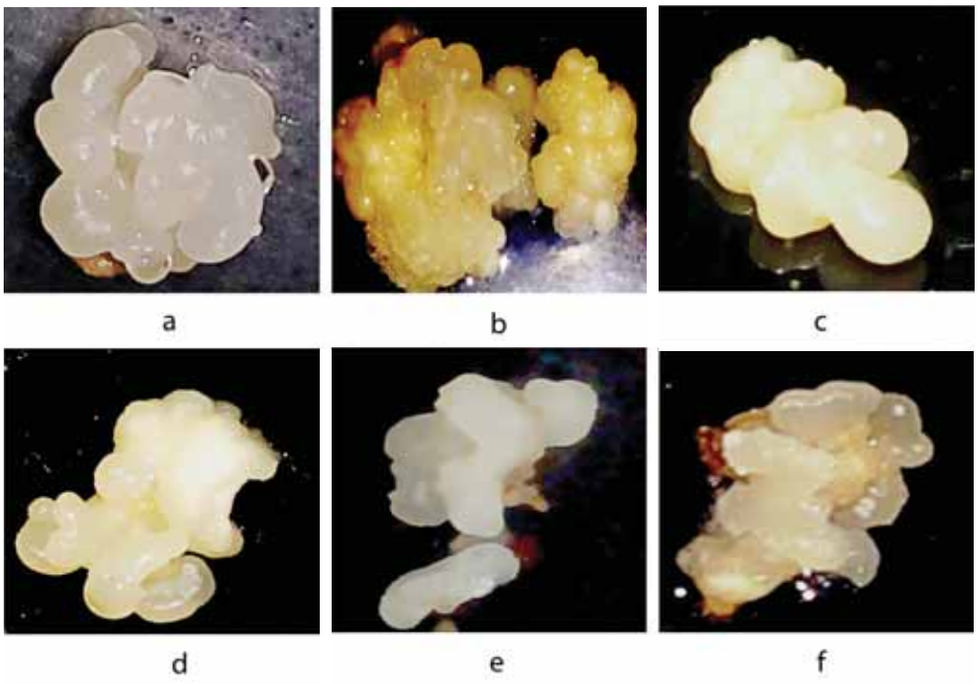


Fig. 37. Effect of different basal media on callus initiation from plumular explants of coconut using picloram as auxin source; a) M72+ 24 mg L^{-1} picloram, b) M72+ 60 mg L^{-1} picloram, c) MS+24 mg L^{-1} picloram, d) MS+ 60 mg L^{-1} picloram, e) Y3+ 60 mg L^{-1} picloram f) Y3+ 24 mg L^{-1} picloram

Effect of different auxins and herbicide forms

Different auxins and herbicide forms (IAA, NOAA, NAA, Atrazine, Dicamba, 2,4,5-T and IBA) at concentrations of 100, 200, 400 and 600 µM L^{-1} were used in Y3 media to study their effect on callus initiation. Callus initiation was noticed in 2,4,5-T, NAA and NOAA at various concentrations (2,4,5,T: 400 µM; NAA: 200 and 400 µM and NOAA: 100 and 200 µM).

Effect of different sugars

The effect of different sugars (glucose, fructose, trehalose, maltose, sucrose, sorbitol and filter sterilized fructose) in Y3 medium at concentrations of 1%, 3%, 5% and 7% was studied for their effect on enhancement of callus initiation from plumular explants of WCT. Callus initiation and multiplication was observed in Y3 medium supplemented with 1% and 3% fructose and sucrose, 1%, 3% and 7% trehalose, 1% maltose and 1% sorbitol.

Effect of charcoal

Plumular explants of WCT cultivar were inoculated onto Y3 media supplemented with different concentrations of charcoal (1, 2, 3, 4 and 5 g L^{-1}). Callus initiation was noticed at lower charcoal concentrations of 1 and 2 g L^{-1}. However, the germination of the shoot meristem was observed in medium supplemented with higher charcoal concentrations (3, 4 and 5 g L^{-1}).

Effect of calcium chloride

Different concentrations of calcium chloride (440, 880, 1320, 1760 and 2200 mg L^{-1}) were supplemented in Y3 media to study their effect on callus induction from plumular explants of WCT. Even though callus initiation was noticed in lower concentrations of calcium chloride (440, 880 and1320 mg L^{-1}), germination of the

shoot meristem was observed in media supplemented with higher concentrations of calcium chloride.

Effect of electric stimulus

Experiments were set up to study the effect of electric stimuli on callus induction from different explants namely embryo, embryogenic callus, shoot meristem and one month old plumular tissue. These explants were subjected to 1 and 3 µA current, continuously and at the rate of 1 hour day^{-1}. The medium used was Y3 supplemented with 2, 4-D (16.5 g L^{-1}) and TDZ (1 g L^{-1}) and special containers, 'phyta jars', were used for the experiments. Initial observations revealed increased callus volume under electric stimuli when compared to control (Fig. 38).

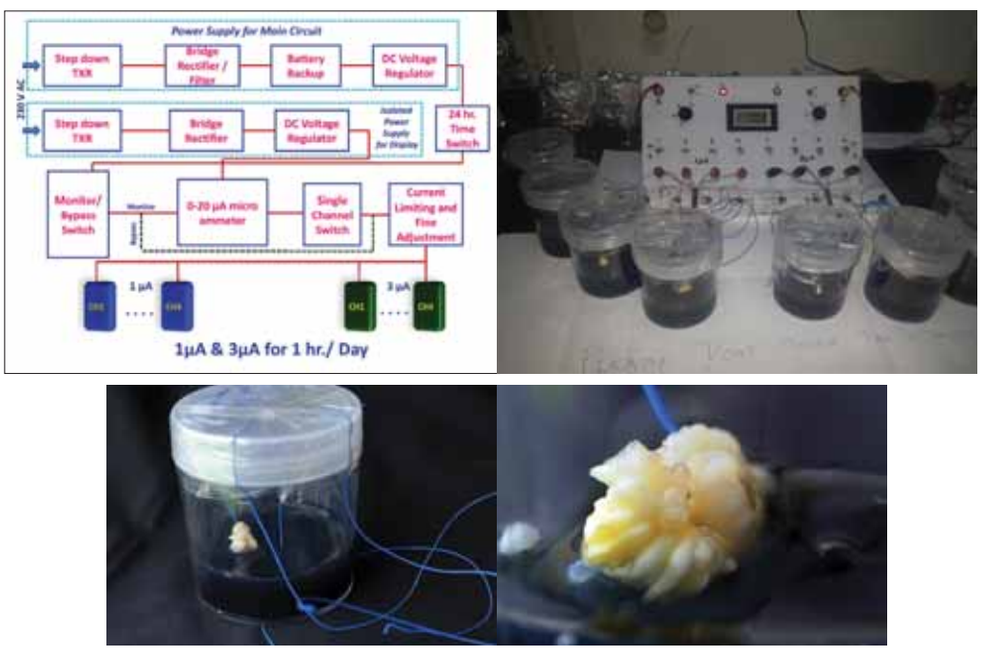


Fig. 38. Effect of electric stimulus on callus induction

Synergistic effect of auxins

To study the synergistic effect of growth regulators on induction of friable callus and somatic embryogenesis in coconut plumular explants from WCT, 2,4-D, picloram and dicamba were supplemented individually in Y3 medium. Medium supplemented with 2,4-D (16.5 mg L^{-1}) and TDZ (1 mg L^{-1}) was used as control. After 30 days of culture incubation, media supplemented with 2,4-D, picloram and dicamba showed 50%, 61% and 50% of callus induction, whereas control showed 70% of callus induction. Studies on synergy of the three auxins in combination indicated that explants inoculated into media supplemented with 2,4-D and dicamba showed better responses, in terms of multiplication of embryogenic calli, compared to other treatments after 60 days of culture incubation. It was also noticed that compared to medium supplemented with 2,4-D (16.5 mg L^{-1}) and TDZ (1 mg L^{-1}), the synergistic effect was less.

Production of secondary calli from primary embryogenic calli

The ability of friable (40 days old cultures) and compact (60 and 90-120 days old) primary calli types, obtained from plumular explants of WCT, to produce secondary embryogenic calli was assessed in Y3 basal medium supplemented with 2, 4-D (16.5 mg L^{-1}).

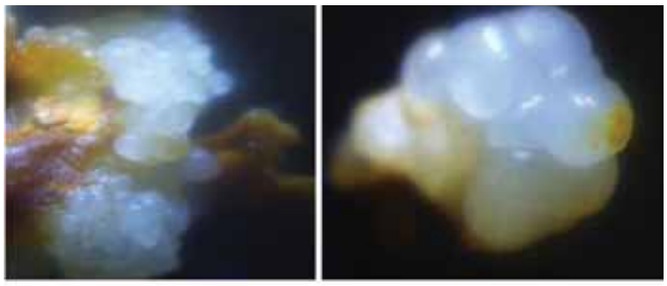


Fig. 39. Formation of secondary callus from (a) 40 and (b) 60 days old primary callus

Secondary embryogenic calli production was observed only with 40 and 60 day old primary calli (Fig. 39.), whereas 90-120 days old primary calli appeared to have lost its regeneration potential.

Effect of higher concentration of 2,4-D

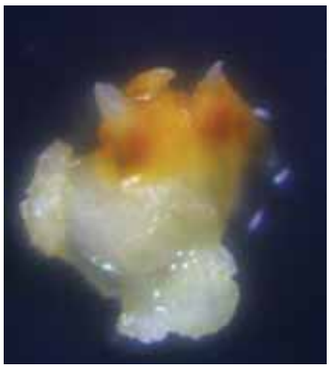


Fig. 40. Callus initiation from plumular explants of MYD in Y3 medium supplemented with high concentration of 2,4-D

Plumular regions of Malayan Yellow Dwarf were inoculated onto Y3 medium supplemented with high concentration of 2, 4-D (600 µM) and maintained under dark condition for three months without subculturing. Callus initiation was observed from 30% of the inoculated plumules (Fig. 40). The cultures are now being maintained in dark in Y3 medium supplemented with lower concentration of 2, 4-D (75 µM).

Effect of osmotic stress

Four concentrations of sucrose (6%, 8%, 10% and 12%) supplemented in Y3 basal media were used for induction of osmotic stress and its effect on formation of callus from plumular explants of WCT. Three concentrations of sucrose (6%, 8% and 10%) were ineffective to induce callus as the plumular explants germinated and developed into plantlets. Minimal callus induction was observed in medium supplemented with 12% sucrose (Fig. 41) as the calli rapidly turned into milky white non-embryogenic type within 15 days of initiation.

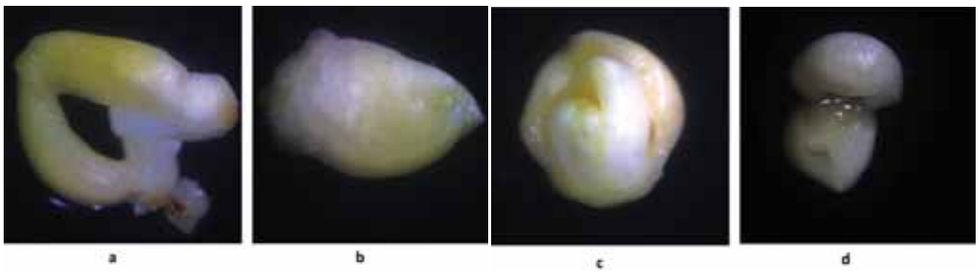


Fig. 41. Effect of different concentrations of sucrose on callus initiation *viz*., a) 6%, b) 8%, c) 10% and d) 12%

Fig. 42. Initiation of callus from plumular explants of coconut at 11 mg L^{-1} of ABA

Effect of ABA

Plumular regions of WCT were inoculated onto Y3 medium supplemented with different concentrations of ABA (5, 7, 9, 11, 13, 15 and 50 mg L^{-1}). Callus initiation was observed in all treatments, but maximum embryogenic callus formation was noticed in Y3 medium supplemented with 11 mg L^{-1} ABA (Fig. 42).

Formulation of new media

Based on nutritional composition of coconut water, Y3 medium was modified and compared with Y3 medium containing different growth regulators at different levels (2, 4-D: 5, 10, 15, 16.5 mg L^{-1}; IAA: 2.5, 5, 10, 15 mg L^{-1}; ABA: 5, 10 mg L^{-1} and atrazine: 10 mg L^{-1}). In two treatments (2, 4-D: 16.5 mg L^{-1} and IAA: 15 mg L^{-1}), 100% callus initiation from the plumules was observed in both the media (Y3 and modified Y3). In addition to this, 30% callusing was also observed in modified Y3 medium supplemented with 2, 4-D (15 mg L^{-1}) in but not in Y3 medium. In almost all the treatments, modified Y3 medium was found to perform slightly better over Y3 medium for embryogenic callus production (Fig. 43) from coconut plumular explants.

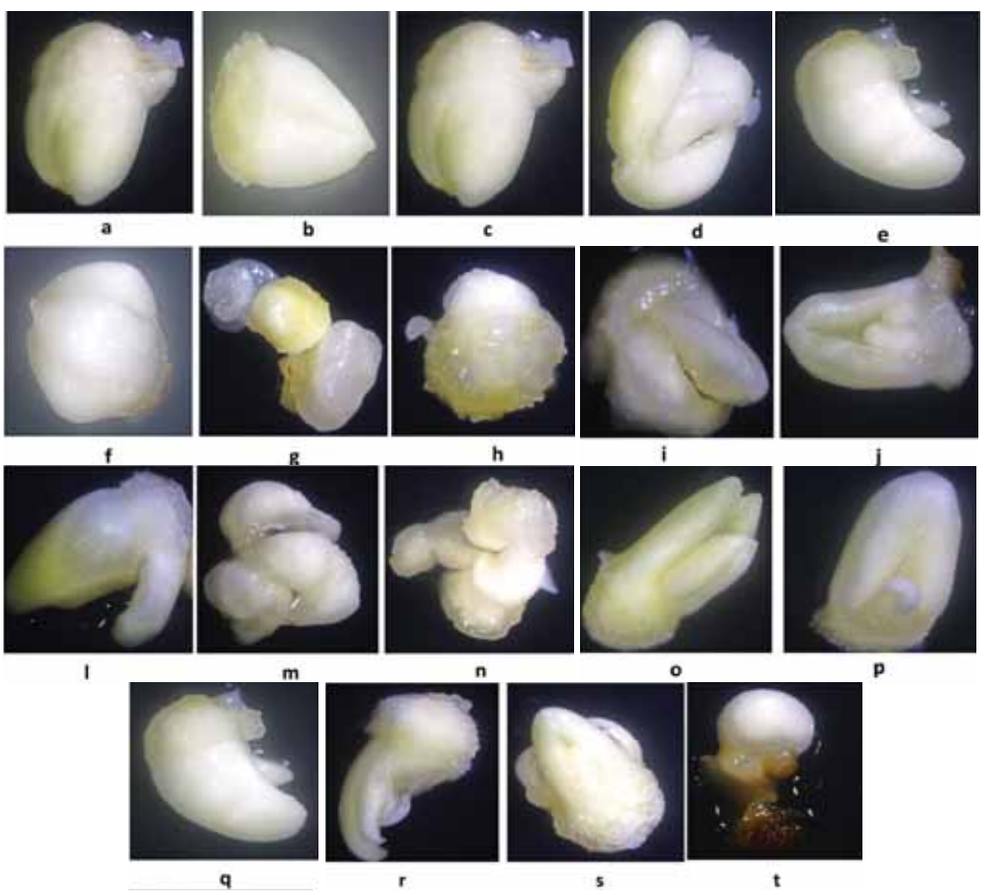


Fig. 43. Effect of media combination and growth regulators on callus initiation from coconut plumule: a) Y3+2.5 mg L^{-1} 2,4-D, b) Modified Y3+2.5 mg L^{-1} 2,4-D, c) Y3+5 mg L^{-1} 2,4-D, d) Modified Y3+5 mg L^{-1} 2,4-D, e) Y3+10 mg L^{-1} 2,4-D, f) Modified Y3+10 mg L^{-1} 2,4-D, g) Y3+15 mg L^{-1} 2,4-D, h) Modified Y3+15 mg L^{-1} 2,4-D, i) Y3+5 mg L^{-1} IAA, j) Modified Y3+5 mg L^{-1} IAA, k) Y3+10 mg L^{-1} IAA, l) Modified Y3+10 mg L^{-1} IAA, m) Y3+15 mg L^{-1} IAA, n) Modified Y3+15 mg L^{-1} IAA, o) Y3+5 mg L^{-1} ABA, p) Modified Y3+5 mg L^{-1} ABA, q) Y3+10 mg L^{-1} ABA, r) Modified Y3+10 mg L^{-1} ABA, s) Y3+10 mg L^{-1} atrazine , and t) Modified Y3+10 mg L^{-1} atrazine

Immature inflorescence culture in coconut

Immature rachillae explants from Chowghat Orange Dwarf, Philippines Ordinary Tall and West Coast Tall were inoculated into different basal media (CHU, Y3, SH, Nitsch, LS, B5, WPM MS) with growth hormones (Auxins: 2, 4-D, picloram and

cytokinins: TDZ and BAP). Browning was less in basal media supplemented with 2,4-D as compared to picloram. Even though direct shoot-like growth was observed in many of the cultures (Fig. 44), they turned brown on subsequent sub-culturing to media containing lower concentration of growth hormones.

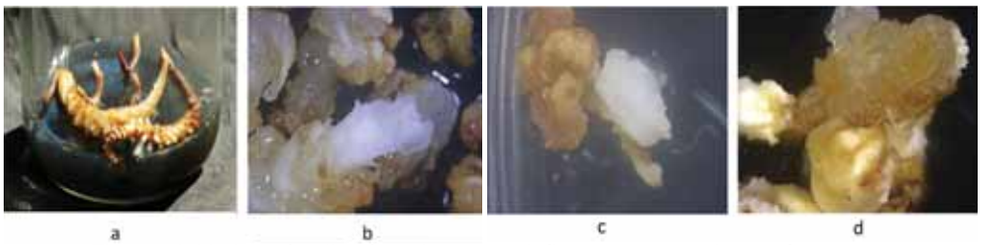


Fig. 44. Initiation of callus from immature inflorescence explants of coconut: a) Y3+2,4-D, b) Y3+Pic+BAP, c) Y3+2,4-D, d) Y3+2,4-D+TDZ

Anther culture in coconut

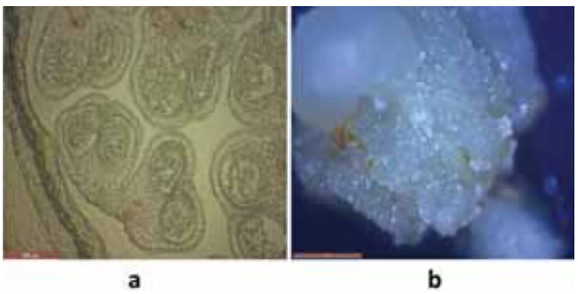


Fig. 45. a) Anthers at tetrad stage b) Callus induction in Y3 medium supplemented with picloram and BAP

Anthers at microspore stage were either inoculated directly (control) or after pre-treatment with elevated temperature (3 days) or cold (5 days) in nine different basal media (CHU, Y3, SH, Nitsch, LS, B5, WPM and MS solid / liquid) supplemented with auxins (2, 4-D or picloram) or cytokinins (TDZ or BAP). Callus initiation was observed in Y3, WPM, B5 and LS medium supplemented with picloram, but upon sub-culturing, the calli turned brown (Fig. 45).

Fig. 46. Microspores isolated from coconut anthers

Microspore isolation and its culture

For microspore isolation (Fig. 46), anthers were split into small bits and blended in 8% sucrose solution at 500-600 rpm for two minutes. The extract, after filtering with 80 µm mesh, was inoculated into 10 different combinations of Y3 liquid medium with 2,4-D, picloram, BAP and TDZ.

Arecanut Tissue Culture

In vitro multiplication of Hirehalli Dwarf, dwarf arecanut hybrids and YLD resistant palms

Immature inflorescence explants from seven arecanut hybrid palms (VTLAH-1 and VTLAH-2), two Hirehalli Dwarf (HD) palms and three YLD disease-free palms were inoculated into 16 different media combinations consisting of four basal media (Y3, WPM, B5 and B5 major + MS minor) and four auxin sources (2, 4-D; picloram; 3, 4-D and dicamba) for callus induction. Serial transfer of explants was carried out from higher to lower auxin concentrations at 30-35 days interval. Callus induction was observed in some cultures after 3-4 months of inoculation.

Formation of somatic embryos was observed from inflorescence explants of Hirehalli Dwarfs and dwarf hybrid palms inoculated during the previous year. Somatic

embryo formation was achieved in hormone-free Y3 medium and germination was achieved when Y3 medium was supplemented with cytokinins (BA, TDZ, kinetin and zeatin). About 100 plantlets are in different stages of development.

In Vitro Conservation

Embryo rescue of soft endosperm coconut types

Embryo cultured plantlets were recovered from coconut palms with soft kernel identified in a farmer's field at Peruvannamuzhi, Kerala. The embryos, which do not germinate in nature, were asceptically cultured in Y3 medium and fully grown plantlets are now ready for potting (Fig. 47).

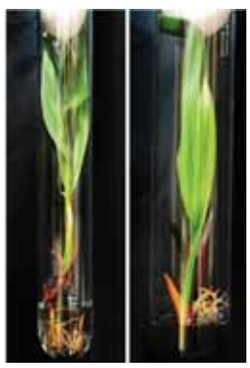


Fig. 47. Plantlets of soft endosperm coconut derived through embryo rescue

Embryo culture of wild *Areca* spp.

Embryos from immature nuts of *Areca triandra* and *Areca concinna* (4 months old) were cultured on to four different basal medium (Y3, half MS, B5 and White's) supplemented with glutamine and vitamins. Germination was highest in Y3 medium (Fig. 48) and lowest in White's medium. Plantlets are in different stages of development.

Fig. 48. Effect of different media on embryo culture of wild *Areca* spp.

Validation of coconut embryo cryopreservation protocol

Cryopreservation of coconut zygotic embryos of four released varieties (Kalpa Haritha, Kalpa Samrudhi, Kalpatharu and Kalpasree), with PVS3 (Plant Vitrification Solution 3) protocol showed varying responses. The percentage of plantlet development after cryopreservation was found to be 40, 30, 30 and 25% in Kalpa Haritha, Kalpa Samrudhi, Kalpatharu and Kalpasree, respectively (Fig. 49). During the current year, embryos from five coconut varieties (Chandra Kalpa, Kalpa Surya, Kalparaksha, Kalpa Jyothi and Kera Chandra) have been subjected to cryopreservation by PVS3 vitrification protocol.

Fig. 49. Plantlets retrieved from cryopreserved coconut zygotic embryos: a) Kalpa Haritha b) Kalpa Samrudhi c) Kalpasree d)Kalpatharu

Long term conservation of pollen

Pollen of three coconut accessions (Philippines Ordinary Tall, Laccadive Ordinary Tall and Malayan Green Dwarf) were stored in liquid nitrogen for long term storage

Fig. 50. Germination observed in cryopreserved coconut pollen

using simple desiccation. Initial viability of more than 25% was ascertained before subjecting the pollen to cryopreservation (Fig. 50).

Long term conservation of arecanut pollen and its viability and fecundity studies

Arecanut pollen from dwarf hybrid (HD x Sumangala) was cryopreserved using simple desiccation protocol. The cryopreserved pollen were retrieved at different intervals, *viz*., 1 month, 1 year and 2 years, and utilized for fertility studies which showed setting of 70, 43 and 62% respectively (Fig. 51).

Fig. 51 a) Germination observed in cryopreserved arecanut pollen b) Normal nut set observed after pollination with pollen cryopreserved for one year

Molecular Markers

Utilization of EST-SSRs for hybrid authentication in coconut

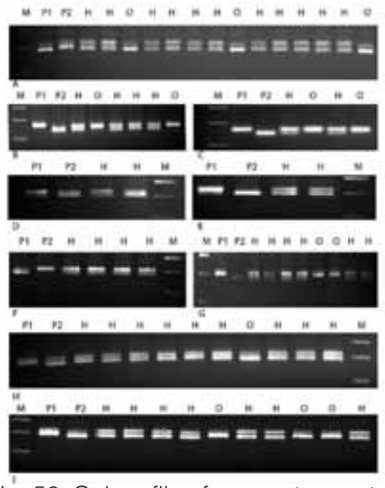


Fig. 52. Gel profile of coconut parents and their hybrids, M: 100bp ladder; P1: Female parent; P2: Male parent; H: Hybrids; O: Offtypes A: CGD x WCT; B: MYD x TPT; C: COD x WCT; D: GBGD x PHOT; E: GBGD x LCT; F: LCT x CCNT; G: GBGD x FJT; H: WCT x COD; I: LCT x COD

In coconut nurseries, hybrid seedlings are generally identified and selected based on morphological traits, which is quite difficult and requires expertise. EST-SSR primers, mined from leaf transcriptome data of Chowghat Green Dwarf, were used to screen polymorphism between 18 parental lines used in hybridization programme. The polymorphic primers, which were capable of differentiating the parental palms, were then utilized for hybrid purity assessment studies of the progenies. True hybrids possessed the banding pattern of both the parents (Fig. 52). The selected markers can be utilized in hybrid seedling assessments, for identification and removal of selfed progenies in the nurseries.

Molecular characterization of cocoa accessions

Ten parental clones, of Nigerian and Malaysian origin, and 10 hybrids derived from them, being assessed for moisture stress tolerance, were characterized using nine microsatellite markers. Screening of the parents using microsatellite markers revealed an allelic diversity of 71 alleles with an average of 7.8 alleles per locus. The observed heterozygosity was higher in Malaysian collections (0.43) compared to Nigerian collections (0.36). The fixation index, in contrast, was lower in Malaysian collections (0.29) compared to Nigerian collections (0.37). Molecular analysis of the 11 hybrids revealed a total of 33 alleles with an average allelic richness of 2.28. Expected heterozygosity varied for all hybrids, I-21 x NC23/43 (He=0.75) recorded the highest value, followed by I-29 x NC42/94 (0.67), II-67 x NC29/66 (0.65), and II-67 x NC42/94 (0.61). For all progenies, heterozygosity deficit was observed except for I-14 x NC29/66 and I-21 x NC42/94. The two axes considered on the basis of their Eigen value (≥ 1), axis 1 (65.33%) and axis 2 (23.49%), expressed 88.82% of the total variability. These two axes distinguished hybrids into four groups, based on genomic markers (Fig. 53).

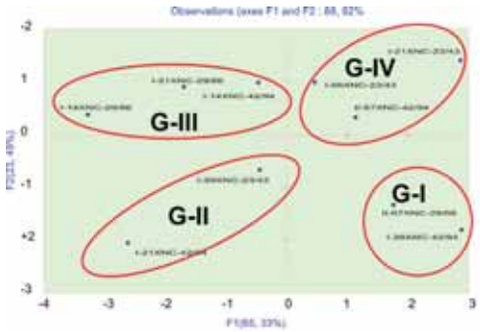


Fig. 53. Grouping of cocoa hybrids performed with genomic SSR primers

Molecular characterization of wild relatives of arecanut

DNA of *Areca catechu* and its wild relatives *viz.*, *Areca triandra, Areca concinna, Normanbya normanbyi* and *Actinorhytis calapparia* were compared using SCoT *(*Start Codon Targeted polymorphism). Among the 25 SCoT primers screened, 15 displayed polymorphism between *Areca catechu* and its wild relatives *viz.*, *Areca triandra* and *Areca concinna.* The polymorphism was confirmed in individual samples of these three palms (Fig. 54). These markers could be utilized to confirm inter-specific hybrids between arecanut and wild *Areca* spp. However, *Normanbya normanbyi* and *Actinorhytis calapparia* showed completely diverse banding pattern compared to *Areca* spp. A phylogenetic analyses of these palms using the nuclear loci *RPB2* and *PRK* revealed that *Normanbya normanbyi* and *Actinorhytis calapparia* were placed in a completely different clade compared to the three *Areca* spp.

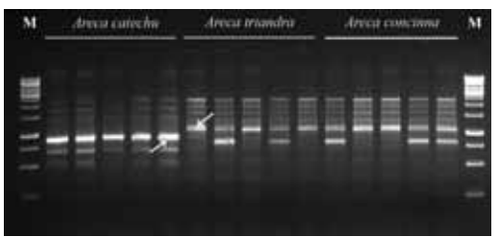


Fig. 54. Profile of arecanut and wild *Areca* spp. using SCoT 22 primer

Gene Cloning

Cloning and characterization of TIR-NBS-LRR disease resistance gene analogues in coconut

Toll and interleukin-1 receptor (TIR) nucleotide binding site-leucine rich repeat (NBS-LRR) resistance gene analogues (RGAs), which are rare in monocots, were

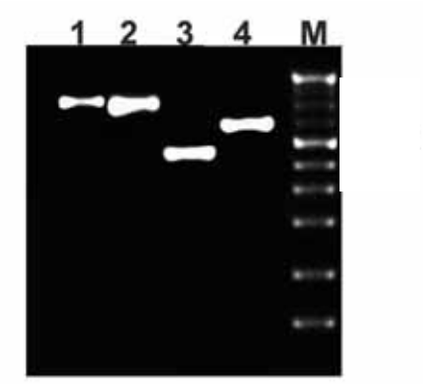


Fig. 55. Full length cDNA amplification of four TIR-NBS-LRR class R-genes in coconut. Lane 1: 100013447 (2523 bp) Lane 2: 100096197 (1608 bp): Lane 3: 100016523 (3016 bp); Lane 4: 100120097 (3021 bp); M- 1Kb DNA ladder

cloned and characterized from Chowghat Green Dwarf by PCR-based amplification with primers designed using a comparative genomics approach. Four TIR-NBS-LRR transcripts from leaf transcriptome dataset were functionally annotated (using BlastX alignment with an E-value <0) and further confirmed by Blast2GO tool. A comparative genomics approach utilizing genome sequences of oil palm and date palm was applied to isolate the full-length coding regions of each of the four coconut transcripts. Coconut TIR-NBS-LRRs with BlastN identity >90% against oil palm and date palm sequences, were selected based on their protein domain analysis. The study also confirmed the presence of TIR and NBS domains in oil and date palm, which have not been reported earlier. The full-length coding region of four TIR-NBS-LRR class *R*-genes were assigned as CnTIR1, CnTIR2, CnTIR3 and CnTIR4 (Fig. 55).

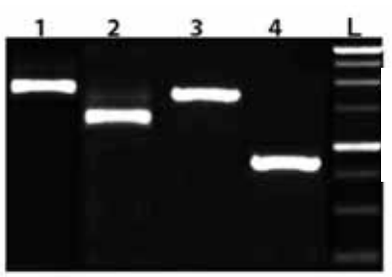


Fig. 56. Isolation of full-length cDNA of genes known to be induced during somatic embryogenesis in coconut

Lane 1: BABYBOOM, Lane 2: AP2, Lane 3: SERK, Lane 4: WUSCHEL, L: 1Kb DNA ladder

Cloning of full-length genes induced during somatic embryogenesis in coconut

Full-length cDNA of four genes viz., *BABY BOOM, WUSCHEL, SERK* and *AP2* were isolated using a primer-walking strategy. Here too, a comparative genomics approach utilizing genome sequences of oil palm and date palm was applied to isolate the full-length coding regions of *BABY BOOM, WUSCHEL, SERK* and *AP2* (Fig. 56.)

Gene Expression Studies

Comparative gene expression profiling during *in vitro* regeneration in two coconut cultivars

A comparative study of gene expression patterns of eight genes during different stages of *in vitro* regeneration in WCT (West Coast Tall) and COD (Chowghat Orange Dwarf) was carried out using RT-qPCR. Enhanced expression of *PKL, SERK* and *WUS* was observed in embryogenic calli as compared to non-embryogenic calli. High expression of *GLP, ECP* and *GST* could be observed in normal somatic embryos compared to abnormal somatic embryos. Enhanced expression of *ECP, LEAFY, GLP* and *WRKY* could be observed in normal meristemoids compared to aberrant meristemoids. Among the two cultivars, higher somatic embryogenesis was noticed in WCT. Embryogenic calli of WCT showed higher expression of *SERK, PKL* and *WUS* in comparison to COD. Somatic embryos of WCT showed high expression of *GLP* and *GST*. Higher expression of *ECP* gene was observed in WCT

as compared to COD. In case of *WRKY* and *LEC*, higher levels of expression were observed in WCT meristemoids. The results revealed significant differences in regeneration potential and gene expression patterns in the two coconut cultivars, suggesting genotypic differences to *in vitro* culture (Fig. 57).

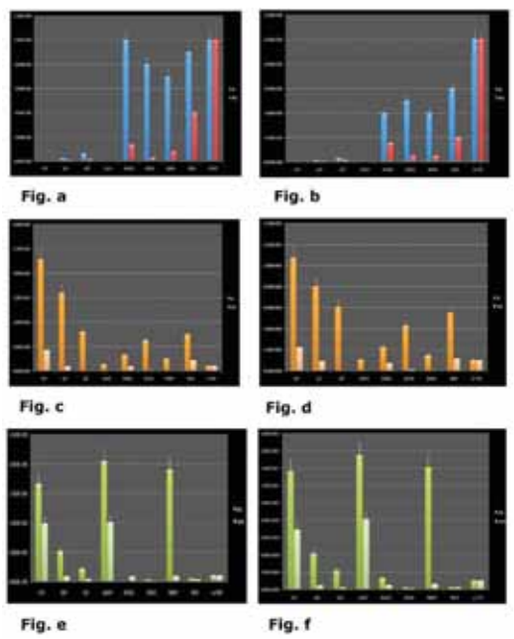


Fig. 57. Gene expression levels of eight genes during different stages of *in vitro* regeneration. In graphical representation X axis indicates the eight different genes and y-axis indicates normalized mRNA expression (normalized to TUBULIN) relative to control samples-(expressed as mean±SEM):

a. Gene expression level of eight genes in EC and NEC of WCT,
b. Gene expression level of eight genes in EC and NEC of COD,
c. Gene expression level of eight genes in SE and ASE of WCT,
d. Gene expression level of eight genes in SE and ASE of COD,
e. Gene expression level of eight genes in MS and AMS of WCT,
f. Gene expression level of eight genes in MS and AMS of COD

Proteomics

Comparative analysis of zygotic and somatic embryogenesis in coconut

A comparative study at proteomic level was conducted between the different stages of somatic embryos and zygotic embryos. Tagged nuts of Chowghat Orange Dwarf (8-11 month old) were harvested to collect zygotic embryos of different stages and plumules scooped out from matured nuts were inoculated into callus induction media to obtain different stages of somatic embryogenesis. The protein concentrations were estimated by comparing the concentration of BSA standards. The estimated proteins were analysed by performing the SDS PAGE (Fig. 58). Selected protein bands were excised from Coomassie stained gels, washed with ddH_2O, and then destained and dehydrated with 100% acetonitrile and vacuum-dried. They were digested with sequencing-grade trypsin at 37^0C for 15 h. The obtained peptides were characterized by matrix assisted laser desorption ionization time-of-flight tandem mass spectrometry (MALDI-TOF/TOF MS) acquisition in an proteomics analyzer using 3,5-dimethoxy-4-hydroxycinnamic acid as the matrix. The enzymolysis product (peptide) of myoglobin was

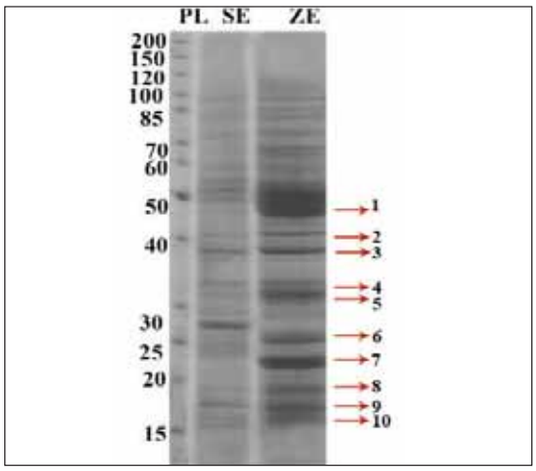


Fig. 58. Protein profile of somatic and zygotic embryos of coconut: PL: Protein ladder, SE: Somatic embryos, 150 days, ZE: Zygotic embryos, 11 months

used as an external standard calibration. The acquired peptide mass fingerprinting data were queried against the MASCOT (version 1.8.0, Matrix Science, London, UK) search engine. Based on the MASCOT score, the matched proteins were identified. Ten major proteins were identified which showed higher expression levels in zygotic embryos in comparison to somatic embryos *viz.*, zetacarotene desaturase, 6-phosphogluconate dehydrogenase, endo-1,3-1,4-beta-D-glucanase, arginine decarboxylase, hypothetical protein L484_015327, adenylate kinase 3, AT5G11810-like protein, LIM domain-containing protein PLIM2c, thioredoxin H2, glycine-rich cell wall structural protein. Out of these, four protein bands were unique to zygotic embryo and identified as zeta carotene desaturase, 6-phosphogluconate dehydrogenase, adentlate kinase and AT5G11810-like protein. The molecular masses of protein bands were approximately 50 kDa, 42 kDa, 27 kDa, 24 kDa, respectively; similar to the theoretical molecular masses of the zeta-carotene desaturase of *Oncidium* hybrid cultivar (62.40 kDa), 6-phosphogluconate dehydrogenase of *Spinacia oleracea* (53.24 kDa), adenylate kinase 3 of *Oryza sativa* (26.67 kDa) and AT5G11810-like protein of *Manihot esculenta* (25.77 kDa).

Bioinformatics

Construction of EST-SSR marker database in coconut

The 'Coconut EST-SSR Marker Database' is a curated and integrated web-based relation database providing access to coconut EST-SSRs. From this database, users can access information on EST-SSR markers in coconut, designed from transcriptome data. The design of the 'Coconut EST-SSR Marker Database' followed the three schema architecture (Fig. 59). The database was developed in MS-Windows environment using Adobe Dreamweaver as Integrated Development Environment. The whole database interfaces were coded using PHP (Preprocessor Hyper Text) version 5.3.4 and HTML (Hyper Text Markup Language). Custom MySQL database version 5.1.53 was used. All the animations and validations in the database were done using JQUERY version 1.11.3. The database also includes Cascading Style Sheets (CSS) that deals with looks and formatting of the user interfaces.

Fig. 59. Home page of coconut EST-SSR database

Conserved miRNA detection in ESTs of *Ganoderma lucidum*

A total of 17 pre-miRNA hairpin loop structures were identified in the genome of *Ganoderma lucidum* formed by a total of nine unique miRNAs (Fig. 60). Target annotation revealed that almost all of these miRNAs could have a role in important physiological processes. Some proteins, the expression of which could be influenced by these miRNAs, are Rho proteins, ribosomal proteins and Utp-14 proteins. The results obtained from the analysis predicted microRNA sequences which shared sequence homology with some of the plant and animal miRNAs. Most of the genes targeted by predicted microRNA were found to be highly conserved in pathogenic fungi and were involved in transcription regulation, DNA binding, ATP binding and protein binding. This work provides an inventory of small RNAs of *G. lucidium*, enabling further exploration of gene regulation on both sides of the host/parasite interaction.

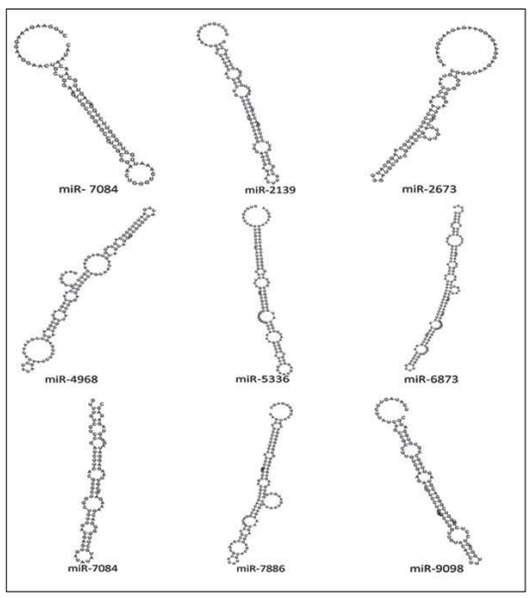


Fig. 60. Precursor structures of conserved miRNAs detected in *Ganoderma* ESTs

Conserved miRNA detection in ESTs of red palm weevil

Transcriptome data of different stages of red palm weevil was assembled into contigs. miRNA sequences were downloaded off the miRBase database and used for comparing with these contigs using stringent parameters so as to identify any miRNA sequences found conserved in the red palm weevil transcriptome. The results obtained were further refined for GC content and redundant results were removed. Target prediction for the miRNAs predicted against the contigs was inferred through miRanda and the functional annotation of the contigs was done using the free version of Blast2GO using default parameters. The predicted data revealed the existence of potential miRNAs having major role in ion transport regulation, gene modification etc (Fig. 61). The recent studies signify the importance of miRNAs in regulating insect physiology. Also, this approach allows identification of a wide range of potential targets for suppression of gene expression in red palm weevil.

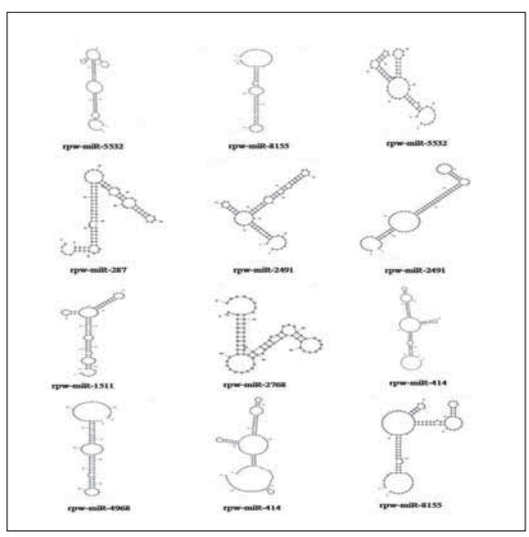


Fig. 61. Hairpin loop structures of predicted miRNAs in red palm weevil

Molecular docking studies of receptors of human pathogens with fatty acids

Structures of targets of human pathogens already available in Protein Data Bank (PDB) were retrieved. Molecular dynamics simulations of the behaviour of selected microbial receptors complexed with different fatty acids present in virgin coconut oil were performed. The binding affinities of fatty acids and triglycerides with selected receptors were determined and the results revealed that the fatty acids present in virgin coconut oil possessed potentiality to act as a lead compounds for identifying new drug candidates against human pathogens (Fig. 62).

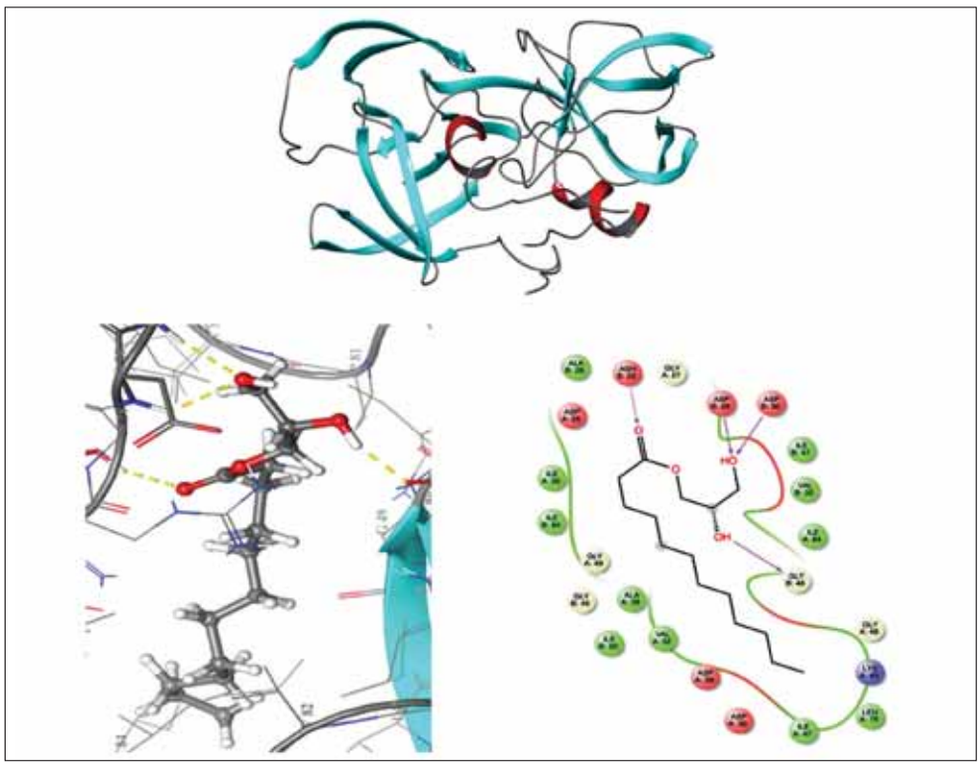


Fig. 62. Monolaurin docked with HIV-1 protease protein and its interaction diagram

CROPPING AND FARMING SYSTEMS

Coconut Based Cropping and Farming System

Integrated farming systems for sustained productivity

The coconut based integrated farming system (CBIFS) comprising coconut, banana, fodder grass (Bajra Napier Co 5), dairy unit (seven cows of Holstein Friesian and one Jersey cross breed), poultry (100 broiler birds batch^{-1}), aquaculture (1000 fingerlings) and goat unit (20 female and one male) is found sustainable. The output achieved from one ha of CBIFS was 21000 coconuts, 16201.6 litres cow milk, 108.2 kg live weight of goat, 287 kg of live weight of broiler birds, 52,377 kg of banana and 385 kg of pepper. The system realized net returns of ₹. 7,17,955/-. Bajra Napier hybrid - Co 5 with the integrated nutrient management practices recorded higher fodder yield of 111 t ha^{-1} yr^{-1} followed by fully organic treatments (104 t ha^{-1} yr^{-1}) and significantly higher than chemical fertilizers alone (70 t ha^{-1} yr^{-1}).

Soil quality assessment through fodder-legume combinations in root (wilt) affected coconut gardens

Inclusion of legumes as components with exhaustive grasses was found to help in maintaining the soil fertility and productivity. This is more important in poor soils like Onattukura soils in Kerala. The fodder grass (var. Suguna), stylosanthes (var. Hamata) and cowpea (EC 4216) as pure crops and their combinations indicated that the combination of fodder grass and stylosanthes with a combined yield of 132 t ha^{-1} was comparable to fodder grass and cowpea combination (126 t ha^{-1}) (Fig.63). The potash content in soil increased to 27.5 ppm with fodder grass + stylosanthes combination as compared to fodder grass alone (23.7 ppm). Similarly, calcium content increased from 211.7 ppm to 303 ppm and magnesium content from 35.5 ppm to 55.1 ppm, indicating the beneficial effect of combining fodder grass and leguminous crops in the enhancement of soil quality and fodder yield mainly by combating the nutrient exhaustion by fodder crops when grown as a pure crop. Baseline average coconut yield per palm in 2012 was 10.7 in the experimental area which increased to 23.1 during 2015, due to complementary effect of inputs like water and nutrients.

a b

Fig.63. A general view of the coconut based cropping system with component crops; a) fodder grass (var. Suguna) b) cowpea

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

Organic nutrient management was standardized for cultivation of Hybrid Napier var. Co 3 as intercrop in coconut plantations (Fig.64). Application of cow dung slurry (750 ml) + vermicompost (200 g) + *Azospirillum + Phosphobacteria* (5 g each) at bimonthly interval after every harvest resulted in highest fodder yield of 139 t ha^{-1}. The yield was positively correlated with plant height (219.4 cm) and leaf length (222.7 cm). This treatment also recorded higher soil nutrient and soil microbial status with available P (122 ppm), Ca (248 ppm), Fe (12.8 ppm), Mn (5.3 ppm), Zn (1.9 ppm), nitrogen fixers (58.5 x 10^4 cfu g^{-1} soil), actinomycetes (75.9 x 10^4 cfu g^{-1} soil) and flourescent *Pseudomonas* (2.5 x 10^2 cfu g^{-1} soil).

After two years of fodder cultivation as intercrop in coconut, there was an increase of 32, 16.7 and 3.8 percent nut yield in apparently healthy (AH), disease early (DE) and disease middle (DM) palms, respectively. The increase in yield was due to additional supply of cow dung (25 kg yr^{-1}) and mulching with coconut wastes in the palm basins coupled with continuous irrigation for the fodder grass in the interspaces of coconut.

Fig. 64. Hybrid Napier as intercrop in coconut garden

High density multi species cropping system under organic and integrated management

Coconut yield in the high density multi species cropping system was on par with fully organic application or 1/3rd recommended chemical fertilizer and recycling biomass (vermicompost) + biofertiliser + green manuring + vermiwash or 2/3rd recommended chemical fertilizer and recycling biomass (vermicompost). The yield ranged from 177 to 188 nuts $palm^{-1}$ yr^{-1}. Black pepper yield also did not differ significantly among the treatments and ranged from 2.97 to 3.58 kg $vine^{-1}$. Cinnamon quill yield of 1.5 to 1.7 kg $tree^{-1}$ was recorded. Banana (var. Kadali) yield ranged from 8 to 9 kg $bunch^{-1}$ and var. Robusta yield also did not differ significantly among the treatments and ranged from 12 kg to 16 kg $bunch^{-1}$. The copra yield did not differ significantly among the treatments and ranged from 4.7 to 5.2 t ha^{-1}.

Intercropping of flower crops under coastal sandy soil

Gladiolus (*Gladiolus grandiflorus*) var. Arka Kesar (Fig. 65) and marigold var. Bangar (Fig. 66) were grown as intercrop in 45 year old West Coast Tall coconut garden with three different soil moisture conservation materials *viz*., coconut husk, coir pith and shredded coconut leaf along with control (without soil moisture conservation measures) under coastal sandy soil. One layer of dried coconut husk, 10 cm layer of coir pith and shredded material were placed at 45 cm depth in respective treatments. In gladiolus, application of shredded coconut leaf resulted in significantly higher plant height (84.1 cm), number of leaves (9.0), number of suckers (3.0), leaf chlorophyll content (2.95 mg g^{-1}) and yield parameters *viz*., days taken for spike initiation (64.7 days), spike length (100.6 cm), number of florets (9.7) and spike weight (69.2 g) over coconut husk, coir pith and control. However the effect of coconut husk and coir pith was on par and significant over control. The result indicates the beneficial effect of moisture conservation practices in coastal sandy soil. Among the three materials used, shredded leaf was more efficient for moisture retention (6.7%) whereas it was 3.51% in control (Fig. 67).

In marigold, application of shredded coconut leaf resulted in significantly higher plant height (138.1 cm), number of leaves (638), number of primary branches (26),

Fig. 65. Performance of gladiolous as an intercrop in coconut garden under different moisture conservation materials

Fig. 66. Performance of marigold as an intercrop in coconut garden under different moisture conservation materials

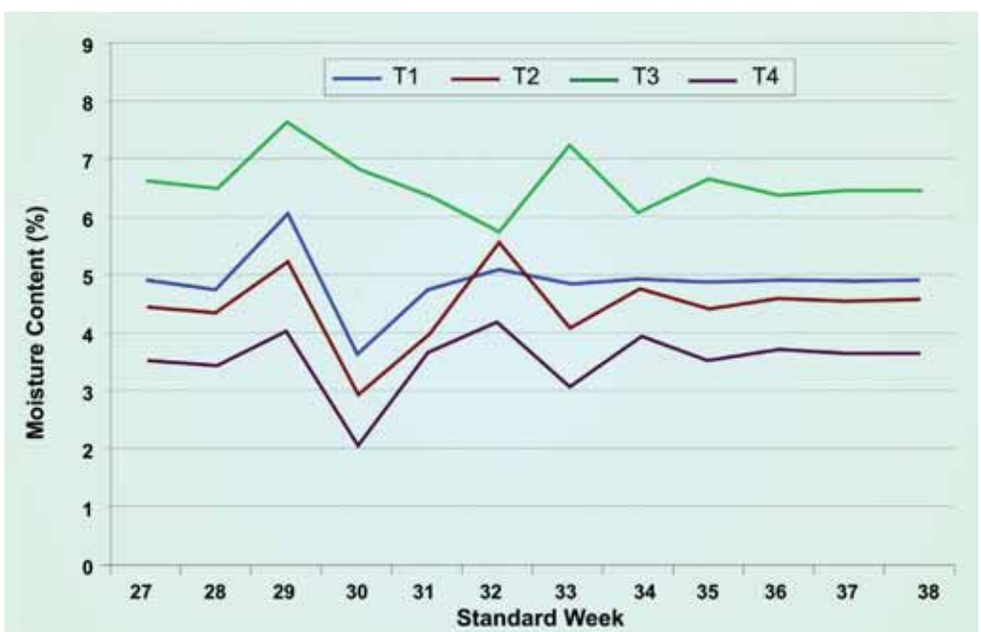


Fig. 67. Effect of moisture conservation materials (T1: Coconut husk, T2: coir pith, T3: shredded coconut leaf, T4: control) on soil moisture content

number of secondary branches (105) and floral characters like flower diameter (6.6 cm), and yield parameters *viz.*, number of flowers/plant (84), flower weight per plant (401 g) and flower yield (5.43 t ha^{-1}) over coconut husk, coir pith and control at 90 days after planting. The effect of coconut husk and coir pith was on par and it was significantly superior over control.

Heliconia as intercrop in coconut garden

Fig. 68. Inflorescence characters of heliconia varieties (1. Iris, 2. Kawauchi, 3. She, 4. Sunrise, 5. Jacquinii and 6. Caribaea)

Growth and flowering habit of six commercial Heliconia varieties under coconut (35 year old WCT palms) canopy is being evaluated since 2012 (Fig. 68). *Heliconia stricta* 'Iris', *H. bihai* x *H. caribaea* 'Kawauchi', *Heliconia stricta* Sunrise and *H. orthotropica* 'She', are found suitable as intercrop in coconut plantations, whereas, varieties *H. caribaea* x *H. bihai* 'Jacquini' and Caribbean Red are poor performers. A combination of varieties *viz.,* 'She' and 'Sunrise' can be planted in 1:1 ratio for year round production of inflorescences. The coconut palms in the intercropped area recorded 63.2 % increase in yield in three year time (2012-2015), which was mainly due to reduction in the percentage of button shedding from 77 to 44 due to complementary use of resources by both the crops.

Growth and flowering pattern of *Heliconia stricta* 'Iris' under various shade level

Fig. 69. Performance of heliconia under open condition

The growth and flowering pattern of *Heliconia stricta* 'Iris' was positively related to shade intensity ranging from open to 75%. The plants grown under 50 and 75% shade levels produced higher number of inflorescences per plant (43 and 48, respectively) with marketable inflorescence of more than one meter length, six to eight bracts and inflorescence girth of more than 9 cm (Fig. 69). These inflorescences also recorded higher values in flower pigment parameters such as carotenoid (0.13 mg g^{-1}) and xanthophyll (0.99 mg g^{-1}) content.

Validation of organic production technologies for yams intercropped in a coconut plantation

Tuber crops *viz.* greater yam (var. Sree Keerthi), lesser yam (var. Sree Latha) and dwarf white yam (var. Sree Dhanya) were planted as intercrops with different nutrient management practices *viz.*, traditional (FYM @ 15 t ha^{-1} and ash @ 1.5 t ha^{-1}), conventional (FYM @ 10 t ha^{-1} and NPK@ 80:60:80 kg ha^{-1}), integrated (FYM @

10 t ha^{-1} and NPK @ 60:30:60 kg ha^{-1}+ Azospirillum+ P solubilizer + K solubilizer @ 3 kg ha^{-1} each) and organic (FYM @ 15 t ha^{-1}, green manure, neem cake @ 1 t ha^{-1}, ash @ 1.5 t ha^{-1}) and the results revealed that all the nutrient management practices were on par with each other (Fig. 70). Yield recorded under different treatments for greater yam was 11.4, 10.3, 9.9 and 10.6 t ha^{-1}, for lesser yam 7.4, 5.9, 8.4 and 6.2 t ha^{-1} and for dwarf white yam 6.8, 6.1, 6.6 and 4.6 t ha^{-1}, respectively.

Performance of tapioca varieties *viz*., Vellayani Hraswa, Sree Vijaya and H-165 were evaluated with nutrient management practices *viz*., traditional (FYM @ 15 t ha^{-1} and ash @ 1.5 t ha^{-1}), conventional (FYM @ 10 t ha^{-1} and NPK@ 80:60:80 kg ha^{-1}), integrated (FYM @ 10 t ha^{-1} and NPK @ 60:30:60 kg ha^{-1}+ Azospirillum+ P solubilizer + K solubilizer @ 3 kg ha^{-1} each) and organic (FYM @ 15 t ha^{-1}, green manure, neem cake @ 1 t ha^{-1}, ash @ 1.5 t ha^{-1}) and yield data was on par with all the nutrient management practices. Yield recorded under different treatments for tapioca variety Sree Vijaya was 9.4, 9.8, 7.8 and 8.4 t ha^{-1}, for Vellayani Hraswa 8.7, 12.4, 11.2 and 7.7 t ha^{-1} and for H-165, 8.7, 10.4, 8.0 and 8.0 t ha^{-1}, respectively.

Fig. 70. Performance of *Dioscorea* sp. and tapioca as intercrops in coconut garden under organic management

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

A study is in progress to know the impact of different harvesting time and sequence on tender nut and mature nut production. The harvesting of tender nut in WCT recorded significantly higher yield (173 tender nuts palm^{-1}) than harvesting of mature nuts (92 mature nuts palm^{-1}).

Coconut Based Cropping System for Island Conditions of Lakshadweep

Cultivation of improved varieties of vegetables and fruits

High yielding and improved varieties of different vegetables (brinjal, chilli, tomato, drumstick, cauliflower, cabbage, snake gourd, sponge gourd, amaranthus and spinach) and fruit crops (banana, sapota, papaya and guava) were cultivated. Production and supply of vegetables/ fruits to islanders was continued and 3.92 t of different vegetables as well as 1.98 t of various fruits were made available to the Islanders (Fig. 71).

Location-specific technologies/planting material for Lakshadweep Islands

Demonstration of protected cultivation of vegetables with shade net/net house in South Bandaram, Minicoy (2 farmers, 5 cents) and Aoumagu Village, CKB Road, Minicoy (1 farmer, 1.5 cents) was taken up and the farmers could meet the entire

requirement of their vegetables. Seed packets/seedlings of various vegetables (tomato, chillies, pumpkin, brinjal, bottle gourd, okra, cowpea, amaranth, palak and coriander) and fruit crops (papaya) were supplied to 229 farmers to encourage development of homestead garden (Fig. 72). In addition, 213 seed nuts and 627 coconut seedlings were also made available.

Technology transfer programmes

Two farmers-scientist interface programmes with the themes "Island Agriculture-Problems and Prospects" and "Organic Cultivation of Vegetables in Island Ecosystem" for the farmers and SHGs were organized on 6th November 2015 at Androth Island and on 8th November 2015 at Minicoy Island, respectively. A total of 90 farmers participated in these programmes (Fig. 73). Training was imparted to farmers on coconut climbing, neera production and value addition. Coconut climbing devices were also distributed to young farmers during the above farmer-scientist programmes (Fig. 74).

Fig. 71. Vegetables for distribution to islanders in Minicoy

Fig. 72. Vegatable seedlings for distribution to farmers in Minicoy

Fig. 73. Interaction by farmer's during interface meeting at Androth

Fig. 74. Distribution of coconut climbing device at Androth

Production Technologies for Sub-Himalayan Terai Region and North Eastern States

Cropping system for sub-Himalayan Terai region

Different medicinal plants were evaluated as intercrop in arecanut and coconut plantation to assess the total system productivity. Higher total system productivity (8.76 t chali ha^{-1}) was achieved in arecanut and asparagus system followed by arecanut and *Aloe vera* (7.27 t chali ha^{-1}). A total of 129% increase in total system productivity was recorded over arecanut monocrop. In case of coconut and medicinal plants cropping system, higher system productivity of 8.78 t copra ha^{-1} was achieved in coconut and asparagus combination, which was 218% more than sole coconut crop. A total system productivity 7.94 t copra ha^{-1} was obtained from coconut and *Aloe vera* combination. In both the cases, yield of arecanut and coconut increased under intercropping system.

Different arecanut based models were evaluated to find out the better system for higher system productivity and also to find out the contributions of different crops to total system productivity. It was found that model involving arecanut+ black pepper+ acid lime + turmeric had highest total system productivity (14953 kg ha^{-1}) followed by the model with arecanut + black pepper + acid lime with a total system productivity of 13558 kg ha^{-1}. Among the different inter/ mixed crops, black pepper contributed maximum (67-70%) to total system productivity in terms of monetary value whereas the main crop arecanut contributed only 22-26%. Cultivation of inter/ mixed crops in arecanut is highly profitable as there was 311-396% increase in total system productivity.

Integrated nutrient management in arecanut

Arecanut leaf from the garden was converted into vermicompost and recycled at Mohitnagar. Control treatment (no fertilizer) resulted in significantly lower yield and yield parameters, indicating application of fertilizer (either organic or inorganic) is essential to get higher yield in different varieties of arecanut. Higher chali yield (4.21 kg $palm^{-1}$) was recorded in Mohitnagar, as compared to the other varieties with 50% N substitution by vermicompost. But in Sumangala and Sreemangala, higher chali yield was recorded with recommended dose of fertilizer *i.e.* fully inorganic form of fertilizers (100 g N, 40 g P and 140 g K). In case of Mangala, higher chali yield (3.48 kg $palm^{-1}$) was recorded with 100% N substitution by vermicompost.

Among the five released varieties of arecanut (Mangala, Sumangala, Sreemangala, Mohitnagar and Kahikuchi) evaluated at Kahikuchi, Assam under different combinations of chemical fertilizer and vermicompost, Kahikuchi variety performed well with yield of 2.93 kg chali $palm^{-1}$ with $1/3^{rd}$ chemical fertilizer + $2/3^{rd}$ as vermicompost.

Arecanut based high density multispecies cropping system

Arecanut based high density multispecies cropping system (HDMSCS) with different crop components: arecanut (Kahikuchi) + black pepper (Panniyur- 1) + banana (Jahanji) + citrus (Assam lemon) + pineapple (Kew type) + turmeric (Lakadong) with organic and integrated nutrient management was evaluated at Kahikuchi, Assam. The initial study showed that higher yield of the main crop arecanut (2.30 kg chali $palm^{-1}$) with $1/3^{rd}$ recommended dose of fertilizer + recycling of biomass + biofertilizer + green manuring crops and the maximum yield of the intercrops like banana (24.1 kg $plant^{-1}$) and turmeric (22.4 t $ha^{-1}$of fresh rhizome) was recorded with $2/3^{rd}$ recommended dose of fertilizer + recycling of biomass. The other intercrops like pineapple and Assam lemon are still in vegetative stage.

Nutrient Management in Plantation Crops for Enhancing Yield and Quality

Nutrient management

To identify the major yield limiting nutrient deficiency, the soil nutrient status of high yielding (>100) and low yielding (<60-80) coconut palms were assessed. The most important yield limiting nutrient deficiency was found to be the soil available potassium, the average content in low yielding group of palms were 11 ppm, whereas, it was observed to be 162 ppm in high yielding palms.

Boron in coconut

Fasciation, inflorescence necrosis, button shedding and 'hen and chick' syndrome were documented as deficiency symptoms of boron. Addition of boron @ 18 g (*i.e.*180 g borax) in four split doses (starting from May, at quarterly intervals) along with husk burial in the basin and vermicompost application @ 20 kg per palm can alleviate the symptoms of boron deficiency. The leaf boron content increased with increasing level of boron application, but the highest response in terms of nut yield (94 nuts palm^{-1} yr^{-1}) was obtained with application of 18 g of boron (Fig. 75).

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

Nutritional requirement of dwarf varieties of coconut (Kalparaksha, Chowghat Orange Dwarf and Kalpasree) in root (wilt) affected area with four nutritional treatments is being evaluated since 2008 (Fig. 76). Application of fertilizers @100 percent on soil test basis + vermicompost (15 kg palm^{-1}) + neem cake (5 kg palm^{-1}) resulted in highest mean number of nuts above and below fist size (56.4 and 61.3, respectively) during 2015. This treatment also recorded the lowest percentage of fallen buttons in all the varieties which ranged from 30.5 to 40%. Both soil test based nutrient application (STBNR) and organics alone resulted in soil potassium levels well below the sufficiency level of 60 ppm, whereas, the values were 67.4 ppm and 86.6 ppm respectively for 100% STBNR added with vermicompost and neem cake and 125% STBNR.

a b c

Fig. 75. Palms showing deficiency of boron (a) and palms recovered from deficiency (b & c)

Delineating micronutrient deficient coconut, arecanut and cocoa growing areas

Zinc deficiency in major coconut, arecanut and cocoa growing areas were delineated using available secondary data from various sources. Soil available zinc deficiency is widespread in the coconut growing tracts of Tamil Nadu, Andhra

Kalparaksha COD Kalpasree

Fig. 76. Performance of Kaparaksha, COD and Kalpasree varieties supplied with combination of fertilizer, vermicompost and neem cake

Pradesh, Gujarat, parts of Karnataka and Maharashtra. Most of the coconut growing areas in Kerala, Karnataka and Odisha are sufficient in soil available Zn. The major arecanut and cocoa growing states *viz*., Kerala, Karnataka and Andhra Pradesh are mostly sufficient in available Zn status, whereas, the deficiency is more in Tamil Nadu. The other widespread micronutrient deficiencies in coconut growing areas are B and Fe. The Cu and Mn deficiency are observed in very limited area. Boron deficiency is more in parts of Kerala, Karnataka and West Bengal. The Fe deficiency was observed in the coconut growing districts of Tamil Nadu and Andhra Pradesh.

Enhancing economic viability of coconut based land use system

A multi-institutional collaborative project for evaluating the economic viability of coconut based cropping system through site-specific management practices was initiated during 2015 in the five agro ecological units (AEU 1, 3, 9, 10, 11) of Kerala State with the financial assistance from Kerala State Planning Board. The project consists of trials and demonstration in farmers plots. Demonstration is being carried out in 10 plots, each consisting of 30-40 palms in each agro ecological unit. Pre-treatment analysis of soil and leaf samples indicated the deficit of copper in the coastal soil of the Agro Ecological Zone 1 (AEU-3 and 9). The excess of soil P was evident in all the AEUs except that of the specific plots in AEU-1. Deficiency of boron was also prevalent in the samples collected from AEU-1, 3, and 9. This was also validated through analysis of leaf samples confirming the deficiency in the availability of boron. Management strategies are being formulated, considering the soil nutrient constraints in different locations of the state.

BIO-RESOURCES MANAGEMENT

Raising areanut and cocoa seedlings in soilless media

Recycled coconut biomass residues such as coconut leaf vermicompost and urea-free coir-pith compost, and their mixtures, were tested as soilless media for raising arecanut and cocoa seedlings (Fig. 77).

Fig. 77. Composted and raw coconut biomass residues used as soilless media substrates; a) vermicompost, b) coir-pith compost, c) coirpith and d) shredded coconut biomass

Prior to testing the mandate crops, the soilless substrates were assessed for raising seedlings of tomato, chilli, papaya and black pepper (Fig. 78). After getting positive results, seed nuts of Mohitnagar variety of arecanut and seeds from Foreastero cocoa were sown in the nursery media. Four combinations of medias with and without soil were prepared for the study *viz*. i) soil+compost (control), ii) coir-pith compost, iii) coir-pith compost + coconut leaf vermicompost and iv) coir-pith compost + coconut leaf vermicompost + PGPR + *Trichoderma harzianum*. The study was conducted in polybags and no additional fertilizer was applied to the media.

Fig. 78. Vegetable seedlings raised in soilless media; a) tomato, b) chilly

Fig. 79. Profuse root biomass produced by arecanut seedlings grown in soilless media (left) compared to soil+compost media

It was observed that both arecanut and cocoa seedlings grew well in the soilless media. Stem girth, number of leaves and total plant dry weight were higher for both the seedlings in soilless media compared to control treatment (Fig. 79).

Addition of PGPRs and *Trichoderma* to soilless media improved the growth parameters of the seedlings. Microbial analysis of the soilless media also indicated a positive response in terms of higher populations of different general and function specific microbial communities for both arecanut and cocoa.

Granular bio-inoculant preparation

Suitability of Pusa hydrogel as carrier material for granular formulation of PGPR *Bacillus megaterium* and *Pseudomonas putida* was assessed. Hydrogel (0.5 g) soaked overnight in 2 ml culture of *Bacillus megaterium*/*Pseudomonas* was dried at room temp (30±2°C) for 2 days. Final count of *Bacillus* was 4.7 x 10^6 cfu g^{-1} dry weight of hydrogel against the initial count of 1.2 x 10^7. *Pseudomonas* did not survive in the hydrogel (Fig. 80 & 81).

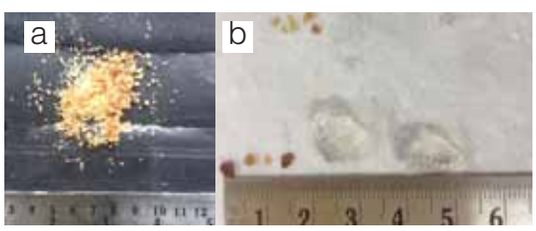


Fig. 80. Pusa hydrogel a) dry and b) hydrated

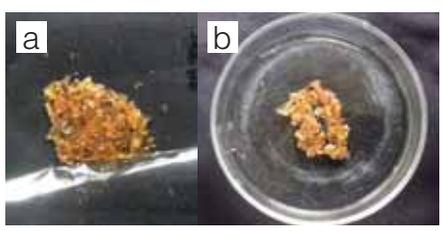


Fig. 81. Hydrogel and PGPR mixture a) 1g hydrogel + 2 ml PGPR culture, b) desiccated hydrogel with PGPR culture

Palm biomass based biochar

Soil mixed with three types of biochar *viz.* tender coconut husk waste, arecanut husk waste and coir pith applied in five graded doses was kept for incubation for 120 days. Soil sub samples were taken fortnightly initially and then at monthly

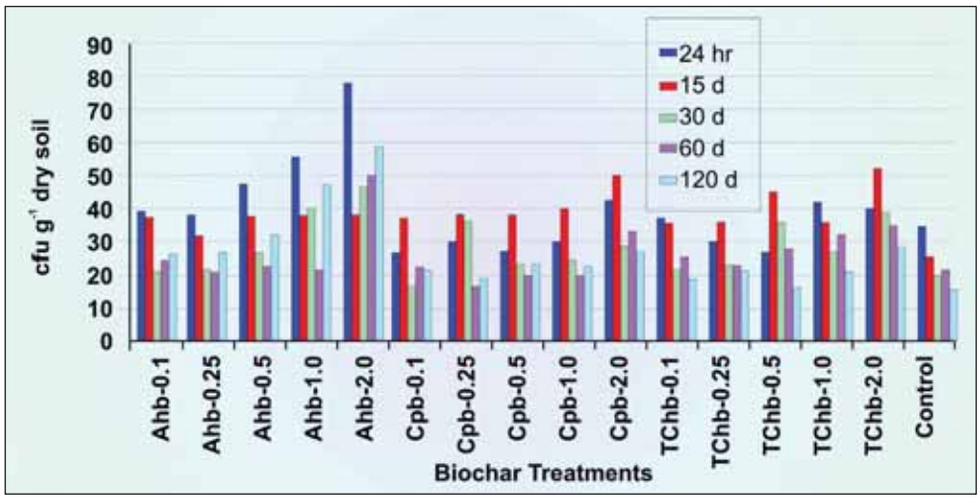


Fig. 82. Effect of application of biochar on bacterial population in soil

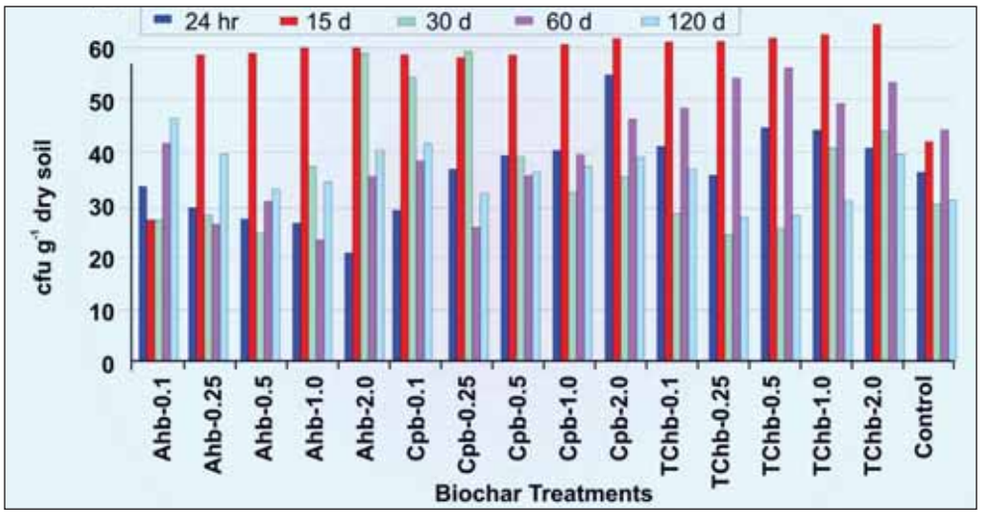


Fig. 83. Fungal population dynamics in soil-biochar incubation studies

intervals for N partitioning (nitrate and ammoniacal-N) and corresponding microbial studies. Microbial parameters for all sub-samples and nutrient partitioning studies for two sub-samples were analysed. The study showed that with increase in biochar dose, availability of nutrients and populations of microbial communities increased in soil (Fig. 82 & 83).

Arecanut husk composting

Areca husk is not easily amenable to composting and attempts were made to compost areca husk using microbial and non-microbial interventions. Different microbes like *Phanerochaetae chrysosporium* and oyster mushroom fungus, non-microbial components like glyricidia leaves, cow urine and dung were included in the composting of areca husk. Microbial amendment with *Phanerochaetae chrysosporium*, oyster mushroom fungus enabled slow composting and addition of cow urine/dung and glyricidia leaves as nitrogen source could hasten the composting process by the fungi.

Studies on Zn solubilizing microorganisms

Isolation of Zn solubilizing microorganisms was attempted from rhizosphere soils of coconut, cocoa and arecanut collected from Kahikuchi Centre of ICAR-CPCRI,

Fig. 84. Zn-solubilizing microorganisms a) arecanut isolates, b) coconut isolates c) cocoa isolates

Assam (Kamrup district). Analysis of soils revealed miniscule levels of available Zn as compared to total Zn levels. A total of 11 Zn solubilizing microorganisms were isolated, four each from arecanut and cocoa, and three from coconut (Fig. 84).

The organisms exhibited varying degrees of solubilizing efficiencies (%) in presence of insoluble Zinc salts – ZnO and $ZnCO_3$. An isolate from cocoa rhizosphere, showed highest solubilization efficiency of 500% after five days of incubation in presence of $ZnCO_3$.

Studies on microbial community in the rhizosphere and endophytic matrix

Twenty three endophytes obtained from healthy coconut palms from permanent manurial trial plots at Kasaragod were screened for PGPR traits. Apart from this, 35 bacteria (including actinomycetes) and 20 fungi were isolated from two healthy coconut rhizosphere from the same plot (Table 8). Of the 23 endophytes, four solubilized P and Zn and two were positive for IAA production. Isolate EP440B11 was positive for IAA production and P & Zn solubilization.

Table 8: Population of endophytes in root samples of coconut palms

Palm No.	Bacterial count Cfu g^{-1} root (wet wt. basis)
PMT 443	4.3×10^2
PMT440	4.67×10^2

A total of 53 rhizospheric and endophytic microbes were isolated from root (wilt) affected and healthy palms for developing PGPR

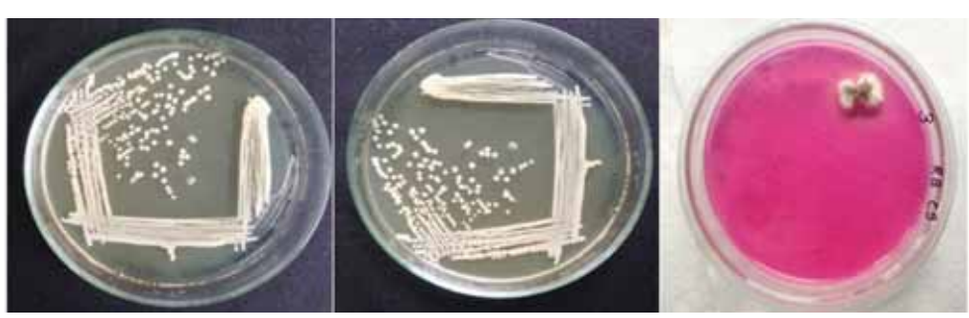


Fig. 85. Endophytes from healthy coconut palm

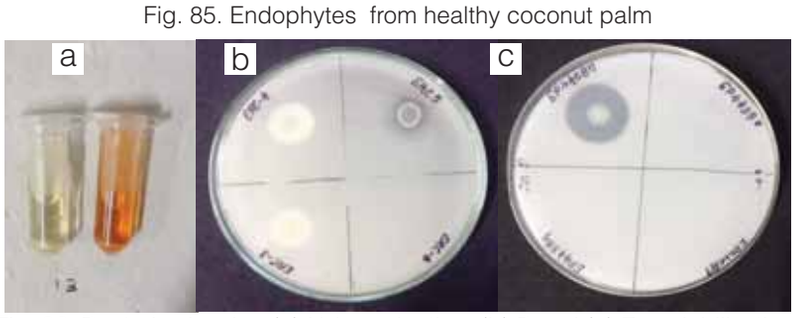


Fig. 86. Bacteria showing (a) IAA production, (b) P and (c) Zn-solubilization

inoculants. Eight fluorescent *Pseudomonas* and 15 phosphate solubilizers were isolated from healthy coconut rhizosphere soil samples from Alappuzha.

Vermicomposting of pulverised coconut fronds

The efficiency of vermicomposting of pulverized coconut fronds including the hard petiole using bio-shredder was compared to the conventional method of chopped leaves in basins as well as in large tanks. The results indicated that vermicomposting of pulverized substrate could be successfully completed in one cycle (90 days) with 80-85% conversion efficiency (Table 9). Conventional method, where the coconut frond is cut in 2-3 pieces, required 2 to 3 cycles for complete vermicomposting with maximum of 70% conversion efficiency per cycle (Fig. 87).

Table 9: Physico-chemical characteristics of vermicompost produced by two different methods

Leaf fronds	Total N %	Total P %	Total K %	OC %	pH	Moisture %
Chopped leaves	1.85	0.25	0.16	16	6.3	61
Pulverized	1.73	0.25	0.26	18	7.4	68

Fig. 87. Vermicomposting of coconut leaves; a) pulverizing coconut fronds, b) tanks filled with pulverized substrate and c) vermicompost produced from pulverised wastes

Large scale production of vermicompost in cement tanks using pulverized coconut leaf fronds

Fig. 88. Mature vermicompost produced from pulverized (left) and conventional (right) method

Nutrient and microbial analysis revealed differences when vermicomposting was done in small volume (plastic basin) followed by larger volumes (tanks). In tanks, analysis showed that vermicompost produced using pulverized coconut residues had higher pH, organic carbon and potassium compared to chopped material. Microbial population, particularly, plant beneficial ones were significantly high in vermicompost produced by pulverized substrate as compared to chopped one (Fig. 88).

Application of Microorganisms

Compatibility of PGPR with *Trichoderma harzianum*

Compatibility studies between PGPR of coconut and cocoa with *Trichoderma harzianum* were carried out *in vitro* in two different media. The results indicated that only *Bacillus megaterium* isolated from the rhizosphere of coconut is compatible

Fig. 89. *Bacillus megaterium* compatible with *Trichoderma harzianum*

with *T. harzianum*. The study indicates possible integration of PGPR with fungal antagonist for effective rhizosphere management (Fig. 89).

Soil microbial study in YLD affected and healthy arecanut palms

Rhizosphere soil samples were collected from arecanut gardens having i) severely YLD affected palms (>70%), ii) medium YLD affected palms (4-50%) and iii) YLD free palms (visual indexing) from Sringeri Taluk of Chikkamagaluru District for their microbial analysis during pre-monsoon period (May) of 2015. A total of 15 samples, seven from severely YLD garden and four each from medium YLD affected and YLD free plots were analysed. Among the different general and functional microbial communities analyzed by culture-dependent method high population of actinomycetes in the rhizosphere soils of YLD free palms was the only discriminating results observed (Fig. 90). The pH as well as the moisture content of the soils also showed less variation.

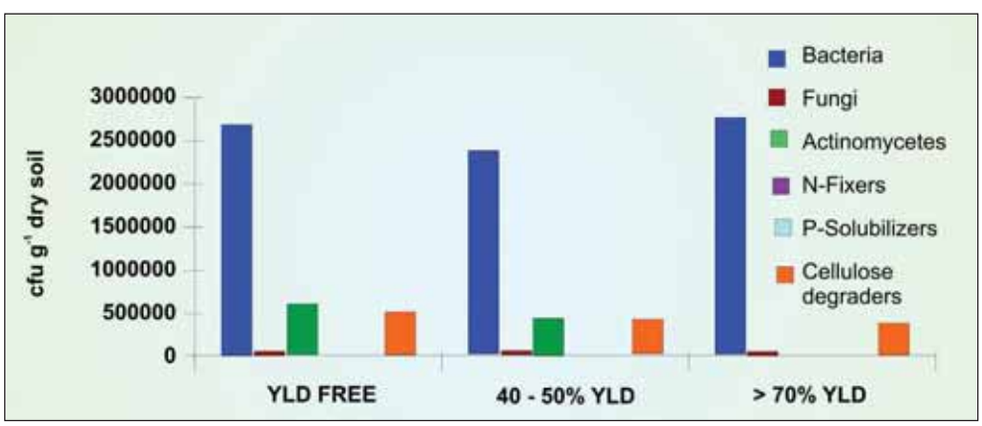


Fig. 90. Microbial studies in the rhizosphere of arecanut palms affected by YLD

Citizen/Client's Charter Services

Different bioresources were produced for use as organic amendments and supplied to farmers and other end users as detailed below (Table 10).

Table 10: Production and distribution of bio-resources during 2015-16

Bioresource	Produced	Sold
Eudrilus sp. (Coconut leaf vermicomposting earthworms)	1,50,000	10,500
Kalpa Organic Gold (Coconut leaf vermicompost)	28 MT	5 MT
Kalpa Soil Care (Urea-free coir-pith compost)	6 MT	1 MT
Kera Probio (PGPR bioinoculant)	120 kg	55 kg
Coconut leaf vermiwash	200 L	--
Mushroom spawn	20 kg	12 kg

Release of compost products

Research carried out in the past on bio-residue utilization, yielded two organic products. Kalpa Organic Gold, vermicompost produced from coconut leaves using indigenous *Eudrilus* sp., and Kalpa Soil Care, urea-free coir pith compost, were released by Honourable DDG (Hort.) Dr. N.K. Krishna Kumar during the ICAR- CPCRI centenary year launch programme held at ICAR-CPCRI premises on 12th March 2016. The products are available for sale to end users and the technology is available for transfer on commercial basis (Fig. 91).

Fig. 91. Organic compost products a) Kalpa Organic Gold and b) Kalpa Soil Care

REDUCING CROP LOSS

Integrated Management of Diseases

Phytophthora diseases

PCR based detection of *Phytophthora* spp.

Specific and sensitive PCR assays were developed for rapid detection of six *Phytophthora* spp. infecting coconut, cocoa and arecanut. PCR assays carried out using species-specific ITS primers showed (Fig. 92) that *P. palmivora* (325 bp), *P. nicotianae* (300 bp) and *P. capsici* (400 bp) could be easily identified based on difference in amplicon size, but *P. meadii*, *P. citrophthora* and *P. colocasiae* showed approximately the same band size (362 bp). Comparison with available sequences of these *Phytophthora* species in NCBI database showed that there was only a single nucleotide difference in the ITS region of these species. In order to differentiate these three species, High Resolution Melt (HRM) curve analysis was used and all the three species could be differentiated by HRM - derivative melt curves (Fig. 93).

Fig 92. PCR profile based on amplification with ITS primer; Gel a - *P. nicotianae*, *P. palmivora*, *P. capsici*, Gel b - *P. meadii*, *P. citrophthora* and *P. colocasiae*

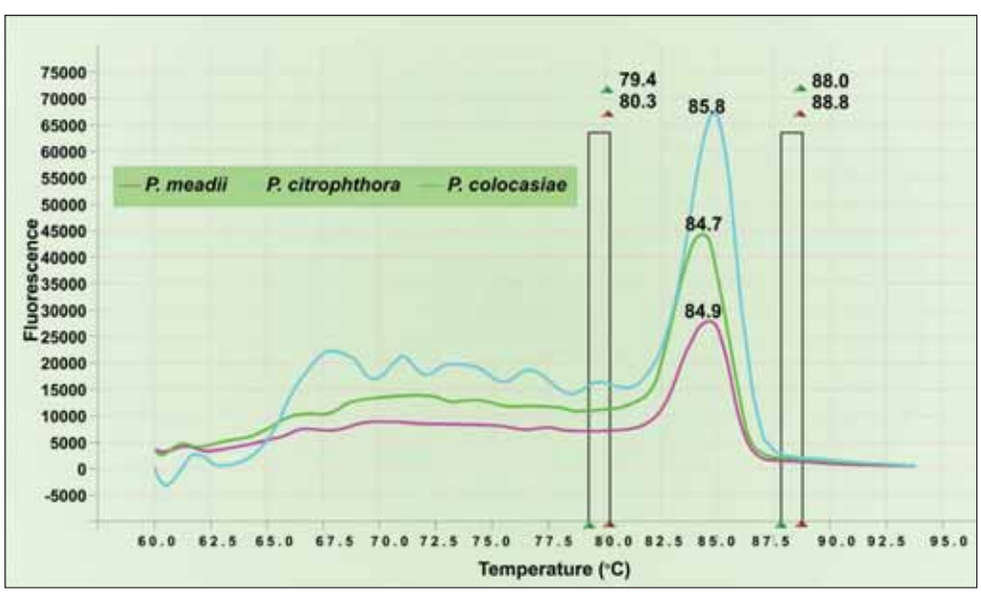


Fig. 93. Identification and differentiation of *Phytophthora meadii*, *P. citrophthora* and *P. colocasiae* through HRM derivative melt curves

Isolation of endophytes and evaluation against *Phytophthora palmivora*

Five endophytic *Trichoderma* isolates were isolated from cocoa and evaluated against three virulent *Phytophthora palmivora* isolates, infecting both cocoa and

coconut, by dual culture method. Among the three *Trichoderma* isolates, isolate number CPCRI-COC-3 recorded complete inhibition of mycelial growth within three days of inoculation (Fig. 94).

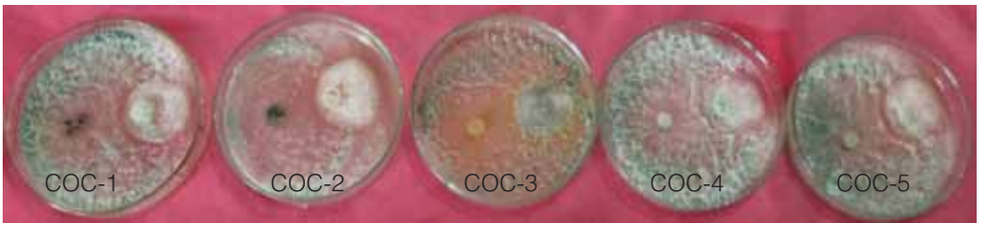


Fig. 94. Efficacy of endophytic *Trichoderma* isolates (COC-1 to COC-5) from cocoa against *Phytophthora palmivora*

Management of coconut bud rot disease

A field trial on the management of coconut bud rot disease was conducted at Konnakkad of Balal panchayath in Kasaragod district, Kerala using nine treatments (placement of different fungicide sachets and *Trichoderma* coir pith cake in the inner most leaf axil of the coconut palm), after recording a pre-treatment disease incidence of 48.5% (Fig. 95). Out of the nine prophylactic treatments, fresh bud rot disease incidence was not observed in palms treated with chlorothalonil 78.12%WP, iprovalicarb 5.5 + propineb 61.25% WP, dimethomorph 50 WP, fosetyl-AL 80 WP + propineb 61.25%WP and metiram 50 + pyraclostrobin 50%WG. However, fresh bud rot incidence of only 3.3% was recorded in palms treated with copper hydroxide 77%WP, copper oxychloride 50%WP and *Trichoderma* coir pith cake.

Fig. 95. Prophylactic treatment for bud rot disease using *Trichoderma* coir pith cake (a) and perforated sachets containing the fungicide iprovalicarb 5.5 % + propineb 61.25 % WP (b)

Another field demonstration trial on bud rot disease management was initiated during 2013 at Manjeshwar and West Eleri panchayaths in Kasaragod district of Kerala using *Trichoderma* coir pith cake (TCPC). During 2014, post-treatment bud rot disease incidence was nil at Manjeshwar and 8.7% at West Eleri and during 2015, it was 2.5% at Manjeshwar and 6.2% at West Eleri panchayath. The field trials indicated that prophylactic treatment with fungicides or *Trichoderma* coir pith cake could significantly reduce the bud rot incidence compared to control.

Management of fruit rot disease of arecanut

Field trial on management of fruit rot disease of arecanut was conducted at Kidu and Vittal using 12 fungicides. The fruit rot disease incidence was noticed from the second week of July in Kidu, but no disease could be recorded in Vittal throughout the season. Lower fruit rot disease incidence was observed in palms treated with mandipropamid 23.3%SC (6.7%) followed by fosetyl-Al 80WP+ propineb 61.25%WP (13.3%) and 1% Bordeaux mixture (20%) sprayed plots in Kidu (Fig. 96).

Control Mandipropamid 23.3%SC sprayed palm

Fig. 96. Management of fruit rot disease of arecanut with mandipropamid 23.3%SC

Ganoderma diseases

Basal stem rot or *Ganoderma* wilt is a major disease of coconut, arecanut and oil palm. In order to refine and develop a *Trichoderma* based IDM, a field trial on the management of *Ganoderma* wilt disease was conducted with six treatments at Arzal, Maniat and Alakode areas in Kannur district of Kerala. Highest reduction in basal stem rot disease index was recorded in plams treated with *Trichoderma harzianum* (CPTD 28) enriched neem cake @ 5 kg per palm^{-1} (Fig. 97).

Fig. 97. Management of basal stem rot in coconut with Trichoderma enriched neem cake

Diagnosis and Management of Root (Wilt) Disease of Coconut and Yellow Leaf Disease of Arecanut

PCR based detection of phytoplasma associated with coconut root (wilt) disease and arecanut yellow leaf disease

Total DNA was isolated from spindle leaves, trunk borings, root and inflorescence rachillae of root (wilt) affected coconut palms and subjected to PCR using P1/P6-R16F2n/R16R2, F3-B3, P4/P7, Sec A for/rev and tuf for/rev primers. Though P1/

P6-R16F2n/R16R2 primer combinations showed amplification at desired base pair level (1250 bp) in some samples, the product on sequencing showed 99 percent identity to bacterial DNA sequence (*Microbacterium* sp.). Analysis of results of nested PCR, real-time PCR and loop-mediated isothermal amplification (LAMP) assays employed for detection of phytoplasma associated with coconut root (wilt) and arecanut yellow leaf disease with combination of different phytoplasma specific primer pairs, revealed further refinement of protocol in all these DNA based detection techniques is essential for reliable and consistent diagnosis of root (wilt) disease of coconut and yellow leaf disease of arecanut.

Screening of fungicides against leaf rot pathogens

Leaf rot caused by fungal pathogens in root (wilt) affected coconut palms aggravate the severeity of the diseases and effective control of leaf rot is essential to reduce the yield loss. Eight fungicides were tested *in vitro* at various concentrations (25-400 ppm) against the leaf rot pathogen *viz., Colletotrichum gloeosporioides*. Among the fungicides tested *in vitro*, propiconazole 25%EC, carbendazim 25% plus flusilazole 12.5%SE, carbendazim 50%WP and difenconazole 25%EC were found to be effective and selected for field evaluation.

Isolation and characterization of endophytes from YLD endemic areas

Eleven fungal and 12 bacterial isolates were isolated from the roots of apparently healthy arecanut palms in yellow leaf disease endemic area of Sringeri in Karnataka.

Collection, identification and cataloguing of auchenorrhynchan fauna in coconut ecosystem

Nisea nervosa (Motschulsky) [Fam: Meenoplidae] was the most common auchenorrhynchan fauna encountered in light trap catches in coconut ecosystem during all seasons. Occurrence of leafhopper *Orosius albicinctus* (Distant) and zigzag leafhopper, *Maiestas dorsalis* (Motschulsky) was intercepted during October.

Molecular detection and characterization of phytoplasma from auchenorrhynchan fauna and weeds

PCR assay of DNA isolated from the insect *N. nervosa* using phytoplasma-specific universal primers (P1/P6-R16F2n/R16R2) in 41 lots (five insects per lot) indicated positive amplification in 16 lots (39.02%). Sequences showed identity to spiroplasma an endosymbiont of *N. nervosa,* which might be involved in nutrition.

Vernonia cinerea *Mollugo disticha*

Fig. 98. Phyllody symptoms on *Vernonia cinerea* and *Mollugo disticha* in root (wilt) affected coconut gardens

Weeds are potential reservoirs of plant pathogens. In order to identify the collateral hosts of coconut root (wilt) disease phytoplasma, weed species showing typical symptoms of phytoplasma infection in the disease affected coconut gardens were collected and subjected to PCR using universal primers for phytoplasma. Phytoplasmas associated with three weeds in coconut gardens *viz., Vernonia cinerea* phyllody, Bermuda grass white leaf and *Mollugo disticha* phyllody were detected and characterized (Fig. 98, 99). The phytoplasma causing phyllody in *V. cinerea* and *M. disticha* was identified as "*Candidatus* Phytoplasma australasiae"-related strain belonging to subgroup 16SrII and that in Bermuda grass white leaf as "*Candidatus* Phytoplasma cynodontis" related strain belonging to subgroup 16SrXIV.

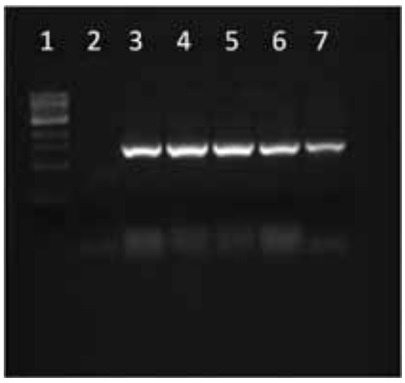


Fig. 99. PCR based detection of phytoplasma associated with plants in coconut root (wilt) affected garden with universal primers (P1/P6-R16F2n/R16R2). Lane1: 1 kb DNA Ladder, 2: Non- template control, 3: Bitter gourd phyllody, 4: *Vernonia cinerea phyllody*, 5 & 6: *Mollugo disticha* phyllody, 7: Sugarcane grassy shoot

Integrated Management of Pests

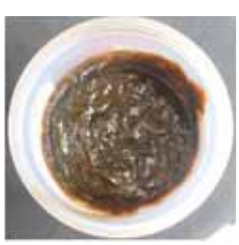
Rhinoceros beetle (*Oryctes rhinoceros* L.)

The botanical cake in tablet-shape used as prophylactic treatment was found sticky during monsoon period and was pushed out with growing spear leaf. Sticky nature of cake was rectified by talc-coating and field evaluated. Placement of two botanical cakes on the top most leaf axils reduced leaf damage by 54% and was found superior to chlorantraniliprole sachets (34%) in reducing rhinoceros beetle attack. A paste based on botanical extracts/oil was developed and swiped over the spindle and adjoining petioles @ 10 g palm^{-1} to safeguard juvenile palms for about two months from rhinoceros beetle attack (Fig.100).

Symptoms of rhinoceros beetle damage on coconut

Rhinoceros beetles

Talc-coated botanical cake



Botanical paste for repelling rhinoceros beetle

Fig. 100. Management of rhinoceros beetle with botanical preparation

A pest-suppressive coconut-based agro-ecosystem was designed through ecological infrastructure within the cropping system such as defenders, volatile cue repulsion, refuge site, predatory birds *etc.* In the system, breeding period of Indian roller safeguarded the palms from rhinoceros beetle attack during April-June. Inner whorls of 19 Kalpa Sankara palms (40 months old), under the influence of mixed-volatile cues of crop plurality (rambutan, nutmeg, curry leaf, banana, turmeric) exhibited lesser rhinoceros beetle damage (21.1%) compared to palms in outer whorls (35%). Orientation response of rhinoceros beetle towards the volatile cues of nutmeg and rambutan was found to be lower than control, indicating repulsion odours from these intercrops.

Dose-induced mortality (6.7 to 100%) of rhinoceros beetle grubs was obtained when exposed to entomopathogenic nematodes (EPN) *viz., Steinernema carpocapsae* and *Heterorhabditis indica* in concentrations ranging from 50 to 250 IJ grub^{-1} (Fig. 101). Application of EPN at 100 and 200 IJs g^{-1} on vermi composting pits (coconut leaf litter + cow dung substrate) had no deleterious effect on earthworm, *Eudrilus* sp. as well as on process of conversion of compost (Fig. 102). Mass production technology of green muscardine fungus (GMF), *Metarhizium anisopliae* was standardized in semi-cooked rice grains yielding a spore count of 3x10^7 cfu g^{-1} of the culture. For liquid broth culture of *M. anisopliae*, carbon source dextrose could be replaced with less expensive jaggery. Tapioca jaggery broth and coconut water jaggery broth were found highly suitable for the liquid broth culture of *M. anisopliae*.

Area-wide technology adoption facilitated by ICAR-CPCRI covering 1500 ha in Alappuzha district indicated 76 to 85% reduction in leaf damage by rhinoceros beetle over the pre-treatment period. Palms infested with rhinoceros beetle were reduced to 54.14% from the initial infestation level of 82.35% in a period of three years. An increase of 13.1% nuts per palm per year was recorded due to these interventions. Farmer Field School (FFS) was found to be an ideal method for technology transfer in coconut health management system and the average knowledge score on pest management of those farmers attending FFS was 51.69 compared to 32.80 in case of non-FFS farmers. Since knowledge is a pre-requisite for technology adoption, FFS is an appropriate extension intervention for improving knowledge of farmers.

Fig.101. EPN infested rhinoceros grubs

Fig. 102. Healthy earthworms in EPN incorporated vermicompost

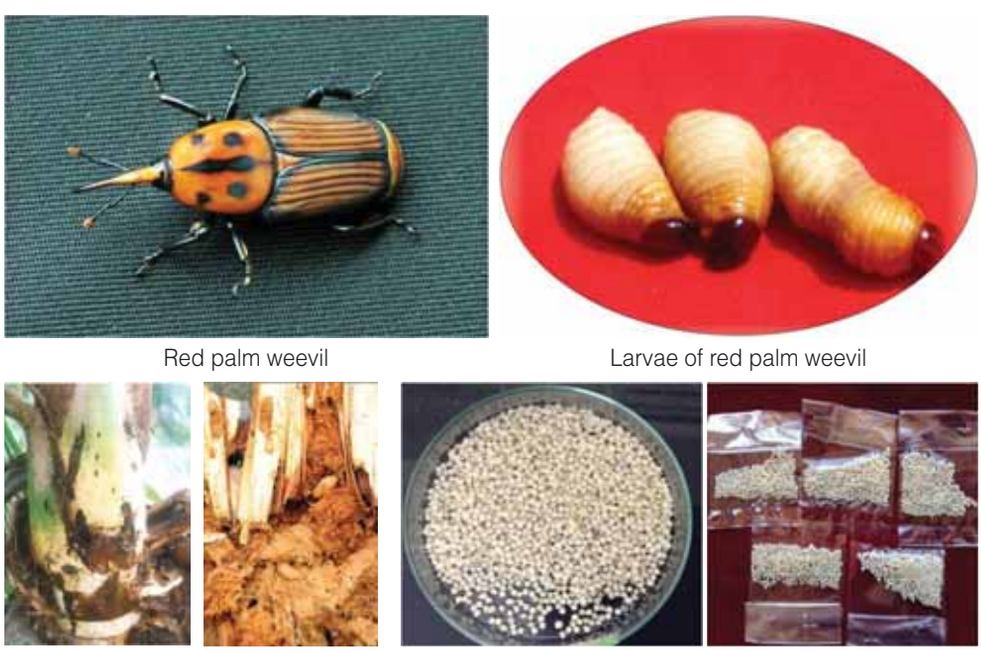
Red palm weevil (*Rhynchophorus ferrugineus* Oliv.)

Prophylactic delivery of filter paper sachets containing 10 *Heterorhabditis indica*-infected *G. mellonella* cadavers in combination with tablet-shape botanical cake on the leaf axils could reduce rhinoceros beetle attack to an extent of 35-85% and shielded palms from red palm weevil invasion during monsoon period.

Laboratory evaluation of a new tablet formulation of a combination insecticide, thiamethoxam (1.2%) and chlorantraniliprole (1.2%) (Virtako 2.4 TB) @ one tablet per petiole, induced 95% mortality of red palm weevil grubs in petiole-based bioassay. Imidacloprid residue was not detectable from day one up to a period of 30 days in tender nut meat, water as well as 14th leaf of coconut when evaluated @ 0.02% on red palm weevil-infested palm, indicating safe level of imidacloprid usage in the management of red palm weevil. Incidence of red palm weevil was found higher (5-6%) in root (wilt) disease endemic spots of Pollachi, Tamil Nadu than disease-free zones (<0.5%). *Microbacterium* sp. was detected in root (wilt) diseased palms as well as from the guts of red palm weevil.

A meridic artificial diet for rearing red palm weevil grubs was developed which sustained larval growth up to 23 days after eclosion, attaining body weight of 1.12 g. Grubs weighing >1.5 g were transferred to coconut petiole for the construction of fibrous cocoon and pupation. Lufenuron, an insect growth regulator, when evaluated on grubs of red palm weevil interfered with larval-pupal transformation (ED_{50} 0.00779%; χ^2 6.45; P=0.168) resulting in blister formation, softening of cuticle and pupal and adult malformation. Lufenuron-treated grubs pupated in 16 days leading to precocious development, whereas the control group pupated only after 44 days indicating acceleration in growth as well as pupation of grubs when treated with lufenuron. Gut microbiome analysis of red palm weevil grubs revealed five culturable bacterial strains *viz., Serratia marcescens, Enterococcus casseliflavus*, *Bacillus* sp., *Klebsiella variicola* and *Stenotrophomonas maltophilia* assuming different functional roles in the fitness behaviour of the insect. Nearly 5.12% of the total bacterial colonies constituted cellulose degrading type in the gut of *R. ferrugineus*.

Botanical repellents (essential oils) were screened by behaviour assay using Y-tube olfactometer against red palm weevil. Results indicated that citriodora oil



Red palm weevil | Larvae of red palm weevil

Damage symptoms of red palm weevil on coconut | Sachets of essential oil beads for leaf axil placement

Fig. 103. Management of red palm weevil with repellents made of essential oils

exhibited more repellent property, which produced 70% repulsion at 1000 ppm concentration, followed by cashew nut shell liquid which caused repulsion to the tune of 60%. Repellent property of citriodora was confirmed by wind tunnel assay in which 13.33% beetles merely exhibited up wind flight response. About 23.33% beetles exhibited downwind flight response after moving up to mid point and 63.33% beetles remained at the point of release in the wind tunnel. Gel based slow release matrix (calcium alginate) of essential oil was developed in which essential oil was impregnated at 5% and 10% concentrations (Fig. 103). Two grams sachets of essential oil beads were placed on coconut leaf axils @ 2 sachets palm^{-1} as prophylactic treatment for field evaluation. Similarly, a gel based slow release matrix for aggregation pheromone of RPW was also developed. Under field evaluation, it could capture 70 beetles in a period of three weeks at Chittarikkal, Kasaragod district of Kerala state.

Coconut eriophyid mite (*Aceria guerreronis* Keifer)

Palms sprayed with coconut oil (200 ml)-sulphur (5 g L^{-1}) emulsion, spiromesifen (1 ml L^{-1}), neem oil (2%) and common salt (2%) plus adjuvant APSA (0.2%) were found effective in the suppression of coconut eriophyid mite (Table 11). The acaropathogenic fungus, *Hirsutella* isolate (CPHKLA-1) was found effective in the bio-suppression of coconut eriophyid mite. The ITS region of *Hirsutella* isolate (CPHKLA-1) was sequenced and the sequences showed 99% identity to *Hirsutella thompsonii.* The coconut variety, Kalpasree was found to be relatively tolerant (8.5%) to mite infestation as compared to Kalparaksha (22.5%).

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

Talc formulation of *Paenibacillus popilliae* (UAS Bengaluru isolate) bio-assayed on third-instar grub of *Leucopholis coneophora* induced 40% mortality at 45 days after treatment. High Resolution Melt (HRM) analysis of *Cyt C oxidase* gene of *Leucopholis* spp. grubs revealed single nucleotide polymorphism among three species (*Leucopholis coneophora, Leucopholis burmeisteri* and *Leucopholis lepidophora*) which could be used for species demarcation.

Field efficacy of newer insecticide molecules (imidacloprid, fipronil, lesenta) was evaluated by root zone application in arecanut for the management of root grubs. Palms treated with imidacloprid 70 WG @ 0.24 g palm^{-1}, lesenta 80 WG @ 0.6 g palm^{-1}, fipronil 80 WG @ 0.3 g palm^{-1} caused reduction in larval population by 72.5%, 71.55% and 69.93%, respectively.

An IPM module was developed for the management of root grubs in arecanut garden by combining timely collection of beetles during emergence period (May-August), application of insecticide chlorpyrifos 20EC @ 2.5 ml L^{-1} or imidacloprid 17.8 SL @ 675 ml ha^{-1} or bifenthrin 10 EC @ 20 litre ha^{-1} as well as liquid formulation of entomopathogenic nematode (*Steinernema carpocapsae*) @ 1.5 billion IJs ha^{-1}. Field validation of IPM package evaluated in farmers' fields at Sringeri and Sullia indicated that soil application of *S. carpocapsae* @ 1.5 billion IJs ha^{-1} in combination with imidacloprid (0.0045%) reduced root grub population by 37-59% with two-fold increase in arecanut yield and overall health of palm (Table 12) (Fig. 104).

Fig.104. Integrated management of root grubs in arecanut a. Demonstration plot in Karnataka, b. EPN application, c. Infective juveniles, d. Nematode infested root grub

Coreid bug

Coreid bug, *Paradasynus rostratus* Dist. is an emerging insect pest of coconut causing spindle-shaped lesions on the nuts and in severe cases leads to immature button shedding. Among the various botanicals and new generation molecules evaluated against coreid bug infesting coconut buttons, palms-treated with chlorantraniliprole (0.018%) recorded highest reduction (75.6%) followed by neem oil- treated palms (73.9%) (Table 13).

Tea mosquito bug (TMB) on cocoa (*Heliopeltis bradyi* Waterhouse)

Prophylactic spraying of neem oil (0.5%) during December-January 2015 reduced 91.22% of TMB infestation on chirelle at 45 DAS, which was on par with spraying of imidacloprid (0.5 ml L^{-1}) that reduced TMB infestation on chirelle by 90.96 % and on pods by 92.29%. Neemazal (4 ml L^{-1}) decreased TMB infestation on chirelle by 88.45%.

Insect associated with coconut seedlings in nursery

Incidence of coleopteran seedling borer was noticed on coconut seedlings raised in nursery beds at Kasaragod. The borer commonly known as sap beetle, belongs to family Nitidulidae, genus *Urophorus* Murray and sub genus *Anophorus* Kirejtshuk. The grubs bore the collar region of the seedling or growing point of sprouting nut (Fig. 105). It tunnels and feeds on the central shoot and as a result, seedling exhibit 'dead heart' symptom.

Boring on collar region | Grub of *Urophorus spp.* | Adult of *Urophorus spp.*

Fig. 105. Coconut seedling borer

Table 11. Effect of botanicals on the control of eriophyid mite

Treatments	Nuts infested (%)	
	Pre-treatment (Jan. 2015)	Post-treatment (Aug. 2015)
APSA (2 ml) + NaCl (20 g L^{-1})	61.03 (7.75)	21.60 (3.69)^{ab}
Spiromesifen (0.8 ml L^{-1})	55.66 (7.40)	11.55 (2.54)^{ab}
Palmolein (200 ml) + soap (12 g L^{-1}) + sulphur (5 g L^{-1})	47.81 (6.83)	31.14 (4.69)^{b}
Coconut oil (200 ml)+ soap (12 g L^{-1}) + sulphur (5g L^{-1})	58.57 (7.61)	8.69 (1.91)^{a}
Neem oil (200 ml) + soap (12 g L^{-1})	64.64 (7.97)	13.05 (3.23)^{ab}
Control	52.87 (7.07)	56.15 (7.48)^{c}
CD (p=0.05)	NS	2.17

Table 12. Effect of *Steinernema carpocapsae* on the suppression of arecanut root grub

Location	Infestation	Root grub population 25 spots^{-1}		Reduction (%)	Yield (kg ha^{-1})		Increase in yield	
		Treated	Farmers practice		Treated	Farmers practice	kg ha^{-1}	%
Koppa (K)	RG alone	8.7	19.5	55.3	720	558	162	29.0
Sringeri (H)	RG + YLD	12.1	29.5	58.9	569	306	263	85.9
Sullia (S)	RG alone	9.0	20.5	56.0	663	480	183	38.1
Sullia (R)	RG alone	14.1	22.3	36.7	306	210	96	45.7

*Farmers practice are untreated gardens, RG: Root grub, YLD: yellow leaf disease

Table 13. Influence of botanicals/ new molecule on coreid bug damage

Treatments	Coreid bug infested nuts (%)		% reduction
	Pre-treatment Feb. 2015	Post-treatment Jul. 2015	
Neem oil (0.5%) + soap	27.19 (5.17)	7.10 (2.48)	73.89
Chlorantraniliprole (0.018%)	31.62 (5.48)	7.73 (2.70)	75.55
Plant product extract (5%) (neem oil + palm oil + NaOH)	34.00 (5.68)	13.05 (3.54)	61.62
Nimbidin (0.003%)	27.82 (5.24)	11.97 (3.39)	56.97
Control	24.77 (4.78)	18.66 (4.19)	24.67
CD (P=0.05)	NS	0.91	

Figures in parenthesis are square root transformed values

Entomopathogenic nematodes (*Steinernema carpocapsae*)

Molecular identification: Cytochrome oxidase sub unit II (*COX II*) gene of mitochondria was used in molecular identification of native EPN isolate, *Steinernema carpocapsae*. The primers (SCCYT FI & RI) were designed from the nucleotide sequences of *COX II* gene and optimized using oligoanalyzer software. In optimal

condition, primers amplified a 972 bp sequence of DNA. The sequence analysis found a significant match up to 94% towards *S. carpocapsae* (Accession No. AF192995.1). Identification based on *COX II* gene has confirmed that the native EPN isolate collected from coconut ecosystem is *S. carpocapsae* and that *COX II* could be a marker for molecular identification of EPN isolates (Fig. 106).

Fig. 106. Amplification of *COX II* in EPN isolate Lane 1: 100bp ladder & Lane 2: Amplified cytochrome oxidase

Synergistic response: *In vitro* mortality of early and late-second instar root grubs (*Leucopholis coneophora*) was higher (82.3%) in the combined application of EPN, *S. carpocapsae* (160 IJs g^{-1} soil) and chlorpyrifos 20 EC (0.3 to 1%) as compared to application of *S. carpocapsae* (40.7%) alone. At lower concentration of chlorpyrifos, EPN had synergistic response inducing quick mortality of grubs (Fig. 107).

Fig. 107. EPN-infected early and late second instar root grubs

Fig. 108. Liquid formulation of EPN

Shelf life of formulation: Low density polyethylene (80 µ thickness) sustained higher survival (69.9%) of *S. carpocapsae* up to 30 days in temperature regime of 25-27°C followed by 60 µ thickness and caused cent percent mortality of *Galleria mellonella* larve in the virulence assay (Fig. 108). Addition of one drop (0.3 - 0.5%) of virgin coconut oil avoids sticking of nematodes to inner surface during packaging of nematodes.

Plant parasitic nematodes

Surveillance for nematode pests in coconut/arecanut cropping system: Root-knot nematode (*Meloidogyne* spp.) incidence was found to be higher in coastal sandy soil (59.8%) with gall index (5.0 %) compared to red soil (2.3%) with gall index (2.3%) in vegetable-coconut cropping system. Black pepper-coconut cultivated in coastal sandy belts of Kasaragod registered higher *Meloidogyne* spp. incidence (21.7%) (Fig. 109).

Fig.109. *Meloidogyne incognita* infestation (knots on roots) in black pepper under coconut cropping system

Fig. 110. Marigold for biosuppression of root-knot nematodes in coconut garden

Fig. 111. Sorghum for biosuppression of root-knot nematode in coconut garden

Marigold for bio-suppression of root-knot nematode: Marigold (*Tagetes erecta*), cultivated as intercrop (in three rows with 30 cm x 30 cm spacing) in coconut garden for two continuous years, suppressed *Meloidogyne* spp. population by 58.9% with reduction of gall index from 5.0 to 2.7. The biocompound α-therthienyl from the root exudates of marigold was found to be toxic to nematodes. Besides, an average yield of flowers of about 4,000 kg acre^{-1} was recorded under coconut garden (Fig. 110).

Effect of integration of rabi sorghum in coconut cropping system: The multiplication rate of *M. incognita* was lowest when rabi sorghum was planted in the coconut cropping system with reduction of nematode population by 45.1% (Fig. 111). The population densities of root- knot nematode (*M. incognita*), burrowing nematode (*Radopholus similis*) and lesion nematodes (*Pratylenchus* spp.) were found to be low in coconut-sorghum-noni-coconut nursery system. Average green fodder yield of 2871 kg acre^{-1} under coconut garden is an additional benefit to farmers.

Effect of native bacterial isolates on root-knot nematode: *In vitro* exposure of cell-free culture filtrate of native bacterial strains *viz*., *Pseudomonas putida*, *Bacillus megaterium* and *B. licheniformis* at different concentrations to second stage juveniles of *M. incognita* induced 75.3, 78.9 and 87.5% mortality, respectively (Fig. 112).

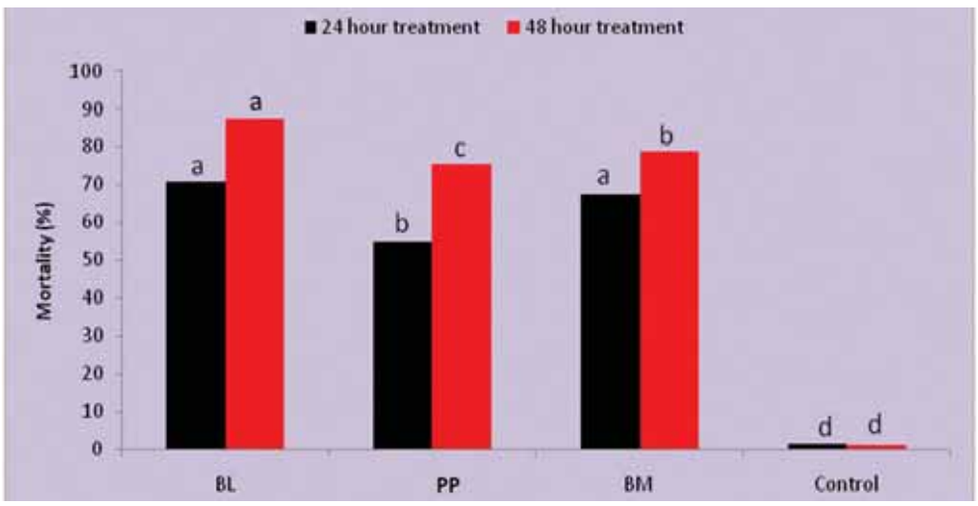


Fig. 112. Effect of different rhizobacterial antagonists (culture filtrate) on the mortality of *M. incognita* juveniles

Integrated management of root-knot nematode in black pepper: Application of *Trichoderma harzianum* (CP-28) enriched neem cake (1.0 kg vine^{-1}) during pre-monsoon and post-monsoon season significantly suppressed the root-knot nematode (*Meloidogyne incognita*) population (57.5%) and *Phytophthora* wilt incidence (34.6%) as compared to application of neem cake and carbofuran (8 g vine^{-1}) in black pepper trailed on coconut palms. Yield increase as high as 31.8% was observed in a period of three years (Fig.113).

Fig. 113. Vine growth of black pepper before and after treatment

CLIMATE RESILIENT ADAPTATION AND MITIGATION

Phenotyping for Climate Resilient Adaptation and Mitigation Strategies

Response to elevated CO_2 and elevated temperature in open top chamber (OTC) grown coconut seedlings

Coconut seedling growth was promoted with elevated temperature CO_2 [ECO_2] while, elevated temperature [ET] 3°C above ambient reduced the growth. [ECO_2] 700 ppm increased plant height, leaf area and biomass production of coconut seedlings by 18%, 16% and 15% respectively as compared to ambient 380 ppm (Fig. 114). The higher root biomass accumulation indicated better CO_2 sequestration with [ECO_2]. Higher growth was due to both increased leaf area and photosynthesis. On the other hand, [ET] significantly reduced both photosynthesis and leaf area and thus affected the plant growth (Fig. 115).

[ECO_2] and [ECO_2+ET] showed 23% and 9 % higher total soluble sugar content over the ambient as well as ET respectively. [ET] on the other hand increased lipid

Fig. 114. Response of coconut seedling to [ECO_2]; (a) Control (b) 550 ppm CO_2 and (c) 700 ppm CO_2

Fig.115. Response of coconut seedling to high temperature;
(a) Control (b) Ambient +3°C (c) 550 ppm CO_2 + Ambient +3°C

peroxidation (16%) and reduced peroxidase enzyme activity (12%) but had no effect on polyphenol oxidase activity.

Phenotyping drought adaptive traits

Eleven coconut genotypes *viz*., seven tall (Federated Malay States Tall (FMST), Kerachandra, Kalpa Dhenu, Kalpa Pratibha, Kalpatharu, West Coast Tall, Kalpa Haritha) and four dwarf (CGD, COD, MOD, MYD) seedlings grown under 100% Field Capacity (FC), 50% FC and 25% FC were compared for their whole plant water use efficiency (WUE). At 100% FC, biomass production of tall varieties was high as compared to dwarf, while at 25% FC the biomass production was on par in all the genotypes. Wide variability was observed amongst tall and dwarf genotypes for WUE (Fig. 116). The tall genotypes *viz*., Kalpa Dhenu, FMST had high WUE (3.5) under 100% FC, while dwarfs exhibited high WUE (3.8) at 25% FC. High WUE was found to be associated with high root biomass and stomatal features. At 25% FC, dwarfs had higher stomatal conductance as compared to tall varieties (Fig. 117). From the study, it was clear that under well irrigated condition, the water requirement per unit biomass production is high in dwarfs as compared to that of talls.

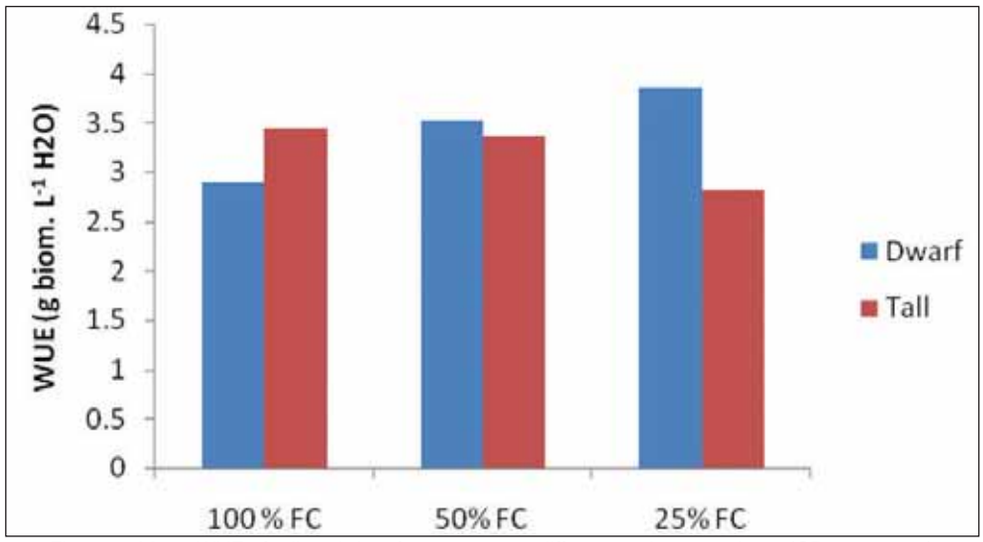


Fig. 116. Mean WUE of tall and dwarf genotypes at different moisture regimes (CD at 5%: 0.8)

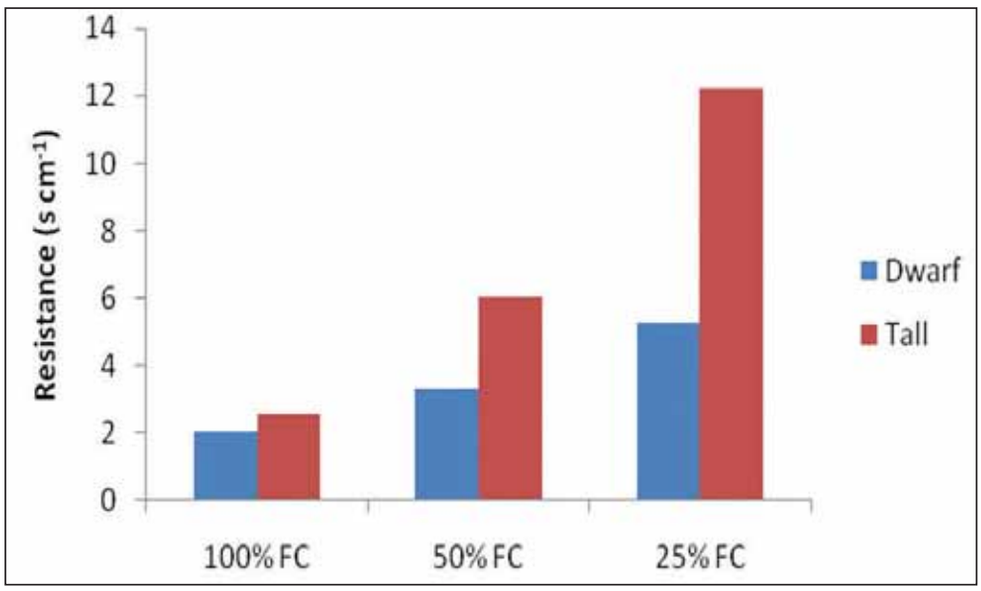


Fig. 117. Mean stomatal resistance of tall and dwarf genotypes at different moisture regimes (CD at 5%: 2.1)

Epicuticular wax content of both control and moisture stress induced plants was less in dwarfs (20%) but it increased with stress, while no changes were observed in talls. Superoxide dismutase (SOD) activity of three cultivars (WCT, FMST and COD) was assayed under stress treatments. It increased in all the genotypes, till 50% FC and decreased with further increase in stress i.e. at 25% FC (Fig. 118).

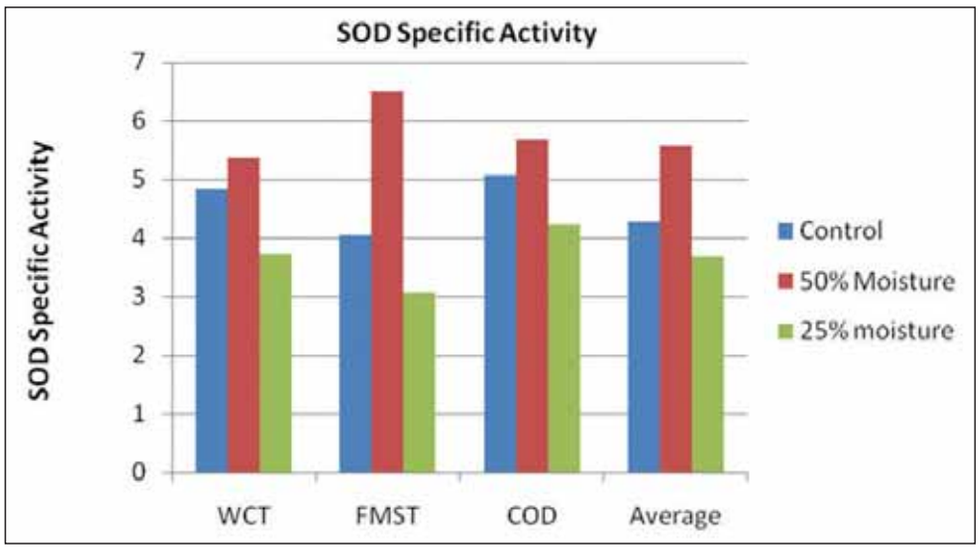


Fig. 118. SOD specific activity under control and moisture deficit stress

Pollen germination at different temperatures

In order to study the response of pollen grains to high temperature in coconut, pollen from CGD, MGD, MYD, MOD and WCT cultivars were evaluated for pollen germination and pollen tube length at different temperatures ranging from 10 to 50ºC on nutrient media [sucrose (10%), H_3BO_3 (0.01%), $Ca(NO_3)_2$ (0.025%), $MgSO_4$ (0.02%), KNO_3(0.01%) and agar (2%)]. Pollen grains were exposed to 10, 15, 20, 25, 30, 35, 40, 45 and 50°C. Maximum pollen germination was reached at 5 hours and maximum pollen tube length at 7 hours after germination across the temperatures and cultivars.The optimum temperature for maximum pollen germination and pollen tube growth was found to be 30°C across the cultivars (Fig. 119). WCT at 30°C had

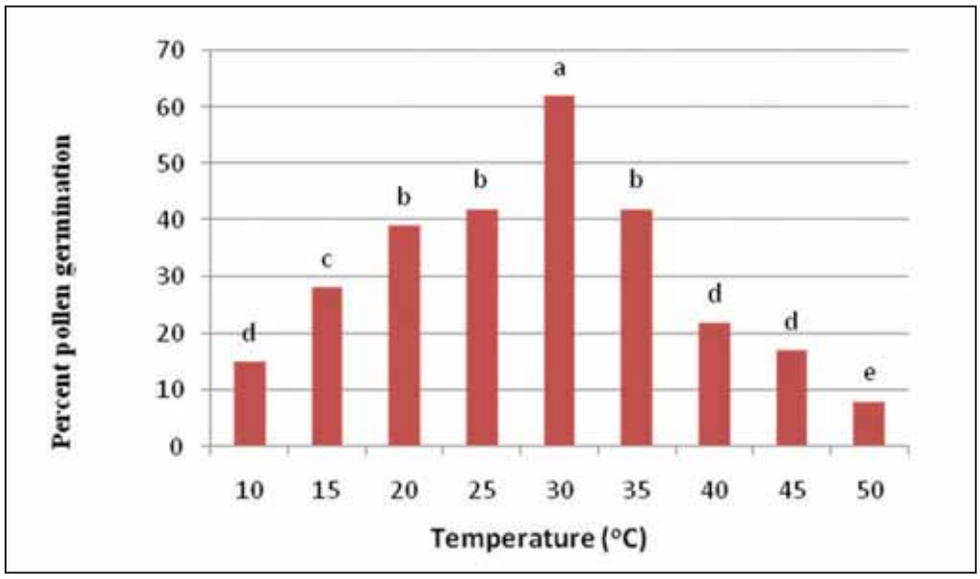


Fig. 119. Mean pollen germination of five coconut cultivars at different temperatures

a pollen germination percentage of 83% which reduced to 6% at T_{max} 50°C and T_{min} 15°C. Similarly, CGD and COD had a T_{min} of 15°C and T_{max} of 35°C. Pollen tube length of WCT at 20°C was 267µm which reduced to 17 µm at 50°C. WCT had significantly higher pollen germination than the dwarf cultivars.

Salt spray effect

Scorching of leaves in coconut, fruit trees, vegetables, and other trees were noticed during the 3rd and 4th week of June 2015 along the West coast of India, especially in Kerala and Karnataka. Careful observation revealed that it was due to salt spray effect. In the year 2015, during 2nd and 3rd week of June, weather was unusual with wind speed of 30-40 km hr^{-1} with less rainfall (660 mm) as compared to the corresponding period with a wind speed of 22-25 km hr^{-1} and 900 mm rain in 2014. During dry weather, the salt from the ocean evaporates as tiny droplets and the gusty wind carries it to a long distance on the sea shore and adjoining areas. Salt deposit on the leaves was seen in those plants which were growing few meters from the sea shore all along the West coast. Lack of sufficient amount of rainfall could not wash off the salts deposited on the leaves and thus affected the tissue causing browning, burning and eventually necrosis (cell or tissue death) (Fig. 120).

Fig. 120. Coconut leaves, towards the wind direction, injured due to salt spray

POST HARVEST TECHNOLOGY AND MECHANIZATION

Value Addition from Kalparasa

Kalparasa sweets

Methodology for the preparation of fresh coconut inflorescence sap (Kalparasa) based milk sweets has been standardised, which will impart the minerals, vitamins, valuable fibre which will not be available in the normal cane sugar based milk sweets. Different types of Kalparasa-based milk sweets have been prepared *viz*., Kalparsa-Kalakand, Kalparasa-peda, Kalparasa-Sandesh, Kalparasa-Kachagolla (Fig. 121).

Fig. 121. Kalparasa based sweets

Fig. 122. Chocolate made using coconut sugar

Kalpa Chocolate

A coconut sugar based chocolate, purely with plant based ingredients (cocoa powder, coconut sugar, natural vanilla extract and sunflower lecithin), has been developed (Fig. 122) This new product, 'Kalpa Choco', has been organoleptically categorized as tasty.

Osmotic dehydration of coconut slices

Studies were undertaken to standardize the soaking time of coconut slices in osmotic solutions made of sugar (1 kg of commercially available sugar dissolved in 1 litre of filtered water) and Kalparasa + sugar (750 g of commercially available sugar dissolved in 1 litre Kalparasa) in order to obtain optimum reduction of moisture content. The TSS of both osmotic solutions was maintained at 50° Brix. The coconut slices were

soaked in these solutions for 15, 30, 45 and 60 minutes and TSS and moisture loss of coconut slices were measured. The osmotic dehydrated coconut slices were dried in tray dryer at 60°C for 6 hours. The initial and final TSS of osmotic solution (sugar and Kalparasa + sugar), initial and final moisture content of osmotic treated coconut slices and crispiness of coconut chips were determined and presented in Table 14.

Table 14: Moisture content of osmotic treated coconut slices, TSS of osmotic solutions and crispiness of coconut chips

Soaking time (min)	Moisture (% wb)		TSS (° Brix)		Crispiness (N)	
	Sugar	Kalparasa + Sugar	Sugar	Kalparasa+ Sugar	Sugar	Kalparasa + Sugar
Control	54.9	54.9	-	-	3.77	3.77
15	37.9	39.7	42.7	42.7	2.39	1.94
30	38.8	39.6	43.2	43.7	3.13	2.16
45	38.9	40.4	43.7	43.8	3.16	2.55
60	38.5	42.6	43.9	44.0	3.53	2.76

No significant reduction in moisture content was observed in the osmotic dehydrated slices beyond soaking time of 15 minutes. No significant difference in TSS and crispiness values was also observed. Hence, 15 min soaking time was considered sufficient for osmotic dehydration of chips.

Chips prepared using Kalparasa + sugar as an osmotic medium had significantly higher ash per cent, phenolics (mg gallic acid equivalent 100 g^{-1}) and antioxidant activity (AOA, mg trolox equivalent 100 g^{-1}) as compared to the chips prepared using sugar solution alone (Fig. 123, 124). Since Kalparasa contains more of phenolics, antioxidants and other nutrients compared to sugar solution, these nutrients were retained in the chips during osmotic dehydration.

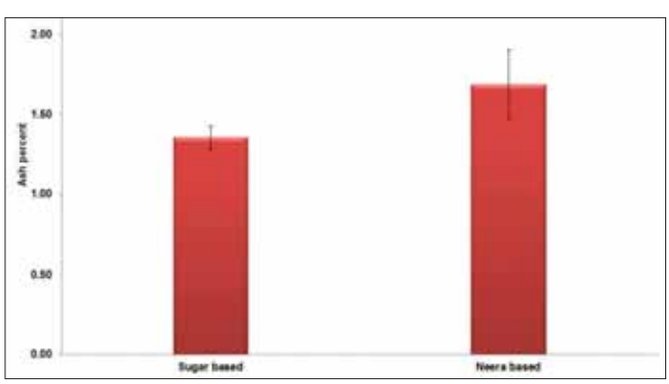


Fig. 123. Ash content of coconut chips

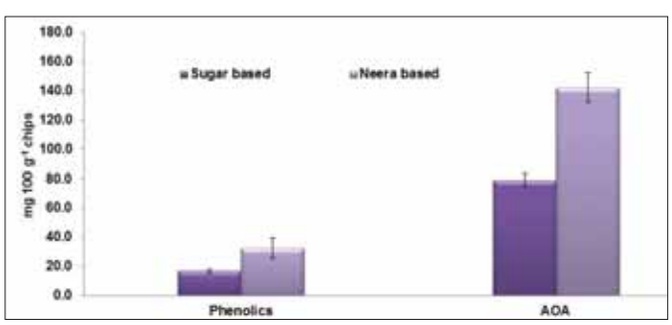


Fig. 124. Phenolics and antioxidant activity of coconut chips

Production of Health Foods from Coconut Milk Residue and VCO Cake

Quality evaluation of coconut milk residue and coconut haustorium based extrudates

Quality parameters like proximate, total sugar, phenolics and antioxidant potential of extrudates prepared using coconut milk residue (CMR) in combination with rice, maize and ragi and coconut haustorium (CH) with rice and maize at different proportions were studied. Results showed that there were significant differences for parameters studied in extrudates with different combinations. Incorporation of CMR led to significant increase in oil content of extrudates irrespective of proportion of rice, maize and ragi. Proportion of coconut milk residue in rice led to significant increase in total soluble sugar content in the extrudates and decrease in available carbohydrate content; whereas no significant difference was observed for phenolics and antioxidant potential. In the case of extrudates prepared by incorporating CMR in rice and maize, there was a significant reduction in phenolics and antioxidant

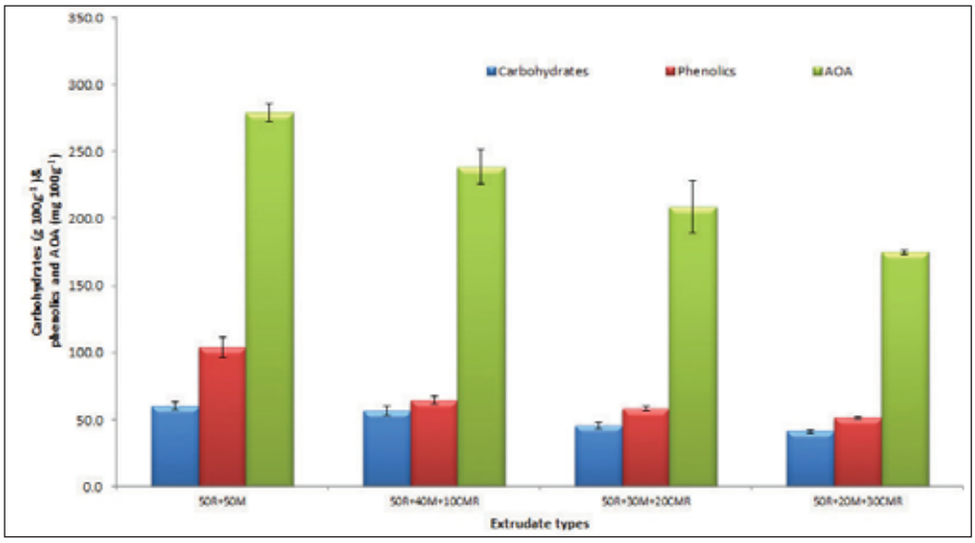


Fig.125. Changes in carbohydrates, phenolics and antioxidant potential of coconut milk residue based extrudates with rice and maize

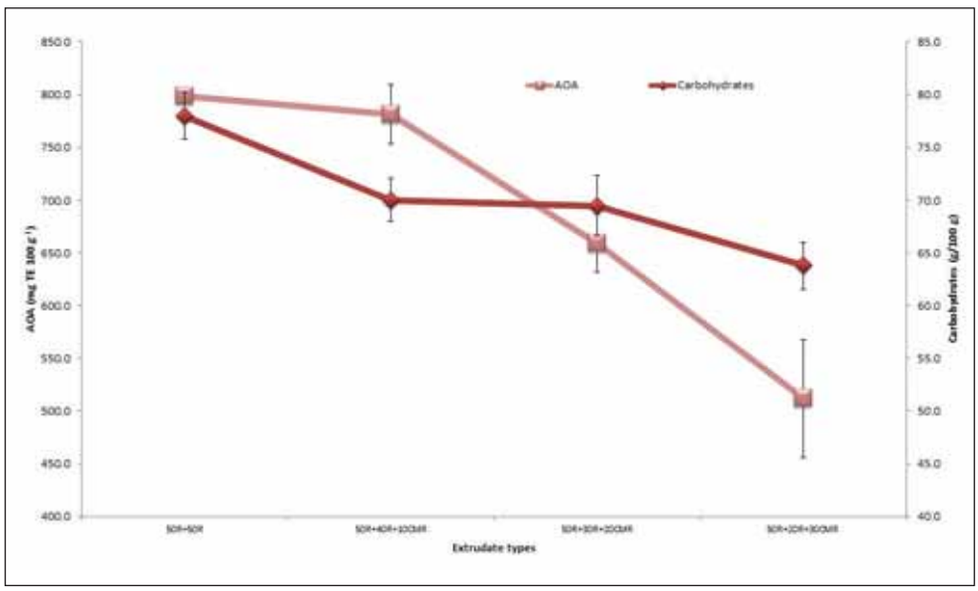


Fig.126. Changes in carbohydrates and antioxidant potential of coconut milk residue based extrudates with rice and ragi

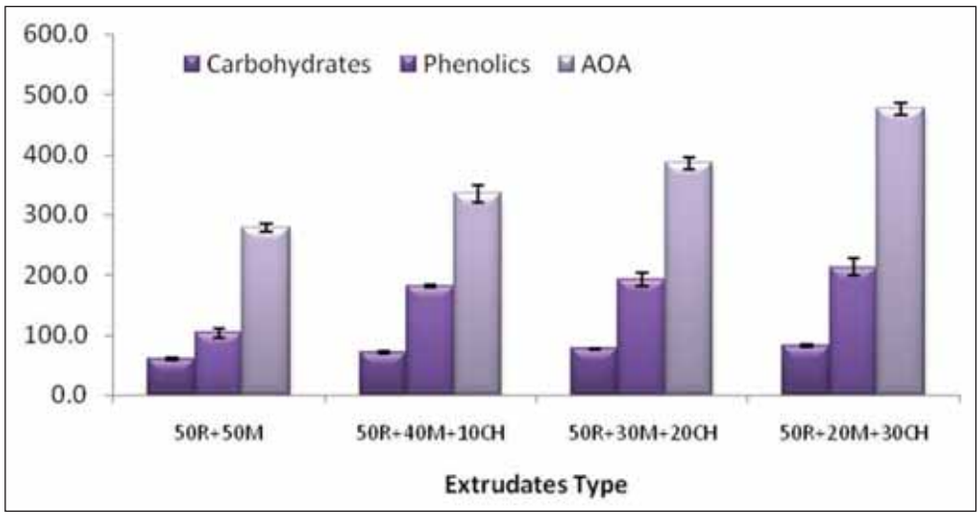


Fig. 127. Changes in carbohydrates, phenolics and antioxidant potential of coconut haustorium based extrudates with rice and maize

potential, and the reduction was due to the replacement of maize with CMR (Fig.125). Decrease in available carbohydrates and antioxidant activity was observed in extrudates prepared by incorporating CMR in rice and ragi (Fig.126). Significant increase in available carbohydrates, total soluble sugar, phenolics and antioxidant potential were observed in the extrudates prepared by incorporating the coconut haustorium in rice and maize based extrudates (Fig.127).

VCO cake based muffins

A study was conducted to utilize the residual cake obtained after the extraction of virgin coconut oil (VCO) for the partial substitution of refined wheat flour (RWF) in the muffin (high calorie baked product) formulation. Standardization of VCO cake concentration, of upto 50%, was carried out in order to find its effect on the proximate composition, physical, textural, microbial and sensory attributes of muffin. VCO cake

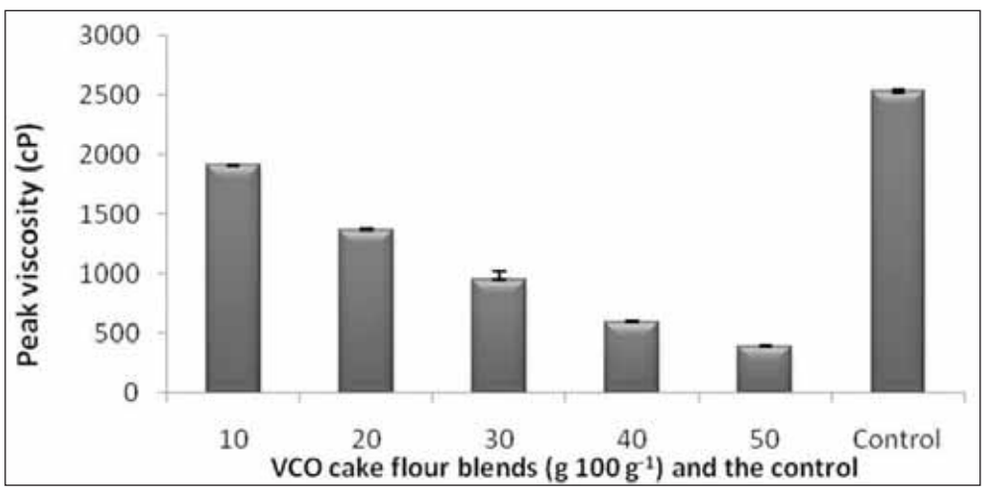


Fig. 128. Effect of VCO cake based muffin formulations on peak viscosity of flour blends

was analyzed for moisture, protein, fat, ash and carbohydrate, and the corresponding values were 4.85± 1.03%, 15.42± 0.31%, 39.23± 4.22%, 5.15± 0.77% and 35.35± 5.39%, respectively. It was observed that progressive replacement of RWF with VCO cake significantly influenced the peak viscosity, trough, setback, final viscosity, and pasting temperature of the flour blend with less influence on peak time. The changing trend in peak viscosity with the varying levels of VCO cake is shown in Fig. 128.

Significant differences were observed for the physical properties such as muffin height, weight loss, colour of the crust and the crumb. Also, significant reduction in height occurred with the addition of VCO cake. It also lead to loss of weight in the muffins after baking. A general trend of decreasing lightness (L) value with increase in the VCO cake concentration was observed. As the VCO cake lacks gluten, its poor water binding capacity resulted in higher weight loss. Lesser air cells present in the VCO cake might also have contributed to more weight loss as compared to RWF. The light brown colour of VCO cake had a significant influence on the colour of final product. The textural properties such as hardness, springiness, resilience and chewiness and the sensory parameters such as appearance, colour, flavour, taste, texture and overall acceptability were analyzed and the result showed that incorporation

Table 15: Effect of VCO cake on textural and sensory attributes of muffin formulations

Level of *VCO cake in the **RWF blend (g 100 g^{-1})	Hardness (N)	Springiness	Resilience	Chewiness (N)	Overall acceptability
10	67.23^{b}± 2.22	0.82^{b}±0.04	0.17^{ab}±0.02	25.35^{b}±0.025	7.32^{c}
20	60.06^{c}±1.16	0.77^{c}±0.05	0.16^{b}±0.01	20.05^{c}±0.68	7.51^{bc}
30	38.86^{d}±4.23	0.72^{d}±0.72	0.14^{bc}±0.04	10.18^{d}±0.15	7.69^{bc}
40	34.66^{e}±1.99	0.59^{e}±0.06	0.093^{c}±0.03	8.66^{d}±0.40	8.50^{a}
50	25.49^{f}±1.61	0.43^{f}±0.04	0.08^{c}±0.03	4.21^{e}±0.43	8.10^{ab}
0 (control)	80.97^{a}±3.74	0.88^{a}±0.01	0.22^{a}±0.1	35.37^{a}±0.86	7.29^{c}

Mean values with different superscripts within the same column differ significantly ($P < 0.01$).
The values are the standard deviation from the mean values.
* Virgin Coconut Oil **RWF, Refined Wheat Flour.

of 40% VCO cake was the most acceptable for the preparation of muffin. The changes in textural and sensory attributes are given in Table 15. Significant decrease was observed in hardness, springiness, resilience, and chewiness of muffins with increasing levels of VCO cake.

Fig.129. VCO cake based muffins

Muffins stored under refrigerated (4±2°C) condition had a lower free fatty acid as compared to those under ambient condition (32±2°C) which had a maximum shelf life of 15 days when packed in LDPE tray. The comparison of the optimized muffin (40 g VCO cake 100 g^{-1} flour blend) with the control showed that it contained 8.49% protein, 18.46% fat, 1.14% fibre and 1.10% minerals, while the control had 7.22% protein, 16.77% fat, 0.16% fibre and 0.58% minerals (Fig.129).

Developing Machineries and Gadgets for Gender Mainstreaming

Prototype Developed

Self loading arecanut dehusking machine and a grading unit

Traditionally arecanut is dehusked manually using a knife. The process is quite cumbersome and time consuming. Various types of manual and mechanical dehuskers are available in the market. The manual dehuskers are slower than the

traditional de-husking. Among the mechanical dehuskers, beating type arecanut dehusker is the fastest and requires a person to feed individual arecanut to dehusking machine. This makes the dehusking operation costly due to extra man power for feeding and slow feeding rate.

The institute has developed a beating type arecanut dehusking machine (Fig. 130). The de-husking unit consists of 32 husking tools made of nylon shaft of 7 cm x 3 cm x 1 cm size. The husking tools are arranged in four compartments, each compartment having eight shafts. One end of these nylon shafts are fixed on a horizontal steel shaft. Prime mower of the dehusking unit is an electric motor. Drive is transmitted from the electric motor to the dehusking unit through a V-belt. The dehusking tool rotates at a speed of 100 rpm. Dehusking of areca nut is done by the beating action of the husking tools.

The husking unit, the prime mower and the power transmission units are mounted on a steel frame. A horizontal platform of 40 cm x 60 cm size is provided at the top. It acts as a cover and also as a feeding tray to keep arecanuts for easy feeding when used manually. An opening is provided to the platform to feed arecanut to the machine. The opening leads to the dehusking unit through a conduit pipe.

The arecanuts to be dehusked are kept on the feeding tray. One person feeds the areca nut in to the machine. The areca nut reaches the de-husking unit through a conduit pipe. When the areca nut comes in to contact with the rotating nylon shaft the husk gets loosened due to the impact force and the hard kernel comes out from the inside. The husk along with the hard kernel falls in to a tray kept at an angle. Air from a blower is blown to the tray and the husks are blown away. The hard kernel falls back due to its weight and is collected in a container kept at the bottom.

A self-loading mechanism to feed the arecanut dehusking machine automatically has also been designed and fabricated. The feeding tray is fixed on four springs and would be vibrated using an electric motor. Because of the vibration the arecanut would fall in to the dehusking chamber.

A grading unit to grade arecanuts before dehusking has also been fabricated. The grader is having three compartments and would grade the arecanut in three different sizes (Fig. 131). However the grader is not required when the nuts are of relatively uniform size.

Fig. 130. Arecanut dehusking machine

Fig. 131. Arecanut grader

ECONOMIC, STATISTICAL AND TECHNOLOGY DELIVERY MODELS

Technology Delivery Models

Area-wide participatory extension approach for red palm weevil management

Area wide community extension approach for management of coconut red palm weevil, the fatal pest of the palm, was pilot tested in Bharanikkavu Grama Panchayath, Alappuzha district in 2000 ha during 2014 and 2015, involving 7068 farm families with 1,74,733 coconut palms at various growth stages. Participatory documentation of farmers' profiles was undertaken with particular reference to red palm weevil management, pest and disease status of the plots, cropping/ farming systems adopted. The GPS plotting of the palms infested by red palm weevil (dead and alive) was recorded during the pre-and-post intervention periods. Awareness building programmes such as stakeholder meetings for discussion and consensus on participatory process to be adopted, mass media utilization (features in AIR, print media), poster campaigns in all the 21 wards of the panchayath, group meetings of stakeholders in every ward, action meetings and launching of Coconut Producers Societies (CPS) and Coconut Producers Federations (CPF) for the area-wide initiation of interventions was visualized. The other innovative components evolved were, formation of 12 coconut plant protection and surveillance groups (CPPSG) in all wards comprising of 2-3 members of women self help groups/representative of coconut farmer organization/volunteers from the ward. These groups were given thorough on-and-off farm trainings and capacity building in documentation or recording of data, use of GPS, symptoms of pest/diseases or deficiency of nutrients, practical skills in plant protection/ use of sprayers/ safe use of pesticides etc. Field level support was offered by Agricultural Officer for mobilizing farmers and execution of the components linking with their activities. Follow-up interventions of appraisal and corrective measures was adopted through organization of 19 Integrated Coconut Field Clinics (ICFC), mobilized in participatory mode for further identification and management. An exclusive mobile number was dedicated and given publicity for farmers to report on red palm weevil incidence in their palms at any time. This was utilized as a reporting mechanism, directing the information to respective CPPSG for visit and control measures and for tracking the farmer response. An SMS service was also started for exchange of information among the farmer leaders and field facilitators. Eighteen master trainers were capacitated for farmer-to-farmer technology transfer and first-level field diagnosis and linkage with research or extension system. In farmers' field conditions, the infestation mode of red palm weevil was mainly of four types: toppling of the crown (60-80%), entry through leaf axils (10-25%), reddish ooze through bore holes in trunk or palm stem (4-8%), and entry through palm bole region (4-5%) in bearing and non-bearing palms, respectively (Table 16).

The spread of the pest in farmer fields was aggregate in nature as depicted by index of patchiness. The spatial distribution of red palm weevil incidence in farmer plots of 21 wards reduced from 2.93 per cent to 0.38 per cent due to the community

Table 16: Infestation mode of red palm weevil farmer fields (n= 3635)

Sl. No.	Infestation mode	Number of palms	Percent	Category wise (%)
	Bearing coconut palms			
1.	Toppling of the crown	2015	55.43	80.05
2.	Through the leaf axils	266	7.32	10.57
3.	Reddish ooze in the bored holes	105	2.89	4.18
4.	Entry through the palm bole	131	3.60	5.20
	Non-bearing coconut palms			100.00
5.	Toppling of the crown	689	18.95	61.46
6.	Through the leaf axils	281	7.73	25.07
7.	Reddish ooze in the bore holes	99	2.72	8.83
8.	Entry through the palm bole	52	1.43	4.64
	Total	3635	100.00	100.00

interventions, an 87% reduction in fresh incidence. The major interventions that contributed to the impact were the wide spread awareness building programmes, intensive personal contact, mobile phone services and reduction of pest population through timely treatment/removal of freshly affected palms. Empirical analysis and farmers, perceptions indicated the following:

- 30-40 per cent of affected palms could be saved through pesticide application.
- The area-wide community extension approach for red palm weevil management is effective and up-scalable.
- Diagnosis of red palm weevil incidence in early stage of infestation is the major drawback in managing the pest and a technology gap.
- Awareness building, community involvement and surveillance are key in sustaining the results. Sustainability of the social mechanisms is of prime importance.
- The potential sources of inoculum are still present in the project area, but were managed by individual farmers.

Farmers recorded their constraints and perceptions in management of red palm weevil of coconut, in the order of ranking as “high labour charges for plant protection of coconut”, “climate change”, “Lack of or low level knowledge on chemicals to be used for controlling the pest”, “infestation of the pest in palms could only be noticed after death of the palms”, and “lack of early identification tools or methods”.

Community-based bio-resource management under coconut-based farming systems

Community based bio-resource management programme, funded by NABARD, with the objective of increasing the productivity and income from coconut-based farming system through integration of bio-resource management, soil moisture conservation techniques and crop diversification is implemented in Kanjikuzhy block of Alappuzha district. Capacity Building programmes (17 nos.), *viz.*, Trainings,

FFS, Field Day & Field Demonstrations/skill development on various topics like integrated nutrient management, intercropping, plant protection, production and mass multiplication of PGPRs, microbial enrichment of organics with bioagents and production of *Trichoderma* cake were conducted with 270 beneficiaries.

Eight native strains of *Trichoderma* were isolated from Kanjikuzhy Block Panchayat area and *Trichoderma* isolate KKT-6 showed highest antagonistic activity to leaf rot and stem bleeding pathogens of coconut under *in vitro* conditions. Training-cum-demonstration was provided to a group on mass multiplication of KKT-6 on different substrate combinations. Combinations of locally available substrates *viz*., neem cake, vermicompost, coirpith, poultry manure and cowdung were evaluated for the field level mass multiplication of *Trichoderma*. Cowdung, coir pith compost and neem cake were found to be ideal individually as well as in combinations for mass multiplication of *Trichoderma* with more than 85 x 10^6 cfu g^{-1} of substrate. Substrates like poultry manure, goat manure and vermicompost, when individually used, did not give promising results, but in combination with cow dung, coir pith compost and neem cake, in lesser proportions, were found to provide better multiplication.

Analysis of 156 soil samples and 52 plant samples from the area revealed magnesium and potassium as limiting nutrients with an average values of 68.5 and 41.04 ppm, respectively. Considering the soil nutrient constraints in terms of K and Mg as well as the micronutrients B, Zn and Cu, modified nutrient recommendations were given. Micronutrients such as boron, zinc and copper were applied to the palms @ 50 g, 20g and 50 g, respectively. Green manure, cow pea seeds @ 100 g $palm^{-1}$ basin, was sown and incorporated.

The interventions resulted in significant increase in setting percentage, with 32% yield improvement, in case of treatment palms and an overall yield improvement to the tune of 16% in the entire demonstration area. Area under vegetables recorded an increase of 53% and the net income from intercrops as well as the total farm income doubled during the reporting period.

Farmers' participatory research-cum-demonstration plots on cocoa

The Project on 'Farmers participatory research-cum-demonstration plots on Cocoa for Enhancing Productivity and Profitability' implemented with financial support from Directorate of Cashew-nut and Cocoa Development, was launched on 21.8.15 at ICAR-Indian Institute of Oil Palm Research, Pedavegi. The programme was inaugurated by Dr. N. K. Krishnakumar, DDG (Hort. Sci.), ICAR, New Delhi and presided over by Dr. P Chowdappa, Director, ICAR-CPCRI. An interface session on cocoa farming involving farmers, scientists, officials of Dept. (Fig. 132) of Horticulture and Mondelez India Foods Pvt. Ltd, Andhra Pradesh was conducted. Field visit was conducted to the farmer's garden in which techniques of cocoa training and pruning was demonstrated. About 350 cocoa growers from five districts of Andhra Pradesh *viz.,*West Godavari, East Godavari, Krishna, Vishakapatinam and Vizianagaram participated in the programme.

Fifty demonstration plots (1 ha each) on cocoa technologies were established during 2015 in five districts *viz.,* West Godavari, East Godavari, Krishna, Vishakapatinam and Vizianagaram of Andhra Pradesh: 25 plots on improved varieties, five plots each

Fig. 132. Launching of Farmers participatory research-cum-demonstration plots on cocoa at ICAR-IIOR, Pedavegi

on pruning, integrated nutrient management, organic farming, pest and disease management and post harvest processing. Adoption of improved technologies will be up-scaled by Department of Horticulture and KVKs.

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

Ten demonstration plots on arecanut-based cropping system with 1 ha each *viz.,* 4 in Puttur taluk, 3 in Belthangady taluk and 3 in Kasaragod taluk were established during 2012 for enhancing productivity and profitability of farming per unit area. Banana variety Kadali, elite cocoa seedlings and Panniyur-5, a shade tolerant and high yielding pepper variety were introduced. Farmers were supplied with critical inputs for first three years for establishing the demonstration plot and trained on latest production technologies with respect to arecanut, banana, cocoa and black pepper.

Arecanut dry kernel yield increased to 2550 kg in 2015-16 from 2135 kg in 2011-12, which clearly indicates that arecanut yield will not be reduced by introducing intercrops. Banana plants were planted in the centre of four areca palms. Besides the main crop, two ratoon crops were harvested in three year period. Additional income realized from banana for three years was ₹ 106753. Banana wastes were recycled/ reused as mulch in the garden for increasing the soil fertility. Cocoa seedlings were planted in alternate rows of arecanut at a spacing 2.7 m x 5.4 m. Cocoa was pruned in August-September and shaped to get a canopy at a height of 1.5 to 2.0 m. Cocoa plants started yielding from 2014 onwards. Arecanut stems were used as live standards for training black pepper and two rooted pepper cuttings were planted on the northern side of the palm at a distance of 75 cm from the base and started giving yield from 2015 onwards. Overall, the productivity and profitability of arecanut farming increased significantly over the years by adoption of cropping system.

Field day was organized on 29 February 2016 at Shri Ramaprasad, Hindaru, Kemminje, Puttur, Dakshina Kannada district for the benefit of 107 stakeholders. Lectures, demonstrations and discussions on arecanut based cropping system were organized by scientists and staff members of ICAR-CPCRI. Exhibits on varieties,

Fig. 133. Demonstration plot of arecanut based cropping system in Puttur taluk, Karnataka

agronomic practices, nursery management, pest and disease management and harvesting of arecanut and cocoa were displayed for giving first-hand information to the farmers (Fig. 133). At the end, farmers expressed their satisfaction and willingness to adopt multicropping system in their gardens.

Organic farming in Kasaragod district – An analysis of field level scenario and stakeholders' perspectives

Under the research project supported by Kerala State Council for Science, Technology and Environment, data were collected from farmers and other stakeholders for analyzing their perception about organic farming and field level experiences. About one third of the farmers (34%) did not possess adequate knowledge about the organic farming practices recommended for the crops they cultivated. Majority (78%) of the farmers opined that organic farming is practically feasible while the remaining 22% were apprehensive about the feasibility. Majority (74%) of the farmers were not aware about organic certification procedures and none of them obtained organic farming certification, though 5% of the farmers had made some efforts for securing the same. Majority (63%) of the farmers perceived that they were not getting premium price for their organically grown farm produce. About 43% of the framers were applying only organic manures to the crops cultivated. More than half (55%) of the farmers were following integrated nutrient management. Among the coconut growers, 82% were applying only organic manure. Even though farmers suffered loss due to pests and disease incidence, the extent of adoption of plant protection measures were very low: 30 farmers (14%) were using botanicals, 93 farmers (43%) were using chemical insecticides and 8 farmers (3.8%) were following mechanical methods. In coconut, only 12% of the farmers were adopting pest management technologies. In arecanut, majority (77%) of the farmers were adopting disease management measures, especially against fruit rot (mahali) disease. Major constraints as perceived by farmers in adopting the eco-friendly organic methods of pest and disease management in crops were lack of knowledge about recommended practices, lack of availability of eco-friendly organic pesticides and bio-inputs, high cost of bio-inputs and lack of extension

support. Some farmers from the district procured chemical pesticides from neighboring districts i.e Kannur in the south and Mangalore in the north when their crops were threatened with pests and diseases. Facilitating formation of farmers' clusters, conducting training programmes, organizing exposure visits, laying out demonstration plots and setting up rural compost and vermicompost units were the important promotional schemes implemented through Krishibhavans to popularize organic farming. Only 26% of the farmers who received incentive from Department of Agriculture under the scheme to promote organic farming for establishing vermi compost units attended the training on vermicompost production. About 57% of the farmers discontinued the practice of vermicompost production mainly due to the perceived problems such as infestation by ants, non availability of labour, lack of availability of substrate, non availability of earthworms and lack of extension support for technical guidance etc. Half of the pesticide dealers and 37% of the fertilizer dealers perceived that farming in Kasaragod district can be fully converted into organic. Dealers opined that in commercial vegetable cultivation, use of chemical pesticides cannot be avoided since many of the pests and diseases of vegetables can't be effectively controlled by the organic pesticides currently available.

Assessment of incidence and intensity of major diseases and pests of coconut in north Kerala

A study was undertaken during 2015-16 to assess the spread and intensity of pests and diseases of coconut in Kasaragod district of Kerala state with the support of State Planning Board, Government of Kerala. In each of the selected panchayaths, four wards were selected representing geographical variability in the Panchayat. A cluster of at least 500 bearing palms with a minimum of 10 households were scored visually for pest and disease infestation. As the second step, 19 panchayaths were selected and observations on palm-wise severity were recorded in two randomly selected clusters out of four selected in the first round survey. Thematic maps were prepared on panchayat level and block level pest and disease incidence (Fig. 134 and 135). The incidence and intensity of pests and diseases of coconut in Kasaragod district as revealed from the study is summarized below in Table 17 and 18.

Table 17: Incidence and intensity of pests of coconut in Kasaragod district

Pest	Incidence (%)	Severity measure	Severity (%)
Rhinoceros beetle	8.46	% leaves attacked	19.75
Red palm weevil	0.15	-	
Eriophyid mite	0.73	<25% nuts infested	48.17
		25-50%	8.28
		>50%	2.18
		0%	40.87
		Overall	23.76
Coreid bug	2.23	% nuts infested	19.46

Table 18: Incidence and intensity of diseases of coconut in Kasaragod district

Disease	% Incidence	Mild	Moderate	Severe
Bud rot	2.38	-	-	-
Stem bleeding	2.27	8.81	24.67	66.52
Thanjavur wilt	0.62	6.10	69.51	24.39

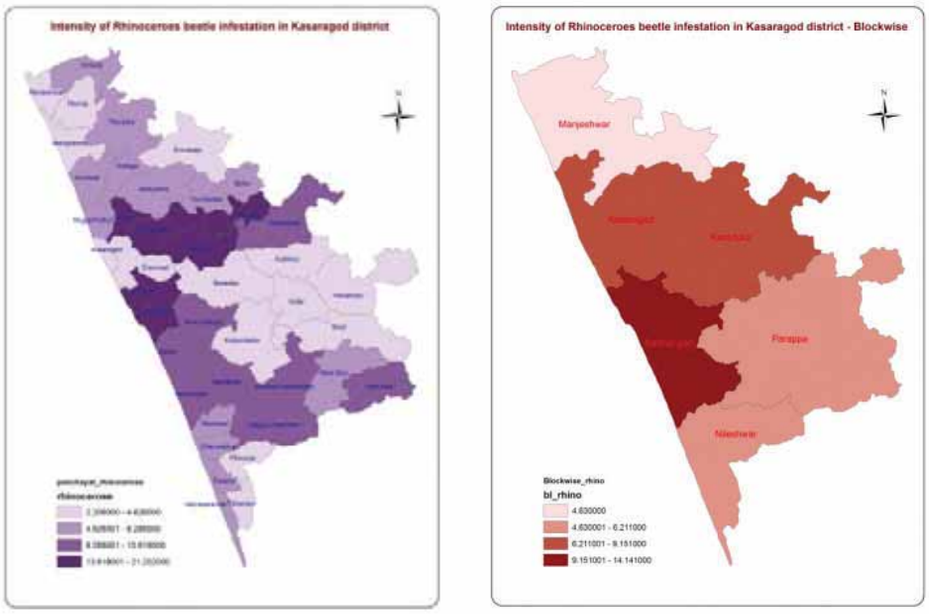


Fig. 134. Panchayat and block level incidence of rhinoceros beetle in coconut in Kasaragod district

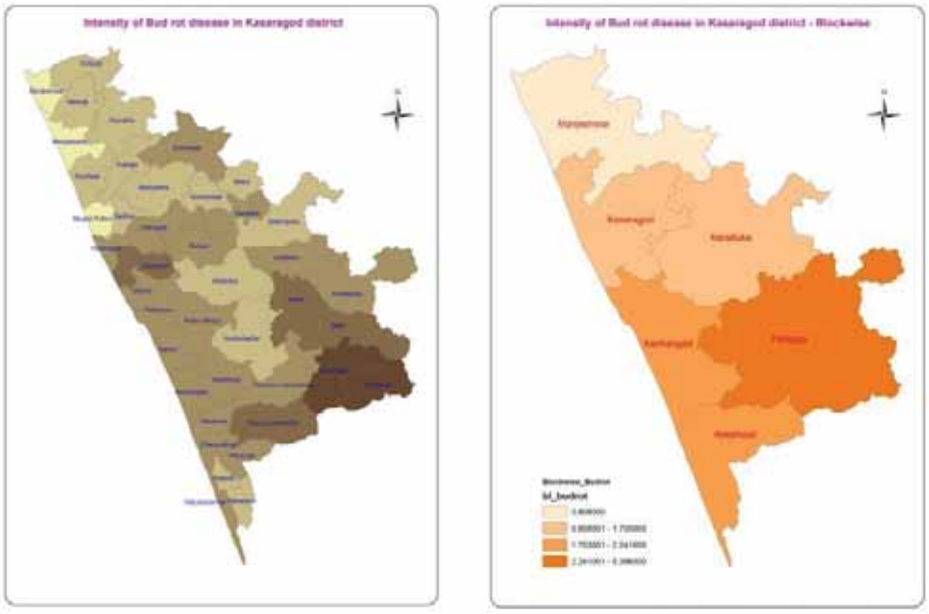


Fig. 135. Panchayat and block level incidence of bud rot disease of coconut in Kasaragod district

The study also revealed that the level of adoption of plant protection measures was very low. Vast majority of coconut farmers (97%) neither could identify the pest and symptom of attack by the red palm weevil nor did they possess adequate knowledge about the IPM measures against the pest. Incidence of bud rot disease was observed in 42% of the coconut gardens, while only 6% of the farmers adopted some disease management practices. Similarly, 46% of coconut gardens were affected by stem bleeding disease, but only 10% of the farmers adopted some control measures. The study also indicated that implementation of systematic interventions to support coconut farmers for adopting control measures against pests and diseases were inadequate. Out of the 41 Krishi Bhavans in the district, only 14 Krishi Bhavans implemented some schemes, mostly focusing on supplying organic inputs like neem cake, *Trichoderma* etc. for the pest and disease

management in coconut. The results of the study highlighted the need for in depth studies required to unearth the causal factors and to evolve appropriate remedial measures against yellowing in coconut palms prevalent in various localities and studies to analyze the association of agro-ecological features on incidence and intensity of diseases.

Development of Statistical and Computational Techniques for Improving Research Methodology

Robust experimentation technique in plantation crops

The performance of the proposed robust nonparametric covariance technique for controlling the effect of outliers was verified using the data on fertigation experiment on arecanut. Robust semiparametric regression with treatment vector as the parameter component and pretreatment yield as the covariate was considered for the analysis. The yield obtained of two years after the start of the experiment was taken as the response variable. The estimated treatment effects and its standard errors using the linear covariance technique, nonparametric covariance technique as well as the robust nonparametric covariance technique with pre-treatment yield as covariate for both weight of nuts and number of nuts were compared. Even though, there was not much difference in the estimated value of the treatment effects employing different methods, the standard error of the estimates and the estimated value of σ were less in the proposed robust method than that of the linear and nonparametric covariance technique.

Spreading pattern of diseases

Semi-variogram, spatial auto correlation, beta-binomial and joint count statistics were used to study the spreading pattern of root (wilt) disease of coconut, ganoderma and yellow leaf diseases of arecanut. Spatial autocorrelation and semi-variogram analysis of the data of YLD in six taluks of Karnataka (4 in Chikmagalur

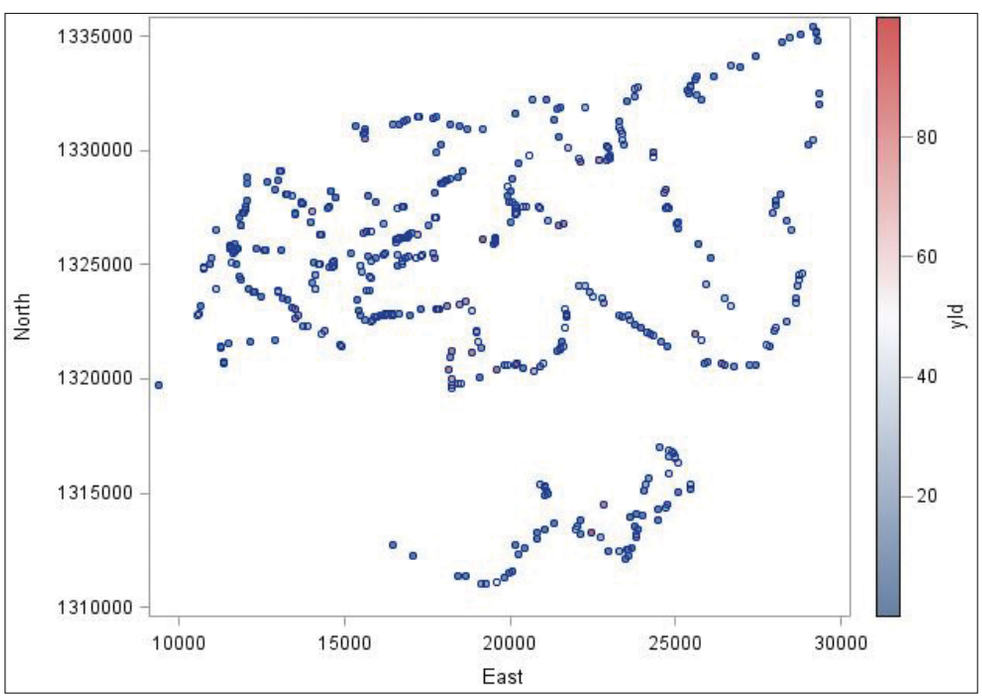


Fig. 136. Spatial distribution of the intensity of YLD in Chickmagalur district

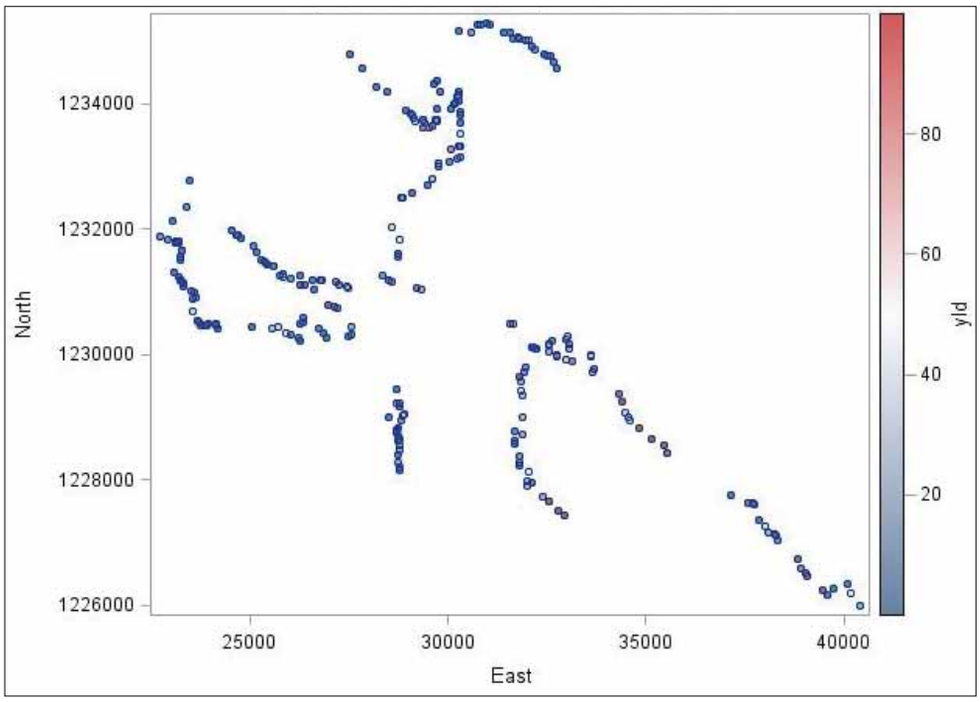


Fig. 137. Spatial distribution of intensity of YLD in Sullia and Madikeri Taluk

and 1 each in Dakshina Kannada and Kodagu) showed a significant positive spatial auto correlation, indicating that the disease incidence is in cluster form. The spatial distribution of the disease in Chikmagalur district and Sullia taluk (Dakshina Kannada) and Madikeri taluk (Kodagu) is presented in Fig. 136 and 137.

Analysis of the spreading pattern of Ganoderma disease of arecanut in five arecanut gardens in Jalpaiguri (West Bengal) was attempted. The result of the Joint Count Statistics to study the spatial correlation coefficient of the disease incidence data showed a positive spatial auto correlation which indicates that the disease incidence is in cluster form (Fig. 138).

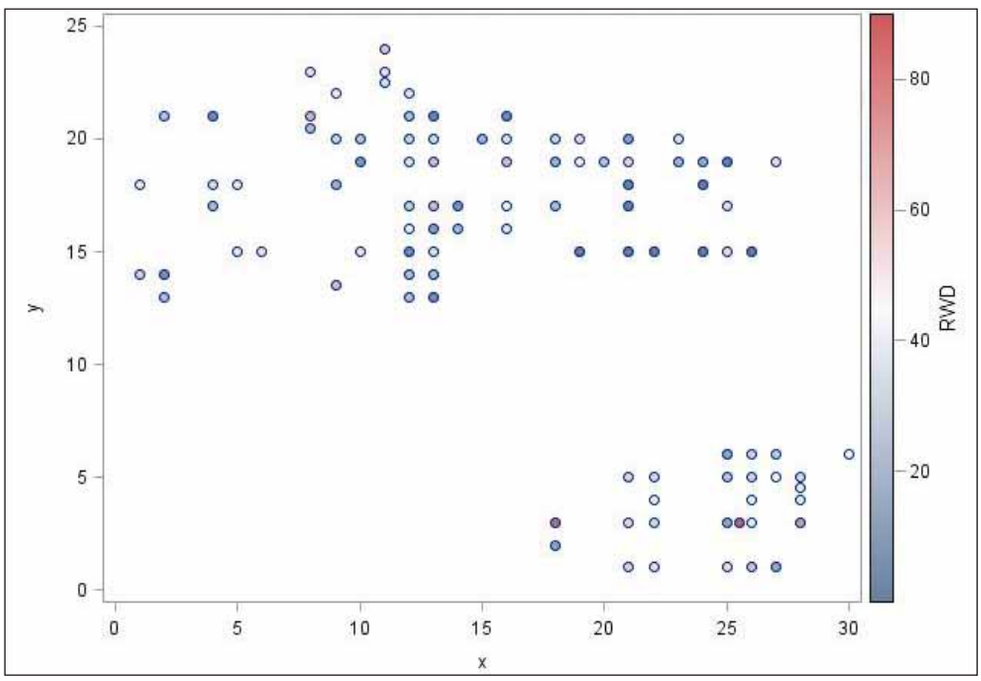


Fig. 138. Spatial distribution of RWD palms

Disease severity index

The disease severity index of YLD of arecanut and RWD of coconut was refined to incorporate the regional and temporal variations in the symptoms and its relationship with the yield. A multiplicative regression model considered for disease index (DI) for RWD of coconut and YLD of arecanut is:

$$DI = X (b_1 + b_2 N + b_3 Z)$$

where, X – yellowing for YLD & flaccidity for RWD, N – necrosis, Z – tapering for YLD & yellowing for RWD. The coefficients b_1, b_2 and b_3 are obtained by regressing the above model with yield as response variable.

Development of need-based computer programme

Computer program was developed in MATLAB to estimate spatial auto correlation of binary data using joint count statistics. SAS codes were written for computing semi-variogram, spatial auto correlation (continuous data), panel data analysis and fuzzy regression. R-program was developed to compute positional weight matrix from any protein sequence data and an algorithm for identification of conserved motifs within protein sequences.

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

The distribution, sample variance and sampling error and data transformation of cocoa yield data were studied and sample size for different levels of precision was estimated. It was observed that for a given level of precision, the required sample size for two years cumulative data was less than 40% of the single year data. The best transformation of data for satisfying the normality and equality of variance was obtained by using the Box-Cox transformation (SAS 9.3). Square root transformation was found to be best for the analysis of yield data of cocoa (both number and weight of pods).

Socio-Economic Dimensions and Value Chain Dynamics in Policy Perspective

Competitiveness analysis of coconut and coconut products to export destinations

It was revealed that competitive advantage of India is lower than major coconut exporting countries like - Philippines, Indonesia and Sri Lanka (Table 19). The

Table 19: Comparative advantage of India in export of coconut products (index)

Country	Coconut oil	DC	AC	VCO	Coconut Milk
India	2.10	1.80	6.90	1.10	na
Indonesia	21.2	4.90	26.20	16.10	na
Malaysia	12.0	4.20	10.60	5.20	5.20
Philippines	32.3	29.10	28.10	38.00	na
Thailand	1.60	5.60	12.60	8.10	39.20

**na-Not available*

intensity of consignment rejection in high value coconut commodities is found to be nil. This, in turn, opens a bright pavement for the coconut products export from India.

Policy dynamics and its effect on mandate crops

From 1999 onwards, import of arecanut to India registered a significant increase due to trade liberalization. Total imports were about 66 thousand tonnes of arecanut, valued at ₹ 67,046 lakhs during 2013-14. The average import intensity for the past six years was 12.50, which is on a higher side and will influence the stability of domestic arecanut prices.

Price analysis of mandate crops in value chain perspective

The price movement of coconut, coconut oil and copra clearly indicates a declining trend from August 2014 onwards. While examining the monthly price differences, the fluctuations are more in the case of coconuts than copra. It can be inferred that the real benefit of higher prices in the coconut oil sector is not proportionally getting transferred to coconuts, and this in turn proves detrimental to the coconut farmers. Moreover, the analysis of demand-supply scenario using stock-use ratio revealed that there is a declining demand for coconut oil from 2012-13 onwards and the wedge between demand and supply has narrowed down (Fig. 139).

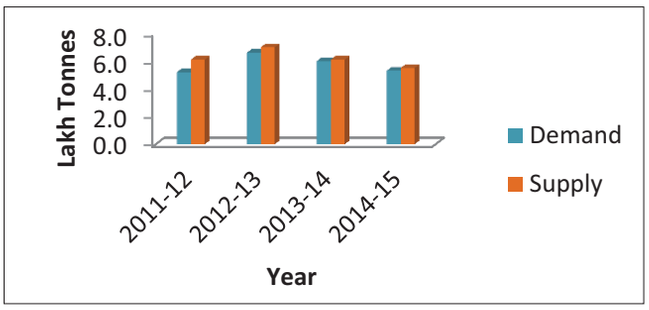


Fig. 139. Demand-Supply scenario of coconut oil

It was observed that there is huge price wedge between domestic and international prices (Fig. 140). As the prices will tend to integrate, there is a possibility of price crash in the near future.

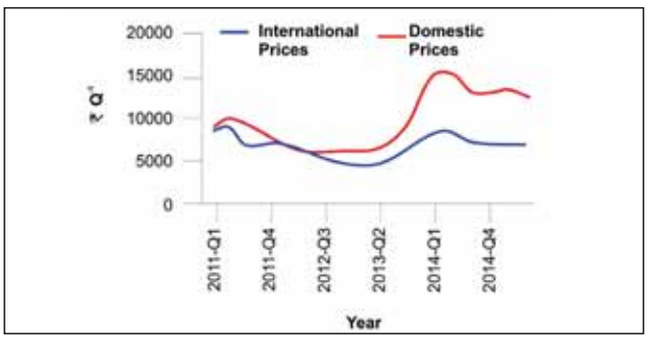


Fig. 140. Domestic and International prices (coconut oil)

Cost of production and production relations of mandate crops

Cost of production of coconut in a well-managed coconut garden is ₹ 8.21 per nut. In this scenario, about 58 percent of the total cost is incurred on labour charges, which can be attributed to higher labour demand and higher cost of labour in the states (Fig. 141).

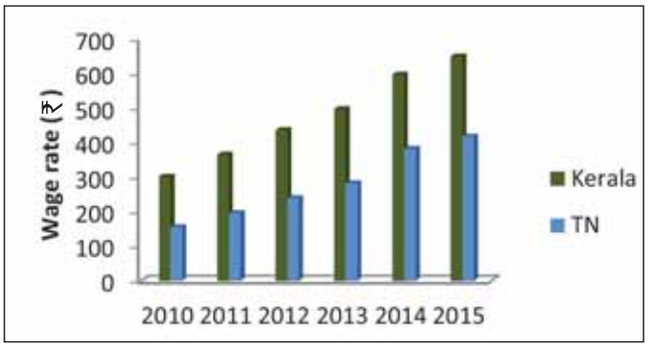


Fig 141.The pattern of wage rates in Kerala and Tamil Nadu (2010-15)

Economic impact studies on crops diversification and technology adoption in horticulture

Regional level spatio-temporal crop pattern changes were delineated. A database (district level) on area, production and productivity of plantation crops in Kerala (35 years data) has been developed. Technologies for impact assessment were identified. Schedule for primary data collection was developed and pilot tested. Analysis of spatio-temporal crop pattern changes revealed that stable commodity prices is the major determining factor of the temporal crop pattern changes, and in Kerala the spatial instability in crop pattern often resulted from impulsive decisions of farmers.

Agri-business incubation centre

Entrepreneurship development and agri-business incubation programmes initiated under Business Planning and Development project (National Agricultural Innovation Project) were further strengthened in the newly initiated project on establishing "Agri-Business-incubation (ABI) Centres" under XII plan National Agriculture Innovation Fund (NAIF).

Terms and conditions for availing the facilities in the ABI centre for preparation of virgin coconut oil (VCO), coconut chips, desiccated coconut and activated coconut shell carbon were published in the institute website. In response to this and other technology awareness programmes of the institute, respectively 50, 42, 4, and 12 have entrepreneurs approached for availing the aforesaid facilities. Enquiries received for other technologies were Kalparasa (40); coconut leaf vermicomposting (22); machineries (15); bioagents (8); pollen cryopreservation (1); coconut varieties (14). After a brief discussion on scope of technologies, business and marketing plan, and ABI services, entrepreneurs were shortlisted for incubation. Final selection for incubation is made by the Institute Technology Management Committee, and in the year 2015-16, two incubatees were selected for VCO, and one each for activated shell carbon and desiccated coconut.

CAPACITY BUILDING INITIATIVES AND TECHNOLOGY TRANSFER

Programmes for Extension Personnel

Model training course on participatory technology transfer approaches

Model training course sponsored by Directorate of Extension, Ministry of Agriculture, Govt. of India on 'Participatory Technology Transfer Approaches for Plantation Crops' was conducted at ICAR-CPCRI, Kasaragod during 23-30 November, 2015 in which 20 officers from four states attended. Dr. P. Chowdappa, Director, ICAR-CPCRI inaugurated the Model Training Course. Dr. Sreenath Dixit, Director, ICAR-ATARI, Bengaluru was the chief guest.

Training-cum-workshop on convergence of extension initiatives

Training-cum-workshop on 'Convergence of extension initiatives in plantation sector for inclusive development' was held at ICAR-CPCRI, Kasaragod during 15-17 June 2015. Dr. R. Muralidhara Prasad, former Associate Director of Extension, Kerala Agricultural University, Thrissur, inaugurated the programme, while Dr. P. Chowdappa, Director, ICAR-CPCRI presided over the inaugural function. Thirty seven extension officers from Rubber Board, State Department of Agriculture and ATMA participated in the workshop.

Training for KVK personnel on coconut production technologies

Training on 'Profitable Production, Processing and Marketing Mechanisms in Coconut, was organized in two batches during 2-3 and 5-6, February, 2016 at ICAR-CPCRI, Kasaragod for 34 Subject Matter Specialists (SMS) from 29 KVKs covering three states, *viz.,* Kerala, Karnataka and Tamil Nadu. Training was organized to empower KVK personnel for formulating interventions for OFT, FLD and other extension activities.

Training-cum-exposure visits

Training–cum-exposure visit programmes were organized at ICAR-CPCRI Kasaragod, Kayamkulam, Vittal, Kahikuchi and Mohitnagar, for 131 extension personnel in 14 batches, in collaboration with Department of Agriculture/ Horticulture, ATMA and other agencies. The extension personnel were exposed to various technologies evolved at the institute.

Programmes for Farmers

Training programmes for farmers on integrated crop management and value addition

ATMA interstate farmers' training programme on 'Integrated Crop Management and Value Addition in Coconut' was organized at ICAR-CPCRI, Kasaragod for 282 coconut farmers from13 districts of Tamil Nadu in 13 batches.

Training programme on cocoa production and processing technology

Training programme on 'Cocoa Production and Processing Technology' was conducted on 30th October, 2015 at ICAR-CPCRI, RC, Kahikuchi, sponsored by Directorate of Cashewnut and Cocoa Development, Kochi. Fifty farmers from Chaygoan, Nahira and Rampur villages of Kamrup (Rural) and Goalpara districts of Assam participated and were benefitted.

Training-cum-exposure visits for farmers

Training and exposure visit programmes were conducted in collaboration with Departments of Agriculture and Horticulture, ATMA and other agencies benefitting 5955 farmers in 124 batches: at Kasaragod (40 batches), Kayamkulam (43 batches), Vittal (26 batches), Kahikuchi (8 batches) and Mohitnagar (7 batches).

Exposure visit to Mondelez India Foods Pvt. Ltd., Eluru, Andhra Pradesh, for 49 farmers from Kamrup and Goalpara districts of Assam, was conducted from 3-9 December, 2015 with the co-ordination of ICAR-CPCRI, RC, Kahikuchi, sponsored by Directorate of Cashewnut and Cocoa Development, Kochi.

Training for Other Clientele Groups

Training programme on hybridization technique in coconut

Training programme on 'Hybridization technique in coconut' was conducted at ICAR-CPCRI, Kasaragod during 16-17 December 2015 in collaboration with Department of Agriculture, Kerala state, in which 20 climbers from Kozhikode district participated.

Training programme on bio-agent production techniques

Training programme on 'Bio-agent production techniques' for technical personnel of Department of Agriculture, as part of strengthening of Parasite Breeding Station, was organized at ICAR-CPCRI, Kasaragod during 7-9 December 2015.

Training under "Friends of Coconut Tree" (FoCT) programme

At CPCRI, Research Centre Mohitnagar, rural youth were trained on coconut climbing using mechanical climbing device and agrotechniques for coconut under the "Friends of Coconut Tree" programme sponsored by CDB, State Centre, Kolkata. A total of 80 trainees were trained in four batches of six days duration each.

Stakeholder interface programmes

The institute organized scientist-farmer interface programme on Coconut and Arecanut at Velliangiri near Coimbatore in Tamil Nadu on 7th May, 2015, in collaboration with Uzhavan Farmer Producer Company and Isha Foundation. Dr. P. Chowdappa, Director, ICAR-CPCRI inaugurated the interface programme. Team of scientists from ICAR-CPCRI interacted with farmers on various aspects of crop improvement, crop production, crop protection and product diversification in coconut and arecanut. About 200 farmers from various parts of Coimbatore district participated in the programme. After the interface programme, a diagnostic

field visit was conducted to nearby farmers' plots. Nutritional disorders, incidence of diseases like stem bleeding, basal stem rot and problems related to irrigation/ water management were observed. Technological interventions were suggested to solve the field problems and follow-up programmes were planned to monitor the interventions and their impact.

Stakeholders' meet on disease management in arecanut

Stakeholders' meet on disease management in arecanut with special emphasis on fruit rot was held on 9th April 2015 at ICAR-CPCRI, Regional Station, Vittal. Dr. P. Chowdappa, Director, ICAR-CPCRI, Kasaragod inaugurated the meeting (Fig. 142). More than 120 stakeholders participated in the meeting. A committee comprising of scientists and arecanut growers were formed to monitor the experiments and demonstrations on fruit rot disease management. A demonstration on preparation of Bordeaux mixture and use of rain guards for the management of the disease was also conducted as part of the interface programme.

Fig. 142. Dr. P. Chowdappa, Director, ICAR-CPCRI inaugurating the "Stakeholder's meet on arecanut disease management" at Vittal. Shri M. Srinivas Achar, President, All India Areca Growers Association and Dr. D.C. Chowta, a progressive farmer are also seen

Stakeholders meet on disease management in arecanut with special emphasis on yellow leaf disease was held on 18th May 2015 at Agriculture and Horticulture Research Station (AHRS), Sringeri. Dr. P. Narayana Swamy, Director of Research, University of Agriculture and Horticulture Sciences (UAHS), Shivamogga inaugurated the meeting. An action plan for the management of Yellow Leaf Disease in arecanut was presented in the meeting. Detailed discussion on Yellow Leaf Disease was held among stakeholders. A committee comprising of ICAR-CPCRI and UAHS Scientists and arecanut growers were formed to monitor the experiments on YLD management.

Stakeholders meet on value addition in coconut

Stakeholders' meeting on 'Value Addition in Coconut' was organized on 28th November, 2015 at APMC meeting hall, Ambajipeta, East Godavari, Andhra Pradesh (Fig. 143). Potential for enhancing income from coconut farming by adopting Kalparasa tapping technology was highlighted in the meet. Subsequent to the interface programme, Dr. P. Chowdappa, Director, ICAR-CPCRI discussed with Shri Chinna Rajappa, Hon'ble Deputy Chief Minister of Andhra Pradesh on the technologies for enhancing the profitability of coconut farming through value addition (Fig. 144). Technology to collect fresh unfermented 'Kalparasa' using coco-

Fig. 143. Dr. P. Chowdappa, Director, CPCRI delivering presidential address at Ambajipeta, A.P. during stakeholders' meet on value addition in coconut

Fig. 144. Dr. P. Chowdappa, Director, ICAR-CPCRI in discussion with Shri Chinna Rajappa, the Hon'ble Deputy Chief Minister of Andhra Pradesh on establishing of coconut parks in A.P.

sap chiller was demonstrated to the of stakeholders. Kalparasa, its value added products and other coconut technologies/products were also exhibited during the programme.

Frontline Demonstrations

Site-specific external inputs and management

The initiative was taken up under the multi-institutional farmer participatory project, funded by State Planning Board, Kerala and implemented by ICAR-CPCRI to demonstrate in farmer's fields across the diverse agro-ecosystems of the state, that through the use of appropriate external inputs and management, the productivity of coconut can be substantially enhanced. A total of 60 coconut gardens spread over six districts of Kerala, @ 10 coconut gardens each with 30-40 palms per district were selected for demonstrating the interventions.

Integrated management of root (wilt) affected coconut gardens

This Frontline demonstration programme is being implemented in seven severely root (wilt) disease affected districts of Kerala State in 5 ha of farmers plots (contiguous area) in each district *viz.*, Thiruvananthapuram (Elakamon), Kollam (Kulasekharapuram), Alappuzha (Cherthala South), Pathanamthitta (Nedumbram), Ernakulam (Parakkadavu), Kottayam (Kuroppada) and Thrissur (Vellangallur). Launching of the FLD programme was done by Dr. N. K. Krishna Kumar, DDG (Hort. Sci.) on 31 May 2015. A total of 90 farmers' plots were selected with 2500

coconut palms at various growth stages. Launching of the FLD and training programme were conducted in all the FLD sites by the team members. Pre-project documentation of farm and farmers profile (as per pre tested interview schedule) and numbering of palms has been completed. The programme is being implemented in participatory mode with people's representatives, officials of Department of Agriculture and coconut farmers' organizations in respective areas.

Indexing of root (wilt) diseased palms indicated that, on an average, 13.2 per cent of palms are Apparently Healthy (AH), 11.55 per cent Disease Early (DE), 52.99 per cent Disease Middle (DM) and 22.44 per cent in Disease Advanced (DA) category. In addition, incidence of rhinoceros beetle (30-75%), eriophyid mite (4-65%), red palm weevil (0-5%), rat (0-2%), coreid bug (0-8%), boron deficiency (2-13%), leaf rot disease (12-26%), stem bleeding (1-6%) were recorded.

Majority of the farmers preferred organic nutrient inputs, and intercropping was practiced by 68% of the participating farmers. Sixty nine per cent of the participating farmers opined that yield could be improved through integrated root (wilt) disease management practices. The widely adopted practices were green manuring, application of cow dung, basin opening and intercropping in coconut gardens. The least adopted were irrigation and water/soil conservation measures, chemical fertilizers, dolomite, crown cleaning and boron deficiency management. Activities were planned for improving the knowledge and adoption of the recommended practices and participatory evaluation of the impact of integrated management on root (wilt) diseased palms.

Root grub management

Frontline demonstration on root grub management was conducted at Dakshina Kannada, Karnataka. Two treatments, *viz.,* soil application of entomopathogenic nematodes (EPN), *S. carpocapsae* @ 0.75 billion IJs ha^{-1} and imidacloprid 17.8SL @ 650 ml ha^{-1} during October, were compared with the usual farmers practice (wherein EPN and imidacloprid were not applied) for management of root grub, *Leucopholis* sp., in arecanut at Ujire of Dakshina Kannada district, Karnataka. Significant reduction in number of grubs at the root zone of infested arecanut palms, from 18.2 to 2.4 (86.8%), was observed due to sustained suppression of root grub multiplication. The EPNs were re-isolated from the treated plots (20%). Plant health also improved and the number of palm deaths due to root grub infestation was also brought down.

Method demonstrations

Five method demonstrations–cum-trainings were conducted on preparation of *Trichoderma* cake and farm level enrichment of different organics/organic substrate combinations with *Trichoderma* sp. to 66 members of SHGs, Karmasena and Agro Service Centres of Kanjikuzhy Block, Kerala.

Farm field schools

Four Farm Field Schools on integrated management of rhinoceros beetle and red palm weevil were conducted in different places of Alappuzha District, Kerala covering a total of 73 farmers.

Exhibitions

The Institute has participated in 26 exhibitions (Kasaragod-12, Kayamkulam-3, Vittal-6, Kidu-1, Kahikuchi -2 and Mohitnagar – 2) providing insight into the various activities to the stakeholders. Technologies on varieties, crop production, protection and processing were displayed to provide first-hand information to the visitors.

Fig. 145. Shri Radha Mohan Singh, Hon'ble Union Minister for Agriculture and Farmers' Welfare, Govt. of India, visiting ICAR-CPCRI stall at Kahikuchi

Shri Radha Mohan Singh, Hon'ble Union Minister for Agriculture and Farmers' Welfare, Govt. of India visited the ICAR-CPCRI stall during 3rd International Agri-Hort Expo held from 6th -10th January, 2016 at Khanapara, Guwahati, Assam (Fig. 145).

Fig. 146. Shri Pon Radhakrishnan, Hon'ble Union Minister of State for Shipping, Govt. of India, visiting ICAR-CPCRI stall at Nagercoil

Shri Pon Radhakrishnan, Hon'ble Minister of State for Shipping visited the ICAR-CPCRI exhibition stall at Nagercoil, Kanyakumari district, Tamil Nadu on 30th May 2015 and was impressed by the significant contribution of ICAR-CPCRI towards holistic welfare of coconut farmers (Fig. 146).

Fig. 147. Dr. Trilochan Mohapatra, Secretary (DARE) & Director General (ICAR), visiting CPCRI Stall at New Delhi during Krishi Unnati Mela

Dr. Trilochan Mohapatra, Hon'ble Director General, ICAR, New Delhi visited the ICAR-CPCRI Stall on 19 March 2016 in connection with Krishi Unnati Mela held during 19-21 March, 2016 at IARI, Pusa Campus, New Delhi (Fig. 147).

As part of Krishi Mela at Kasaragod on 12 March 2016, scientist-farmer interface programme was organized for the benefit of farming community. About 30 exhibition stalls showcased their technologies for providing first-hand information to the farmers/ stakeholders.

ATIC services

ATIC at Kasaragod provided technology advisory services, planting material of coconut, arecanut and cocoa and other technology inputs through a single window system (Table 20).

As part of farm advisory services, replies were provided to farmer's queries related to production, protection and value addition aspects of coconut, arecanut and cocoa (Table 21).

Table 20: Details of technologies/ products sold through ATIC

Sl. No.	Item	Total	
		Qty/Nos.	Amount (₹)
1.	Books (Nos)	218	9606
2.	CDROM (Nos)	4	440
3.	Earthworms (Nos)	11600	9164
4.	Vermi compost (kg)	5639	53167
5.	Coirpith compost (kg)	175	1925
6.	Coconuts (Nos)	25492	335580
7.	Mushroom spawn (kg)	5	440
8.	Coconut seedlings- Tall (Nos)	7576	421191
9.	Coconut seedlings – Dwarfs (Nos)	4786	368522
10.	Coconut seedlings - Hybrids (Nos)	17843	3925460
11.	Polybag coconut seedlings (Nos)	1080	155161
12.	Coconut seednuts (Nos)	106	3564
13.	Kera Probio (kg)	199	5473
14.	Immature coconuts (Nos)	82	443
15.	Vermiwash (L)	5	550
	Total		52,90,686

Table 21: Details of farmer advisory services

Sl. No.	Topic	No. of queries replied to			
		Telephone	E-mail	Postal	Total
1.	Availability of planting material	1981	257	2911	5149
2.	Hybrids and improved varieties	925	163	282	1370
3.	Integrated nutrient management	218	13	2	233
4.	Organic farming technologies	93	4	0	97
5.	Irrigation and water management	6	3	3	12
6.	Integrated pest management	398	0	6	404
7.	Integrated disease management	416	2	1	419
8.	Post-harvest technologies	283	2	1	286
9.	Availability of printed farm literature	28	16	39	83
10.	Training and other TOT programmes	112	2	11	125
11.	Consultancy programmes	8	0	5	13
12.	Other items	98	1	16	115
	Total	4566	463	3277	8306

Cyber extension

Interface programme on coconut development initiatives by Coconut Development Board (CDB) was conducted on 24 November 2015 involving Chairman CDB, Kochi,

extension personnel and scientists at ICAR-CPCRI Kasaragod. ICT components have been developed for real time data documentation, field problem solving, synchronized farming application for new farmers, farmer's diary and website.

A mobile-based ICT package 'E-Kalpa' for the coconut farmers of root (wilt) disease affected area was developed. The components are survey application (real time data documentation/ archiving/ paperless/ customized/ fast/ economical), knowledge base (multi mode), farmers' issue reporting and solving application (real time, mobile based, multimode message system-audio, video, text, image), advisory notifications, synchronized coconut farming application (new plantings and issue based) and farmers diary (date wise technology updating and reporting). These applications will be integrated for enhancing usage efficiency.

Utilization of mass media

Seven video films on selected technologies, *viz.* snowball tender coconut, virgin coconut oil, coconut chips, coconut sugar, integrated disease management, integrated pest management and organic farming techniques were produced in English and regional languages with financial support from NABARD. Fifty eight popular articles on various technologies and success stories, four radio programmes and six TV programmes were used for dissemination of technologies to a large number of stakeholders.

World soil day celebration and distribution of soil health cards

World Soil Day was celebrated on 5 December 2015 at ICAR- CPCRI, Kasaragod, CPCRI Regional Station Kayamkulam and KVK Alappuzha.

Shri P. Karunakaran, Member of Parliament, Kasaragod, inaugurated the World Soil Day celebration and distributed soil health cards to selected farmers from Kasaragod district at a function organized by the ICAR-CPCRI, Kasaragod (Fig. 148). Dr. P. Chowdappa, Director, ICAR-CPCRI, presided over the inaugural function and highlighted the research efforts to evolve resource conserving technologies, especially technologies for soil and water conservation suitable for coconut and arecanut based cropping systems. Shri C. Prabhakaran, President, Madikkai Grama Panchayat, Shri A. Rajan Kuttyanam, an award-winning farmer, and Dr. Ravi Bhat, Head Division of Crop Production offered felicitations. A training programme for farmers on

Fig. 148. Shri P. Karunakaran, Hon'ble Member of Parliament, Kasaragod, distributing soil health cards at ICAR-CPCRI, Kasaragod

soil health management was also organized on the occasion. Dr. K.U.K. Nampoothiri, formerly Director, ICAR-CPCRI inaugurated the training programme.

A seminar-cum-farmers' meet was organized at ICAR-CPCRI, Regional Station, Kayamkulam on 5 December, 2015 to highlight the importance of soil health management through soil fertility evaluation (Fig. 149). Chettikulangara Grama Panchayath was identified for collection, analysis and preparation of soil health cards based on a preliminary screening. A campaign was organized in Erezha (S) of the Panchayath highlighting the importance of soil test-based fertilizer application and the method of collection of soil samples for analysis. A total of 100 soil samples were collected from different farmer's fields. Dr. V. Krishnakumar, Head of the Station presided over the function, while Dr. George. V. Thomas, formerly Director, ICAR-CPCRI delivered the keynote address on "Soil health for sustainability of mankind". The programme was inaugurated by Shri N. Padmakumar, IAS, District Collector, Alappuzha. The soil health cards prepared by the Regional Station, Kayamkulam were distributed to the farmers for understanding and monitoring the general fertility status of the soil. Soil health indicators such as pH, electrical conductivity, organic carbon, major secondary and micro nutrient status of soil were printed in each card. Recommendations based on the soil fertility parameters are envisaged in the soil health card for the major crops such as coconut, banana, and some vegetables, commonly cultivated by the farmers in the locality. A field visit was also arranged to the experimental plots, wherein the farmers were given an opportunity to understand the importance of soil health management in achieving potential productivity of coconut palms. Shri Sreedhara Kurup, President, Keragramam Coconut Producers Federation, Chettikulangara offered felicitations.

World Soil Day was celebrated on 5th December, 2015 at Aryad Sansad Adarsh Gram, Alappuzha district, in a meeting organized by KVK, Alapuzha, with the participation of more than 100 farmers. Sri. K. C. Venugopal, Hon. Member of Parliament, Alappuzha, inaugurated the programme and soil health card distribution (Fig. 150). An awareness talk on 'Healthy soils for a healthy life' was delivered by Dr. P. Muralidharan followed by discussions. Soil Health Cards were distributed to 250 farmers based on analyses of geo-referenced soil samples collected from different parts of the panchayath.

At Mohitnagar, a workshop-cum-training programme on "Enhancement of soil fertility for horticultural crops" was organized as part of "International Year of Soils-2015" in collaboration with North Bengal Science Centre, Siliguri. A total of 40 farmers attended the workshop.

Fig. 149. Shri. N. Padmakumar, IAS, District Collector, inaugurating World Soil Day at Kayamkulam

Fig. 150. Shri K.C. Venugopal, M.P., inaugurating World Soil Day Programme at Aryad, Alappuzha district, Kerala

World Coconut Day

World Coconut Day was celebrated at three places, *viz*. Cheruthazham, Kannur in collaboration with Krishibhavan, ICAR-CPCRI Regional Station, Kayamkulam and Tumkur University in collaboration with Bhoomi Sustira Abhivradhi Sanste, Hassan.

World Coconut Day was jointly organized by CPCRI-Kasaragod, Tumkur University and Bhoomi Sustira Abhivradhi Sanste, Hassan on 2 September, 2015 at University Campus, Tumkur. In line with this year's theme of APCC *viz*., 'Coconut for Family Nutrition, Health & Wellness, ICAR-CPCRI selected the topic of Kalparasa. While inaugurating the programme, Shri T.B. Jayachandra, Hon'ble Minister for Law, Justice and Animal Husbandary, Government of Karnataka complimented the efforts of ICAR-CPCRI to popularize the neera technology and its value added products for empowering coconut producers and wellness of consumers (Fig. 151). Shri Krishna, former Speaker, Karnataka Legislative Assembly, Government of Karnataka released a technical bulletin on Kalparasa and stressed the need for evolving a neera policy in Karnataka for the benefit of producers and consumers. Dr. P. Chowdappa, Director, ICAR-CPCRI explained that the Kalparasa technology could improve the economy of small and marginal farmers, create green-collar jobs in rural areas and also empower rural youth and women. He stressed that the future of coconut depends on value addition and Kalaparasa could play a greater role, can be proved as a sports drink and due to low glycemic index, even diabetic patients can consume it. Shri Jayaprasad, Bhoomi spoke on the benefits of Kalparasa. In his presidential address, Prof. A.H. Rajasab, Vice Chancellor, Tumkur University emphasized the need for development of a neera policy in Karnataka and urged the scientists to develop a technology to store neera at room temperature, without fermentation. Dr. K. B. Hebbar, Head, PB&PHT, ICAR-CPCRI presented a detailed account of Kalparasa collection method, its handling, transportation, quality standards and processing into value added products like sugar, jaggery, honey and other confectionary products. Kalparasa and its value added products and coconut products were exhibited during the programme. A demonstration of collection of fresh and unfermented 'Kalparasa' using coco-sap chiller was arranged for the benefit of stakeholders. About 350 coconut growers from Karnataka participated in the programme.

Fig. 151. Dr. P. Chowdappa, Director, CPCRI offering Kalparasa to Shri T.B. Jayachandra, Hon'ble Min. Law, Justice and Animal Husbandry, Karnataka

KRISHI VIGYAN KENDRAS

KVK, KASARAGOD

KVK, Kasaragod undertook five On-farm Trials (OFTs) and 18 Frontline Demonstrations (FLDs) during 2015-16 as a part of its mandatory activities.

On-farm Trials

Sl. No.	Title	Technology	Location
1.	Eco-friendly management of rhinoceros beetles in coconut	Botanical cake in tablet form (developed by ICAR-CPCRI)	Mangalpady and Mogral Puthur
2.	Performance evaluation of dwarf varieties of coconut in farmers' plots	Dwarf varieties of coconut released by ICAR-CPCRI (Kalparaksha, Kalpa Jyothi, Kalpa Surya and Kalpasree)	Mogral Puthur
3.	Performance of fodder grass varieties as intercrop in coconut garden	Fodder grass varieties like Hybrid Bajra Napier (CO 5), Australian Napier and Thamburmuzhy-1 with Co 3 as control	Kinanoor-Karindalam
4.	Micronutrient management in black pepper	Dolomite application followed by *Trichoderma viride* enriched compost and *Pseudomonas fluorescens* basal application and aerial spray with 1% BM	Karadka
5.	Validation of 'wonder climber' for arecanut harvesting	'Wonder Climber' developed by Prakashan Thattari, an innovator farmer	Mangalpady

Frontline Demonstrations

Sl. No.	Title	Technology	Location
1.	Coastal sandy soil management for higher coconut productivity	Appropriate soil moisture conservation measures, growing inter-crops (banana, vegetables and fodder grass) using coconut husk in sandy soil.	Padanne and Nileshwar
2.	Prophylactic method for control of bud rot disease in coconut	Placement of *Trichoderma* enriched coir pith cakes around the spindle leaves of coconut palms during monsoon periods	Manjeshwar and West Eleri
3.	Integrating bee colonies for better pollination and yield enhancement in coconut gardens	Increasing yield of coconut through better pollination by honey bees	Kodavalam village (Pullur–Periye), Baradka (Badiadka) and Puluvinchi (Kuttikkol)
4.	Management of root grub in arecanut using bio control agents	Biocontrol of root grubs with a native EPN isolate of *Steinernema carpocapsae*	Melbare village of Uduma
5.	Canopy management in cocoa	Training and pruning techniques and plant protection in cocoa	Delampady
6.	Management of *Phytophthora* foot rot disease in black pepper	Dolomite application followed by application of *Trichoderma* enriched compost and *Pseudomonas fluorescens*	Aadhur and Mulleria villages of Karadka
7.	Organic cultivation of paddy	Varieties suitable for organic cultivation (Ezhome I, Ezhome II and Ezhome III).	Mangalpady

Sl. No.	Title	Technology	Location
8.	Effectiveness of mini set techniques in ginger, turmeric and amorphophallus	High yielding varieties like Varada, Pratiba and Gajendra were used as mother seed in ginger, turmeric and amorphophallus, respectively	Mangalpady
9.	Management of pseudostem weevil in banana using cassava bioformulations	Application of lime/dolomite, application of neem cake in planting pits, phyto sanitary measures, prophylactic application of NANMA	West Eleri, Ballal and Uduma
10.	Role of stingless bees in pollination of cucurbitaceous vegetables	Efficiency of stingless bees in pollinating cucurbitaceous vegetable crops and promoting stingless bee keeping in each homestead	Mangalpady and Mogral Puthur
11.	Management of pod borers in Yard long bean	Spraying of neem based bioformulations at 1.5% concentration and application of *Beuvaria bassiana* after one week thereafter	Mangalpady and Mogral Puthur
12.	Introducing high yielding varieties of sesame in paddy fallows	High yielding varieties of sesame, Thilarani and Thilak are introduced	Mangalpady, Thrikkaripur, Nileshwar, Pullur-Periye, Uduma and Kanhangad
13.	Demonstration of technologies to prevent crop damage due to wild life intrusion	Wild boar olfactory repellant powder and reflecting ribbons	Mangalpady
14.	Micronutrient management in banana laterite soils	'Ayar'- a mixture of micronutrients	Kuttikkol
15.	Entrepreneurship Development Programme on Value addition	Value added products from amla, mushroom, honey	Kuttikkol
16.	Bio-enrichment of areca leaf sheath	Microbial consortium to break the cellulose structure in arecanut leaf sheath	Manjeshwar and West Eleri

Training Programmes

KVK conducted 146 training programmes from April 2015 to January 2016 benefitting 1681 farmers and 1128 farm women.

Extension Programmes

Sl. No.	Programme	Date	Location
1.	Jai Kisan - Jai Vigyan Diwas	23.12.2015	Kinanoor-Karindalam
2.	Paddy harvest festival	10.11.2015	Mangalpady
3.	Harvest festival of ginger, turmeric and tuber crops	19.01.2016	Kinanoor-Karindalam
4.	Farmers' meet and exhibition	28.09.2015	Kinanoor-Karindalam
5.	Opening of the sales outlet	16.07.2015	CPCRI Ksaragod
6.	Plant protection campaign	25.05.2015	Mangalpady
7.	Convergence meeting	09.04.2015	KVK Kasaragod

Extension activities

Sl. No.	Activity	Numbers
1.	Exhibitions	2
2.	TV Programmes	3
3.	Success stories in print media	9
4.	Popular articles	4

Production and supply of products

Category	Products supplied	Quantity
Seed materials –Varieties (kg)	Vegetables	35 kg
Planting material – Varieties (Number)	Vegetable seedlings and grafts	5760
Planting material – Hybrids (Number)	Papaya	3682
Fish fingerlings (Number)	Fish fingerlings	56600
Bio products (kg)	NANMA	631 kg
Mushroom (kg)	Spawn	108 kg

KVK, ALAPPUZHA

KVK, Alappuzha undertook seven OFTs and 10 FLDs during 2015-16 as part of its mandatory activities.

On-farm Trials

Sl. No.	Title	Technology	Location
1.	Assessing the performance of pro tray germinated planting material of ginger	Ginger seeds of 2.5-5.0 cm length weighing 20-25 grams each, having one or two good buds in comparison to ginger seeds of single bud having 5 grams germinated in pro tray (ICAR-IISR)	Aryad
2.	Assessing the performance of high yielding CTCRI cassava varieties in coconut gardens	ICAR–CTCRI tapioca varieties – Sree Jaya, Sree Vijaya and Sree Pavithra	Aryad
3.	Assessing the effect of IISR micronutrient mix in turmeric cultivation	Recommended INM practices + IISR micronutrient mix (5g L^{-1}) @ 60 & 90 DAP in comparison to recommended INM practices (KAU)	Aryad
4.	Assessment of alternative growing media for grow bag cultivation	Spent mushroom substrate + soil as growing media in comparison to EM- composted water weeds+ soil as growing media	Cheppad, Chunakkara, Muttar, Aryad
5.	Assessing the performance of PGPR Mix II against downy mildew of snake gourd	PGPR Mix II spray 2% in comparison to 2% *Pseudomonas* spray and Mancozeb 0.3% spray	Aryad, Thamarakulam, Pallipad, Haripad
6.	Assessing the performance of milky mushroom species, *Calocybe gambosa*	*Calocybe gambosa* (KAU) in comparison to *Calocybe indica*	Aryad, Thiruvanvandoor, Cheppad, Kayangulam
7.	Management of biting flies in dairy animals	External application of Kusum Oil (extracted from the seed of the Ceylon oak - *Schleicheraoleosa)* at 14 days interval in comparison to 7 days interval	Aryad

Frontline Demonstrations

Sl. No	Title	Technology	Location
1.	Scientific cultivation of turmeric variety (IISR- Prathibha) in coconut gardens	Site specific nutrient management and IPDM for high yielding var. Prathibha	Aryad, Bharanickavu
2.	Recycling of aquatic weeds by EM composting for soil health management	Composting of aquatic weeds using EM solution for crop production	Veliyanad, Muttar
3.	Oyster mushroom production using banana pseudo stem waste and value addition	Oyster mushroom production using banana pseudo stem waste, value addition and marketing	Aryad
4.	Introduction of Kadaknath breed in backyard poultry rearing	Kadaknath breed	Aryad
5.	Minimal processing and marketing of tender and fresh jack fruit	Blanching and application of various preservatives for enhancing appearance and keeping quality of tender and fresh jackfruit.	Chenganur
6.	Resource conserving and eco-friendly technologies in paddy cultivation	Soil test based dolomite and nutrient application; sowing using drum seeder, and eco friendly pest and disease management	Kainakary
7.	Demonstration of millet based low glycemic index flour mix	Production of low glycemic index flour mix using different types of millets, packaging, labelling and marketing	Aryad
8.	Management of banana pseudo stem weevil using biopesticides	Prophylactic spray (Nanma 12.5 L ha^{-1}) two sprays at 4^{th} month and at bunch emergence stage and curative stem injection with Menma 15 ml $plant^{-1}$	Aryad
9.	Demonstration of Hydroponics method of fodder production for dairy	Production of fodder grass by hydroponics method	Aryad
10.	Demonstration of cream separator for enhancing profitability of dairy units	Cream separator (ICAR-NDRI)	Mararikulam

Training programmes

Training	No. of batches	Participants		
		Men	Women	Total
On campus	40	516	515	1031
Off campus	30	355	338	693
Sponsored	28	211	457	668
Vocational	2	8	8	16
Extension officials	2	6	28	34
Total	102	1096	1346	2442

ALL INDIA CO-ORDINATED RESEARCH PROJECT ON PALMS

The All India Co-ordinated Research Project on Palms, initiated in 1972, with headquarters at ICAR-CPCRI, Kasaragod, has at present 29 centres. The coordinating centers are located in 13 states and one Union Territory covering 13 SAU's, one Central Agricultural University and four ICAR institutes (Fig. 152). Of these, 15 centres (in 12 states and one Union Territory) are conducting research on coconut, eight (in seven states) on oil palm, four (three states and one UT) on arecanut, two (two states) on palmyrah and one on sulphi palm.

Mandate

- To identify, conserve and utilize elite genetic resources for useful traits in palms from different agro-climatic regions and to evaluate performance of varieties/ hybrids under different locations and to facilitate release of varieties/ hybrids.
- To improve input use efficiency and develop location-specific palm based integrated farming systems to enhance the productivity per unit area, and organic cultivation packages for palms and palm based farming system.

Fig. 152. Map showing coordinating centres under the AICRP on Palms

- To evaluate bio-intensive insect-pest and disease management strategies, modeling and forecasting of disease incidence and documentation of insect-pest dynamics in changing scenario of palm ecosystem.
- To develop of post-harvest technologies in palmyrah and to demonstrate and transfer technologies to the farmers.

The budget for the year 2015 - 16 was ₹ 528 lakhs and the scheme is implemented through the respective state Agricultural/Horticultural Universities on 75:25 basis, with 75% ICAR share and with 100% ICAR funding in the case of Central Agricultural University and ICAR Institutes.

RESEARCH ACHIEVEMENTS

Coconut

Crop Improvement

High yielding coconut hybrid LCT x CCNT for Tamil Nadu

Towards developing a superior coconut hybrid with high nut yield, copra output and oil yield, 14 cross combination have been evaluated since 1986 in different AICRP centres. This has resulted in identification of a superior high yielding cross combination, LCT (Laccadive Ordinary Tall) x CCNT (Cochin China Tall) at AICRP on Palms centre, Veppankulam (TNAU, Tamil Nadu). This hybrid was recommended

Fig. 153. Hybrid LCT x CCNT : A view of the crown

Fig. 154. Longitudinal section of nut showing kernel thickness

Table 22: Cumulative mean performance of VHC 4 (LCT x CCNT)

Sl. No.	Character	VHC 4 (LCT x CCNT)	Hybrid check	Local tall check
			VHC-1	ECT
1.	Mean annual nut yield (nos. palm^{-1})	161.00	112.00	99.00
	% increase in nut yield over check		43.80	62.60
2.	Nut yield (in'000) ha^{-1} yr^{-1}	28.18	19.60	17.33
3.	Copra content (g nut^{-1})	149.80	142.80	133.10
4.	Copra (kg palm^{-1} yr^{-1})	24.12	16.33	13.18
	% increase over the check for copra out turn		47.70	83.00
5.	Copra out turn (t ha^{-1} yr^{-1})	4.22	2.86	2.31
6.	Copra oil content (%)	70.00	69.50	68.40
7.	Estimated oil yield (t ha^{-1} yr^{-1})	2.95	1.99	1.58
	% increase in oil yield over check		48.20	86.70

for release during 24th Annual Group meeting of AICRP on Palms held at ICAR-CCARI, Goa during 26-28 May 2015 as VHC4 for Tamil Nadu state (Fig. 153, 154). The mean nut yield of the hybrid during the stabilized bearing period was 161 nuts palm^{-1} yr^{-1} which is 62.6 and 43.8 per cent higher than ECT (East Coast Tall) and VHC-1 (Veppankulam Hybrid Coconut-1), respectively (checks). It has a copra content of 149.8 g nut^{-1} and oil content of 70% (Table 22).

Crop Production

- The coconut based cropping models were developed at different AICRP on Palms centres, which showed higher productivity and more income than monocrop of coconut. At Aliyarnagar centre, the cropping system of coconut + cocoa + banana + pineapple with 75% of recommended NPK coupled with organic recycling through vermicompost, recorded higher net income of ₹ 3.77 lakhs per ha followed by ₹ 3.46 lakhs ha^{-1} with fully organic treatment. At Arsikere centre, the cropping system of coconut + cocoa + lime + drumstick recorded higher net returns ₹ 2.95 lakhs ha^{-1} with fully organic nutrient management followed by ₹ 2,84,410 ha^{-1} with 50% of recommended NPK + organic recycling with vermicompost + vermiwash application + biofertilizer application and *in situ* green manuring .

- Intercropping of coconut garden with gerbera at the Kahikuchi centre generated net return of ₹ 6,25,665 ha^{-1} followed by ₹ 4,55,299 ha^{-1} with coconut + gladiolus. The coconut monocrop recorded the lowest net return of ₹ 70,858 ha^{-1} (FIg. 155).

Fig. 155. Coconut + gladiolus in AICRPP Centre at Kahikuchi

- Six cocoa clones *viz.,* VTLCC – I, VTLCH – I, VTLCH – 2, VTLCH – 3, VTLCH – 4 and VTLC – 1 were evaluated for their performance under coconut gardens at Ambajipeta centre, and among them the clone VTLCH – 1 recorded highest yield of 2.95 kg dry beans tree^{-1} (Fig. 156).

Fig. 156. Pods of high yielding cocoa clone

Crop Protection

Black headed caterpillar

About 37 lakh parasitoids were supplied to contain outbreak of coconut black headed caterpillar in coastal districts of Andhra Pradesh (Fig. 157). A total of 2,08,100 nos. of the parasitoids *Bracon brevicornis,* mass reared at Biocontrol Lab, Coconut Research Station, Aliyarnagar were supplied to farmers of Tiruppur, Namakkal, Dindigul and Coimbatore districts in Tamil Nadu for release in an infested area of 99 acres.

Fig. 157. Black headed caterpillar infested coconut garden

Basal stem rot

- *In vitro* screening of Triazole fungicides like tebuconazole, tetraconazole, hexaconazole, tebuconazole + trifloxystrobin showed complete inhibition of mycelial growth of *Ganoderma lucidum* and *Ganoderma applanatum*.

Stem bleeding

- Cake formulation of *Trichoderma harzianum* (CPTD 28) employed against stem bleeding disease of coconut was found effective under field conditions in

Fig. 158. Sporulation of *Trichoderma harzianum* (CPTD 28) on treated palm

Ambajipeta, Andhra Pradesh. The biocontrol agent established on the coconut palm and produced sporulation (Fig. 158).

- Triazole fungicides such as tebuconazole, tetraconazole, difenconazole, propiconazole exhibited complete inhibition of growth of *Thielaviopsis paradoxa* under *in vitro* conditions.

Oil Palm

Among the 10 hybrids planted during 2006 at Pattukottai (Tamil Nadu), the hybrid NRCOP-17 (Fig. 159) recorded significantly higher fresh fruit bunch yield (163.34 kg palm^{-1} and 23.35 t ha^{-1}) during 2015-16 (9th year of planting). Under comparative performance of different hybrid combinations, planted during 2007, at Vijayarai centre in Andhra Pradesh, the hybrid NRCOP-4 recorded sign ificantly higher FFB yield (24.9 t ha^{-1}) followed by NRCOP-5 (19.86 t ha^{-1}). Oil palm planted during 2006 at Pasighat, Arunachal Pradesh, with integrated management practices, produced an average yield of 17.7 FFB t ha^{-1}.

Fig. 159. NRCOP-17 at Pattukottai centre

Fig. 160. Palmyrah germplasm collected from Midnapur district of West Bengal

Palmyrah

Germplasm collection

Germplasm survey was conducted at Midnapur district of West Bengal by AICRP, Killikulam and Pandrimamidi centres, and a total of five accessions with distinct characters were collected for conservation and evaluation (Fig. 160).

Post harvest technology in palmyrah

Fig. 161. Cookies prepared from palmyrah tuber flour

Bitterness in Palmyrah tuber (apicolon) was removed by using cold extraction method *i.e.,* flour is soaked in water at room temperature for six hours and water is drained and flour dried at 50°C. It was observed that nutritional losses due to soaking in water is low. Value added products such as cookies, cake and noodles were developed from the flour (Fig. 161).

24th Annual Group Meeting of AICRP on Palms

The 24th Annual Group Meeting of All India Coordinated Research Project on Palms was organized from 26th to 28th May, 2015 at ICAR-Central Coastal Agricultural Research Institute, Goa. The Annual Group Meeting was inaugurated by Mr. Manoj Kumar Sahoo, IAS, Secretary, Agriculture, Govt. of Goa. Dr. S.K. Sharma, Director, ICAR-CIAH, Bikaner, presided over the meeting. Dr. P.L. Saroj, Director, ICAR-DCR, Puttur and Dr. A.S. Kumaraswamy, former, Dean of Education (UAHS), Shivamogga, graced the occasion. Head of Divisions of ICAR- CPCRI, scientists from different centres of AICRP on Palms and scientists from different ICAR institutes participated in the programme. Dr. H.P. Maheswarappa, Project Coordinator (Palms) presented a brief report of the AICRP on palms. In his report, he highlighted the achievements made during 2014 -15 and progress of work under different technical programmes. Dr. N. P. Singh welcomed the delegates and enumerated the problems in palms cultivation in Goa. Dr. S.K. Sharma highlighted the role of palms in national economy and suggested that post harvest technology and value addition are required to be strengthened to increase the income of the farmers. Dr. P. L. Saroj emphasized that integrated nutrient management is an important issue and recycling can reduce input requirement and improve the productivity. Dr. A.S. Kumaraswamy opined

that co-operation between SAUs and ICAR institutes is very much essential for the overall development of the plantation sector. He suggested that basic research could be undertaken by post-graduate students during their research programme and provision of fellowships could be made to facilitate the work. Interdisciplinary research needs to be strengthened and research is also required to study the effect of climate change on incidence of pests and diseases and productivity of coconut. He also suggested that droughts are a growing concern and minimum water requirement to save the palms needs to be studied. Further, slow release fertilizers and crop specific nutrient mixtures needs to be developed and tested. Mr. Manoj Kumar Sahoo appreciated the concept of AICRP as a platform for sharing ideas for carrying out research for overall development of the sector at ground level. He urged that consolidated efforts are required from all the stakeholders to reduce the problems of farmer's suicide and bring back people to agriculture. He also requested to make agriculture a profitable venture by development and adoption of improved technologies. Four publications were released from the AICRP centres during the inaugural session namely 'AICRP on Palms at a Glance', 'Prospects of mushroom cultivation in coconut garden in Odisha', 'RCRS, Bhatye Research at a Glance (Marathi),' 'Oil palm cultivation' (Marathi) from Mulde centre.

The plenary session was held on 28th May 2015 under the chairmanship of Dr. N.K. Krishna Kumar, DDG (Hort. Sci.), ICAR, New Delhi (Fig. 162). Dr. P. Chowdappa, Director, ICAR-CPCRI and Dr. P. Kalidas, Actg. Director, ICAR-IIOPR, Pedavegi were present on the occasion. Dr. H.P. Maheswarappa, Project Coordinator (Palms), briefed about the discussion held for two days along with recommendations. The performance of AICRP centres is evaluated every year and during 2014-15, AICRP on palms centre, Mulde has been judged as the best performing centre. DDG (Horticulture Science) gave away the certificate and memento to Mr. M.S. Gawankar, Scientist in-charge of the centre (Fig. 163). Recommendations from the various sessions were presented for approval in the plenary session. In his chairman's remarks, DDG (Horticulture Science) stated that, AICRP on palm work should be strengthened through and multi location trials (MLT) for variety release or any technology development.

Fig. 162. Address by Dr. N.K. Krishna Kumar, DDG (Hort. Sci.,)

Fig. 163. Award for the best centre being received by Mr. M.S. Gawankar, Scientist, AICRP on Palms, Mulde

The following recommendations emerged from the group meeting:

- LCT x CCNT, a superior Tall x Tall hybrid, identified for release based on its higher yield at AICRP on Palms Centre, Veppankulam. It recorded a mean nut yield of 161 nuts palm^{-1} yr^{-1}, which was 62.6 and 43.8 per cent higher than checks, ECT and VHC -1, respectively.
- The suitable flower crops identified under coconut are marigold, gomphrena, celosia, zinnia and chrysanthemum at Aliyarnagar Centre (Tamil Nadu) and chrysanthemum, crossandra, china aster and marigold at Arsikere Centre (Karnataka).
- Red gram and bengal gram were found to be effective as indicator plants for early detection of basal stem rot disease of coconut.

PUBLICATIONS

The institute has accomplished excellent research outputs to its credit, as discernible from the high volume of top-quality research publications with a sizable number in national/international journals with high impact factor. During the period, 65 research papers in peer reviewed journals, one review article, 33 papers presented in national level seminars/ symposia/ conferences/ workshops, 66 papers in semi technical jounals/ magazines, 8 books and 12 book chapters, have been published. Besides, a large number of extension publications with 12 technical bulletins, 34 extension pamphlets, two e-publications and 12 number of training manuals were also published from the institute.

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Varieties notified

'*Kalpatharu*' coconut variety notified in the Gazette of India by Ministry of Agriculture (Department of Agriculture and Cooperation) vide S.O. No. 2277 (E) dated 17th August 2015 (No.1775, The Gazette of India, August 20, 2015) in exercise of powers conferred by section 5 of the Seeds Act, 1966 (54 of 1966).

'*Kalpa Samrudhi*' coconut hybrid notified in the gazette of India by Ministry of Agriculture (Department of Agriculture and Cooperation) vide S.O. No. 2277 (E) dated 17th August 2015 (No.1775, The Gazette of India, August 20, 2015) in exercise of powers conferred by section 5 of the Seeds Act, 1966 (54 of 1966).

TECHNOLOGIES ASSESSED AND TRANSFERRED

COCONUT VARIETIES NOTIFIED

Kalpatharu

A tall coconut variety, Kalpatharu, with a high yield of 117 nuts palm^{-1} yr^{-1} under rainfed condition and suitable for ball copra production (3.59 copra ha^{-1} yr^{-1}), has been released jointly by ICAR-CPCRI and AICRP (Palms). This variety has been notified in the Gazette of Govt. of India for cultivation in Kerala, Tamil Nadu and Karnataka.

Kalpa Samrudhi

This D x T coconut hybrid with high nut yield (117 nuts palm^{-1} yr^{-1}), high copra out turn (4.5 t ha^{-1} yr^{-1}) and oil yield (3.04 t ha$^{-1)}$ under rainfed condition has been notified in the Gazette of Govt. of India for cultivation in Kerala and Assam. Besides, this hybrid has good tender nut water quality and quantity (346 ml nut^{-1}) and has been found to be relatively tolerant to moisture deficit stress compared to other released hybrids.

COCONUT VARIETY RECOMMENDED FOR NOTIFICATION

Kalpa Sreshta

Kalpa Sreshta is a D x T coconut hybrid with higher nut yield (167 nuts palm^{-1} yr^{-1}), high copra out turn (6.28 t ha^{-1} yr^{-1}) and good tender nut water quality and quantity (368 ml nut^{-1}). The variety bears green coloured, oval fruits and the dehusked fruits are round in shape. It has been recommended by the Central Sub Committee on Crop Standards and Release of Varieties of Horticultural Crops for release and notification for cultivation in Kerala and Karnataka states.


Kalpatharu


Kalpa Samrudhi


Kalpa Sreshta

CRYOPRESERVATION OF COCONUT POLLEN

Conservation of coconut diversity in the form of coconut pollen in cryo-storage facilitates its long-term conservation. Pollen is stored in liquid nitrogen at -196^{o}C. Pollen germination percentage after cryopreservation has been observed to be on

par with desiccated pollen. Nut set in hand pollinated palms by using cryopreserved pollen after 4-7 years of storage was found to be normal. It is feasible to set up pollen cryo-bank of coconut that could be utilized for long term storage and transport to aid hybridization. This technology has already been commercialized.

BIORESOURCES AND BIOCONTROL AGENTS

Kalpa Organic Gold

'Kalpa Organic Gold' is the trade name for vermicompost produced from coconut leaves by ICAR-CPCRI technology. This product is a good soil vitalizer for horticultural and field crops as it contains macro and micro nutrients, plant growth promoting substances and large populations of plant-beneficial microbes.

Kalpa Soil Care

Composted coir-pith produced without the addition of urea by ICAR-CPCRI technology has been given the trade name 'Kalpa Soil Care', reflecting its capacity to improve soil aeration, moisture holding capacity and improve plant growth through addition of necessary nutrients and microorganisms.

VALUE-ADDED PRODUCTS

Kalparasa

Bottled Kalparasa

A complete package of technologies and machineries for the production-to-consumption value chain for Kalparasa (neera) have been developed at ICAR-CPCRI, Kasaragod, to be marketed either as a health drink or to be processed further into value added products *viz.*, coconut sugar, jaggary, concentrate, syrup etc. Further, milk-based sweets have been prepared from Kalparasa, without the addition of cane sugar. Similarly, dark chocolate, 'Kalpa-choco', has been prepared from coconut sugar.

MACHINERY AND GADGETS

Coconut de-shelling machine

A coconut desheller, useful for large scale copra processing units, has been developed for overcoming cumbersome manual deshelling of coconut. This power operated coconut de-shelling machine has the capacity of processing 120 nuts hr^{-1} , thereby saving requirement of labor and time considerably. Heavy duty construction and geared motor drives the desheller. Besides, it is easy to replace the cutting blade, whenever required. It can be used for deshelling coconuts of any size.

Coconut desheller

INTELLECTUAL PROPERTY AND TECHNOLOGY MANAGEMENT

The institute has achieved creditable results in converting scientific knowledge into technologies/ products for empowering the farming community in the present day competitive global scenario. Two patents were granted during the period. Besides, ICAR-CPCRI has been selected as the institutional consultants/ evaluators by the Directorate of Soil Survey and Soil Conservation / Commissionerate of Rural Development, Govt. of Kerala for evaluating the watershed/ soil and water conservation projects undertaken by them, in recognition of its professional excellence in the relevant field.

Patent granted

Following two patents were granted during the period:

Sl.No.	Name of the Patent	Patent No.	Inventors
1.	Coconut and Arecanut Palm Climbing Device	268548 dated 22-09-2009	Dr. A.C. Mathew and Shri M.V. Krishnan
2.	Shell Fired Copra Dryer	269186 dated 04-05-2005	Dr. T. Vidhan Singh

Consultancy services

Consultancy services and contract research projects were taken up as part of the Professional Service Functions of the Institute during 2015-16 as detailed below:

Sl.No.	Consultancy service	Client	Amount (₹)
1.	Nutrient analysis of organic manure	Agricultural Officer, Krishi Bhavan, Badiyadka, Kasaragod	1,250
2.	Micronutrient analysis of nine soil samples	NITK, Surathkal, Project Sub Division-1, CPWD, Mangaluru	22,500
3.	Nutrient analysis of neem cake and fish meal	Agricultural Officer, Krishi Bhavan, Perumbala, Kasaragod	2,500
4.	Nutrient analysis of two organic manure samples	Agricultural Officer, Krishi Bhavan, Madhur, Kasaragod	2,500
5.	Nutrient analysis of neem cake and organic manure	Agricultural Officer, Krishi Bhavan, Enmakaje, Kasaragod	2,500
6.	Nutrient analysis of groundnut cake	Malabar Agro Industries, KINFRA Small Industries Park, Seethangoli, Kasaragod	1,250
7.	Nutrient analysis of neem cake, bone meal and organic manure	Agricultural Officer, Krishi Bhavan, Puthige, Kasaragod	3,750
8.	Analysis of micronutrients of soil samples	Asst. Director, Office of the Asst. Director (Soil Survey), Kasaragod	7,725
9.	Crop management	ABC Group of Estates, Chikmangalore Dist, Karnataka	3,000
		Total	46,975

Contract research

Sl.No.	Particulars	Client	Amount (₹)
1.	Evaluation of bio-efficacy, phytotoxicity and effect on natural enemies of lesenta 80 WG against white grub of arecanut	Bayer Crops Science Ltd., Mettupalayam Road, Opp. Venugopal Hospital, Thudiyalur, Coimbatore	3,97,200
2.	Evaluation of 'Mangala Kolenashak' against fruit rot disease of arecanut	Mangalore Chemicals and Fertilizers Ltd, Kenchamba Building, Belur Road, Kendali P O, Hassan	1,28,495
3.	Evaluation of 'Integrated Water Management Programme'.	Poverty Alleviation Unit, Payyanur	5,369
4.	Monitoring and evaluation of soil conservation schemes	Directorate of Soil Survey & Soil Conservation, Vazhuthacaud, Thiruvananthapuram	9,93,000
5.	Evaluation of III phase of 'Integrated Water Management Programme'	Commissionerate of Rural Development, Thiruvananthapuram	4,34,059
		Total	19,58,123

Sale of technology products

During the year, technology products worth ₹ 134.39 lakhs were sold as detailed below.

Sl.No.	Item	Qty/No	Amount (₹)
1.	Books	233	12,171
2.	CD ROMs	4	440
3.	Earthworms	11,600	9,164
4.	Mushroom spawn (kg)	5	440
5.	Coconut leaf Vermicompost (kg)	5,639	53,167
6.	Coir pith compost	175	1,925
7.	Vermiwash (Bottles)	5	550
8.	Coconut	42,605	6,07,713
9.	Arecanut seed nuts	5,28,395	29,00,172
10.	Arecanut seedlings	1,31,779	19,65,230
11.	Coconut seed nuts (Tall varieties)	15,463	6,17,780
12.	Coconut seedlings (Tall varieties)	11,953	6,47,271
13.	Coconut seedlings (Hybrids)	20,807	45,18,260
14.	Coconut seedlings (Dwarf varieties)	7,467	5,76,002
15.	Coconut seednuts (Dwarf varieties)	6,995	3,49,654
16.	Coconut polybag seedlings (Tall varieties)	655	57,768
17.	Coconut polybag seedlings (Dwarf varieties)	474	79,063
18.	Coconut polybag seedlings (Hybrids)	89	29,370
19.	Kera Probio	199	5,473
20.	Black pepper cuttings	13,010	1,24,520
21.	Bay Leaf air layer	4,329	1,08,225
22.	Bay Leaf (kg)	1,667	25,000
23.	Green black pepper (kg)	1,790	2,05,850
24.	Cocoa seedling	50,933	5,09,330
25.	Cocoa grafts	440	8,800
26.	Cocoa seed pods	354	13,760
27.	Cinnamon air layers	461	11,525
	Total		1,34,38,623

Technology commercialization

During the period, 21 technologies were commercialized through non-exclusive licensing with memorandum of understanding.

Sl. No.	Technology transferred	Licensee	Fee (₹)
1.	Production of virgin coconut oil by hot process	Mrs. Nalini K.V.,Vaiga Virgin Coconut Oil, Nileshwar, Kasaragod district, Kerala	25,000
		Mr. Raju K., Coco Wings Enterprises (P) Ltd, Karunagappally P.O, Kollam, Kerala	25,000
		Mr. Swaroop V.R., Rani Food Products, Vadakara, Kozhikode, Kerala	25,000
		Mr. Kamaraj C. M., Sakthi Coco Products, Pollachi, Tamil Nadu	25,000
		Mr. Biju P.V., Keezhmala, Nileshwaram, Kasaragod, Kerala	25,000
		Mr. Menon B.C., President, Sanjeevini farmers Social Welfare Coperative Society, Kollam, Kerala	25,000
		Mr. Rama Krishnan D., Santhosh Farms, Pollachi, Tamil Nadu	25,000
		M/s AVS Agrolife Products, Tiptur, Tumkur, Karnataka	25,000
		Mrs. Sushmita Neelesh Neurekar, Kerant, Caranzalem, Goa	25,000
2.	Collection of fresh and hygienic Kalparasa and production of natural coconut sugar	M/s Krishna Plantations (Pvt.) Ltd, Margao, Goa	10000
		Mr. Gautham R, Udumalpet, Tirupur, Tamil Nadu	10000
		Mr. Arun Kumar, Kodibengre Post, Udupi Taluk, Karnataka	10000
		Mr. K.P. Mohan Das, Kasaragod, Kerala	10000
		Mr. Obalanarasimhaiah, C Nandihalli Coconut Federation, Tumkur District, Karnataka	10000
		Mr. Madhusoodhanan.K, Keranidhi Federation of Coconut Producers Societies, Kannur district, Kerala	10000
		Mr. Kausik Ghosh, Balagarh (P.S), Hooghly, West Bengal	10000
		Mr. Vinayan E.V., Thrissur Coconut Producers Company, Kuttanellur, Kerala	10000
		Mr. Sachidanandan K.K., Kodungallur Coconut Producers Company Ltd., Perinjanam, Thrissur, Kerala	10000
3.	Coconut chips production process	M/s Therthally Federation of Coconut Producers Society, Kannur, Kerala	10000
		Mr. V.P. Raveendran, Calicut, Kerala	10000
		Mr. Raju. K, Coco Wings Enterprises (P) Ltd, Karunagappally P.O, Kollam, Kerala	10000
		Mr. Suresh R., Kodihalli Post, Chitradurga District, Karnataka	10000
		Mr. Biju P.V., Keezhmala, Nileshwaram, Kasaragod, Kerala	10000
		Mrs. Sushmita Neelesh Neurekar, Kerant, Caranzalem, Goa	10000
		Mr. Menon B.C., Sanjeevini farmers Social Welfare Coperative Society, Kollam, Kerala	10000
		Mrs. Aishwarya Balaji, M/s Ascend Exports And Imports, Chennai, Tamil Nadu	10000
		M/s AVS Agrolife Products, Tiptur, Tumkur (Dist.), Karnataka	10000

Sl. No.	Technology transferred	Licensee	Fee (₹)
4.	Coconut leaf vermicompostng technology	Mr. Raam Mohan N.U. , Venkittapuram Post,Palladam (TK), Tirupur, Tamil Nadu	5000
		Mr. A.C.Appu,Vikas Organic Fertilizers, Calicut, Kerala	5000
		Mrs. Thresiamma Thomas, Rajapuram, Kasaragod, Kerala	5000
5.	Cryopreservation of coconut pollen	Mr. Raam Mohan N.U., Palladam (TK), Tirupur, Tamil Nadu	50000
6.	Utilization of *Metarhizium anisopliae* culture as biocontrol agent	Mr. Raam Mohan N.U., Palladam, Tirupur, Tamil Nadu	5000
7.	Coconut de-shelling machine	Mrs. Angalaeswari S., Kudikkadu, Tamil Nadu	1000
8.	Snow ball tender nut machine	Mrs. Pavithra S, Paakumara Thottam, Coimbatore, Tamil Nadu	2500
9.	Machineries associated with production of VCO and coconut chips	M/S Pro B Products, Peenya Industrial Area, Bangalore, Karnataka	1,20,000
		Total	5,97,500

LIBRARY AND INFORMATION SERVICES

General Information

The Library and Information Centre, with a comprehensive collection of resources on plantation crops, plays a pivotal role in catering to the information needs of the scientific, technical and administrative staff of the institute, the researchers from universities, post graduate students, industries on plantation crops and other related organizations.

Services

The library web page

The library web page under the institute website gives the gist of activities and services provided by the library, which include:

- The Online Public Access Catalogue (OPAC)
- Institute publications
- Institute Digital Repository
- Consortium of E-resources in Agriculture (CeRA)/Krishikosh/Krishiprabha/ Agricat
- Links to subscribed e-books/online databases
- Online journals/archives
- Databases developed in-house
- Open access resources

ICAR-CPCRI Digital Repository

The institute digital repository, holding a literature collection to the tune of 5900, is very user friendly with six communities and provides full text access to its resources through the intranet. The access to the digital repository is provided in the institute website under the webpage for library. The usage of the digital repository came to around 400 hits per month.

- Research Papers by ICAR-CPCRI Staff
- Institute Publications
- Mandate Crops-Other than ICAR-CPCRI
- Reprints
- RPF
- Theses/Project Reports

Online journals / databases / E-books

The institute subscribed to 17 e- journals the access to which as well as journal archives of previous years were made available in the library web page. Besides, the links to get access to the subscribed online databases “CAB abstracts online”,

"Indiastat.com" and "Advances in Agronomy" and "CAB E-books" were also provided in the library web page.

Document Delivery Service

As part of the resource Sharing programme under CeRA, Library provided online document delivery dervice to the tune of 255 articles to 250 individuals.

Newspaper clippings service

A newspaper clippings service "The glimpse" covering news items related to agriculture and allied sciences was brought out every month. Besides, news items related to the institute were made available under the link CPCRI in media in the institute web site.

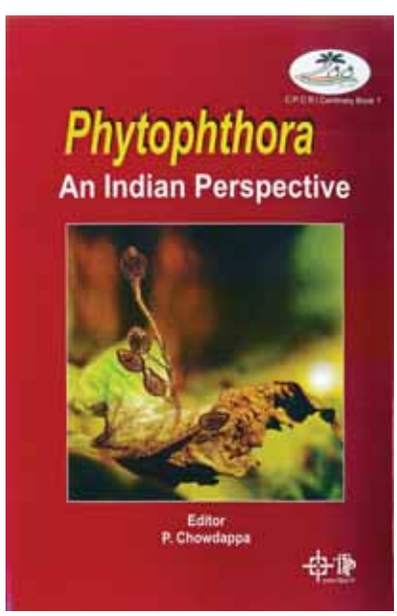
Reprography service

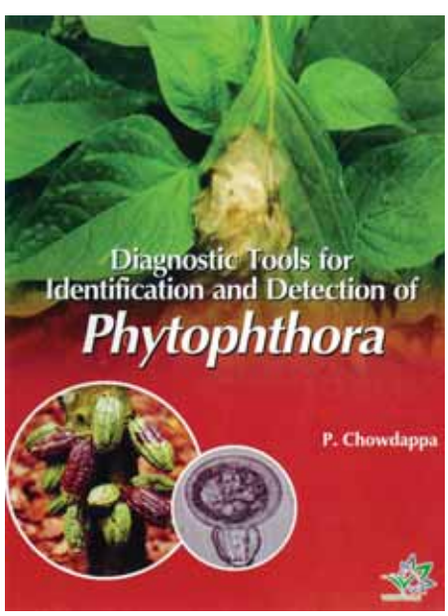
Library and Information Centre provided reprography service such as scanning and photocopying of resources to clientele as well as to visitors.

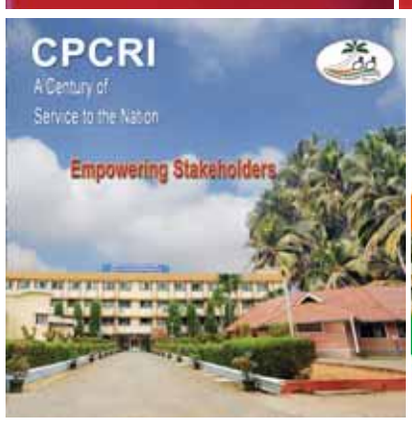
Exchange of publications

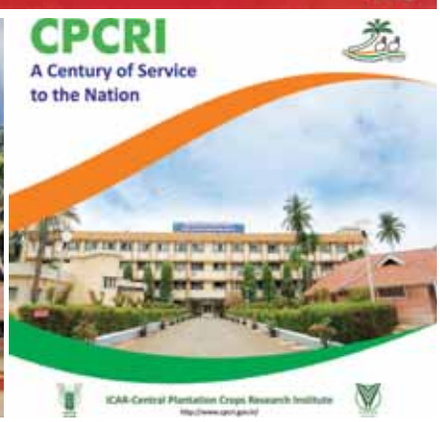
The institute received around 300 publications such as Annual Reports, Research Highlights and Vision documents on exchange from other institutes.

Books published









MERA GAON MERA GAURAV

ICAR-CPCRI, Kasaragod and its regional stations and research centres have implemented "*Mera Gaon Mera Gaurav*" (My Village My Pride) initiative in 69 villages by conducting training programmes, demonstrations, farm advisory visits and mobile advisory services. The innovative initiative "*Mera Gaon- Mera Gaurav*" by Ministry of Agriculture and Farmers' Welfare, Govt. of India, has been planned to promote the direct interface of agricultural scientists with the farmers to hasten the lab to land process. The objective of this scheme is to provide farmers with required information, knowledge and advisories on regular basis by adopting villages.

Workshop on '*Mera Gaon Mera Gaurav*'

A workshop on '*Mera Gaon Mera Gaurav*' was organized at ICAR-CPCRI, Kasaragod. Dr. P. Chowdappa, Director, ICAR-CPCRI presided over the workshop. Dr. M. Govindan, Dean, College of Agriculture, Kerala Agricultural University, Padannakkad and Mr. P. Pradeep, Principal Agricultural Officer, Kasaragod participated in the workshop and offered felicitations. Discussion on selection of villages, interface with stakeholders, base-line survey, linkage with other agencies, demonstration of technologies *etc.* were held in the workshop. Scientists from CPCRI participated in the workshop.

Dr. P. Chowdappa, Director inaugurating the workshop

List of villages identified for *Mera Gaon Mera Gaurav* programme

Team No.	Name of the Scientists	Name of selected villages
ICAR-CPCRI, Kasaragod		
I	Dr. Rajkumar, Dr. D. Jaganathan, Mr. Krishna Prakash, Mr. M. Arivalagan	Kuntikana, Bela, Kilingar, Neerchal, Kunjar
II	Dr. V. Niral, Dr. P. P. Shameena Beegum, Dr. V.H. Pratibha, Dr. C. Thamban	Periya, Ayampara, Pukkalam Kudanam, Udayapuram
III	Dr. Murali Gopal, Dr. K.P. Chandran, Dr. K. Devakumar, Dr. P.S. Prathibha	Kundamkuzhy, Kundoochi, Chembakad, Periya
IV	Dr. Anitha Karun, Mr. S. Jayasekar, Dr. M. Sujithra, Dr. P. Subramanian	Kulathur, Kuttikol, Kalakkara, Kattamkavala

V	Dr. Ravi Bhat, Dr. B. A. Jerard, Dr. V. Selvamani, Dr. M. Neema	Karicherry, Panayal, Koottakani, Veltholi
VI	Dr. Vinayaka Hegde, Dr. K. Muralidharan, Dr. K. Samsudeen, Dr. Mukesh Kumar	Ujjeerkara, Kallankayi, Balloor, Kambar, Kottakunnu
VI	Dr. K.B. Hebbar, Smt. G. Panjavarnam, Dr. M.K. Rajesh, Dr. Alka Gupta, Dr. S. Neenu	Berike, Meenja, Thalakala, Chigurupade, Thalakala
VIII	Dr. A.C. Mathew, Dr. Aparna Veluru, Smt. Surekha, Ms. S. Sumitha, Dr. M.R. Manikantan	Kanjirapoyil, Erikulam, Kolikunna, Kakkattu, Keekamkode, Malapachery
ICAR-CPCRI, RS, Kayamkulam		
I	Dr. S. Kalavathi, Dr. Regi J. Thomas, Dr. Merin Babu	Cherthala South, Arthunkal, Cherthala North, Thiruvizha
II	Dr. Chandrika Mohan, Dr. A. Abdul Haris, Dr. V.K. Chaturvedi, Dr. K. Nihad, Dr. Jeena Mathew	Kopparethu, Koipallykaraima, Menampally, Velanchira, Erezha South, Nadakkavu
III	Dr. P. Anithakumari, Dr. A. Joseph Rajkumar, Dr. M. Shareefa, Dr. S. Indhuja and Dr. V. Krishnakumar	Ilippakkulam, Kattachira, Kattanam, Pallickal, Bharanikkavu, Vettikkode
ICAR-CPCRI, RS, Vittal		
I	Dr. K.S. Ananda, Shri Bhavishya	Ilanthila, Mundaje, Koyyur, Badage-Karandoor,
II	Dr. S. Elain Apshara, Ms. M. Chaitra	Manchi, Goltamajalu
III	Dr. C. T. Jose, Dr. N. R. Nagaraja, Dr. K.S. Karthika, Ms. U. Keerthana	Savanoor, Nellyady, Kuppepadavu, Balpa
ICAR-CPCRI, RC, Kahikuchi		
I	Dr. A.K. Gogoi, Dr. Alpana Das, Dr. L.S Singh, Mr. Anok Uchoi	Agsia, Kallapara, Nahira, Anderijuli, Bongora
ICAR-CPCRI, RC, Mohitnagar		
I	Dr. Arun Kumar Sit, Shri Sandip Shil	South Matiali, South Berubari
ICAR-CPCRI, RC, Kidu		
I	Shri Khadke Ganesh Navanath	Bilinele

Farmers' Meet and Field Demonstration

A Farmers' Meet (*Kisan Gosti*) and Field Demonstration was conducted as part of '*Mera Gaon Mera Gaurav*' - 'My Village-My Pride' initiative of ICAR-Central Plantation Crops Research Institute. The programme was conducted at Kolikunnu village in Madikkai grama panchayat in Kasaragod district on 28-09-2015. The topic of the Farmers' Meet was 'Technologies for Soil Health Management for Sustainable Agricultural development'. Dr. P. Chowdappa, Director, ICAR-CPCRI inaugurated

Dr. P. Chowdappa, Director, inaugurating the demonstration in farmers' garden

Kisan Gosti under *Mera Gaon-Mera Gaurav,* initiative at Kolikunnu, Madikkai

the Farmers' meet and field demonstration. Field demonstration was conducted on methods of collecting soil samples. Soil health cards were distributed to selected farmers in the panchayat as part of the national initiative. Dr. C. Thamban, Dr. A.C. Mathew and Smt. Surekha, scientists from ICAR-CPCRI, Kasaragod handled different sessions in the farmers' meet. The programme was organized in collaboration with Madikkai Coconut Farmers Federation.

ICAR- CPCRI, Kasaragod and its regional stations and research centres have started implementing the initiative as per the guidelines. During the period (October, 2015-

Management of slow wilt in black pepper at Nirchal, Badiadka

Farm advisory visit to Madikai

Field day at Cherthala South

Farmers' meet at Kattachira

Interface programme at Sullia

Training programme at Manchi

Venue	No. of scientists	No. of villages	No. of training programmes / meetings organized	No. of farmers benefitted
ICAR-CPCRI, Kasaragod	32	36	66	2912
ICAR-CPCRI, RS, Kayamkulam	13	16	34	1410
ICAR-CPCRI, RS, Vittal	8	8	13	780
ICAR-CPCRI, RC, Kahikuchi	4	5	10	340
ICAR-CPCRI, RC, Mohitnagar	2	3	9	386
ICAR-CPCRI, RC, Kidu	1	1	2	252
Total	60	69	134	6080

March 2016), training programmes, demonstration on improved practices, farm advisory visits, mobile advisory services were organized in the selected villages for the benefit of farming community.

JAI KISAN JAI VIGYAN CAMPAIGN

Essay writing competition for vocational students, scientist-farmer interface and front line demonstration on selected technologies were conducted as part of '*Jai Kisan Jai Vigyan'* campaign at ICAR-CPCRI Kasaragod during 23-29 December 2015. Dr. P. Chowdappa, Director, ICAR-CPCRI distributed prizes to the winners of essay writing competition. Scientist-farmer interface programme on coconut and arecanut farming as well as demonstration of IDM practices against bud rot disease of coconut were conducted at Nirchal village, Kasaragod district.

Inauguration of scientist-farmer interface at Nirchal

Dr. P. Chowdappa, Director, ICAR-CPCRI inaugurating the programme at Kinnanoor-Karindalam

As part of '*Jai Kisan Jai Vigyan'* programme, a scientist-farmer interface was conducted at Thyckal, Cherthala on 29th December 2015 by ICAR-CPCRI, Regional Station, Kayamkulam. Scientific farming concepts with emphasis on vegetable and coconut production system were imparted to about 130 farmers who participated in the programme.

'Jai Kisan Jai Vigyan' programme was organized on 20th December 2015 at Kalichamaram Milk Producers Coop Society, Kinanoor-Karindalam. Shri V.V. Vellunga, President Kalichamaram Milk Producers Coop Society presided over the function. The programme was inaugurated by Dr. P. Chowdappa, Director, ICAR-CPCRI Kasaragod. In his inaugural address, he highlighted the importance and contributions of farmers in developing the nation and the scientists participation to achieve higher agricultural production.

As part of '*Jai Kisan Jai Vigyan'* week celebration, KVK-Alappuzha organized different programmes for farmers *viz*., on-campus training on "Preparation and usage of organic manures and bio pesticides" for women farmers from Mavelikkara block, on-campus training on "Value added products from jack fruit", vaccination campaign for backyard poultry at Aryad, *Sansad Adarsh Gramb* and fodder day celebrated at Kaithathil Primary Co-operative Society of Aryad in Alappuzha district on 23rd December 2015.

SWACHH BHARAT ABHIYAN

Elaborate plans have been chalked out at Headquarters as well as Regional Stations/Research Centres to implement the honourable Prime Minister's call for National Sanitation Campaign (‘Swachh Bharat Abhiyan’).

The institute is taking painstaking efforts to meet the targets of the monthly, annual as well as five year action plan which has been chalked out. Special cleaning drives have been organized every Friday evening to clean the Institute premises and its surrounding areas.

As part of 'Swachh Bharat Abhiyan', a ‘human chain' was formed with the participation of all staff members in front of the main gate of ICAR-CPCRI on 25th September 2015 and 08th October 2015, which captured the attention of the general public and provided inspiration for all to join the mission. Thereafter, an intensive cleaning drive was also undertaken outside the campus, on both sides of the National Highway.

At Regional Station, Kayamkulam, weeds were cleared all along the barbed wire fence in a joint cleaning initiative with the participation of Kayamkulam Municipality. Besides, four vegetable cultivation groups have been formed comprising of all staff of the Regional Station. Vegetables have been harvested by the groups regularly.

Staff of ICAR-CPCRI, Kasaragod engaged in cleaning activities in front of the main gate and along the railway line on the rear side of the main campus

Different cleaning activities undertaken at ICAR- CPCRI, RS, Kayamkulam

View of vegetable farming at ICAR-CPCRI, RS, Kayamkulam

Formation of human chain as a part of the Swachh Bharat Mission

TRAINING AND CAPACITY BUILDING

During the period, 11 scientists, 20 technical, 34 administrative and two skilled support staff have undergone training within the country.

Trainings organized for staff at the institute

Training on Diagnosis of Pests and Diseases

Training-cum-refresher course on "Diagnosis of Pests and Diseases in Palms and Cocoa with a Special Emphasis on Emerging Pest and Diseases" was organized on 4th July 2015 at ICAR-CPCRI, Kasaragod. A total of 17 technical staff and two supporting staff, including surveillance squad members of ICAR-CPCRI, Kasaragod, ICAR-CPCRI, RS, Vittal and ICAR-CPCRI, RC, Kidu, attended the programme. The participants were trained on laboratory techniques on rearing and maintenance of insect cultures viz. parasitoids of *Opisina arenosella*, entemopathogenic nematodes on *Galleria mellonella* and multiplication of *Trichoderma* including preparation of *Trichoderma*-neem based formulation and *Trichoderma* coir pith cake. Subsequent to the training, a two day field visit was organized to CPCRI, RS, Vittal and CPCRI, R C, Kidu to acquaint them with the disease and pest damage symptoms of arecanut and cocoa and also to yellow leaf disease and root grub affected arecanut gardens in Sullia Taluk of Dakshina Kannada district of Karanataka.

Training on administrative rules and office procedures

A training programme for LDC's and UDC's of the institute was conducted at ICAR-CPCRI, Kasaragod during 22-06-2015 to 24-06-2015. There were 24 participants including administrative staff from headquarters, Regional Stations at Vittal and Kayamkulam and Research Centres at Kidu, Mohitnagar and Kahikuchi. The training included administrative rules and office procedures.

Category-wise trainings attended by personnel during 2015-16

Name & designation	Title of training	Place and date
SCIENTIFIC		
Dr. Ravi Bhat, Head	Management Development Programme on Leadership Development (a pre-RMP programme)	ICAR- NAARM, Hyderabad 16-06-2015 to 27-06-2015
Dr. Vinayaka Hegde, Head, Dr. VH Prathibha and Ms. M. Chaithra, Scientists	Workshop on "Rapid Diagnostic Tools for Phytophthora on Horticultural Crops".	ICAR-IIHR Bengaluru, 08-09-2015
Dr. MR Manikantan, Sr. Scientist	National Training on "Entrepreneurship Development & Management" for Scientists and Technologists with the Government Sector	EDII, Ahmedabad 07-12-2015 to 11-12-2015
Dr. K.P. Chandran, Sr. Scientist	R software	Christ University, Trivandrum 17-08-2015 to 19-08-2015

Name & designation	Title of training	Place and date
Dr. K. Nihad, Scientist , Dr. Jeena Mathew, Scientist	Analysis of Experimental Data	ICAR-NAARM, Hyderabad 17-08-2015 to12-08-2015
Dr. M. Sujithra, Scientist	Operation of chemical ecology tools like GC, EAG, head space volatile collection, wind tunnel olfactometer techniques	IICT, Hyderabad 06-07-2015 to 01-07- 2015
Dr. L.S. Singh, Scientist	Statistical Advances for Technological Enhancement in Agricultural Research	ICAR-IASRI, Pusa, New Delhi 19-01-2016 to 08-02-2016
Shri Anok Uchoi, Scientist	Integrated Farming System Approaches for Sustainable Hill Agriculture under Changing Climate Scenario	ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra 28-10-2015 to 06-11-2015
TECHNICAL		
Shri B.M. Mohammed Basheer, CTO, Shri K. Devadas, ACTO, Shri P. Ravindran, Sr. Tech. Officer, Shri V. Balakrishnan, Tech. Officer, Shri M.V. Sreedharan, Shri C. Purandhara, Shri C. Abdul Aziz, Shri A.S. Gopalakrishna, Sr. Tech. Assts., Shri K. Raghavan, Shri M.V. Madhavan, Shri P. Santhosh Kumar, Shri A. Sanjeeva, Smt. M.S. Nivedhitha, Shri B. Ananda Gowda, Tech. Assts., Shri V. Radhakrishnan and Smt. M. Vimala Technicians	Diagnosis of Pests and Diseases in Palms and Cocoa with Special Emphasis on Emerging Pest and Diseases	ICAR-CPCRI, Kasaragod 04-07-2015
Dr. S. Ravi and Shri M.S. Rajeev, ACTO (SMS)	Capacity Building Programme on “Technology demonstration for climate resilience and value-added agro-met advisories”	ICAR-CRIDA, Hyderabad 28-01-2016 to 29-01-2016
Dr. C. Kesavan Nampoothiri, ACTO and Shri B. Anilkumar, TO	Competency Enhancement Training Programme for Technical Officers of ICAR Institute	ICAR-NAARM, Hyderabad 01-03-2016 to 10-03-2016
ADMINISTRATIVE		
Mr. Suresh Kumar, CAO	Administration and Finance	ICAR-NAARM, Hyderabad 11-10-2015 to 14-10-2015
Mr. T.E. Janardhanan, AAO	Public procurement	NIFM, Faridabad 30-11-2015 to 05-12-2015
Mr. Pradeepkumar Vasu, AAO	Hindi Training	Central Hindi Training Institute, New Delhi 16-11-2015 to 20-11-2015
Mrs. Luisy D’ Souza, Assistant	Intensive Hindi Workshop	Central Hindi Training Institute, New Delhi 21-09-2015 to 25-09-2015
Mrs. Prasanna Sarangan,PA, Mrs. Regitha, K.R., Steno Gr.III, Mrs. Arathi, A. R., Steno Gr.III	Hindi Training	Central Hindi Training Institute, New Delhi, 02-11-2015 to 06-11-2015
Mrs. Narayani K., PS and Mr. Narayana Naik P., UDC	Intensive Hindi workshop	Central Hindi Training Institute, New Delhi, 30-11-2015 to 12-05-2015

Name & designation	Title of training	Place and date
Smt. K.T.K. Sheenakumari, Smt. Rupa Manikandan, Shri Narayana Naik, Smt. K. Preethi, Shri Paulson Sam George, Smt. Madhavikutty, Smt. Annamma N. Topino, Shri N. Lakshmana, Smt. K. Jayashree, Shri Ashwin Reghunath, Shri T. J. Saji, UDCs, Smt. T. R. Remya, Shri T.K. Gangadharan, Shri P.K. Pramodkumar, Shri Jayarajan V., Shri Ratan Singh, Shri Umesh Kumar, Shri Dinesh, Shri Mohd. Haneefa, Shri Lakshminarayana, Shri Arun N.K. Raj, Shri S.B. Moharana, Shri Deepak Meena, LDCs	Administrative rules and office procedures	CPCRI, Kasaragod 22-06-2015 to 24-06-2015
Shri T.J. Saji, UDC	Workshop on noting and drafting	ISTM, New Delhi 9.11.2015 to 10.11.2015
SKILLED SUPPORT STAFF		
Shri P. Madhavan Nair and Shri V.S. Pakeera, SSS	Diagnosis of Pests and Diseases in Palms and Cocoa with Special Emphasis on Emerging Pest and Diseases	ICAR-CPCRI, Kasaragod 04-07-2015

HRD Database

A database of training particulars, with reference to trainings undergone as well as trainings to be attended by staff members under the scientific as well as technical categories was developed and hosted on the institute website.

HRD financial outlay and expenditure (Lakh ₹)

Budget Estimate			Actual Expenditure
Plan	Non plan	Total	
5.5	1.46	6.96	6.56

Higher Education

Dr. Mukesh Kumar, Scientist (Biochemistry) was awarded doctoral degree from the Department of Chemistry and Biochemistry, Choudhary Charan Singh Haryana Agricultural University, Hisar, during July 2015 for his thesis entitled "Biochemical Investigations on Nutritional Properties of Pearl Millet (*Pennisetum glaucum* (L) R. Br.)" under the guidance of Dr. L.K. Chugh, Sr. Scientist (Biochemistry).

Dr. Prathibha P.S., Scientist (Agri. Entomology) has been awarded Ph. D. in Agricultural Entomology for her thesis entitled "Behavioural studies of palm white grubs, *Leucopholis* spp. (Coleoptera: Scarabaeidae) and evaluation of new insecticides for their management" under the guidance of Dr. A. R. V. Kumar, Professor, Entomology, University of Agricultural Sciences, Bengaluru.

Dr. Avrajyoti Ghosh, Senior Technical Officer, RC, Mohitnagar was awarded Ph.D. in Agricultural Extension on 15-09-2015 for his thesis on "Studies on Small Tea Growers in North Bengal - Prospects and Perspectives" under the guidance of Dr. Pravat Kumar Pal, Associate Professor (Agril. Extension), Uttar Banga Krishi Viswavidyalaya, Poondibari, Coochbehar.

WORKSHOP, SEMINAR, SUMMER INSTITUTE, FARMERS' DAY

International Symposium on *Phytophthora*

The 3rd International Symposium on "*Phytophthora*: Taxonomy, Genomics, Pathogenicity, Resistance and Disease Management" was organised by ICAR-CPCRI, Kasaragod in association with ICAR-IIHR and AAPMHE at Indian Institute of Horticultural Research Bengaluru during 9-12, September, 2015. In his inaugural address, Dr. T. Janakiram, ADG (Hort. Sci.-I), ICAR-ICAR, New Delhi urged scientists to utilize the opportunity to develop partnerships at global level to reduce the impact of *Phytophthora* diseases on Indian horticulture.

Dr. P. Chowdappa, Director, ICAR-CPCRI, Kasaragod, in his key note address, pointed out that *Phytophthora* infect an array of plantation, tuber, spices, fruit, ornamental and vegetable crops in India and, in some cases, are reducing yields up to 80%. He highlighted the dramatic increase in late blight problems on potato and tomato crops in India since 2008 due to the introduction of the 13_A2 clonal lineage from Europe. In India, crop losses are especially difficult to manage for marginal and small-scale producers due to lack of resources and access to the fungicides. He gave a strong message that *"Phytophthora* never sleeps, neither should you". In his valedictory address, Dr. N. K. Krishnakumar, DDG (HS), ICAR, New Delhi, highlighted the success of Indian horticulture and said that horticultural production in India reached to 268 million tonnes and surpassed the food grain production of 252 million tonnes. Despite increase in horticultural production, problems such as pests and diseases, particularly the strengthening of bio-security in agricultural trade is the key to avoiding introduction of invasive pests.

About 200 delegates had participated ioncluding delegates from Australia, Canada, Netherlands, Peru, U.K. and U.S.A. Special issues of "Indian Horticulture" and "Spice India" on *Phytophthora* and a book entitled *"Phytophthora:* An Indian perspective" were released during the symposium.

Inaugural session of the International Symposium on *Phytophthora* in progress

Training Workshop on Rapid Diagnosis of *Phytophthora*

Hands-on training on "Rapid Diagnostic Tools for *Phytophthora* on Horticultural Crops" was organized by Dr. Jean Beagle Ristaino, Dr. D.E.L. Cooke and Dr. P. Chowdappa, as satellite workshop for benefit of students, young researchers from academia, officials from Industry and plant quarantine. About 40 delegates participated in the workshop. The workshop consisted of lectures and practical demonstrations on identification, based on morphology and molecular techniques.

Centenary Celebrations of ICAR-CPCRI launched

Centenary celebrations of ICAR-CPCRI was launched on 12th March 2016 at ICAR-CPCRI, Kasaragod. Dr. N.K. Krishna Kumar, Deputy Director General (Hort. Sci.), ICAR, New Delhi inaugurated the programme. Dr. P. Chowdappa, Director presided over the function and outlined the various programmes planned for the centenary celebrations during the year. He said, price fluctuations are common in these crops and have to be tackled through intercropping, which not only helps to sustain income but also is an integral part of organic cultivation through recycling biomass. He opined that value addition is the essence of prosperity for the farmer. Though more than 80% of the produce is consumed by the internal market, neera and value-added products like coconut milk, virgin coconut oil, coconut sugar, ice creams, coconut chips and coconut fatty acids, need to be promoted to stabilize prices and improve profitability of coconut cultivation.

Dr. N.K. Krishna Kumar, DDG (Hort.Sci.), in his inaugural address, said that problems of farmers are identical everywhere in India. Forming groups, joining hands with private-public partnership ventures for marketing of their produce is advocated. ICAR-CPCRI is a research institute of international standards and it has a responsibility of encouraging the growers to maintain environmental safety and sustainability, with lowest toxic input to the nature compared to many other crops. He opined that coconut oil is one of the best oils and superior to most of the edible oils. He called for concerted efforts and research on marketing of packaged soft drinks as the demand for fresh tender coconut is tremendous in the country.

A unique feature of the launching ceremony was the simultaneous planting of one hundred coconut seedlings (belonging to 18 released varieties of ICAR-CPCRI by one hundred farmers in one minute to establish a "Centenary Coconut Park",.

Releasing publication on "CPCRI – A Century of Service to the Nation"

Unveiling of centenary painting and centenary logo

Dr. P. Chowdappa, Director, addressing the gathering during the Kisan Mela

Dr. N.K. Krishna Kumar, DDG (Hort. Sci.), Dr. P. Chowdappa, Director and former Directors of CPCRI, officials from developmental agencies also joined hands in this endeavour.

The "Centenary Logo of ICAR-CPCRI" and a painting by Shri P.S. Punichithaya on the theme "100 years journey of CPCRI", were also unveiled during the occasion. Three publications, a special chocolate "Kalpa Choco" (made out of coconut sugar) two, organic products ("Kalpa Organic Gold" and "Kalpa Soil Care") also were released during the function.

Shri S.R. Sathishchandra, President, CAMPCO, Mangaluru in his keynote address urged for urgent research attention for developing tools for identifying arecanut from different countries available in the Indian market, detailed study on effects/ potential benefits of biochemical components of arecanut on human health and developing efficient machineries for mechanization in arecanut farming. Former Directors of ICAR-CPCRI, Dr. K.V. Ahmed Bavappa, Dr. K.U.K. Namboothiri, Dr. George V. Thomas have also spoken on the occasion, Directors of various ICAR institutes under Horticulture and Fisheries, financial institutions, farmers and officials from department of agriculture also felicitated the Institute on its centenary. Around 3000 farmers participated in the function. An exhibition was arranged as a part of the Kisan Mela, showcasing various technologies and products of horticultural research.

In the afternoon session, the KVK-Kasaragod also organized two seminars on "soil health management" and "Pradhan Mantri Fasal Bima Yojana" (with the SBI General Insurance) for sensitizing the farmers.

Participatory demonstration on "Management of root (wilt) disease of coconut"

The participatory demonstration project on "Integrated management package for root (wilt) disease of coconut' was launched by Dr. N.K. Krishna Kumar, DDG

Dr. N.K. Krishna Kumar, DDG (Hort. Sci.) launching the participatory demonstration project

(Hort. Sci.), ICAR, New Delhi on 31-05-2015. This programme is being implemented by the ICAR-CPCRI, RS, Kayamkulam in seven southern districts of Kerala and one district of Tamil Nadu. In the key note address, Hon'ble DDG stressed the importance of developing entrepreneurship among coconut farmers and put forward a road map for research and development in coconut. Dr P. Chowdappa, Director, ICAR-CPCRI presided over the function. Dr. T. Janakiram ADG (HS I), Dr. H. P. Maheswarappa, Project Coordinator, (AICRP Palms) and stakeholders from local government institutions were also present during the occasion. Six publications (centenary series 2-7) were released. About 75 farmers from various panchayaths, and extension officials attended the programme.

Kisan Mela and National Seminar at Kahikuchi

Kisan Mela and National Seminar on "Technological options for bringing second green revolution in North East India" was conducted on 13th -14th February, 2016 at CPCRI, RC, Kahikuchi by ATARI, Barapani in collaboration with different ICAR Institutes of North Eastern Region and others Government Organizations. National seminar was conducted on 13th February, 2016 where Dr. P. Chowdappa, Director, was the chief guest. of the programme and on 14th February, 2016 Shri Radha Mohan Singh, Hon'ble Minister for Agriculture and Farmers' Welfare, Govt. of India, was the Chief Guest in the Kisan Mela. About 2,300 farmers participated in the programme. An exhibition was also arranged as part of the programme.

Shri Radha Mohan Singh, Hon'ble Minister for Agriculture and Farmers' Welfare, along with dignitaries, releasing ICAR-CPCRI publications

Farmer-scientist-interface at Androth Island, Lakshdweep

A farmer-scientist-interface on "Island Agriculture-Problems and Prospects" was organized jointly by the Research Centre, Minicoy and Dept. of Agriculture in the Multi Purpose Hall, Androth Island on 6th November 2015. Dr. P. Chowdappa, Director, ICAR-CPCRI, presided over the programme. In his presidential address, Dr. Chowdappa stressed on the wide scope for organic farming in Island ecosystem. He emphasised on the importance of product diversification and value addition in coconut. Shri P.V.P. Hussain, Chairperson, Dweep Village Panchayat, Androth inaugurated the programme. In his inaugural address, he stressed upon the livelihood concerns of the farmers in the Island. He welcomed programmes for imparting training on new technologies as well as developing marketing facilities. Coconut climbing devices were distributed to farmers who have undergone training on mechanical climbing at Research Centre, Minicoy. Around 60 farmers participated in the interface programme.

Shri P.V.P. Hussain, Chairperson, Dweep Village Panchayat, Androth inaugurating the programme at Androth

Dream Big Kalpa – 2016

An institute - industry interface meet "Dream Big – Kalpa 2016" was held at ICAR-CPCRI Kasaragod on 29th February 2016 in collaboration with Kerala Gramin Bank. More than 200 delegates participated in the programme. Shri Krishnan Kutty, GM, Kerala Gramin Bank, Shri Jotis Jagannadh, AGM, NABARD, Dr. Sajan Kurien, Director of Research, KAU, Thrissur were the guests of honour.

Dr. P. Chowdappa, Director, ICAR-CPCRI in his presidential address, expressed the importance of research institutes to take the technologies to the common man. During the interface, technology transfer were made with Pro B Products,

Shri Krishnan Kutty, GM, Kerala Gramin Bank addressing the participants of the interface meeting

Bengaluru, to the tune of ₹1,20,000/- through MoUs in respect of virgin coconut oil and coconut chips production machineries. An exhibition on technologies including biotechnological processes, bio-fertilizers, bio-control agents, value added products such as kalparasa, virgin coconut oil, coconut chips for agro-industries and varieties and hybrids of coconut, arecanut and cocoa was also arranged. Experts made presentation and took part in one-to-one interaction with entrepreneurs.

Seminar on "Organic cultivation of vegetables in Island ecosystem"

The seminar cum scientist-farmers interface on "Organic cultivation of vegetables in Island ecosystem" was conducted in the Rangmanch Hall, Minicoy Island on 8th November 2015. Dr. P. Chowdappa, Director, ICAR-CPCRI, Kasaragod presided over the function. In his address, Dr. Chowdappa highlighted the importance of organic vegetable production in the Islands for a healthy and better living. Shri Ibrahim Oludu, Vice Chairperson, Dweep Village Panchayat, in his inaugural address, emphasized the importance of agriculture in our day to day life and called up on youth to take up farming as a profession.

WOMEN'S CELL

International Women's Day

The International Women's Day was celebrated at the institute on the 8th March 2016 under the aegis of the institute women's cell. Dr. V. Niral, Chairperson, Women's Cell welcomed the gathering and highlighted the genesis of the women's movement, efforts towards gender parity, and the United Nations theme of 'Planet 50-50 by 2030: Step It Up for Gender Equality'. Dr. P. Chowdappa, Director, presided over the function and stressed on the importance of women in society and the national commitment to promote women's rights and gender equality in the country. Mrs. A. Anitha, Associate Professor, Department of Social Work, Sree Sankarachrya Sanskrit University, Payyanur, was the chief guest and delivered an interesting talk on the subject "Sexual Harassment at Work Place in India". Mrs. Nivedthia M.S., T-3 Farm Assistant, gave a talk on gender equality. Representatives from the scientific, technical, administrative, accounts cadre of the institute, *viz.* Mr. Suresh Kumar, CAO, Mr. T.D.S. Prakash, FAO, Dr. Murali Gopal, Principal Scientist and Dr. K. Samsudeen, Principal Scientist delivered a 'one minute talk' on the important women in their lives. Shri. N. Dinesh Kumar, T-2 Junior Technical Assistant, presented a Malayalam poem glorifying women. A group song, portraying the importance of women was rendered by Mrs. Lalitha Bai, Skilled Supporting Staff, N.V. Sasikala, Skilled Supporting Staff, Shri. N. Dinesh Kumar, T-2 Junior Technical Assistant, Shri P.K. Pramodkumar, Lower Division Clerk and Shri T.K. Gangadharan, Lower Division Clerk. Mrs. S Jayashree, Senior Technical Officer, SMS (Agri. Extension) KVK, presented a classical song on women. Mrs. Sulochana Nair, Convener, Women Cell, delivered the vote of thanks. On the occasion, Dr. Shameena Begum, Scientist, along with Mrs. Girija Chandran, Private Secretary, conducted different competitions for the staff *viz.*, pencil drawing and collage, on the theme of the celebration and prizes were distributed to the winners. The event evoked active and enthusiastic participation of staff members from all cadres at the institute.

Mrs. A. Anitha, Associate Professor, inaugurating the World Women's Day celebration at Kasaragod

Women Complaints Committee

A meeting of the Institute Women Complaints Committee was held at CPCRI, Kasaragod on 26th June 2015 under the chairmanship of Dr. (Mrs.) V. Niral, Principal Scientist (Genetics). The members, Mrs. K. Shobha, Asst. Chief Technical Officer (Library), Mrs. A. Anitha, Associate Professor, Department of Social Work, Sree Sankaracharya University of Sanskrit, Payyannur, and Shri B. Sathish, Administrative Officer and Member Secretary, attended the meeting. The committee decided to organize a sensitization talk on 'Harassment of women in work places and public places' for the staff of the institute. It was also decided that the member secretary will try to collect and archive all relevant official circulars and orders, relating to harassment of women, for ready reference.

Other activities

A secondary agriculture skill upgradation programme on virgin coconut oil (VCO) production for women entrepreneurs was organized as an off-campus programme in Bharanikkavu panchayath in Alappuzha district. Twelve women attended the programme in which hands on training with method demonstration and product diversification in coconut were imparted to the participants.

Women cell members of ICAR-CPCRI, RS, Vittal visited Ishwaramangala village and interacted with farm women on arecanut based cropping system, to commemorate the women's day on 8th March, 2016.

During the period under report, three retiring women staff members, Mrs. Usharani C.H., Assistant Administrative Officer, Mrs. Lalitha K., Skilled Support Staff and Mrs. Kuttiamma K., Canteen Staff, were honoured and felicitated under the initiative of the Women's Cell.

OTHER IMPORTANT EVENTS

Establishment of coconut seed gardens in Open Prison

ICAR-CPCRI has initiated establishment of coconut seed gardens in two open prisons located at Nettukaltheri, Thiruvananthapuram and Cheemeni, Kasaragod, in Kerala State, aiming for large-scale production of coconut hybrids in the future. The programme is taken up as a joint venture of ICAR-CPCRI and Department of Prisons, Govt. of Kerala. Shri Ramesh Chennithala, Hon'ble Minister for Home & Vigilance, Govt. of Kerala inaugurated the first phase of the programme at Open Prison, Nettukaltheri on 19th May 2015. Dr. P. Chowdappa, Director, ICAR-CPCRI, Mr. T. P. Senkumar, Director General of Police, Kerala State, Dr. V. Krishnakumar, Head, ICAR-CPCRI, Regional Station, Kayamkulam, were present. The programme is aimed at production and distribution of released coconut hybrids, engaging the prison inmates.

Shri Ramesh Chennithala, Hon'ble Home Minster, Govt. of Kerala inaugurating coconut seed garden

Dr. P. Chowdappa, Director, ICAR-CPCRI planting coconut seedling at Open Prison

Kalparasa launched at Goa

'Kalparasa' a fresh, hygienic and unfermented energy drink from coconut inflorescence has been launched for its collection and sale in Goa by Dr. N.K. Krishna Kumar, Deputy Director General (Hort. Sci.), ICAR on 28th May 2015 in the brand "Nanu Kalparasa". Shri Krishna Plantations, Goa, signed a memorandum of Agreement with ICAR-CPCRI for its collection using 'Coco-sap Chiller' technology and the fresh unfermented juice devoid of preservatives and other additives will be sold in resorts and local markets. Dr. N.K. Krishna Kumar, DDG (Hort. Sci.) appreciated the Kalparasa drink, which being rich in its nutrients and other phytochemicals like minerals, amino acids, vitamins and antioxidants, makes it not only an ideal health drink but also could be a sport drink. He handed over the bottled Kalparasa named as 'Nanu Kalparasa' to the Chairman of Nanu Enterprises Mr. Crisna (Bhau) Naik. Dr. P. Chowdappa, Director, ICAR-CPCRI, Kasaragod gave a detailed account of innovations made in Kalparasa collection, its quality standards, value addition, marketing and financial benefits. He emphasized that switching over to Kalparasa tapping provides multiple advantages to the economy, environment, farmer and consumer. Mr. Orlando Rodrigues, Director of Agriculture

released a technical bulletin on 'Kalparasa- Collection and Value addition' published by the Institute. Dr. N.P. Singh, Director, ICAR-CCARI, Goa, offered felicitations. Dr. K.B. Hebbar, Head, PB&PHT Division, ICAR - CPCRI, Kasaragod demonstrated the collection of Kalparasa using 'Coco-sap Chiller'.

Dr. N. K. Krishna Kumar, DDG (HS) launching Nanu Kalparasa at Goa

ASPIRE-2015 for inspired research excellence

ASPIRE-2015 crash course was held at ICAR-CPCRI, Regional Station, Kayamkulam on 16th May 2015. Sixty eight students in and around Kayamkulam participated in the programme. In tune with the ICAR's twin major initiatives "*Farmer First*" and "*Student Ready*" to accelerate agricultural research and development, ASPIRE-2015 programme was designed to infuse farming instincts among the budding talents at school level. Dr. K. Muralidharan, Acting Head, Division of Social Sciences, ICAR-CPCRI, Kasaragod addressed the students and urged them to take up agriculture as a passion in their career. A Training manual - "*Gleanings in Agriculture*" and "*E-manual*" (CD) containing the lecture notes and power point presentations were released during the programme.

Dr. K. Muralidharan, Acting Head, Division of Social Sciences addressing the students

PARTICIPATION IN CONFERENCES, MEETINGS, WORKSHOPS AND SYMPOSIA

VISITS ABROAD

Two scientists from the institute were deputed to prestigious international conferences/ workshops for presenting their research findings/sharing expertise and enhancing the knowledge-base and visibility of the institute/ICAR in international research arena.

Dr. (Mrs.) Chandrika Mohan, Principal Scientist (Agricultural Entomology), ICAR-CPCRI, Regional Station, Kayamkulam, Kerala was deputed to Saudi Arabia for presenting a status paper on 'Management of red palm weevil in India' in the 'International Workshop on the Management of Red Palm Weevil', jointly organized by FAO, Rome and Ministry of Agriculture, Kingdom of Saudi Arabia, at Riyadh during 10-12 May 2015. The current management strategies of red palm weevil practiced across the globe were critically examined and a future road map was chalked out. The importance of farm and palm hygiene, pheromone based mass trapping and monitoring, use of GIS and creation of a database, chemical/bioagents for pest suppression and comprehensive palm health management strategies were stressed for a holistic management of the pest in coconut and date palm.

Dr. S. Elain Apshara, Principal Scientist (Horticulture) was deputed to the Asia-Pacific Regional Cocoa Research Workshop organized by the University of Southern Mindanao, Philippines from 12-15 October 2015. She has presented an overview of breeding programmes and planting material production at ICAR-CPCRI, quality issues in Indian cocoa and regional breeding initiatives under the International Group for Genetic Improvement of Cocoa (INGENIC). Uniform criteria to be followed in evaluation of germplasm and strategies for selection of traits and resistance to common pests and diseases in the cocoa breeding programmes of the Asia Pacific countries was deliberated upon and approved in the meeting.

Dr. Chandrika Mohan with red palm weevil experts at Saudi Arabia

Dr. S. Elain Apshara with international cocoa experts at Malaysia

PARTICIPATION IN CONFERENCES/SYMPOSIA/WORKSHOPS IN INDIA

Name and designation	Title of the programme	Place and date
Dr. P. Chowdappa, Director	World Coconut Day Celebrations	University Campus, Tumkur University, Tumkur, Karnataka, 02-09-2015
	Workshop on Rapid Diagnosis of *Phytophthora*	ICAR-IIHR, Bengaluru, Karnataka, 07-08-2015
	Coconut Farmers and Entrepreneurs Meet	Fisheries College, Mangaluru, Karnataka, 11-07-2015
Dr. P. Chowdappa, Director; Dr. Ravi Bhat and Dr. Vinayaka Hegde, Heads of Division	Seminar on Rejuvenation of Vanilla in Arecanut Gardens	Sirsi, Karnataka 10-10-2015
Dr. P. Chowdappa, Director; Dr.Vinayaka Hegde, Head of Division; Dr. V.H. Prathibha, Ms. M. Chaitra and Ms. U. Keerthana, Scientists	International Symposium on *Phytophthora*: Taxonomy, Genomics, Pathogenicity, Resistance and Disease Management	ICAR-IIHR, Bengaluru, Karnataka 09-08-2015 to 12-08-2015
Dr. P. Chowdappa, Director; Dr. K. B. Hebbar, Head of Division and Dr. D. Jaganathan, Scientist	Conference on Sweet *Neera* Policy in Karnataka	University Campus, Tumkur University, Tumkur, Karnataka 02-09-2015
Dr. P. Chowdappa, Director; Dr. Vinayaka Hegde, Head of Division; Dr. V. H. Prathibha and Ms. U. Keerthana, Scientists	6th International Conference on 'Plants, People and Pathogens'	ICAR-NASC Complex, New Delhi 23-02-2016 to 27-02-2016
Dr. H.P. Maheswarappa, Project Coordinator (Palms)	Annual Group Meeting of AICRP on Spices	ICAR-IISR, Kozhikode, Kerala 06-10-2015 to 07-10-2015
	International Conference on Weed Science for Sustainable Agriculture Environment and Biodiversity	Profesor Jayshankar Telangana State Agricultural University, Hyderabad, Telangana 13-10-2015 to 14-10-2015
Dr. K.B. Hebbar, Head of Division	3rd International Plant Physiology Conference	Jawaharlal Nehru University, New Delhi 11-12-2015 to 14-12-2015
Dr. K.B. Hebbar, Dr. K. Muralidharan, Dr. Anitha Karun, Dr. Ravi Bhat, Heads of Division; Dr. K.S. Ananda, Dr. V. Krishnakumar, Heads of Stations; Dr. V. Niral, Dr. B. Augustine Jerard, Dr. P. Subramanian, Dr. Chandrika Mohan, Dr. A. Joseph Rajkumar, Dr. Elain Apshara, Principal Scientists; Dr. Merin Babu, Scientist	24th Annual Group meeting of AICRP on Palms	ICAR-CCARI, Goa 26-05-2015 to 29-05-2015
Dr. Chandrika Mohan, Principal Scientist	24th Biocontrol Workers Group Meeting of AICRP on Biological Control of Crops	TNAU, Coimbatore, Tamil Nadu 02-06-2015 to 03-06-2015
Dr. C. Thamban, Principal Scientist; Dr. P. Muralidharan, Senior Scientist and Head, KVK	4th International Congress on Kerala Studies	A.K.G. Centre for Research and Studies, Palakkad 27-04-2015 to 28-04-2015

Name and designation	Title of the programme	Place and date
Dr. C. Thamban, Principal Scientist	Brainstorming session on 'Extension Research in NARES of Kerala: Current Progress and Future Perspectives'	ICAR-CTCRI, Thiruvananthapuram 18-04-2015
	Sensitization Workshop on '*Mera Gaon Mera Gaurav'* Initiative	UAS, Bengaluru, Karnataka 3-10-2015
	Workshop on 'Social Protection and Agriculture'	Thrissur, Kerala 16-10-2015
	4th International Congress on Kerala Studies	Thiruvananthapuram 09-01-2016
	Seminar on 'Social Protection and Agriculture'	Sahitya Academy Hall, Thrissur 16-10-2015
Dr. S. Kalavathi, Principal Scientist	Resilient-Agriculture: Challenges of Extension	College of Agriculture, Vellayani, Kerala 23-11-2015
Dr. V. Niral, Principal Scientist	Competency Development Programme for HRD Nodal Officers of ICAR	ICAR-NAARM, Hyderabad, Telangana 10-02-2016 to 12-02-2016
Dr. K.S. Ananda, Head of Station; Dr. V. Niral, Principal Scientist	10th Review Meeting of DUS Test Centres	Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharastra 26-02-2016 to 27-02-2016
Dr. S. Elain Apshara, Principal Scientist	Steering Committee Meeting on Cocoa	Horticulture Information Centre, Bengaluru, Karnataka, 8-06-2015
Dr. A. Joseph Rajkumar, Principal Scientist	National Seminar on Spectroscopic Techniques-Present Scenario	T.K. Madhava Memorial College, Nangiarkulangara, Kerala 17-09-2015.
	Round Table Discussion on Semiochemicals	ICAR-NBAIR, Bengaluru 06-08-2015
Dr. M.K. Rajesh, Principal Scientist	National Seminar on 'Recent Advances in Molecular Biology'	Department of Molecular Biology, Kannur University, Kerala 9-04-2016
Dr. P. Muralidharan, Senior Scientist and Head, KVK	Review – cum –Action Plan Workshop of NICRA	ICAR-ATARI, Bengaluru, Karnataka 11-05-2015 and 12-05-2015
	Annual Review Workshop (2014-15) for KVKs of Zone VIII	UAHS, Shivamogga, Karnataka 20-05-2015 to 23-05-2015
	Workshop on 'Formation of Farmer Producers Organizations'	KVK, Thrissur, Kerala 4-08-2015
	Workshop on 'Road Map for Agricultural Development in the West Coast Plains and Ghats Agro-Climatic Zone'	ICAR-CCARI, Goa 16-10-2015
	National Conference on KVKs	ICAR-RCER, Patna, Bihar 25-07-2015 to 26-07-2015

Name and designation	Title of the programme	Place and date
Dr. M.R. Manikantan, Senior Scientist	National Workshop on 'Packaging of Fresh and Processed Foods for Cottage, Micro, Small and Medium Entrepreneurs'	Indian Institute of Packaging, Thiruvananthapuram, Kerala 07-08-2015
	Workshop on 'Fish Processing'	College of Fisheries, Mangaluru, Karnataka 24-02-2016
Dr. Rajkumar and Mrs. Surekha, Scientists	Asian Pacific Weed Science Conference	Profesor Jayshankar Telangana State Agricultural University, Hyderabad, Telangana 13-10-2015 to 16-10-2015
Shri S. Jayasekhar, Scientist (SS)	Annual Agricultural Economics Research Association Conference	ICAR-CIFE, Mumbai, Maharashtra 02-12-2015 to 04-12-2015
Dr. Mukesh Kumar and Mr. Arivalagan, Scientists	11th International Food Data Conference on Food Composition and Public Health Nutrition	National Institute of Nutrition, Hyderabad, Telangana 03-11-2015 to 05-11-2015
Dr. M. Shareefa, Scientist	International Symposium on 'Biodiversity, Agriculture, Environment and Forestry	Association for the Advancement of Biodiversity Science, Ooty, Tamil Nadu 11-12-2015 to 12-12-2015
Dr. S. Leena, CTO (SMS), KVK	National Workshop on 'Vrikshayurveda in Plant Health Management'	State Planning Board, Thiruvananthapuram, Kerala 18-09-2015
Mr. Rajeev M.S., Mrs. Lekha G., and Dr. S. Ravi ACTOs	First KVK symposium-ATARI, Zone VIII	UAS, Dharwad 20-01-2016 to 21-01-2016

AWARDS AND RECOGNITION

INSTITUTIONAL AWARDS

AICRP on Palms gets the prestigious Chaudhary Devi Lal Outstanding AICRP Award for 2014

Chaudhary Devi Lal outstanding AICRP Award for 2014 was conferred on the All India Co-ordinated Research Project on Palms (ICAR-CPCRI, Kasaragod, Kerala) for its contribution in developing many location-specific technologies in crop improvement, production and plant health management of mandate crops *viz.,* coconut, oil palm and palmyrah. Dr. H.P. Maheswarappa, Project Co-ordinator (Palms) received the award from Dr. Sanjeev Kumar Balyan, the hon'ble Minister of state for Agriculture and Farmers' Welfare, Govt. of India during the 87th ICAR Foundation and ICAR award ceremony held at Patna, Bihar on 25th July, 2015, which was inaugurated by Hon'ble Prime Minster Shri Narendra Modi. The award was given by Hon'ble Minister of State for Agriculture & Farmers' Welfare, Dr. Sanjeev Kumar Balyan.

Dr. H. P. Maheswarappa, Project Co-ordinator, AICRP (Palms), receiving the award from Dr. Sanjeev Kumar Balyan, Hon'ble Minister of State for Agriculture & Farmers' Welfare, Govt. of India

Best KVK Award

KVK, Alappuzha was rated as one of the best KVKs of Zone VIII by the Zonal Project Directorate based on the activities of 2014 -15 during the Annual Review Workshop (2014- 15) held at University of Agricultural and Horticultural Sciences, Shivamogga from 20th to 23rd May, 2015.

McKee Ground Water Protection International Award

Doctoral research work carried out by Dr. Manoj P. Samuel, Principal Scientist, ICAR-NAARM, at ICAR-CPCRI, Kasaragod was awarded the Water Environment Federation 'McKee Ground Water Protection, Restoration, for Sustainable Use' International Award for 2015.

Best presentation award

The research paper "Isolation, structural studies and homology modelling of 6-phosphogluconate dehydrogenase in coconut" by Lakshmi Jayaraj K., Amal Vasu , Gangaraj K.P., Bhavyashree U., Hemalatha N., Rajesh M.K. and Anitha Karun received the award for best oral paper in the the International Conference on Advanced IT, Engineering and Management, organized by Department of Computer Applications, Software Technology and Bioinformatics, St. Aloysius College, Mangalore, during 7th & 8th October 2015.

Shri M. Arivalagan, Scientist (Biochem.) received IFDC-2015 best poster presentation award for the poster 'Proximate composition, nutritional quality, phenolics and antioxidant potential of coconut milk residue and VCO cake' in the 11th International Food Data Conference held during 3rd to 5th November, 2015 at National Institute of Nutrition (NIN), Hyderabad, Telangana State.

Dr. M.K. Rajesh, Principal Scientist (Biotech.), received the Silver Medal for securing second rank with distinction in the 'Post-Graduate Diploma in Technology Management in Agriculture (PGDTMA)' jointly offered by ICAR- National Academy of Agricultural Research Management (ICAR-NAARM) and University of Hyderabad on 5th September, 2015 at ICAR-NAARM, Hyderabad from Dr. David J. Bergvinson, Director General, ICRISAT.

Shri M. Arivalagan, Scientist receiving the best paper award

Dr. M. K. Rajesh, Principal Scientist receiving the Silver Medal

Recognitions

Dr. S. Elain Apshara, Principal Scientist (Hort.) has been recognized as research guide in the field of Biosciences under Mangalore University.

LINKAGES AND COLLABORATIONS

Fostering International Linkages

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

Strengthening Inter-Institutional Collaborations in India

ICAR Institutes

ICAR-CCARI, Goa	Cropping systems research
ICAR-CIARI, Port Blair	Coconut genetic resources and breeding
ICAR-CIAE, Bhopal	Development of labour saving machineries and gadgets
ICAR-CIFT, Kochi	IP management and commercialisation of technologies
ICAR-CRIDA, Hyderabad	Climate change network and NICRA
ICAR-CTCRI, Thiruvanthapuram	Cassava and coconut based value added products, intercropping of tuber crops in coconut gardens
ICAR-DCR, Puttur	Research activities in plantation crops
ICAR-IIHR, Bengaluru	Phytoplasma disease related studies, varietal screening, cropping systems, agricultural tools and machinery and horticultural IP related activities
ICAR-IISR, Kozhikode	Cropping system studies, *Phytopthora* diseases in plantation crops
ICAR-NBAIR, Bengaluru	Biological control programmes
ICAR-NBAIM, Mau	Microbial research network
ICAR-NBPGR, New Delhi	Germplasm registration and exchange of PGR
ICAR-IIOPR, Pedavegi	Phytoplasma disease related studies and other common activities under plantation crops sector, tissue culture and biotechnological investigations
ICAR-NAARM, Hyderabad	HRD of staff, academic research activities
ICAR-NRC for Orchids, Pakyong	Technology Mission for the development of horticulture in North Eastern states
ICAR-SBI, Coimbatore	ICAR-CPCRI is a constituent of the Regional Committee VIII (convened by the SBI)

Agricultural and other Universities

Kannur University	Academic research activities
KAU, Thrissur	Plant genetic resources, breeding investigations and region specific agricultural extension activities, academic research activities
Mangalore University	Academic research activities
TNAU, Coimbatore	BPD under NAIP, coconut and cocoa research, region specific activities, academic research activities
UAS, Bengaluru	HRD of personnel and other academic research activities
UHS, Bagalkot	Coconut , arecanut and cocoa research, region specific activities, academic research activities

Other Institutions

ARDF/ CAMPCO, Mangalore	Arecanut/ cocoa research and development
CDB, Kochi	Research and development in coconut
JNSCASR, Bengaluru	Development of nanomaterials as carriers of pesticides/ fungicides/ pheromones
C-DAC, Thiruvananthapuram	Development of acoustic detector for red palm weevil
DASD, Kozhikode	Research and development in arecanut
DBT, New Delhi	Advancements in biotechnology and bioinformatics
DCCD, Kochi	Research and development in cocoa
DIT, New Delhi	Bioinformatics programmes
DST, New Delhi	Molecular biology research and women empowerment programmes
NABARD, Mumbai	Developing/ demonstrating model coconut clusters in root (wilt) affected areas / bioresources management
PPV & FRA, New Delhi	DUS Centre for coconut, arecanut and cocoa, developing DUS guidelines in arecanut and cocoa
KSCSTE, Thiruvananthapuram	Research in biotechnology
State Departments/ Directorates of Agriculture/Horticulture	Transfer of technology of mandate crops

RESEARCH PROJECTS 2015-16

Institute projects

Sl. No.	Proj. No.	Title of Project	Project Leader	Associate (s)
1.	1000761028	Genetic resources management in coconut, arecanut and cocoa	V. Niral	K.S. Ananda, S. Elain Apshara, B. Augustine Jerard, K. Samsudeen, N.K. Ganesh, A. K. Sit, N. R. Nagaraja, K.B. Hebbar, M. Chaithra, M. Senthil Amudhan, C. Thamban, Ravi Bhat, Murali Gopal, Regi Jacob Thomas, Alpana Das, L.S. Singh, Scientist from ICAR-CIARI, Port Blair
2.	1000761029	Genetical investigations and breeding in coconut, arecanut and cocoa	B. Augustine Jerard	K.S. Ananda, S. Elain Apshara, Regi Jacob Thomas, V. Niral, K. Samsudeen, M. Shareefa, N.K. Ganesh, A. K. Sit, N. R. Nagaraja, Merin Babu, A. Josephrajkumar, L.S. Singh and Scientist from ICAR-CIARI, Port Blair S. Sendur Kumaran
3.	1000761031	Development of robust tissue culture techniques in coconut	Anitha Karun	M.K. Rajesh, K. Devakumar, M. Neema, Krishna Prakash and V. Aparna
4.	1000761030	Biotechnological applications in palms and cocoa	M.K.Rajesh	Anitha Karun, K.S. Ananda, K. Devakumar, Alpana Das, N. R. Nagaraja, Regi Jacob Thomas, M. Shareefa, S. Elain Apshara, Krishna Prakash, M. Neema and V. Aparna
5.	1000763057	Cropping/farming approaches for improving soil health and system productivity in coconut, arecanut and cocoa	P. Subramanian	Ravi Bhat, V. Krishnakumar, Surekha, V. Selvamani, Alka Gupta, S. Sujatha, A. Abdul Haris, Jeena Mathew, K. Nihad, A.K. Gogoi, Anokh Uchoi, A. K. Sit, S. Neenu, U. K. Priya, S. Sumitha, S. Indhuja
6.	1000763058	Enhancing nutrient and water use efficiency for sustained productivity in coconut, arecanut and cocoa	Ravi Bhat	P. Subramanian, V. Krishnakumar, K. Nihad, V. Selvamani, Neenu, A. Abdul Haris, Jeena Mathew, Sureka, S. Sujatha, U. K. Priya, Alka Gupta, Merin Babu, Murali Gopal, Indhuja, A.K. Gogoi, Anok Uchoi and A. K. Sit
7.	1000763055	Bioresources management in coconut, arecanut and cocoa	Alka Gupta	Ravi Bhat, Murali Gopal, S. Sujatha, P. Subramanian, U. K. Priya, S. Neenu, Surekha, S. Indhuja, Jeena Mathew

Sl. No.	Proj. No.	Title of Project	Project Leader	Associate (s)
8.	1000765039	Integrated approaches for management of fungal diseases of palms and cocoa	Vinayaka Hegde	M. Chaitra, V. H. Prathibha
9.	1000765040	Diagnostics and management of root (wilt) disease (RWD) in coconut and yellow leaf disease (YLD) in arecanut	Vinayaka Hegde	K.B. Hebbar, A. Joseph Rajkumar, V.K. Chaturvedi, Murali Gopal, M. Chaithra and S. Indhuja
10.	1000765041	Integrated pest management in coconut, arecanut and cocoa	Chandrika Mohan	A. Joseph Rajkumar, P.S. Prathibha, Rajkumar, A.K. Sit, M. Chaithra and M. Sujithra
11.	1000266014	Phenotyping for climate resilient adaptation and mitigation strategies	K.B. Hebbar	M. Arivalagan, V.K. Chaturvedi, M. Senthil Amudhan, A.K. Gogoi, Anok Uchoi, AICRPP Scientists
12.	1000767018	Mechanization of farm operations, post harvest processing for value addition and product diversification	M. R. Manikantan	K.B. Hebbar, M. Arivalagan, A.C. Mathew, M. Senthil Amudhan, N.R. Nagaraja
13.	1000767017	Developing machineries and gadgets for gender mainstreaming in palms and cocoa	A. C. Mathew	M. R. Manikantan
14.	1000767016	Development of pilot level process and technology for the production of health foods from coconut milk residue and VCO cake	M.R. Manikantan	A. C. Mathew, M. Arivalagan
15.	1000769019	Development of statistical and computational techniques for improving research methodology	C.T. Jose	K. Muralidharan, K.P. Chandran, D. Jaganathan, S. Jayasekhar, Sandip Shil
16.	1000769020	Technology transfer and co-learning action research approaches	C. Thamban	K. Muralidharan, D. Jaganathan, P. Anithakumari, S. Kalavathi, P. Subramanian, V. Selvamani, S. Jayasekhar, C. T. Jose, K.P. Chandran, V. H. Pratibha, P. Muralidharan, K. Nihad, A.C. Mathew, Alpana Das, A. Abdul Haris, A.K. Gogoi, Anok Uchoi, Rajkumar
17.	1000769013	Socio-economic dimensions and value chain dynamics in policy perspective	S. Jayasekhar	K.P. Chandran, C.T. Jose, K. Muralidharan, C. Thamban

Externally funded projects

Sl. No.	Proj. No.:	Title of Project	Project Leader	Associate (s)
1.	2010760004	Seed production in coconut, arecanut, cocoa	K. Samsudeen	K. S. Ananda, V. Niral, B. Augustine Jerard, S. Elain Apshara, Regi Jacob Thomas, M. Shareefa, Merin Babu, K. Devakumar, Surekha, N.K. Ganesh
2.	1050761086	DUS centre for coconut	V. Niral	K. Samsudeen
3.	1050761111	Developing of DUS testing criteria and establishment of National Gene Bank for Arecanut (*Areca catechu* L.)	K.S. Ananda	
4.	1050761106	Consortium Research Platform on Agro-biodiversity at ICAR-CPCRI	V. Niral	B. Augustine Jerard K. Samsudeen
5.	1050231012	Development of a database for plantation crops for biologists	M.K. Rajesh	P. Chowdappa, Anitha Karun, K. Devakumar
6.	1050761091	Molecular docking and 3-D QSAR studies to evaluate the mechanism of antimicrobial action of fatty acids from virgin coconut oil and monolaurin	M.K. Rajesh	
7.	1050761087	Generation and analysis of expressed sequence tags (ESTs) with reference to root (wilt) disease of coconut	M. Shareefa	Regi Jacob Thomas M.K. Rajesh
8.	1050761097	Network Project on Organic Horticulture	P. Subramanian	H. P. Maheswarappa, Surekha, V. Selvamani, Murali Gopal, V. H. Prathibha, Sujithra, V. Krishnakumar, A. Abdul Haris, K. Nihad, S. Indhuja, AICRP scientists from Aliyarnagar, Ambajipet and Arasikere
9.	1050761099	Network project on Micronutrient management in horticultural crops for enhancing yield and quality	V. Selvamani	H.P. Maheswarappa, K.B. Hebbar, Ravi Bhat, Alka Gupta, S. Sujatha, Jeena Mathew, M. Arivalagan
10.	1050761098	Enhancing economic viability of coconut based land use system for land use planning in Kerala	V. Krishnakumar	Jeena Mathew, A. Abdul Haris, Merin Babu, P. Anithakumari, A. Joseph Rajkumar, Ravi Bhat, V. Selvamani, C. Thamban, K.P. Chandran. S. Neenu
11.	2010760009	Outreach project on *Phytophthora, Fusarium* and *Ralstonia* diseases of horticultural and field crops (*Phytophthora* diseases of coconut and cocoa)	Vinayaka Hegde	V. H. Prathibha, M. Chaitra

Sl. No.	Proj. No.:	Title of Project	Project Leader	Associate (s)
12.	1050761089	Phytoplasma diseases of coconut and arecanut: development of molecular diagnostics	Vinayaka Hegde	
13.	1050761088	Refinement of production technology of green muscardine fungus and participatory field validation of integrated biocontrol technology against rhinoceros beetle of coconut	Chandrika Mohan	P. Anithakumari
14.	1050761101	Outreach programme on the management of sucking pests of horticultural crops (ORP-SP)-Coconut and cocoa	Chandrika Mohan	A. Joseph Rajkumar, M. Sujithra, Prathibha P.S.
15.	1050761100	Consortium Research Platform on Borers in Network Mode (Coconut: Red palm weevil)	A. Joseph Rajkumar	Chandrika Mohan and P.S. Prathibha
16.	1050761105	Demonstration of EPN in arecanut for the management of root grubs	Rajkumar	D. Jaganathan
17.	1050761095	Development of forewarning model using regression and simulation approach for management of rice leaf folder, *Cnaphalocrosis medinalis* Guenee (Lepidoptera: Pyralidae" (Transferred from IARI)	M. Sujithra	
18.	1050761093	Area wide community approach for integrated management of RPW of coconut using GPS as decision support and evaluation tools	P. Anithakumari	A. Joseph Rajkumar, K.P. Chandran, Merin Babu and K. Muralidharan
19.	1050761092	Community based bio-resource management for sustaining production and livelihood security under coconut based farming systems	S. Kalavathi	Jeena Mathew and S. Indhuja
20	1050233003	Farmers' Participatory Research cum Demonstration Plots on Arecanut Based Cropping System	D. Jaganathan	C. T. Jose, N. R. Nagaraja and Rajkumar
21.	2010761091	Business Planning and Development Unit, CPCRI, Kasaragod	K. Muralidharan	A.C. Mathew, S. Jayasekhar
22.	1050761094	Organic farming in Kasaragod district – An analysis of field level scenario and stakeholders' perspective	C. Thamban	S. Jayasekhar, P. Subramanian

Sl. No.	Proj. No.:	Title of Project	Project Leader	Associate (s)
23.	1050761102	Assessment of incidence and intensity of pests and diseases of coconut in north Kerala	C. Thamban	K.P. Chandran, V.H. Prathibha, P.S. Prathibha
24.	1050761103	Economic impact studies on crops diversification and technology adoption in horticulture	S. Jayasekhar	K.P. Chandran, C. Thamban
25.	2010760007	Intellectual property management and transfer/ commercialization of agricultural technology scheme (up-scaling of existing component i.e., intellectual property right (IPR) under the ICAR headquarters scheme on management of information services	P. Chowdappa	K. Muralidharan and A.C. Mathew

RESEARCH AND ORGANISATIONAL MANAGEMENT

Research Advisory Committee Meeting

The 18th meeting of Research Advisory Committee was held at ICAR-CPCRI, Kasaragod on 18th February 2016. Dr. S. Edison, former Director, ICAR- CTCRI, Thiruvananthapuram and Chairman, Dr. Brahma Singh, formerly Director, Life Sciences, DRDO, Delhi, Dr. V.S. Korikantimath, former Director, ICAR Research Complex for Goa, Dr. S. Arulraj, former Director, ICAR-IIOPR, Pedavegi, Andra Pradesh, Dr. Subhash Narayanan, Professor and Head, Anand Agricultural University, Gujarat, Dr. T.M. Manjunath, former Director (R&D), Monsanto Research Centre, Bengaluru, Dr. P. Chowdappa, Director, ICAR-CPCRI, members and Dr. Anitha Karun, Head, Division of Crop Improvement ICAR-CPCRI and Member Secretary were present.

Dr. P. Chowdappa, Director, in his welcome address, highlighted the various programmes contemplated to empower the stakeholders during the centenary year of the institute. The Chairman, RAC appreciated the achievements of ICAR-CPCRI of high standards set in the arena of quality planting material production, field demonstrations on management yellow leaf disease of arecanut, root (wilt) disease of coconut, promotion of cocoa as intercrops under palms, developing technology fo bottling of Kalparasa and its popularization, to name important ones. Chairman RAC also suggested to explore the possibilities to develop appropriate technologies for packaging of coconut products.

Dr. S. Edison, Chairman, RAC, addressing the scientists

Chairman and members of RAC along with scientists of ICAR-CPCRI

Institute Research Committee Meeting

The 44th Annual Institute Research Committee Meeting of the ICAR-CPCRI was held at CPCRI, Kasaragod from 1st to 5th March 2016. Progress of work and achievements made under the ongoing research projects, including externally funded projects, during the year 2015-16, were discussed in detail and the technical programme for the year 2016-17 has been formulated during the meeting. Recommendations of the RAC, QRT and inputs from farmers, agribusiness entrepreneurs and officials from the developmental departments were incorporated in the respective projects. During the meeting, seven new projects were approved and nine projects were concluded. Coconut tissue culture, large scale demonstration of management strategies for root (wilt) disease of coconut and YLD of arecanut, coconut genome sequencing, soilless media for production of planting material and a technology for bottling of 'Kalparasa' were identified as priority areas of research for 2016-17.

Dr. P. Chowdappa, Director, addressing members during Plenary session of IRC meeting. Dr. M. Maheswaran, Director of Research, TNAU and Dr. J. Dilip Babu, Director of Research, YSRHU are also seen

Institute Management Committee Meeting

Institute Management Committee (IMC) meetings were held on 17-11-2015 and on 29-02-2016 at ICAR-CPCRI, Kasaragod. Dr. P. Chowdappa, Director, chaired the meetings, in which important decisions on research and development of the institute were taken.

IMC meeting held at Kasaragod on 29th February 2016

Institute Biosafety Committee Meeting

The first meeting of the reconstituted Institute Biosafety Committee (IBSC), ICAR-CPCRI, Kasaragod was held on 19th February, 2016 under the chairmanship of Dr. P. Chowdappa, Director, at ICAR-CPCRI, Kasaragod. During the meeting, Dr. George Thomas, Scientist F, Rajiv Gandhi Centre for Biotechnology, Thiruvananthapuram (DBT Nominee), Dr. Rekha Rai, Professor (Microbiology), K. S. Hedge Medical Academy, Mangalore (Medical Officer), Dr. Ginny Antony, Assistant Professor, Central University of Kerala, Kasaragod (External member), Dr. Anitha Karun, Head, Division of Crop Improvement, ICAR-CPCRI, Dr. Vinayak Hegde, Head, Division of Crop Protection, ICAR-CPCRI, Dr. A. Joseph Rajkumar, Principal Scientist, ICAR-CPCRI (RS), Kayamkulam and Dr. M.K. Rajesh, Principal Scientist, ICAR-CPCRI, Kasaragod (Member Secretary) were present.

OFFICIAL LANGUAGE IMPLEMENTATION

In compliance of the Official Language Act 1963 Section 3(3), maximum efforts have been undertaken to issue the documents under Section 3(3) in bilingual form. A separate register has been maintained for letters received in Hindi and for ensuring the compliance of Rule 5, 100% of letters received in Hindi were replied in Hindi. Maximum efforts have been taken to achieve the annual target of 55% under Hindi correspondence.

Under Official Language Rule 1976 Rule 11, all name plates have been displayed bilingually and as a part of centenary year of this Institute, new sign boards were displayed trilingually on one side (with English, Hindi and Malayalam) and Kannada language was included on the other side. All stationery materials, including rubber stamps, identity cards of staff members, banners of various programmes and certificates of training programmes, were prepared in bilingual format. Proper guidance and suggestions were given to all Regional Stations/ Research Centres for the compliance of the Act and Rules and the progress on the implementation of the stations/ centres were reviewed periodically.

Official Language Implementation Committee meetings

Under the chairmanship of the Director, four meetings of the Official Language Implementation Committee were conducted and the progress made in the implementation during the above period were reviewed.

Training Programmes

Five scientists were enrolled for Prabodh, Praveen and Pragya courses. Seven administrative staff from Headquarters and one from Research Centre, Mohitnagar were registered for Hindi Typewriting Course under the correspondence course programme of Central Hindi Training Institute, Official Language Department, New Delhi.

Hindi Workshop

The following five workshops were organized for the staff of the Institute:

- Desk to desk programme on Unicode activation on 18.11.2015 and 19.11.2015
- Training on the usage of Hindi keyboard on 29.07. 2015
- Article 351 - Development of Hindi Language on 20.10.2015
- Technical Terminology on 28.01.2016
- Hindi workshop to promote the usage of Hindi in official work at Regional Station, Kayamkulam on 23.06.2015 and 10.12.2015.

Intensive Training Programme

An intensive training programme on noting and drafting in Hindi was conducted by Central Hindi Training Institute, Official Language Department in which 15 officials have participated from Headquarters and Regional Stations at Kayamkulam and Vittal.

Hindi *Chetna Mas* Celebration

As per the direction of ICAR, Hindi *Chetna Mas* was celebrated from 14th September 2015 at the Headquarters and Regional Stations/ Centres. Different competitions were organized and winners of various competitions were felicitated. Under special incentive scheme, cash incentives were granted to 26 Officers and staff of the institute (9 from Kasaragod and 17 from Kayamkulam).

Dr. P. Chowdappa, Director, ICAR-CPCRI, addressing the staff during the Hindi Chetana Maas

Town Official Language Implementation Committee

Two half-yearly meetings (on 4th August 2015 and 28th January 2016) were conducted under the chairmanship of the Director, ICAR-CPCRI and in the presence of the Deputy Director (Implementation), Official Language Department, Kochi. A joint Hindi Workshop was conducted for TOLIC members on introduction of Hindi keyboard using Unicode.

In connection with the Joint Hindi Week celebration, separate competitions in Hindi were conducted for the CBSE and State School students and cash awards and certificates were distributed to the winners.

Participation in official language meetings

- Sr. Technical Officer (OL) participated in the one day Seminar (7th November 2015) on "Official Language Implementation in Scientific Institutes" conducted by the Directorate of Knowledge Management in Agriculture, New Delhi and Hindi Section of ICAR, New Delhi.
- Sr. Technical Officer (OL) Attended the Half Yearly meeting of Town Official Language Implementation Committee, Kayamkulam, NTPC on 10th December 2015.
- Sr. Technical Officer (OL) participated in the Annual Regional Official Language Conference on 19th February 2016 at Ernakulam, Kerala, organized by the Regional Implementation Office, Department of Official Language, New Delhi
- Head, Regional Station, Kayamkulam attended the Town Official Language Implementation Committee, Kayamkulam, NTPC on 24th April 2015 and 10th December 2015.

TOLIC Hindi fortnight inauguration at Vittal

Hindi workshop at Kayamkulam

Efforts were made to bring out publications in the official language. During the year, the following publications were brought out:

Hindi Publications

- ICAR-CPCRI Annual Report - Summary (2014-2015)
- ICAR-AICRP Annual Report – Summary (2014-2015)
- वरजिन नारियल तेल (बुलेटिन)
- नारियल चिप्स का वाणिज्यिक उत्पादन (बुलेटिन)
- के.रो.फ.अ.सं. - वृत्त चित्र (डोक्युमेंटरी फिल्म)

Inspection on Official Language Implementation

ICAR, Krishi Bhavan, New Delhi conducted the inspection and reviewed the progress on the implementation of Official Language in ICAR-CPCRI, Kasaragod on 07th January 2016.

Deputy Director, Regional Implementation Office, Kochi conducted inspection on the Official Language implementation at ICAR-CPCRI, Regional Station, Kayamkulam on 10th December 2015.

BUDGET AND EXPENDITURE

The Budget and Expenditure under Non-Plan and Plan for the financial year 2015-16 in respect of ICAR-CPCRI, Kasaragod is presented below: *(Figures in lakh ₹)*

Budget Head	Non-Plan		Plan	
	Budget	Expenditure	Budget	Expenditure
Revenue				
Estt. Charges	2350.00	2333.57	0.00	0.00
OTA	0.15	0.04	0.00	0.00
TA	22.00	21.98	25 .00	25.00
Other Charges	554.00	622.62	107.00	106.23
Works Repair & Maintenance				
Office Buildings	85.00	94.60	0.00	0.77
Residential Buildings	144.50	115.17	3.00	0.15
Minor Work	139.85	90.04	0.00	1.89
Miscellaneous Expenses (including HRD)	22.85	22.75	5.50	6.29
Tribal Sub Plan - General	0.00	0.00	11.50	11.48
Capital				
Equipments	15 .00	14.99	79.50	67.79
Information Technology	5.00	4.98	17.00	17.89
Library	0.00	0.00	23.12	26.08
Furniture & Fixtures	5.00	4.97	11.75	11.84
Works	0.00	0.00	118.63	126.37
Minor Work	0.00	0.00	0.00	0.00
Tribal Sub Plan - Capital	0.00	0.00	0.00	0.00
TOTAL	3343.35	3325.71	402.00	401.78
Pension	1950.00	1923.93		
Loans & Advances	17.00	11.89		
Other projects	Opening Balance	Receipts	Expenditure	Refund
Other Plan Schemes	28.33	593.47	595.28	15.91
Deposit Schemes (Externally funded)	123.04	276.59	139.10	90.27
Revolving Fund Scheme	76.49	161.67	98.84	0.00
KVK, Kasaragod & Alappuzha	1.20	212.90	214.04	0.00
Revenue receipts				
Head	Target		Achievement	
Income from sales/ services	543.90		187.15	
Fee/Subscription	4.88		8.54	
Income from Royalty, Publication etc.	0.08		0.08	
Other Income	0.00		182.98	
STD Interest	0.00		66.91	
Recoveries on Loans & Advances			28.57	
TOTAL	548.86		474.23	

RFD ACHIEVEMENTS (2014-15)

S. No.	Objectives	Weight	Actions	Success Indicators	Unit	Weight	Target / Criteria Value					Achievements	Performance		Percent achievements against Target values of 90% Col.*
							Excellent 100%	Very Good 90%	Good 80%	Fair 70%	Poor 60%		Raw score	Weighted score	
1	Production management and post harvest technologies	50	Development of production & plant health management technologies	Production technologies developed	No.	*15*	7	6	5	4	3	7	100	15.0	116.7
				Plant health management technologies developed	No.	*15*	6	5	4	3	2	6	100	15.0	120.0
			Production of breeder seeds/ quality and disease free planting materials	Quality planting material produced	No. (in 000)	*10*	648	540	432	324	216	705	100	10.0	130.6
			Farm mechanization and value addition	Machineries/ gadgets/ value added products developed	No.	*10*	5	4	3	2	1	5	100	10.0	125.0
2	Genetic resource conservation & utilization	20	Management of genetic resources	Germplasm accessions collected	No.	*5*	17	14	11	8	5	17	100	5.0	121.4
				Improved varieties developed	No.	*15*	7	6	5	4	3	5	80	12.0	83.3

S. No.	Objectives	Weight	Actions	Success Indicators	Unit	Weight	Target / Criteria Value					Achievements	Performance		Percent achievements against Target values of 90% Col.*
							Excellent 100%	Very Good 90%	Good 80%	Fair 70%	Poor 60%		Raw score	Weighted score	
3	Dissemination of knowledge	10	Transfer of technology to farmers and other stakeholders	Trainings and interface programmes organized	No.	*10*	150	125	100	75	50	159	100	10.0	127.2
	Publication/Documentation	5	Publication of the research articles in the journals having the NAAS rating of 6.0 and above	Research articles published	No.	*3*	5	4	3	2	1	11	100	3.0	275.0
			Timely publication of the Institute Annual Report (2013-2014)	Annual Report published	Date	*2*	June 30, 2014	July 2, 2014	July 4, 2014	July 7, 2014	July 9, 2014	June 30, 2014	100	2.0	
	Fiscal resource management	2	Utilization of released plan fund	Plan fund utilized	%	*2*	98	96	94	92	90	99.39	100	2.0	
	Efficient Functioning of the RFD System	3	Timely submission of Draft RFD for 2014-2015 for Approval	On-time submission	Date	*2*	May 15, 2014	May 16, 2014	May 19, 2014	May 20, 2014	May 21, 2014	May 15, 2014	100	2.0	
			Timely submission of Results for 2013-2014	On-time submission	Date	*1*	May 1 2014	May 2 2014	May 5 2014	May 6 2014	May 7 2014	April 11, 2014	100	1.0	
	Enhanced Transparency / Improved Service delivery of Ministry/Department	3	Rating from Independent Audit of implementation of Citizens' / Clients' Charter (CCC)	Degree of implementation of commitments in CCC	%	*2*	100	95	90	85	80	100	100	2.0	

S. No.	Objectives	Weight	Actions	Success Indicators	Unit	Weight	Target / Criteria Value					Achievements	Performance		Percent achievements against Target values of 90% Col.*
							Excellent 100%	Very Good 90%	Good 80%	Fair 70%	Poor 60%		Raw score	Weighted score	
	Administrative Reforms	7	Update organizational strategy to align with revised priorities	Date	Date	*2*	Nov.1 2014	Nov. 2, 2014	Nov. 3, 2014	Nov. 4, 2014	Nov. 5, 2014	Sep. 29, 2014	100	2.0	
			Implementation of agreed milestones of approved Mitigating Strategies for Reduction of potential risk of corruption (MSC).	% of implementation	%	*1*	100	90	80	70	60	100	100	1.0	
			Implementation of agreed milestones for ISO 9001	% of implementation	%	*2*	100	95	90	85	80	100	100	2.0	
			Implementation of milestones of approved Innovation Action Plans (IAPs).	% of implementation	%	*2*	100	90	80	70	60	100	100	2.0	

DISTINGUISHED VISITORS

Shri Radha Mohan Singh, Hon'ble Minister for Agriculture and Farmers' Welfare, visited the Research Centre, Kahikuchi on 30-01-2016 and also on 14-02-2016 during the Kisan Mela and National Seminar on "Technological options for bringing second green revolution in North East India".

Shri Radha Mohan Singh, Hon'ble Union Minister for Agriculture & Farmers' Welfare, visiting seedling nursery at ICAR-CPCRI, RC, Kahikuchi

Dr. Bhumidhar Barman, Hon'ble Minister of Revenue & Disaster Management, Administration Reforms and Training, Government of Assam visited RC, Kahikuchi on 06-04-2015. He visited the nursery and experimental plots such as arecanut based cropping system, vermicompost unit and held discussions on mandate and achievements of the centre.

Dr. Bhumidhar Barman, Hon'ble Minister, Govt. of Assam, visiting CPCRI, RC, Kahikuchi

Dr. N.K. Krishna Kumar, Hon'ble DDG (Hort. Sci.) and Dr. T. Janakiram, ADG (Hort. Sci.-I) visited the Regional Station, Kayamkulam on 31-05-2015 and reviewed the ongoing research programmes including field experiments. Dr. N.K. Krishna Kumar

Dr. N.K. Krishna Kumar, DDG (H.S.) performing ceremonial planting at CPCRI, RS, Kayamkulam

also harvested mature coconuts of Kalpa Sankara hybrid (33-month old) along with Director, ICAR-CPCRI and other scientists of the Regional station and undertook a ceremonial planting of Kalparaksha variety.

Dr. Anupam Barik, Assistant Commissioner of Agriculture, Govt. of West Bengal, visited RC, Mohitnagar on 13-02-2016.

Dr. A. K. Singh, DDG (Agricultural Extension) visited Research Centre, Kahikuchi on 14-02-2016 in connection with the Kisan Mela and National Seminar on "Technological options for bringing second green revolution in North East India".

Dr. N.K. Krishna Kumar, DDG (Horticultural Science) visited Research Centre, Kahikuchi on 16-02-2016.

Dr. N.K. Krishna Kumar, DDG (Hort. Sci.), Dr. Dr. N.P. Singh, Director CCARI, Goa, Dr. P.L. Saroj, Director, ICAR-DCR, Puttur, Dr. C.N. Ravishankar, Director, ICAR-CIFT, Kochi, Dr. James Jacob, Director In-charge, ICAR-CTCRI, Thiruvananthapuram, Shri P.K. Raman, Regional Manager, State Bank of India, Kannur, Shri N.K. Krishnankutty, General Manager, Kerala Gramin Bank, Shri Jyothis Jaganadh, AGM, NABARD, former Directors of CPCRI, Dr. K.V. Ahmed Bavappa, Dr. K.U.K. Namboothiri and Dr. George V. Thomas have visited ICAR-CPCRI, Kasaragod for the launching programme of Centenary celebrations of ICAR-CPCRI at Kasaragod on 12-03-2016.

Dr. N.K. Krishna Kumar, DDG (Hort. Sci.), planting coconut seedling to mark Centenary Celebration

Dr. Gurbachan Singh, Chairman, ICAR-ASRB, New Delhi visited the Regional Station Kayamkulam on 08-06-2015 and interacted with the scientists and technical officers.

Shri K.C. Venugopal, M.P., Alappuzha visited KVK, Alappuzha on 09-09-2015 during the training programme on 'Jackfruit processing and value addition'.

Shri Oommen Chandy, Hon'ble Chief Minister of Kerala, visited CPCRI, RS, Kayamkulam on 27-09-2015 and interacted with the Head of the Station.

Dr. Gurbachan Singh, Chairman, ASRB being received by the Head, RS, Kayamkulam

Shri P.J. Joseph, M.L.A. visited CPCRI, Kasaragod on 27-11-2015 and acquainted with the various activities of the Institute.

Shri P. Karunakaran, Member of Parliament, Kasaragod has participated in World Soil Day at ICAR-CPCRI, Kasaragod on 05-12-2015 and distributed soil health card to farmers.

Shri K.C. Venugopal, Member of Parliament, Alappuzha and Shri N. Padmakumar, IAS, District Collector, Alappuzha visited CPCRI, RS, Kayamkulam on 05-12-2015 and participated in World Soil Day celebrations.

Dr. G. Lingappa, Deputy Director, Dr. Dhanapal, K. Deputy Director (Research), Shri G. S. Ghatani, Assistant Director (Marketing), Shri S. S. Bora Scientist, Spices Board, Gangtok and Shri D. M. Barman Assistant Director, Spice Board, Kalimpong, visited RC, Mohitnagar on 23-12-2015.

PERSONNEL

As on 31/3/2016; Not a gradation list.

Sl. No.	Name	Designation
SCIENTIFIC		
Kasaragod		
1.	Dr. P. Chowdappa	Director
2.	Dr. H.P. Maheswarappa	Project Coordinator (Palms)
3.	Dr. Ravi Bhat	Head of the Division (Crop Production)
4.	Dr. K.B. Hebbar	Acting Head of the Division (PB & PHT)
5.	Dr. Vinayaka Hegde	Head of the Division (Crop Protection)
6.	Dr. (Mrs.) Anitha Karun	Head of the Division (Crop Improvement)
7.	Dr. C. Thamban	Acting Head of the Division (Social Sciences)
8.	Dr. K. Muralidharan	Principal Scientist (Agril. Statistics)
9.	Dr. Murali Gopal	Principal Scientist (Agril. Microbiology)
10.	Dr. (Mrs.) Alka Gupta	Principal Scientist (Agril. Microbiology)
11.	Dr. (Mrs.) V. Niral	Principal Scientist (Genetics)
12.	Dr. P. Subramanian	Principal Scientist (Agronomy)
13.	Dr. A.C. Mathew	Principal Scientist (Soil & Water Conservation Engg.)
14.	Dr. B. Augustine Jerard	Principal Scientist (Horticulture)
15.	Dr. K. Samsudeen	Principal Scientist (Economic Botany)
16.	Dr. M.K. Rajesh	Principal Scientist (Agril. Biotechnology)
17.	Dr. K.P. Chandran	Senior Scientist (Agril. Statistics)
18.	Dr. M.R. Manikantan	Senior Scientist (Agril. Process Engg.)
19.	Dr. K. Devakumar	Senior Scientist (Agril. Biotechnology)
20.	Mr. S. Jayasekhar	Scientist (Agril. Economics)
21.	Dr. D. Jaganathan	Scientist (Agril. Extension)
22.	Dr. V. Selvamani	Scientist (Soil Science)
23.	Mr. Mukesh Kumar	Scientist (Biochemistry)
24.	Mr. M. Arivalagan	Scientist (Biochemistry)
25.	Dr. (Mrs.) P.S. Prathibha	Scientist (Agril. Entomology)
26.	Dr. Rajkumar	Scientist (Nematology)
27.	Dr. (Mrs.) V.H. Prathibha	Scientist (Plant Pathology)
28.	Mrs. Surekha	Scientist (Agronomy)
29.	Dr. (Mrs.) M. Sujithra	Scientist (Agril. Entomology)
30.	Mrs. S. Neenu	Scientist (Soil Science)
31.	Dr. (Mrs.) M. Neema	Scientist (SPM&AP)
32.	Ms. S. Sumitha	Scientist (SPM&AP)
33.	Mr. Krishna Prakash	Scientist (SPM&AP)
34.	Mrs. Aparna Veluru	Scientist (SPM&AP)
35.	Mrs. Shameena Begum	Scientist (SPM&AP) since 10.04.2015
36.	Mrs. G. Panjavarnam	Scientist (Fruit Science) since 10.04.2015
37.	Mr. Man Mohan Deo	Scientist (FM&P) since 12.10.2015
38.	Dr. S. Paulraj	Scientist (Microbiology) 28.12.2015
KVK, Kasaragod		
39.	Dr. T. S. Manoj Kumar	Principal Scientist & Head
RC, Kidu		
40.	Mr. Khadke Ganesh Navanath	Scientist (SPM&AP) & Sci. In charge
RC, Mohitnagar		
41.	Dr. Arun Kumar Sit	Senior Scientist (Hort.) & Sci. In charge
42.	Mr. Sandeep Shil	Scientist (Agril. Statistics)

Sl. No.	Name	Designation
RC, Kahikuchi		
43.	Dr. A.K. Gogoi	Principal Scientist (Agronomy) & Sci. In charge
44.	Dr. (Mrs.) Alpana Das	Senior Scientist (Agril. Biotechnology)
45.	Mr. Anok Uchoi	Scientist (SPM&AP)
46.	Dr. Leichombam Singhajit Singh	Scientist (SPM&AP)
RS, Kayamkulam		
47.	Dr. V. Krishnakumar	Principal Scientist & Head
48.	Dr. (Mrs.) Chandrika Mohan	Principal Scientist (Ag. Entomology)
49.	Dr. (Mrs.) P. Anitha Kumari	Principal Scientist (Ag. Extension)
50.	Dr. (Mrs.) S. Kalavathy	Principal Scientist (Ag.Extension)
51.	Dr. V.K. Chaturvedi	Senior Scientist (Biochemistry)
52.	Dr. A. Abdul Haris	Principal Scientist (Agronomy)
53.	Dr. Regi Jacob Thomas	Principal Scientist (Hort.)
54.	Dr. A. Joseph Rajkumar	Principal Scientist (Ag. Entomology)
55.	Dr. (Mrs.) K. Nihad	Scientist (Hort.)
56.	Dr. (Mrs.) Jeena Mathew	Scientist (Soil Science)
57.	Dr. (Mrs.) M. Shareefa	Scientist (Hort.)
58.	Dr. (Mrs.) Merin Babu	Scientist (Plant Pathology)
59.	Dr. (Mrs.) S. Indhuja	Scientist (Microbiology)
KVK, Alappuzha		
60.	Dr. P. Muralidharan	Sr. Scientist & Head
RS, Vittal		
61.	Dr. K.S. Ananda	Head
62.	Dr. C.T. Jose	Principal Scientist (Agril. Stat.)
63.	Dr. S. Sujatha	Principal Scientist (Agronomy) up to 05.12.2015
64.	Dr. S. Elain Apshara	Principal Scientist (Hort.)
65.	Dr. M. Senthil Amudhan	Senior Scientist (Biochemistry)
66.	Dr. N.R. Nagaraj	Scientist (Plant Breeding)
67.	Ms. M. Chaithra	Scientist (Plant Pathology)
68.	Ms. Priya U.K.	Scientist (Soil Science)
69.	Dr. (Mrs.) K.S. Karthika	Scientist (Soil Science) since 10.04.2015
70.	Mr. Bhavishya	Scientist (SPM&AP) since 10.04.2015
71.	Ms. Keerthana Umapathy	Scientist (Plant Pathology) since 11.05.2015
72.	Mr. Shivaji Hausrao Thube	Scientist (Agril. Entomology) since 12.10.2015
TECHNICAL		
Kasaragod		
73.	Mr. Saran Kumar Rizal	Chief Technical Officer (Field/Farm)
74.	Mr. H. Muralikrishna	Chief Technical Officer (Tech. Information)
75.	Mr. M.P. Ramesh Kumar	Chief Technical Officer (Lib) up to 08.07.2015
76.	Dr. (Mrs.) K.K. Sajini	Chief Technical Officer (Lab.)
77.	Mr. John George	Chief Technical Officer (Lab.)
78.	Mr. Sebastian George	Chief Technical Officer (Lab)
79.	Mr. B.M. Mohammed Basheer	Chief Technical Officer (Lab)
80.	Mrs. K. Shobha	Asst. Chief Technical Officer (Library)
81.	Mr. K. Devadas	Asst. Chief Tech. Officer (Field/Farm)
82.	Dr. H. Moosa	Asst. Chief Tech. Officer (Field/Farm)
83.	Mr. K.G. Narayana Swamy	Sr. Tech. Officer (Mech. Engg.)
84.	Mrs. Sugatha Padmanabhan	Sr. Tech. Officer (Lab.)
85.	Mrs. K. Sreelatha	Sr. Tech. Officer (OL)

Sl. No.	Name	Designation
86.	Mr. M. Krishnan	Tech. Officer (Field/Farm)
87.	Mr. A. Sadanandan	Tech. Officer (Mech. Engg.)
88.	Mr. M.P. Rajendran Nair	Tech. Officer (Mech. Engg.)
89.	Mr. G.S. Hareesh	Tech. Officer (Instrumentation Engg.)
90.	Mr. K. Balakrishnan	Tech. Officer (Field/Farm)
91.	Mr. K. Ajith Kumar	Tech. Officer (Civil Engg.)
92.	Mr. V.K. Gopalakrishnan	Tech. Officer (Civil Engg.)
93.	Mr. V. Balakrishnan	Tech. Officer (Field/Farm)
94.	Mr. B. Koragu Naik	Sr. Tech Assistant up to 30.05.2015
95.	Mr. S. Manohara	Sr. Tech. Assistant (Vehicles)
96.	Mr. K.N. Radhakrishnan Nambiar	Sr. Tech. Assistant (Field/Farm)
97.	Mr. V. Suresh Kumar	Sr. Tech. Assistant (Field/Farm)
98.	Mr. K. Krishnan Nair	Sr. Tech. Assistant (Field/Farm)
99.	Mr. M.V. Sreedharan	Sr. Tech. Assistant (Field/Farm)
100.	Mr. K.N. Pankajakshan	Tech. Assistant (Vehicles)
101.	Mr. K. Devaraj	Tech. Assistant (Ele. Engg.)
102.	Mr. K. Raghavan	Tech. Assistant (Field/Farm)
103.	Mr. M.V. Madhavan	Tech. Assistant (Field/Farm)
104.	Mr. A. Sanjeeva	Tech. Assistant (Field/Farm)
105.	Dr. K.S. Muralikrishna	Tech. Assistant (Field/Farm)
106.	Mrs. M.S. Nivedhitha	Tech. Assistant (Field/Farm)
107.	Mrs. Jesmi Vijayan	Tech. Assistant (Field/Farm)
108.	Mr. Panduranga	Sr. Technician (Field/Farm)
109.	Mr. P.K. Krishnankutty	Sr. Technician (Field/Farm)
110.	Mr. Bhavani Sankar Naik	Sr. Technician (Field/Farm)
111.	Mr. A. Divakaran	Sr. Technician (Field/Farm)
112.	Mr. A.R. Padmanabha Naik	Sr. Technician (Field/Farm)
113.	Mr. K. J. Sebastian	Sr. Technician (Field/Farm)
114.	Mr. A.V. Satheesh Kumar	Sr. Technician (Vehicles)
115.	Mr. N. Dinesh Kumar	Sr. Technician (Field/Farm)
116.	Mr. S. Sunil	Technician (Electrical Engg.)
117.	Mrs. M. Vimala	Technician (Field/Farm)
118.	Mr. V. Radhakrishnan	Technician (Field/Farm)
KVK, Kasaragod		
119.	Dr. S. Leena	Chief Technical Officer (SMS)(Entomology)
120.	Mr. R. Sanal Kumar	Chief Technical Officer (SMS)(Plant Pathology)
121.	Dr. Saritha Hegde	Chief Technical Officer (SMS)(Home Science)
122.	Mrs. M.P. Jayashree	Sr. Tech. Officer (SMS) (Agrl Extn)
123.	Dr. Neelofar Illias Kutty	Asst. CTO (Programme Assistant)(Home Science)
124.	Mr. K. Manikandan	Sr. Tech. Officer (Programme Assistant) (Hort.)
125.	Mr. K. Shyama Prasad	Asst. CTO (Programme Assistant) (Audio –Visual)
126.	Mr. A.K. Ramadas	Tech. Assistant (Vehicles)
RS, Kayamkulam		
127.	Dr. C. Keshavan Nampoothiri	Asst. CTO (Statistics)
128.	Mr. S. Thajuddin	Asst. CTO (Library)
129.	Dr. G. Rajeev	Asst. CTO (Lab.)
130.	Mr. Jacob Kurian	Asst. CTO (Field/Farm)
131.	Dr. M. Shanavas	Asst. CTO (Lab.)
132.	Dr. C.G. Narayanan Namboothiri	Senior Tech. Officer (Field/Farm)

Sl. No.	Name	Designation
133.	Mr. K.K. Sudhanandan	Senior Tech. Officer (Field/Farm)
134.	Mr. K. Soman	Tech Officer up to 31.10.2015
135.	Mr. Ramachandran Pillai	Technical Officer up to 30.11.2015
136.	Mr. A.J. Bhadran	Technical Officer up to 30.11.2015
137.	Mr. B. Anilkumar	Tech. Officer (Field/Farm)
138.	Mr. K. Rajendran	Tech. Officer (Field/Farm)
139.	Mr. E.R. Asokan	Tech. Officer (Photography)
140.	Mr. K.P. Udayabhanu	Tech. Officer (Field/Farm)
141.	Mr. Sunny Thomas	Senior Tech. Assistant (Field/Farm)
142.	Mr. A.O. Varghese	Senior Technician (Field/Farm)
143.	Mr. P.K. Sunil Kumar	Tech. Assistant (Field/Farm)
144.	Mr. Jinu Sivadasan	Tech. Assistant (Field/Farm)
145.	Mr. V.P. Joy	Tech. Assistant (Field/Farm)
146.	Mr. R. Vijayan	Tech. Assistant (Vehicles)
KVK, Alappuzha		
147.	Mr. M.S. Rajeev	Asst.CTO (SMS) (Agronomy)
148.	Dr. S. Ravi	Asst.CTO (SMS) (Animal husbandry)
149.	Mr. T. Sivakumar	Asst.CTO (SMS) (Agrl. Entomology)
150.	Mrs. G. Lekha	Asst.CTO (SMS) (Plant Pathology)
151.	Mrs. Jissy George	Asst.CTO (SMS) (Home Science)
152.	Dr. Sajnanath	Asst.CTO (SMS) (Soil Science)
153.	Mrs. Arathy K. Balakrishnan	Sr. Tech. Asst (Prog.Asst.) (Agril. Extn.)
154.	Mr. K.M. Ansary	Technical Assistant (Computer)
155.	Mrs. Bijila P.V.	Technical Assistant (Hort.)
156.	Mr. Dayanandan Unnithan T.	Technical Assistant (Vehicles)
RS, Vittal		
157.	Mr. N. Ramakrishnan	Sr. Technical Officer (Field/Farm)
158.	Mrs. Meenakshy Patil	Sr. Technical Officer (Library)
159.	Mr. C. Purandhara	Technical Officer (Field/Farm)
160.	Mr. B. Koragu Naik	Sr. Technical Assistant
161.	Mr. Adolpheno Francis Mascaranchas	Sr. Technical Assistant (Ele.Engg.)
162.	Mr. Y. Sreenivasa Bhat	Sr. Technical Assistant (Field/Farm)
163.	Mr. Abdul Aziz	Sr. Technical Assistant (Field/Farm)
164.	Mr. B. Ananda Gowda	Technical Assistant (Field/Farm)
165.	Mr. V. Chandrasekhara Shetty	Technical Assistant (Vehicles)
166.	Mr. Ramanna Gowda	Technical Assistant (Vehicles)
167.	Mr. Santhosh Kumar P.	Technical Assistant (Field/Farm)
168.	Mr. K. Tharanatha Naik	Sr. Technician (Vehicles)
RC, Minicoy		
169.	Mr. P. Ravindran	Asst. CTO (Field/Farm)
170.	Mr. Shareefuddeen Hassan Karangothi	Technical Assistant (Field/Farm)
171.	Mr. M.I. Arif	Technician (Field/Farm)
RC, Kidu		
172.	Mr. N. Nagesh	Technical Officer (Field/Farm)
173.	Mr. Chandra Nairy	Technical Officer (Field/Farm)
174.	Mr. Manamohan	Technical Officer (Mech. Engg.)
175.	Mr. M. Narayana Naik	Sr. Technical Assistant (Field/Farm)
176.	Mr. A.S. Gopalakrishna	Sr. Technical Assistant (Field/Farm)
RC, Mohitnagar		
177.	Mr. Avrajyothi Ghosh	Sr. Technical Officer (Field/Farm)
178.	Mr. Jagadish Roy Burman	Technical Assistant (Field/Farm)

Sl. No.	Name	Designation
179.	Mr. Pratap Kumar Sarkar	Technical Assistant (Field/Farm)
180.	Mr. Jagadish Roy	Technical Assistant (Vehicles)
RC, Kahikuchi		
Sl. No.	Name	Designation
181.	Dr. Bikash Chowdhury	Asst. CTO (Field/Farm)
182.	Mr. Balen Kalita	Technical Officer up to 31.12.2015
183.	Mr. N.C. Das	Technical Officer (Field/Farm)
184.	Mr. Gopinath Malekar	Technical Assistant (Vehicles)
185.	Mr. Prakash Burman	Sr. Technician (Field/Farm)
ADMINISTRATIVE		
Kasaragod		
186.	Mr. Suresh Kumar	Chief Administrative Officer
187.	Mr. K.M. Jayarama Naik	Administrative Officer
188.	Mr. T.D.S. Prakash	Finance & Accounts Officer
189.	Mr. B. Sathish	Administrative Officer up to 26.08.2015
190.	Mrs. C.H. Usharani	Assistant Adminstrative Officer up to 31.07.2015
191.	Mr. T.E. Janardhanan	Assistant Administrative Officer
192.	Mr. K.S. Ramakrishnan	Assistant Administrative Officer
192.	Mrs. K. Prabhavathy	Assistant Administrative Officer
193.	Mrs. Sumithra Nambiar	Assistant Administrative Officer
194.	Mr. K.R. Nithianandan	Assistant Administrative Officer
195.	Mr. P.A. Radhakrishnan	Private Secretary up to 31.03.2016
196.	Mrs. K. Narayani	Private Secretary
197.	Mrs. Girija Chandran	Private Secretary
198.	Mrs. Sulochana Nair	Private Secretary
199.	Mr. K. Kunhiraman Nair	Private Secretary
200.	Mr. M.S. Antony	Assistant up to 30.11.2015
201.	Mrs. M. Reetha	Assistant
202.	Mrs. M. Ravindran	Assistant
203.	Mrs. Luizy D'Souza	Assistant
204.	Mrs. K.S. Vishalakshi	Assistant
205.	Mr. P.M. Thomas	Assistant
206.	Mr. K. Ramadasan	Assistant
207.	Mr. K.G. Bhageerath	Assistant
208.	Mr. K.T. Unni	Personal Assistant
209.	Mr. Neil Vincer	Personal Assistant (on deputation to NIANP, Bengaluru)
210.	Mrs. P.P. Sheeja	Junior Accounts Officer
211.	Ms. K.T.K. Sheenakumari	Upper Division Clerk
212.	Mrs. Rupa Manikandan	Upper Division Clerk
213.	Mr. P. Narayana Naik	Upper Division Clerk
214.	Mrs. K. Preethi	Upper Division Clerk
215.	Mr. Paulson Sam George	Upper Division Clerk
216.	Mrs. T.R. Remya	Lower Division Clerk
217.	Mr. T.K. Gangadharan	Lower Division Clerk
218.	Mrs. A.J. Mary	Lower Division Clerk
219.	Mr. N. Udayakumar	Lower Division Clerk
220.	Mr. P.K. Pramodkumar	Lower Division Clerk
221.	Mr. Jayarajan Valiyaveetil	Lower Division Clerk
222.	Mr. Ratan Singh	Lower Division Clerk
223.	Mr. Umesh Kumar	Lower Division Clerk
224.	Mr. Dinesh	Lower Division Clerk
225.	Mrs. A.R. Arathi	Stenographer Gr. III

Sl. No.	Name	Designation
RS, Kayamkulam		
226.	Mr. Pradeep Kumar Vasu	Assistant Administrative Officer
227.	Mr. S.B. Baburaj	Asst. Finance & Accounts Officer
228.	Mrs. Jainamma Job	Assistant up to 30.11.2015
229.	Mrs. Lathika Kumari D.	Assistant
230.	Mr. K. Haridas	Assistant
231.	Mr. K. Venugopal	Assistant
232.	Mrs. K. Sreelatha	Assistant
233.	Mrs. Vijaya Dileep	Private Secretary up to 30.11.2015
234.	Mr. C. Ramesh Babu	Personal Assistant
235.	Mrs. Prasanna Sarangan	Personal Assistant
236.	Mrs. V. Madhavikutty	Upper Division Clerk
237.	Mrs. Annamma N. Topino	Upper Division Clerk
238.	Mrs. Rejitha K.R.	Stenographer Gr. III (KVK)
239.	Mrs. Prema Pillai	Assistant (KVK)
RS, Vittal		
240.	Mr. P. Krishna Naik	Asst. Admn. Officer
241.	Mr. T.H. Nagaraj	Asst Admn. Officer up to 30.06.2015
242.	Mr. K.K. Sasi	Asst. Finance & Accounts Officer
243.	Mrs. K. Arunakumari	Assistant up to 29.02.2016
244.	Mrs. K. Subhadra	Assistant
245.	Mr. O. Pundarika	Upper Division Clerk up to 31.12.2015
246.	Mr. N. Lakshmana	Upper Division Clerk
247.	Mrs. K. Jayashree	Upper Division Clerk
248.	Mr. Aswin Reghunath	Upper Division Clerk
249.	Mr. P.K. Mohammed Haneefa	Lower Division Clerk
RC, Minicoy		
250.	Mr. T.N. Vidhyadharan	Assistant
RC, Kidu		
251.	Mr. P.K. Surendran	Assistant Administrative Officer
252.	Mr. Lakshmi Narayana	Lower Division Clerk
253.	Mr. Arun N.K. Raj	Lower Division Clerk
RC, Mohitnagar		
254.	Mr. Sushanta Roy	Assistant
255.	Mr. Sathya Bratha Moharana	Lower Division Clerk
RC, Kahikuchi		
256.	Mr. Subash Paul	Assistant
257.	Mr. T.J. Saji	Upper Division Clerk
258.	Mr. Deepak Meena	Lower Division Clerk

SKILLED SUPPORT STAFF	
Kasaragod	
Sl. No.	Name
259.	Mr. Mohd. Ashraf up to 30.04.2015
260.	Mrs. K. Lalitha up to 31.10.2015
261.	Mrs. Kuttiyamma up to 31.12.2015
262.	Mr. K. Rama
263.	Mr. M. Shankara
264.	Mr. Bhaskara Velichapad
265.	Mr. Srihari Ballaya
266.	Mr. Haridas Poojary
267.	Mr. P. Madhavan Nair

Sl. No.	Name
268.	Mr. P. Narayanan Nair
269.	Mr. K. Narayanan Nair
270.	Mrs. K. Baby
271.	Mr. K. Kunhikannan
272.	Mr. A. Mohana
273.	Mr. K. Keshava
274.	Mrs. K. Banu
275.	Mr. K. Sukumaran
276.	Mr. K.V. Krishnan
277.	Mr. P.A. Chaniya Naik
278.	Mr. P. Kumaran

Sl. No.	Name
279.	Mr. V.S. Pakeeran
280.	Mrs. V. Thambai
281.	Mrs. G. Kamala
282.	Mr. M. Murugan
283.	Mr. K.G. Sureshbabu
284.	Mr. T.J. Ninan
285.	Mr. K. Krishnankutty
286.	Mrs. Chithralekha Kodoth
287.	Mr. B. Chandrahasa
288.	Mr. V.T. Rameshan
289.	Mr. K. Krishnankunhi
290.	Mrs. K. Shobhana
291.	Mr. M. Krishnan
292.	Mr. V.A. Leela
293.	Mrs. U. Sarojini
294.	Mr. V. Krishnankutty
295.	Mr. P.P. Prabhakaran
296.	Mr. B. Ramachandran
297.	Mr. B. Sanjeeva Patali
298.	Mrs. N.V. Sasikala
299.	Mr. Lakshmana Naik
300.	Mrs. Lalitha Bai
301.	Mr. M. Velayudhan
302.	Mrs. S. Mohini
303.	Mr. N. Bhaskaran
304.	Mr. B. Sundara
305.	Mr. K. Suresan
306.	Mr. A. Madhu
307.	Mr. K.A. Madhavan
308.	Mr. K. Babu
309.	Mr. E.M. Aneesh
310.	Mrs. Vanamalini
RS, Kayamkulam	
311.	Mrs. U. Janaki up to 31.10.2015
312.	Mr. S. Sasidharan Pillai up to 30.11.2015
313.	Mr. K. Haridas up to 30.11.2015
314.	Mr. Sasidharan Achary
315.	Mr. M.E. Sivan
316.	Mr. K.B. Thankachan
317.	Mr. R. Ravindran
318.	Mr. K. Soman
319.	Mr. K. Omanakuttan
320.	Mr. K.C. Damodaran
321.	Mr. V.T. Unnikrishnan
322.	Mr. T.K. Mani
323.	Mr. K. Ravi
324.	Mr. K.V. Vijayan
325.	Mr. K.K. Sreedharan
326.	Mr. C. Sukumaran
327.	Mrs. K. Valsala
328.	Mr. C. Sundaran

Sl. No.	Name
329.	Mr. K.N. Sajeev
330.	Mr. K.P. Ibrahim
331.	Mrs. N. Suma
332.	Mr. A.T. Harikuttan
333.	Mrs. K. Saseendra
334.	Mr. C.R. Babu
335.	Mr. K.K. Shobhana
336.	Mr. Ajith Mattappadan
337.	Mr. R. Rajesh
338.	Mrs. L. Leena
339.	Mr. Ancil Pereira
340.	Mr. S. Rajesh
RS, Vittal	
341.	Mr. Poovani up to 30.04.2015
342.	Mr. Shivarama up to 30.11.2015
343.	Mr. Narayana Paleri
344.	Mr. Harischandra
345.	Mr. Chandu Naika
346.	Mr. Sudhakara
347.	Mr. A. Gopala
348.	Mr. D. Isubu
349.	Mr. B. Dharmapala
350.	Mr. K. Vinod
351.	Mr. Ibrahim
352.	Mr. K.C. Chinnappa
353.	Mr. B. Choma
354.	Mr. Iswara
355.	Mr. Mohana
356.	Mr. K. Somappa
357.	Mr. M. Ananda
358.	Mr. N.B. Mahesan
359.	Mr. K. Monappa Gowda
360.	Mr. K. Ismail up to 31.03.2016
RC, Minicoy	
361.	Mr. M.I. Abdulla
362.	Mr. Ibrahim D. Bidderge
363.	Mr. Valuge Ibrahim
364.	Mr. N. Reghu
RC, Kidu	
365.	Mrs. S.K. Mohini up to 30.05.2015
366.	Mr. Romayya Gowda up to 30.05.2015
367.	Mr. Sreedhara Gowda up to 30.05.2015
368.	Mrs. Rukmini
369.	Mr. Baliappa Gowda
370.	Mr. Medappa Gowda
371.	Mr. M. Parameshwara
372.	Mr. Balappa Gowda
373.	Mr. S. Venkataramana

Sl. No.	Name
374.	Mr. S. Chennappa
375.	Mrs. N. Bhavani
376.	Mrs. S. Susheela
377.	Mrs. Lolakshi
378.	Mr. S. Janardhana
379.	Mr. Dasappa Gowda
380.	Mrs. T. Susheela
381.	Mr. Padmayya Gowda
382.	Mrs. B. Bhavani
383.	Mrs. S. Rukmini
384.	Mr. S. Bhojappa
385.	Mr. S. Narayana
386.	Mrs. Komalangi
387.	Mr. V. Chennappa
388.	Mr. V. Jathappa Gowda
389.	Mr. S. Sheenappa Gowda

Sl. No.	Name
390.	Mr. S. Neelappa
391.	Mr. S. Regappa
392.	Mrs. Chandravathi
393.	Mr. M. Durgesha
RC, Mohitnagar	
394.	Mrs. Janaki Devi
395.	Mr. Sailen Seal
396.	Mr. Krishna Kumar Mandal
397.	Mr. Nripendra Chandra Roy
398.	Mr. Kartick Chandra Biswas
399.	Mr. Sushanta Burman
400.	Mr. Mahadev Misra
RC, Kahikuchi	
401.	Mr. Gopal Thapa
402.	Mr. Sathish Baishya
403.	Mr. Pankaj Das

CANTEEN STAFF

Kasaragod

Sl. No.	Name	Designation
404.	Mr. K. Jayaprakash	Bearer, (Canteen)
405.	Mr. B. Balakrishnan	Bearer (Canteen)
406.	Mr. K. Vijayan	Coupon Clerk (Canteen)
RS, Kayamkulam		
407.	Mr. Justin Jayaraj Das	Tea/Coffee Maker
408.	Mr. S. Parameshwaran	Wash Boy
409.	Mr. K. Raghavan	Bearer
RS, Vittal		
410.	Mr. A. Shivarama Poojary	Bearer
RC, Kidu		
411.	Mr. K. Honnappa	Tea/Coffee Maker up to 25.12.2015

WEATHER DATA 2015-16

ICAR-CPCRI, Kasaragod

Months	Temperature		RH %		Wind velocity (km h^{-1})	Sunshine (h)	Evaporation (mm)	Rainfall (mm)	Rainy days
	Min (°C)	Min (°C)	FN	AN					
April 2015	32.7	23.4	83	64	1.8	6.4	3.7	104.4	6
May 2015	32.6	23.6	86	69	1.4	5.3	3.0	073.0	5
June 2015	30.7	22.3	88	83	3.1	2.7	1.7	643.8	23
July 2015	29.7	22.3	93	83	1.7	3.7	1.8	806.0	25
Aug. 2015.	29.6	22.1	94	80	1.3	4.2	1.8	437.6	21
Sept. 2015	30.2	22.0	90	76	1.6	5.7	2.6	224.4	13
Oct. 2015	30.9	22.2	90	74	2.0	5.8	2.5	357.2	13
Nov. 2015	31.5	21.5	85	69	1.5	5.7	2.8	127.3	5
Dec. 2015	32.3	20.7	80	58	1.7	8.2	3.0	022.2	2
Jan. 2016	32.6	20.8	80	52	1.8	8.8	3.2	005.7	1
Feb. 2016	32.4	22.8	87	60	2.0	8.1	3.5	000.0	0
Mar. 2016	33.5	25.1	84	63	2.5	7.5	4.0	000.0	0

ICAR-CPCRI, Regional Station, Kayamkulam

Months	Temperature		RH %		Wind velocity (km h^{-1})	Sunshine (h)	Evaporation (mm)	Rainfall (mm)	Rainy days
	Max (°C)	Min (°C)	FN	AN					
April 2015	32.7	26.8	92	77	2.1	8.5	4.1	321.8	9
May 2015	31.9	26.4	92	79	1.7	6.7	3.6	271.5	11
June 2015	31.3	25.4	92	81	1.9	6.0	3.4	522.5	21
July 2015	30.5	24.4	93	84	2.2	6.1	3.4	202.8	19
Aug. 2015.	31.2	25.1	92	82	2.5	7.9	3.8	115.7	11
Sept. 2015	31.1	25.0	93	81	2.0	6.6	3.5	241.6	12
Oct. 2015	31.1	24.1	93	82	1.4	5.7	3.4	440.4	17
Nov. 2015	31.6	23.5	93	79	1.2	5.3	3.3	197.4	14
Dec. 2015	32.5	22.7	93	79	1.3	7.7	3.7	097.9	6
Jan. 2016	33.7	21.1	91	69	1.5	9.2	3.9	001.2	1
Feb. 2016	36.0	23.7	92	69	2.2	9.4	4.6	049.4	1
Mar. 2016	35.6	25.0	92	64	2.6	9.4	4.8	029.6	4

ICAR-CPCRI, Regional Station, Vittal

Months	Temperature		RH %		Wind Velocity (km h^{-1})	Sunshine (h)	Evaporation (mm)	Rainfall (mm)	Rainy days
	Max (°C)	Min (°C)	FN	AN					
April2015	34.7	23.6	93.2	55.8	2.8	5.3	4.3	036.4	3
May 2015	33.6	23.8	95.6	65.8	2.6	4.4	3.1	298.4	14
June 2015	30.7	23.3	97.6	79.4	3.0	2.0	2.0	604.9	19
July 2015	29.8	22.6	98.1	81.0	2.5	2.7	2.3	949.6	18
Aug. 2015	29.9	22.9	97.5	80.6	2.5	2.9	2.1	547.3	23
Sep. 2015	31.6	22.9	96.2	68.8	2.4	4.4	2.9	147.0	10
Oct. 2015	32.6	22.8	95.2	69.4	2.1	5.2	2.9	239.4	11
Nov. 2015	33.0	22.7	94.3	61.6	1.9	5.4	2.8	125.4	8
Dec. 2015	34.1	21.0	92.7	48.5	2.1	6.8	3.2	013.2	1
Jan. 2016	33.8	17.7	93.9	41.3	2.1	7.0	3.6	000.0	0
Feb. 2016	34.8	20.8	94.3	45.9	2.5	5.7	4.0	000.0	0
Mar. 2016	36.4	23.4	93.4	49.6	2.9	4.7	5.0	000.0	0

ICAR-CPCRI, Research Centre, Kidu

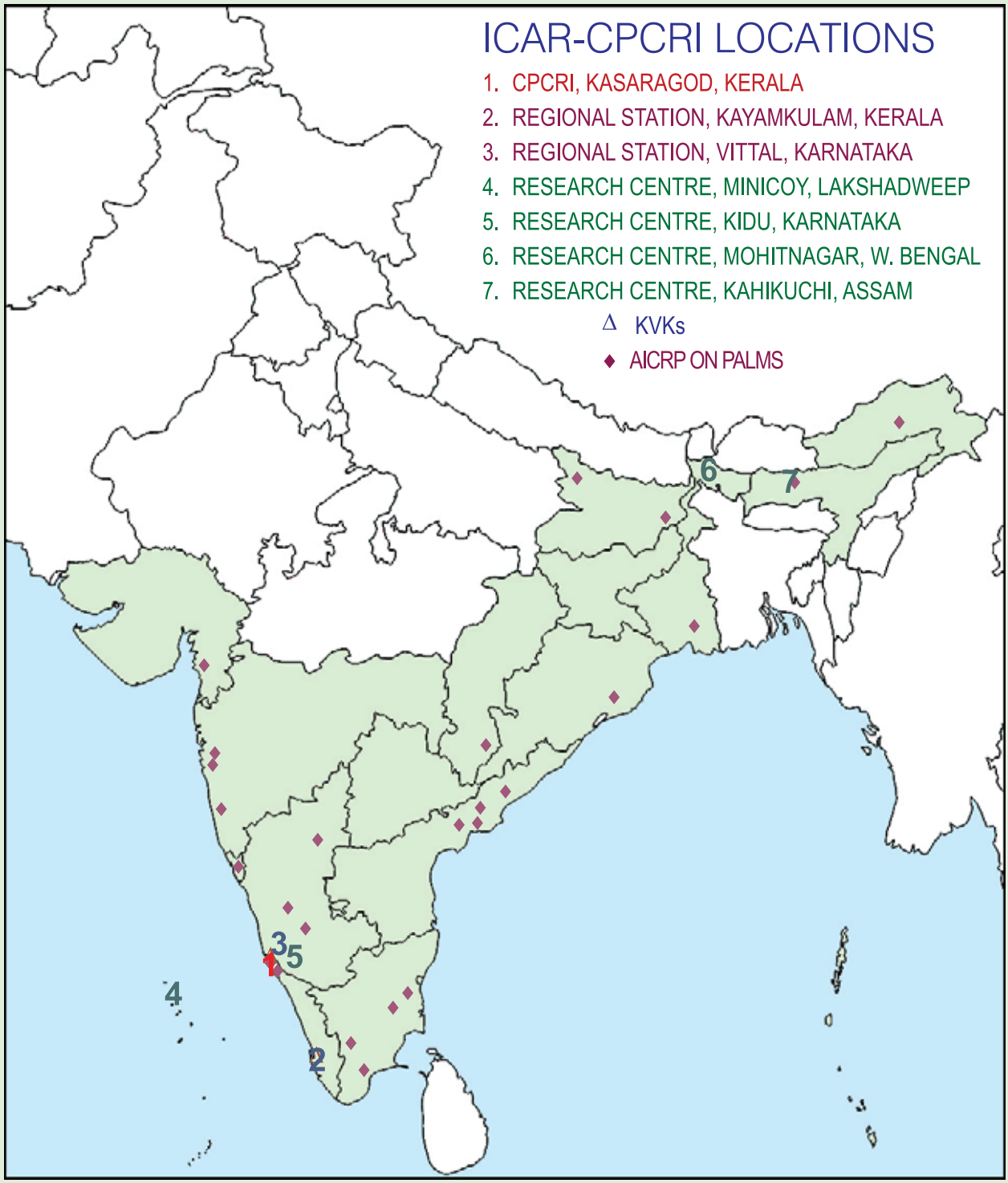
Months	Temperature		RH %		Wind velocity (km h^{-1})	Sunshine (h)	Evaporation (mm)	Rainfall (mm)	Rainy days
	Max (°C)	Min (°C)	FN	AN					
April 2015	35.2	21.2	94	53	---	7.6	6.2	313.6	13
May 2015	33.7	21.7	93	62	---	5.2	4.8	271.6	10
June 2015	30.3	20.8	95	83	---	2.1	3.4	712.0	25
July 2015	28.6	20.6	95	85	0.1	4.7	3.1	892.8	30
Aug. 2015	31.4	20.5	94	81	---	2.1	3.9	766.8	28
Sept. 2015	31.7	20.8	93	67	---	4.7	4.1	354.0	22
Oct. 2015	33.0	22.0	93	64	---	6.5	4.3	406.2	17
Nov. 2015	33.0	21.5	91	63	---	5.4	3.5	055.0	9
Dec. 2015	34.0	19.9	87	50	---	7.7	4.3	092.20	3
Jan.2016	34.5	16.7	90	41	---	8.7	4.1	---	---
Feb. 2016	35.7	20.9	91	43	---	7.7	5.0	---	---
Mar. 2016	37.3	23.1	91	43	---	7.3	6.4	---	---

ICAR-CPCRI, Research Centre, Minicoy

Months	Temperature		Wind Velocity (km h^{-1})	Sunshine (h)	Rainfall (mm)	Rainy days
	Max (°C)	Min (°C)				
April 2015	33.1	25.9	22	237.7	72.1	7
May 2015	32.9	26.7	38	191.5	90.5	16
June 2015	31.6	26.0	46	117.4	217.4	24
July 2015	31.4	25.5	40	194.0	286.6	24
Aug. 2015	31.8	25.8	30	255.6	203.6	22
Sept. 2015	30.3	24.6	40	163.3	209.5	21
Oct. 2015	30.5	25.3	34	198.1	192.5	20
Nov. 2015	30.9	25.0	30	135.3	304.2	19
Dec. 2015	32.7	26.8	22	158.40	207.5	13
Jan.2016	32.0	25.0	22	261.0	36.8	2
Feb. 2016	32.2	25.6	22	256.5	44.3	5
Mar. 2016	34.4	27.1	18	265.40	50	1

ICAR-CPCRI, Research Centre, Kahikuchi

Months	Temperature		R.H. (%)	Sunshine (h)	Rainfall (mm)	Rainy days
	Max (°C)	Min (°C)				
April 2015	35.0	18.3	77.40	5.27	183.0	9
May 2015	35.3	20.9	82.82	5.48	277.0	19
June 2015	35.1	22.9	87.07	4.53	235.0	16
July 2015	36.0	24.1	83.70	5.34	236.0	11
Aug. 2015	36.4	24.6	87.97	4.40	293.0	13
Sept. 2015	35.9	23.1	86.75	4.53	239.0	9
Oct. 2015	34.7	19.3	82.28	5.33	24.0	2
Nov. 2015	30.7	13.9	81.30	5.40	1.0	0
Dec. 2015	27.4	7.9	83.78	4.39	12.0	1
Jan. 2016	24.9	15.97	84.26	4.05	18.0	-
Feb. 2016	30.5	19.69	75.18	4.32	4.0	-
Mar. 2016	34.6	14.5	67.85	4.45	183.5	-


ICAR-CPCRI LOCATIONS
1. CPCRI, KASARAGOD, KERALA
2. REGIONAL STATION, KAYAMKULAM, KERALA
3. REGIONAL STATION, VITTAL, KARNATAKA
4. RESEARCH CENTRE, MINICOY, LAKSHADWEEP
5. RESEARCH CENTRE, KIDU, KARNATAKA
6. RESEARCH CENTRE, MOHITNAGAR, W. BENGAL
7. RESEARCH CENTRE, KAHIKUCHI, ASSAM
KVKs
AICRP ON PALMS
1
2
3
4
5
6
7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