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भा.कृ.अनु.प. - काजू अनुसंधान निदेशालय
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पुत्तूर–574 202 कर्नाटक, भारत

ICAR-Directorate of Cashew Research
(ISO 9001:2008)
Puttur - 574 202, Karnataka, India

भाकृअनुप ICAR

काअनि DCR

ICAR-Directorate of Cashew Research

Annual Report 2019

Shri. Parshottam Rupala, Union Minister of State for Agriculture and Farmer's Welfare and other dignitaries on the occasion of webcasting of inaugural function of PM-KISAN Scheme by Hon'ble Prime Minister of India on 24 February 2019 at ICAR-DCR, Puttur

Submission of Quinquennial Review Team (QRT) report of the ICAR-DCR, Puttur and AICRP on Cashew for the period 2013-2018 to Dr. T. Mohapatra, Secretary (DARE) & Director General (ICAR), New Delhi on 12 February 2019

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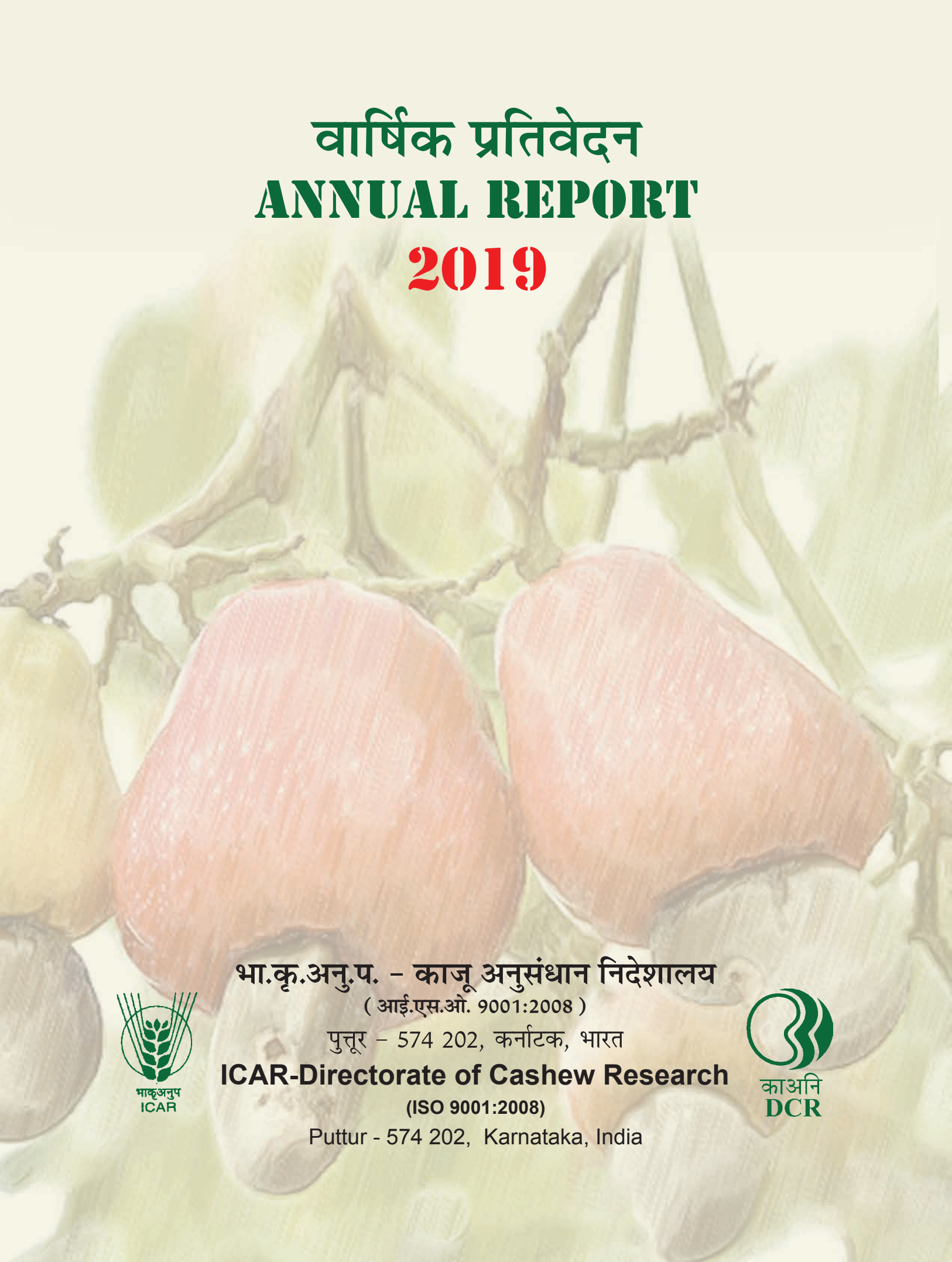
ANNUAL REPORT
2019



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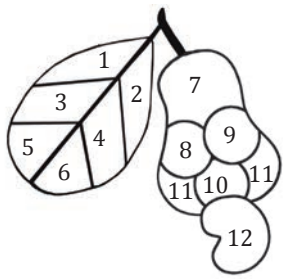
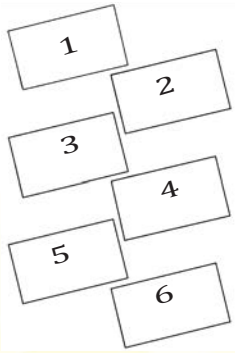
Front cover

1) Occupancy of artificial nests by cashew pollinator, *Braunsapis picitarsus*; 2) TMB males trapped in baited traps; 3) Cashew phenology; 4) Mobile app for nutrient management; 5) Gene ontology (GO) of cashew genome; 6) Panicle of semi tall accession of cashew BDB-626-58; 7) Micro-wave plasma atomic emission spectrometer facility for nutrient analysis; 8) Cashew apple jelly; 9) "Cashlime", a cashew apple and lemon juice blended RTS beverage; 10) Cashew apple chew; 11) Cashew apple cider; 12) Kernels of H-130, a bold nut cashew hybrid developed at ICAR-DCR.



Back cover

From top to bottom: 1) Valedictory function of Vigilance awareness week; 2) Swacchata pakhwada cleanliness drive; 3) Web casting of address by Sri Narendra Modiji, Hon'ble Prime Minister of India on the occasion of International women's day; 4) Exhibition stall of ICAR-DCR at Krishi Mela of ICAR-CPCRI, Regional Center, Kidu; 5) Signing of MoU with M/s Newtech Industries, Mangaluru for commercialization of ICAR-DCR technologies; 6) Inaugural function of Hindi week by Puttur TOLIC at ICAR-DCR.



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प्राक्कथन

मुझे, भाकृअनुप – काजू अनुसंधान निदेशालय (ICAR-DCR), पुत्तूर का वार्षिक प्रतिवेधन 2019 प्रस्तुत करते हुए अत्यंत हर्ष का अनुभव हो रहा है। इस प्रतिवेदन में रिपोर्टाधीन अवधि के दौरान, संस्थान की गतिविधियों के साथ साथ फसल सुधार, फसल प्रबंध, फसल सुरक्षा, फसलोत्तर प्रौद्योगिकी एवं प्रौद्योगिकी हस्तांतरण के क्षेत्र में हासिल की गई उल्लेखनीय अनुसंधान उपलब्धियों पर प्रकाश डाला गया है।

फसल सुधार के अंतर्गत, चलाए गए प्रमुख कार्यक्रमों में शामिल हैं : बौने तथा सुगठित काजू संकरों का विकास करने के लिए प्रजनन कार्यक्रम, क्लस्टेर धारण करने वाले जीनप्ररुपों में बीज आकार में सुधार के लिए प्रजनन कार्यक्रम, उपज गुणों, टी मॉस्किटो बग (TMB) सहिषणुता जैसे वांछनीय गुणों के लिए जननद्रव्य प्राप्तियों का लक्षणवर्णन करना, श्रेष्ठ काजू फल गुणवत्ता वाले काजू जीनप्ररूपों की पहचान करना, सूक्ष्म सेटेलाइट मार्करों का विकास करना, काजू में आनुवंशिक लिंकेज का नक्शा एवं पोपुलेशन अथवा संख्या संरचना अध्ययन तथा क्यूटीएल द्वारा नियंत्रित काजू बिज उपज और काजू के छिलके में तेल अंश (CNSL) का आनुवंशिक पृथक्करण । फसल प्रबंधन संभाग के अंतर्गत हासिल की गई प्रमुख अनुसंधान उपलब्धियों का मुख्य फोकस काजू की किस्म भास्कर के घटनाविज्ञान पर उर्वरकों को प्रयोग करने के समय के प्रभाव का पता लगाने और अल्ट्रा उच्च सघनता रोपण के तहर खनिज पोषण आवश्यकता का इष्टतमीकरण करने पर बना रहा। फसल सुरक्षा संभाग के तहत, टी मॉस्किटो बग (TMB) तथा काजू तना एवं जड़ बेधक (CSRB) का सेमियो केमीकल्स आदारित प्रबंधन करने और काजू के इन प्रमुख नाशीजीवों के प्रबंधन हेतु वैकल्पिक कीटनाशकों का विकास करने की दिशा में लगातार प्रयास किए गए। रिपोर्टाधीन वर्ष के दौरान, टी मॉस्किटो बग (TMB) एवं लेपिडोप्टेरोंन कीड़े सहित पुष्पक्रम नाशीजीवों का भारी संक्रमण देखने को मिला। फसलोत्तर प्रौद्योगिकी संभाग के अंतर्गत, हासिल की गई प्रमुख उपलब्धियों में शामिल है : काजू बीज की गुणवत्ता का आकलन करने के लिए अनुभवजन्य मॉडल्स का विकास करना, मैकेनाइज्ड़ काजू फल स्लाइसर की डिजाइन में सुधार करना, काजू बीज, बिना छिले तथा छिले हुए काजू बीज में नमी की मात्रा का पता लगाने के लिए मैसर्स इमकॉन के साथ सहयोग करके विकसित नमी मीटर का मापांकन करना, काजू फल तथा काजू अंकुरों से मूल्यवर्धित उत्पादों का विकास करना जिनमें शामील हैं, काजू फल चिव, काजू फल अंजीर, काजू फल चटनी, काजू फल क्रिस्प, कैशलाइम, साइडर, जैम तथा जैली।

काजू से जुड़े हितधारकों तक काजू उत्पादन एवं फसलोत्तर प्रौद्योगिकी का हस्तांतरण करना निदेशालय की गतिविधियों का प्राथमिकता क्षेत्र बना रहा। आरकेवीवाई – रफतार (RKVY-RAFTAAR) द्वारा वित्त पोषित परियोजना के तहत प्रिसीजन कृषि के अंतर्गत ऑन–फार्म प्रदर्शन प्लॉट स्थापित किया गया। इसके अलावा, उत्तर कन्नड, दक्षिण कन्नड एवं उडुपी जिलों में भागीदारी अनुसंधान के साथ प्रदर्शन लगाए गए। निदेशालय ने काजू प्रौद्योगिकियों का प्रसार करने के उद्देश्य से देश के अनेक भागों में आयोजित प्रदर्शनियों में अपनी भागीदारी दर्ज कराई। किसानों को सशक्त एवं समर्थ बनाने के प्रयास में, निदेशालय द्वारा काजू की खेती पर एक मोबाइल ऐप और पोषक तत्व प्रबंधन पर सॉफटवेयर एवं मोबाइल ऐप विकसित किए गए। निदेशालय के वैज्ञानिकों ने रेडियो वार्ता में भाग लिया और विभिन्न कार्यक्रमों में संसाधन व्यक्तियों के रूप में व्याख्यान प्रस्तुत किया। भाकृअनुप – काजू अनुसंधान निदेशालय (ICAR-DCR), पुत्तूर द्वारा स्वयं विकसित की गई काजू प्रौद्योगिकियों का व्यावसायीकरण करने के लिए विभिन्न संगठनों के साथ समझौता ज्ञापन (MoU) पर हस्ताक्षर किए गए।

रिपोर्टाधीन वर्ष के दौरान, निदेशालय द्वारा अनेक कार्यक्रम आयोजित किए गए जैसे कि अखिल भारतीय समन्वित काजू अनुसंधान परियोजना की वार्षिक समूह बैठक, काजू दिवस, प्रधानमंत्री – किसान सम्मान निधि उद्घाटन कार्यक्रम, अंतर्राष्ट्रीय महिला दिवस, निदेशालय का स्थापना दिवस, हिन्दी सप्ताह, सतर्कता जागरूकता सप्ताह, स्वच्छता पखवाड़ा, संविधान दिवस तथा काजू प्रसंस्करण पर प्रशिक्षण कार्यक्रम। निदेशालय के वैज्ञानिकों द्वारा अनेक पुरस्कार एवं सम्मान हासिल किए गए और अनेक अनुसंधान लेख, सम्मेलन सारंश, लोकप्रिय लेख, प्रसार लीफलेट्स, तकनीकी बुलेटिन एवं पुस्तक अध्याय का प्रकाशन कराया गया।

निदेशालय की मृदा विज्ञान प्रयोगशाला में अनुसंधान सुविधाओं को RKVY-RAFTAAR परियोजना के तहत आधुनिक एवं मूलभूत उपकरणों की खरीद एवं स्थापना करके प्रोन्नत किया गया। रिपोर्टाधीन वर्ष में सृजित की गई अन्य सुविधाओं में शामिल हैं : संस्थान रजत जयंती भवन में म्यूज़ियम का प्रथम चरण, एक खेत भण्डार तथा प्रक्षेप द्वार।

अपना सत प्रोत्साहन, मार्गदर्शन और सहयोग प्रदान करने के लिए मैं, डॉ. त्रिलोचन महापात्र, सचिव, डेयर एवं महानिदेशक, भाकृअनुप, डॉ ए.के. सिंह, उप महानिदेशक (बागवानी विज्ञान), तथा डॉ. डब्ल्यू एस. ढिल्लो, सहायक महानिदेशक (बागवानी विज्ञान), भाकृअनुप का अत्यंत आभारी हूं। निदेशालय द्वारा की गई प्रगति में अपना मूल्यवान योगदान देने के लिए मैं संस्थान के सभी वैज्ञानिकों एवं स्टाफ सदस्यों को धन्यवाद देता हूं। इस वार्षिक प्रतिवेधन के प्रभावी संकलन में सम्पादन एवं प्रकाशन समिति के सदस्यों द्वारा किए गए सार्थक प्रयासों के प्रति मैं अपना आभार व्यक्त करता हूं।

स्थान : भाकृअनुप – डीसीआर, पुत्तूर
दिनांक : 10 अप्रैल, 2020

(एम.गंगाधर नायक)
निदेशक (प्रभारी)

PREFACE

I am delighted to present the Annual Report 2019 of ICAR-Directorate of Cashew Research (ICAR-DCR), Puttur. The report presents a bird's eye view of the achievements made by this Directorate during the year in the areas of crop improvement, crop management, crop protection, post harvest technology and transfer of technology along with other institutional activities.

Under the crop improvement, the major programmes include breeding for developing dwarf and compact cashew hybrids, breeding for improvement of nut size in cluster bearing genotypes, characterisation of germplasm accessions for desirable characters such as yield traits, Tea Mosquito Bug (TMB) tolerance, identifying the cashew genotypes with superior apple quality, development of microsatellite markers, linkage analysis and population structure studies in cashew and genetic dissection of QTLs governing nut yield and cashew nut shell liquid (CNSL). Under crop management, the major focus was on finding out the influence of time of fertiliser application on the phenology of cashew variety Bhaskara and optimising the mineral nutrition requirement under ultra high density planting. In the crop protection, efforts were continued to develop semiochemicals based management of TMB and Cashew Stem and Root Borer (CSRB), and also the research for alternate insecticides for management of these major pests of cashew were continued. Heavy infestation of inflorescence pests including TMB and lepidopterans was observed during the year. In post harvest technology section, major achievements include the development of empirical models for assessing the quality of raw cashewnuts, modifying the design of mechanized cashew apple slicer; calibration of moisture meter developed by M/s EMCON, Kochi for the estimation of moisture content in raw cashewnuts, unpeeled and peeled cashew kernels; and the development of value-added products from cashew apple, which include cashew apple chew, cashew apple fig, cashew apple sauce, cashew apple crisp, cashlime, cider, jam and jelly , and other products from cashewnut sprouts

The transfer of cashew production and post harvest technologies to the stakeholders was a priority area of activity of the Directorate. On-farm demonstration plot under precision farming was established under the project funded by RKVY-RAFTAAR. Besides, demonstration with participatory research was undertaken in the districts of Uttara Kannada, Dakshina Kannada and Udupi. The Directorate participated in exhibitions in various parts of the country to disseminate the technologies. In an effort to empower farmers, a mobile App on cashew cultivation, and a software and a mobile App on cashew nutrient management were developed. The scientist of the Directorate also delivered radio talks and lectures as resource persons in different programmes. The Directorate also entered into MoU with different organisations to commercialise the technologies developed by it.

The Directorate organised different programmes such as Annual Group Meeting of AICRP on Cashew, Cashew day, PM-Kisan inaugural programme, International women's day, Foundation day, Hindi week, Vigilance awareness week, Swacchata pakhwada, Constitution day and a training programme on Cashewnut processing. The scientists secured several awards and honours and published a number of research articles, conference abstracts, popular articles, extension leaflets, technical bulletins and book chapters.

The research laboratory facilities of Soil Science section of the Directorate was strengthened with the purchase and installation of both advanced and basic instruments under RKVY-RAFTAAR project. The other facilities created include establishment of phase I of the museum in the silver jubilee building, a field store and field gates.

I am grateful to Dr. T. Mohapatra, D.G., ICAR; Dr. A.K. Singh, DDG (Hort.); and Dr. W.S. Dhillon, ADG (Hort.) for their constant encouragement, guidance and support. I am thankful to all the scientists and staff members for their valuable contribution in the progress made by the Directorate. I sincerely acknowledge the efforts made by the members of the editorial and publication committee for the effective compilation and editing of the Annual Report.

Place : ICAR-DCR, Puttur
Date : 10th April, 2020

(M. Gangadhara Nayak)
Director (Acting)

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1. कार्यकारी सारांश

भाकृअनुप - काजू अनुसंधान निदेशालय (ICAR-DCR), पुत्तूर, काजू फसल के उत्पादन, प्रसंस्करण तथा मूल्य वर्धन के संवर्धन हेतु अनुसंधान एवं प्रसार गतिविधियां चलाने में पथ-प्रदर्शक बना हुआ है। रिपोर्टाधीन अवधि के दौरान, पांच प्रमुख अनुसंधान कार्यक्रमों यथा आनुवंशिक संसाधनों का प्रबंधन, फसल सुधार, फसल प्रबंधन, फसल सुरक्षा तथा फसलोत्तर प्रौद्योगिकी के तहत भाकृअनुप - काजू अनुसंधान निदेशालय (ICAR-DCR) पुत्तूर की उल्लेखनीय उपलब्धियों और साथ ही किसानों एवं अन्य हितधारकों तक प्रौद्योगिकी हस्तांतरण में हासिल की गई उपलब्धियों को यहां सारांश रूप में प्रस्तुत किया गया है।

फसल सुधार

काजू के छिलके में तेल अंश (CNSL), काजू उद्योग का एक प्रमुख उपोत्पाद है जिसका कि अत्यधिक औद्योगिक एवं औषधीय मान होता है। वर्तमान वर्ष में, काजू के छिलके में तेल अंश (CNSL) का पता लगाने के लिए कुल बीस जननद्रव्य प्राप्तियों का मूल्यांकन किया गया। काजू जननद्रव्य डाटाबेस (http://cashew.icar.gov.in/dcr) को 76 जननद्रव्य प्राप्तियों से जुड़े 842 चित्रों के साथ समृद्ध बनाया गया और रिपोर्टाधीन वर्ष में इस डाटाबेस को कुल 2929 बार देखा गया।

उत्परिवर्तन अथवा म्यूटेशन के माध्यम से नवीन आनुवंशिक भिन्नताा उत्पन्न करने के लिए काजू की दो लोकप्रिय किस्मों यथा भास्कर एवं उल्लाल-3 की कुल 113 पौद तथा कलमों (गामा किरणों से उपचारित बीज एवं कलमें) को विकसित किया जा रहा है और बौनापन, अत्यधिक शाखा प्रवृति आदि जैसे गुणों के लिए मूल्यांकन किया जा रहा है। काजू जीनप्ररूपों के डीयूएस लक्षणवर्णन के भाग के तौर पर, वर्ष 2019 के दौरान कुल 30 मानाक किस्मों को स्थापित किया गया और उनका रख-रखाव किया गया।

बौनी तथा सुगठित काजू संकर किस्मों का विकास करने की दिशा में किए गए प्रयासों के परिणामस्वरूप रिपोर्टाधीन वर्ष के दौरान धना x एनआरसी-492 (बौना जीनप्ररूप) से उत्पन्न एक आशाजनक अर्ध ऊंचा जीनप्ररूप, वृक्ष संख्या 8 का चयन करने में मदद मिली। इसके अलावा, दो संकरों यथा क्राँस मडक्कथारा-2 x एनआरसी-492 की वृक्ष संख्या 102 तथा क्राँस वेंगुर्ला-4 x तालीपरम्बा-1 की वृक्ष संख्या 5 में क्रमश: 11.10 किग्रा. तथा 10.86 किग्रा. की उच्चतर संचयी बीज उपज दर्ज की गई जबकि इनकी तुलना में स्थानीय तुलनीय किस्म भास्कर में 10.74 किग्रा., की बीज उपज ही दर्ज की गई। इन दोनों संकर किस्मों की पहचान की गई। काजू में प्रमुख गुणों के लिए जीन कार्रवाई की प्रवृति का पता लगाने के उद्देश्य से इस वर्ष छ: पीढियों यथा P_1, P_2, F_1, F_2, B_1, B_2 को शामिल करते हुए पीढ़ी माध्य विश्लेषण पर एक अध्ययन किया गया। काजू फल तथा काजू के गुणों के लिए कुल 17 चयनित काजू जननद्रव्य प्राप्तियों की छंटाई करने पर पता चला कि वसा मात्रा में भिन्नता एनआरसी-18 में 22 प्रतिशत से लेकर एनआरसी-38 4 में 29 प्रतिशत तक थी। पुन: एनआरसी-301 में सबसे लंबे (9.33 सेमी.) तथा भारी काजू फल (188.80 ग्राम) थे जबकि सबसे चौड़ा काजू फल एनआरसी-389 (7.09 सेमी.) में दर्ज किया गया। 9-प्वाइंट हेडोनिक स्केल का उपयोग करके, ताजा फलों का ज्ञानेन्द्रिय सुग्राह्य (ऑर्गेनोलेप्टिक) मूल्यांकन किया गया जिसमें पता चला कि एनआरसी-301 के काजू फल, अपने रंग एवं सुगंध के आधार पर आकर्षक थे और इस वंशक्रम की कुल मिलाकर स्वीकार्यता जांची गई प्राप्तियों में बेहतर थी जबकि कुल मिलाकर स्वीकार्यता के संबंध में अधिकतम मान वेंगुर्ला-8 के साथ पाए गए। संकर जीनोम एसेम्बली युक्ति का प्रयोग करके पहली बार लोकप्रिय भारतीय काजू की व्यावसायिक किस्म भास्कर का एक मसौदा जीनोम अनुक्रमण उत्पन्न किया। 2.55 Mb के स्काफोल्ड N50 के साथ 4,981 स्काफोल्ड में व्यवस्थित काजू जीनोम का कुल जीनोम एसेम्बली 385 Mb (92 प्रतिशत) है। एकचित्र किए गए जीनोम की जीन व्याख्या तथा जीन पूर्वानुमान में कुल 40,264 प्रोटीन कोडिंग जीन प्रदर्शित हुए जिनमें से 32,194 व्याख्या वाले प्रोटीन और 8,070 गैर व्याख्या वाले प्रोटीन थे। पुन:

59 प्रतिशत डाइ-रिपीट्स एवं तदुपरांत 24.4 प्रतिशत ट्राई-न्यूक्लियोटाइड, 3.6 प्रतिशत टेट्रा - न्यूक्लियोटाइड, 1 प्रतिशत पेंटा - न्यूक्लियोटाइड तथा 0.8 प्रतिशत हेक्सा - न्यूक्लियोटाइड रिपीट्स एवं 11.1 प्रतिशत कॉम्पलेक्स एसएसआर मोटिफ को शामिल करते हुए कुल 47,646 एसएसआर की पहचान की गई। काजू जीनोम की डिकोडिंग करने से काजू में जीनोमिक सहायतार्थ प्रजनन का आधार तैयार होता है जो काजू में उपज, जैविक तथा अजैविक दबाव सहिष्णुता, परिवर्तित पौधा संरचना अथवा बनावट, गुणवत्ता विशेषताओं और अन्य उपयोगी गुणों में सुधार ला सकता है।

क्यूटीएल नियंत्रित बीज उपज तथा काजू के छिलके में तेल अंश (CNSL) का मानचित्रण करने के लिए विकसित की गई दो मानचित्रण पौधो समूह यथा भास्कर x एनआरसी -188 एवं वेंगुर्ला-7 x एनआरसी-116 को आगे बढ़ाया गया। अन्य पांच क्रॉस यथा भास्कर x एच-130 (यूवी), एनआरसी-492 (बौना) x एच-130, एनआरसी-492 (बौना) x तालीपरम्बा, एनआरसी-492 (बौना) x वेंगुर्ला-7, तथा वेंगुर्ला-7 x एनआरसी-492 (बौना) के साथ इन संख्याओं की पौद बढ़वार विशेषताओं की तुलना करने पर पौद ऊंचाई और पत्ती आकार जैसे गुणों में उल्लेखनीय भिन्नता प्रदर्शित हुई।

फसल प्रबंधन

काजू की किस्म उल्लाल-3 के घटनविज्ञान अथवा फीनोलॉजी पर उर्वरक आवेदन के समय के प्रभाव का अध्ययन किया गया जिसमें पता चला कि सितम्बर के महीने में उर्वरकों का प्रयोग करने पर कंट्रोल की तुलना वाले उपचारों में प्रजनन संबंधी फीनोलॉजिकल विकास चरणों की अगेती शुरूआत को उत्तेजित किया। प्रौद्यागिकी को प्रचलित करने के लिए युडीपी के तहत काजू का पोषणिक प्रबंधन करना आज समय की मांग है। काजू फसल में युडीपी के तहत प्रारंभिक मृदा पोषण स्तरों का विश्लेषण किया गया ताकि खनिज पोषण का इष्टतमीकरण किया जा सके और काजू में युडीपी के लिए एक उर्वरक पोषक तत्व प्रबंधन पैकेज का विकास किया जा सके। परिणामों में मृदा में पीएच की सीमा 5.5 से 5.92, विदयुत चालकता 0.053 से 0.056 dSm^{-1}, 0 से 30 सेमी. परत वाली सतह में जैविक कार्बन की मात्रा 0.59 से 0.69 प्रतिशत पाई गई । सतह परत में उपलब्ध नाइट्रोजन मात्रा में 275 से 325 किग्रा. प्रति हेक्टेयर की भिन्नता प्रदर्शित हुई।

फसल सुरक्षा

भारत में काजू फसल में टी मॉस्किटो बग (TMB) एक प्रमुख नाशीजीव है जिसके कारण गंभीर रूप से उपज नुकसान होता है। टी मॉस्किटो बग (TMB) की रोकथाम के लिए सेमियो-केमीकल्स पर किए गए अध्ययन से पता चला है कि टी मॉस्किटो बग (TMB) नरों को आकर्षित करने के लिए टी नव मादाओं की अधिकतम फिरोमॉन सक्रियता आविर्भाव उद्भव के उपरान्त (DAE) चौथे एवं पांचवे दिन के बीच होती है।

कीट नाशीजीवों की प्रभावी रोकथाम करने के लिए बेहतर कीटनाशक विशेषताओं वाले नए रसायन अणुओं अथवा माल्युकूल्स की पहचान करना जरूरी है। टी मॉस्किटो बग (TMB) की रोकथाम के लिए नवीन अणुओं अथवा माल्युकूल्स का मूल्यांकन करने पर पता चला कि थियामिथॉक्सम (0.2 ग्राम/लिटर) तथा λ - सैहलोथ्रिन (0.6 मिलि./लिटर) के साथ उपचार करने के 15 दिन बाद नुकसान अथवा क्षति स्कोर 0.5 से कम पाया गया। हालांकि, ये आशाजनक कीटनाशक उपचार के 30 दिन बाद नुकसान अथवा क्षति स्कोर को 0.5 से कम नहीं कर सके और साथ ही प्रयोगशाला मूल्यांकन के तहत उपचार के 45 दिन बाद नुकसान अथवा क्षति स्कोर 2.0 से कमतर नहीं कर सके।

काजू के पुष्पक्रम नाशीजीवों पर किए गए अन्वेषणों में प्रदर्शित हुआ कि भाकृअनुप-काजू अनुसंधान निदेशालय (ICAR-DCR), पुत्तूर के प्लॉटों में डिसम्बर के महीने में टी मॉस्किटो बग (TMB) का उच्चतर संक्रमण (20 से 30 प्रतिशत) और पुष्प कैटरपिल्लर के कॉम्पलेक्स का उच्चतर संक्रमण (25 से 35 प्रतिशत) पाया गया। कृत्रिम मधुमक्खी छत्तों में काजू के एक प्रमुख परागक *बी.पिसिटार्सस* द्वारा आवास अधिभोग पर किए गए अन्वेषण में प्रदर्शित हुआ कि *बी.पिसिटार्सस* के लिए सफल कृत्रिम आवास हेतु 3 मिमी. व्यास वाला आवास अथवा छत्ता सुराख उपयुक्त होता है।

फसलोत्तर प्रौद्योगिकी

काजू फल के लिए एक मैकेनिकल स्लाइसर का विकास किया गया और निजी फर्म द्वारा विकसित काजू गीरी और कच्चे काजू बीज के लिए थ्री इन वन आधारित नॉन गिरी डैस्ट्रक्टिव नमी मीटर का मापांकन एवं मूल्यांकन किया गया। भारत में विभिन्न श्रेणियों की काजू प्रसंस्करण इकाइयों के तुलनात्मक प्रदर्शन पर अध्ययन किया गया था और उत्पादकता बढ़ाने के लिए आने वाली समस्याओं की पहचान की गई। इसके अलावा, काजू फल से निर्जलीकृत उत्पाद जैसे कि वैक्यूम फ्राइड काजू फल चिप्स तथा काजू फल पाउडर आधारित एक्सटूडेट, काजू फल चिव, काजू फल अंजीर तथा काजू फल क्रिस्प विकसित किए गए। काजू के इन मूल्यवर्धित उत्पादों से काजू फल की आर्थिक उपयोगिता बढ़ने की अपेक्षा की जाती है अन्यथा अपनी अत्यधिक पेरीशेबल अर्थात् जल्दी खराब होने वाली प्रवृति के कारण अधिकांशत ये अपशिष्ट बन जाते हैं।

प्रौद्योगिकी हस्तांतरण एवं शिक्षा

प्रौद्योगिकी हस्तांतरण के भाग के रूप में आरकेवीवाई - रफतार (RKVY-RAFTAAR) द्वारा परियोजना को वित्तीय सहायता प्रदान की गई जिसके तहत कर्नाटक में काजू की खेती करने वाले जिलों में कुल 59 प्रदर्शन प्लॉट विकसित किए गए ताकि उच्चतर उपज हासिल करने हेतु उन्नत प्रौद्योगिकियों की उपयोगिता को प्रदर्शित किया जा सके। किसानों की भागीदारों के साथ इन खेत प्रदर्शनों से काजू की खेती करने वाले किसानों को अपने खेतों में प्रौद्योगिकियों के प्रभाव से लाभ मिलेगा। रिपोर्टाधीन वर्ष में, प्रौद्योगिकी हस्तांतरण के तहत कुल सात किसान खेत दौरे/प्रक्षेत्र दिवस /नैदानिकी खेत दौरे किए गए और काजू उत्पादन एवं प्रसंस्करण पर कुल 18 व्याख्यान/टीवी वार्ता/रेडियो वार्ता प्रस्तुत की गई। इसके अलावा, देश में काजू की खेती करने वाले किसानों व हितधारकों को जानकारी देने के लिए दो मोबाइल ऐप विकसित किए गए। मोबाइल फोन ऐप यथा ''कैश्यू इंडिया'' ऐप को भारत की 11 भिन्न भाषाओं में तैयार किया गया ताकि किसानों को काजू उत्पादन से संबंधित जानकारी दी जा सके। काजू में पोषक तत्व प्रबंधन के लिए एक अन्य मोबाइल ऐप विकसित किया गया। निदेशालय द्वारा कुल छः एम.एससी. छात्रों को अपनी अनुसंधान परियोजनाओं को करने और थीसिस लेखन कार्य में सुविधा प्रदान की गई। इसके साथ ही संस्थान द्वारा अखिल भारतीय समन्वित काजू अनुसंधान परियोजना के वैज्ञानिकों की वार्षिक समूह बैठक का भी समन्वयन किया गया जिसका आयोजन दिनांक 13-14 दिसम्बर, 2019 के दौरान बागवानी विज्ञान विश्वविद्यालय, बागलकोट में किया गया था। संस्थान प्रौद्योगिकी प्रबंधन इकाई (ITMU) जिस पर इस निदेशालय में विकसित प्रौद्योगिकियों का व्यावसायीकरण करने की जिम्मेदारी है, द्वारा कुल 6 काजू प्रसंस्करण मशीनरी प्रौद्योगिकियों के व्यावासायीकरण के लिए निजी फर्मो के साथ समझौते किए गए। संस्थान प्रौद्योगिकी प्रबंधक इकाई (ITMU) द्वारा पेटेन्ट कार्यालय, चैन्नई में दर्ज किए गए पेटेन्ट एप्लीकेशन की स्थिति का नियमित रूप से अवलोकन किया जा रहा है। पुनः अनुसंधान एसोसिएट, संस्थान प्रौद्योगिकी प्रबंधन इकाई (ITMU) ने गुजरात राज्य का दौरा किया ताकि वहां इस निदेशालय में विकसित प्रौद्योगिकियों के लिए संभाव्य लाइसेंसी की खोज की जा सके।

पंचवर्षीय समीक्षा दल (QRT) द्वारा वर्ष 2013 से 2018 की अवधि के लिए भाकृअनुप - काजू अनुसंधान निदेशालय (ICAR-DCR), पुत्तूर तथा अखिल भारतीय समन्वित काजू अनुसंधान परियोजना द्वारा किए गए कार्य की समीक्षा की गई और इसकी रिपोर्ट दिनांक 12 फरवरी, 2019 को भारतीय कृषि अनुसंधान परिषद् को प्रस्तुत की गई। निदेशालय द्वारा अनेक कार्यक्रमों जैसे कि स्थापना दिवस समारोह, अंतर्राष्ट्रीय योग दिवस, स्वच्छता ही सेवा अभियान, सतर्कता जागरूकता सप्ताह, वार्षिक काजू दिवस, प्रधानमंत्री किसान सम्मान निधि (PM-KISAN) तथा अंतर्राष्ट्रीय महिला दिवस का आयोजन किया गया। निदेशालय के हिन्दी सेल ने हिन्दी सप्ताह का आयोजन किया और साथ ही तिमाही एवं छमाही हिन्दी कार्यशालाओं का आयोजन भी किया। साल 2019-20 की अवधि के दौरान निदेशालय द्वारा और किसानों को 1,85,314 काजू कलम की आपूर्ति की गई। निदेशालय की मृदा विज्ञान प्रयोगशाला में आरकेवीवार्ड-रफतार (RKVY-RAFTAAR) द्वारा वित्त पोषित परियोजना के तहत स्टेट ऑफ आर्ट प्रयोगशाला सुविधाओं के साथ आधुनिक उपकरणों तथा माइक्रों वेव प्लाज्मा एटॉमिक इमीशन स्पेक्ट्रोमीटर (MP-AES), Agilent 4210, यूवी विजीबल स्पेक्ट्रोफोटोमीटर, Shimadzu UV-1900 तथा आठ गौण उपकरणों की स्थापना करके पोषक तत्व प्रबंधन में उत्कृष्टता केन्द्र का सृजन किया गया।

1. EXECUTIVE SUMMARY

ICAR-Directorate of Cashew Research (ICAR-DCR), Puttur has been in the forefront in carrying out research and extension activities to enhance the production, processing and value addition of the cashew crop. The significant achievements of ICAR-DCR in the five major research programmes i.e. management of genetic resources, crop improvement, crop management, crop protection and post harvest technology and also the achievements made in transfer technologies to the farmers and other stakeholders during the year 2019 are summarized here.

CROP IMPROVEMENT

CNSL is an important by-product of cashew industry having a great industrial and medicinal value. In the current year, twenty germplasm accessions were evaluated for CNSL content. The cashew germplasm database was enriched with 842 images belonging to 76 germplasm accessions and the database has been visited 2919 times during the year 2019.

To create novel genetic variations through mutations, 113 seedlings and grafts (from gamma-ray treated seeds and scion sticks) of two popular varieties i.e. Bhaskara and Ullal-3 have been raised and being evaluated for traits such as dwarfness, excessive branching etc. As part of DUS characterization of cashew genotypes, a total of 30 reference varieties have been established during 2019 and maintained.

The efforts to develop dwarf and compact cashew hybrids have yielded in the selection of a promising semi-tall genotype, Tree No. 8 derived from Dhana x NRC-492 (Dwarf genotype) during the reporting year. Besides, two hybrids viz., Tree No.102 of the cross Madakkathara-2 x NRC-492 and Tree No.5 of the cross Vengurla-4 x Thaliparamba-1 recorded higher 4-years cumulative nut yield of 11.10 kg and 10.86 kg, respectively, compared to that of local check Bhaskara (10.74 kg).

A study on generation mean analysis involving six generations viz., P_1, P_2, F_1, F_2, B_1 and B_2 was initiated to estimate the nature of gene action on important traits in cashew. Screening of 17 selected cashew germplasm accessions for cashew apple and nut characters showed that the fat content varied from 22% in NRC-18 to 29% in NRC-384 accessions. Further, NRC-301 had the longest (9.33 cm) and heaviest apples (188.80 g), and the broadest apple was recorded in NRC-389 (7.09 cm). The Organoleptic evaluation of fresh apples of these accessions according to the 9-point Hedonic scale showed that the cashew apple of NRC-301 was appealing based on colour and fragrance and the overall acceptability of this accession was better among the tested accessions, while the check Vengurla-8 scored the highest points with respect to the overall acceptability.

A draft genome sequence of the popular Indian cashew cv. Bhaskara was generated for the first time using the hybrid genome assembly approach. The total genome assembled is 385 Mb (92%) of the cashew genome arranged in 4,981 scaffolds, with a scaffold N50 of 2.55 Mb. The gene annotation and gene prediction of the assembled genome showed a total of 40,264 protein coding genes, of which 32,194 were annotated proteins and 8,070 were unannotated proteins. Further, a total of 47,646 SSRs were detected comprising of 59% of di-repeats followed by 24.4% tri-nucleotide, 3.6% of tetra-nucleotide, 1% of penta-nucleotide, and 0.8% of hexa-nucleotide repeats and 11.1% complex SSR motifs. The decoding of cashew genome forms the

basis for genomics assisted breeding in cashew to improve yield, biotic and abiotic stress tolerance, altered plant stature, quality traits and other useful traits in cashew.

The two mapping populations viz. Bhaskara x NRC-188 and Vengurla-7 x NRC-116 developed for mapping of QTLs governing the nut yield and CNSL was raised. The comparison of seedling growth characteristics of these populations with the five crossings viz. Bhaskara x H-130 (UV), NRC-492 (Dwarf) x H-130, NRC-492 (Dwarf) x Thaliparamba-1, NRC-492 (Dwarf) x Vengurla-7, and Vengurla-7 x NRC-492 (Dwarf) revealed significant differences for the traits like seedling height and leaf size.

CROP MANAGEMENT

The evaluation of the influence of time of fertilizer application on the phenology of cashew cultivar Ullal-3 showed that application of fertilizer in September month stimulated early onset of reproductive phenological growth stages compared to the control. Nutritional management of cashew under Ultra Density Plants (UDP) is the need of the hour to popularize the technology. An experiment was setup under UDP in cashew to optimize the mineral nutrition and to develop a fertilizer nutrient management package for UDP in cashew. The results of the initial soil analysis showed that soil pH ranged from 5.5 to 5.92, electrical conductivity from 0.053 to 0.056 dSm^{-1}, organic carbon from 0.59 to 0.69% in the surface 0 to 30 cm layer. The available nitrogen content in the surface layer varied from 275 to 325 kg ha^{-1}.

CROP PROTECTION

TMB is a major pest of cashew in India which causes severe yield losses. The investigations on semio-chemicals for management of TMB showed that the maximum pheromone activity of TMB virgin females to attract males occurs between 4th and 5th days after emergence (DAE).

Identification of new chemical molecules with better insecticidal properties is essential for effective management of insect pests. The evaluation of newer molecules for management of tea mosquito bug (TMB) showed that thiamethoxam (0.2g L^{-1}) and λ-cyhalothrin (0.6ml L^{-1}) could result in a damage score below 0.5 after 15 days after treatment (DAT). However, these promising insecticides could not lead to damage scores lower than 0.5 after 30 DAT and lower than 2.0 at 45 DAT under the laboratory evaluation.

The investigations on inflorescence pests of cashew showed that in the month of December, higher infestation by TMB (20-30%) and a complex of flower caterpillars (25-35%) was noticed in the ICAR-DCR plots. An investigation on nest occupancy by *Braunsapis picitarsus*, a major pollinator of cashew, in the artificial bee nests showed that for successful artificial nests for *B. picitarsus*, the nest hole of 3 mm diameter is ideal.

POST HARVEST TECHNOLOGY

A mechanical slicer for cashew apples, and a capacitance based 3 in 1 non-destructive moisture meter for raw cashewnuts, and for peeled and unpeeled cashew kernels were developed by ICAR-CIAE, Bhopal and M/s EMCON, Kochi and was calibrated and evaluated at ICAR-DCR, Puttur. A comparative performance study of various categories of cashewnut processing units in India helped to delineate the underlying problems for enhancing the productivity of industries. Besides, dehydrated products from cashew apple such as vacuum fried cashew apple chips and cashew apple ponace powder-based extrudates, cashew apple chew, cashew apple fig and cashew apple crisp were developed. These value-added products of cashew are expected to enhance the economic utility of cashew apples, which mostly go waste due to their highly perishable nature.

TRANSFER OF TECHNOLOGY AND EDUCATION

As part of technology transfer, in the project funded by RKVY-RAFTAAR, 59 demonstration plots were developed in cashew growing districts of Karnataka to showcase the usefulness of improved technologies to realize higher yield. These field demonstrations with farmer's participation is expected to benefit the growers to appreciate the impact of technologies in the field. In the year 2019, a total of 8 farmer's field visits/field days/ diagnostic field visits and 11 lectures/TV talks/Radio talks on cashew production and processing were given as part of the transfer of technology. Besides, two mobile apps were also developed for the transfer of know-how to the cashew farmers and stakeholders in the country. Mobile phone app viz. "Cashew India" app was developed in 11 different languages of India for transferring the cashew production-related knowledge to the farmers. Another mobile app for nutrient management in cashew was developed. The directorate also facilitated carrying out six M.Sc. students' research projects and thesis writing. The institute also coordinated the Annual Group Meeting (AGM) of Scientists of AICRP on Cashew which was organised at the University of Horticultural Sciences, Bagalkote from 13 to 14 December 2019. The Institute Technology Management Unit (ITMU), which shoulders the responsibility of commercialisation of technologies developed at the Directorate steered commercialization of 6 cashew processing machinery technologies to the private firms. ITMU unit is regularly following up the status of the patent application filed at the patent office, Chennai. Further, the research associate of ITMU visited the Gujarat state to explore the potential licensees for the technologies developed at this Directorate.

The Quinquennial Review Team (QRT) reviewed the work done by the ICAR-Directorate of Cashew Research, Puttur and All India Coordinated Research Project (AICRP) on Cashew for the period 2013-2018 and submitted its report to ICAR on 12 February 2019. The Directorate organised various events such as Foundation day, International day of yoga, Swachhata Hi Sewa campaign, Vigilance awareness week, Annual cashew day, Pradhan Mantri Kisan Samman Nidhi (PM-KISAN) and International women's day. The Hindi cell of the Directorate conducted Hindi week and also quarterly and half-yearly Hindi workshops. During the FY 2019-20, the Directorate generated Rs. 116.45 Lakhs revenue through the sale of grafts and other services. The directorate has supplied 1,85,314 cashew grafts to farmers from 2019-20. In the project funded by RKVY-RAFTAAR, a centre for excellence in nutrient management with the state of art laboratory facilities was created in the Soil Science Section of the Directorate with the installation of modern instruments such as Micro-wave Plasma Atomic Emission Spectrometer (MP-AES-Agilent 4210), UV-Visible Spectrophotometer (Shimadzu UV-1900) and eight minor equipments.

2. INTRODUCTION

2.1. History

Cashew (*Anacardium occidentale* L.) is a tree native of Eastern Brazil, which was introduced to India by the Portuguese in the 16th Century. Over the years, cashew became a crop with high economic value and is earning considerable foreign exchange for the country. Research on cashew in India was first initiated in the early 1950s. The Indian Council of Agricultural Research (ICAR), sanctioned ad hoc schemes for Research Centres located at Kottarakkara (Kerala), Ullal (Karnataka), Bapatla (Andhra Pradesh), Daregaon (Assam) and Vengurla (Maharashtra). In 1971, ICAR also sanctioned an All India Coordinated Spices and Cashew Improvement Project (AICS & CIP) with its headquarters located at ICAR-Central Plantation Crops Research Institute (CPCRI), Kasaragod. The CPCRI Regional Station, Vittal, Karnataka was given the mandate to carry out research work on cashew while four Centres under different Universities (viz. Bapatla, Vridhachalam, Anakkayam and Vengurla) were assigned the research component on cashew under AICS & CIP. During the V and VI plan periods, three more Centres (viz. Bhubaneswar, Jhargram and Chintamani) came under the fold of AICS & CIP and with shifting of work of Anakkayam Centre to Madakkathara. The recommendations made by the Quinquennial Review Team (QRT) constituted by ICAR in 1982, the working group on Agricultural Research and Education constituted by the Planning Commission for VII Plan Proposals and the Task Force on Horticulture constituted by ICAR resulted in the establishment of National Research Centre for Cashew (NRCC) at Puttur on 18 June 1986. During the VII Plan period, AICS & CIP was bifurcated into two separate projects, one on cashew and another on spices. The headquarters of independent AICRP on Cashew was shifted to the newly established NRCC, Puttur in 1986. NRCC was upgraded and renamed as **Directorate of Cashew Research (DCR)** by ICAR on 23 March 2009 under XI Plan. At present, the AICRP on Cashew is operating at 14 Centres distributed in major cashew growing regions of the country. The prefix "ICAR" was added before the Institute name since 2014 as per the instruction of ICAR, New Delhi.

2.2. Location

The main campus of ICAR-DCR is situated 5 km away from Puttur town at Mottethadka village of Kemminje (12.45°N latitude, 75.15°E longitude and 90 m above MSL). The main campus has an area of 69 ha having an administrative block, research laboratories and field experiment plots. Besides, the Directorate has an Experimental Station at Shantigodu, located 13 km away from the main campus which has an area of 80 ha. The institute is conducting and coordinating research on different aspects of cashew such as germplasm collection and conservation, crop improvement, crop production, crop protection, post harvest technology and transfer of technology.

2.3. Vision, Mission and Mandates

Vision

- Accomplishing self-sufficiency in raw cashewnut production and maintaining the premier position as the largest producer, processor and exporter at the global level.

Mission

- To promote overall growth through the enhancement of production and productivity in cashew.

Mandates

- To undertake strategic, basic and applied research for enhancing productivity, quality, processing efficiency and value addition of cashew.
- To serve as a national repository of genetic resources and scientific information on cashew.
- To coordinate All India Coordinated Research Project on Cashew for addressing location and region-specific problems.

- To promote capacity building through the transfer of technology and consultancy services to stakeholders.

2.4. Organogram

The Director is the administrative head of the Directorate. The Institute Management Committee (IMC), Research Advisory Committee (RAC) and Institute Research Committee (IRC) assist the Director in the matters relating to the management and research activities of the directorate respectively (Fig. 2.1). The research and extension on various aspects of cashew are conducted in five sections viz., Crop improvement, Crop management, Crop protection, Post harvest technology and Transfer of technology. The institute also has different laboratories for sections of Horticulture, Soil Science, Plant Breeding, Plant Physiology, Biotechnology, Plant Protection and Postharvest Technology. The other facilities available at the directorate include Audio Visual Laboratory, Priority Setting, Monitoring and Evaluation Cell (PME), Institute Technology Management Unit (ITMU), Agricultural Knowledge Management Unit (AKMU), Vigilance Cell, Women cell, Library and Museum. The Directorate also functions as headquarter for the All India Coordinated Research Project on Cashew.

2.5. Library/AKMU/ITMU

The Directorate has got a well-established library in the field of cashew research. The library is serving as an Information Centre on all aspects of cashew research and development in the country. The CD database viz. CABHORT, CABPEST, AGRICOLA and AGRIS, SOIL CD, CROP CD, PLANTGENE CD and TROPAG CD and online CAB database are also available. The library is equipped with automation software and barcoding facility. The library has 1938 books and 2030 back volumes of various journals. The library subscribes 35 national and 2 international journals. The library is a member of Consortium of Electronic Resources on Agriculture (CeRA), New Delhi. Tech-Focuz digital library software is also available for CD Database search.

The Agricultural Knowledge Management Unit (AKMU) was established with the responsibility of developing Information and Communications Technology (ICT) in agricultural research, maintaining the Institute's network, the website and the webserver administration. The AKMU is managing the internet facilities and wi-fi connectivity at the Directorate. The Institute Technology Management Unit (ITMU) was established for intellectual property management and transfer/commercialization of agricultural technologies developed. At this Directorate, ITMU takes care of commercialization of technologies developed by ICAR-DCR, Puttur.

2.6. Staff

The Institute has a sanctioned strength of 17 scientific, 19 technicals, 15 administrative, 19 skilled support staff and 1 canteen staff, of which 13 scientists, 11 technical staff, 7 administrative staff and 18 skilled support staff are in position and the remaining are vacant (Table 2.1).

Table 2.1. Staff position as on 31.12.2019

Category	Sanctioned	Filled	Vacant
Director (RMP)	1	-	1
Scientific	17	13	4
Technical	19	11	8
Administrative	15	7	8
Canteen staff	1	-	1
Skilled support staff	19	18	1
Total	**72**	**49**	**23**

2.7. Budget

During the financial year (FY) 2019-20, the total budget allotted to the Directorate was Rs. 1121.86 Lakhs of which Rs. 1056.47 Lakhs were utilised (Table 2.2). Under externally funded projects, the total receipts were Rs. 132.20 Lakhs, of which Rs. 41.96 Lakhs was utilised (Table 2.3). The revenue generation during FY 2019-20 was Rs. 116.45 Lakhs (Table 2.4).

Table 2.2. Budget and expenditure details of DCR for FY 2019-20 (Rs. in Lakhs)

Particulars	Allocation	Utilization
GIA capital	100.00	98.48
GIA salary	592.26	538.39
Pension	88.60	88.43
GIA general	250.00	250.19
TSP	-	-
SCSP	91.00	80.98
NEH	-	-
Total	**1121.86**	**1056.47**

Table 2.3. Receipts and expenditure under externally funded schemes at DCR for FY 2019-20 (Rs. in Lakhs)

Particulars	Allocation	Utilization
RKVY-RAFTAAR, Govt. of Karnataka	104.33	19.48
PPV&FRA, New Delhi	5.80	1.49
DCCD, Kochi	5.00	4.00
ABI	9.48	9.48
ITMU	7.59	7.51
Total	**132.20**	**41.96**

Table 2.4. Revenue generation at ICAR-DCR during FY 2019-20 (Rs in Lakhs)

Revenue target (2019-20)	Revenue generated (2019-20)
118.17	116.45

2.8. Production of planting materials

ICAR-DCR has cashew nurseries at both of its campuses: Kemminje and Shantigodu, accredited by Directorate of Cashewnut and Cocoa Development (DCCD), Kochi with four-star rating to cater the need of planting material. Softwood grafts of varieties like Bhaskara, NRC Selection-2, Ullal-3, Ullal-1, VRI-3, Vengurla-7, Vengurla-4, H-130, Dhana etc. are produced in the two nurseries between June and August every year for supplying to the farmers. During 2019-20, a total of 1,85,314 cashew grafts (84,127 lakh from Kemminje campus and 1,01,187 from Shantigodu campus) were supplied to farmers.

2.9. Infrastructure and assets

The major infrastructures developed during the year 2019 are provided in Table 2.5. During the period, instrumental facilities of the Soil Science section was strengthened with the purchase of modern equipments in the project funded by RKVY.

Table 2.5. Infrastructure and assets developed during 2019

Sl. No.	Infrastructure/ Assets/ Equipment	Amount (Rs. Lakhs)	Budget head
1.	Museum (Phase I)	19.13	RKVY-RAFTAAR
2.	Field store	4.45	
3.	Microwave Plasma Atomic Emission Spectrometer (MP-AES, Agilent 4210)	29.75	
4.	UV-Visible Spectrophotometer (Shimadzu UV-1900)	5.20	
5.	Minor equipment: Electronic balance, Tree pruner, Earth auger, Battery and UPS for Spectrophotometer, UPS, wall work table and air conditioner for MP-AES	4.72	
6.	Field gates for demonstration plots	0.83	

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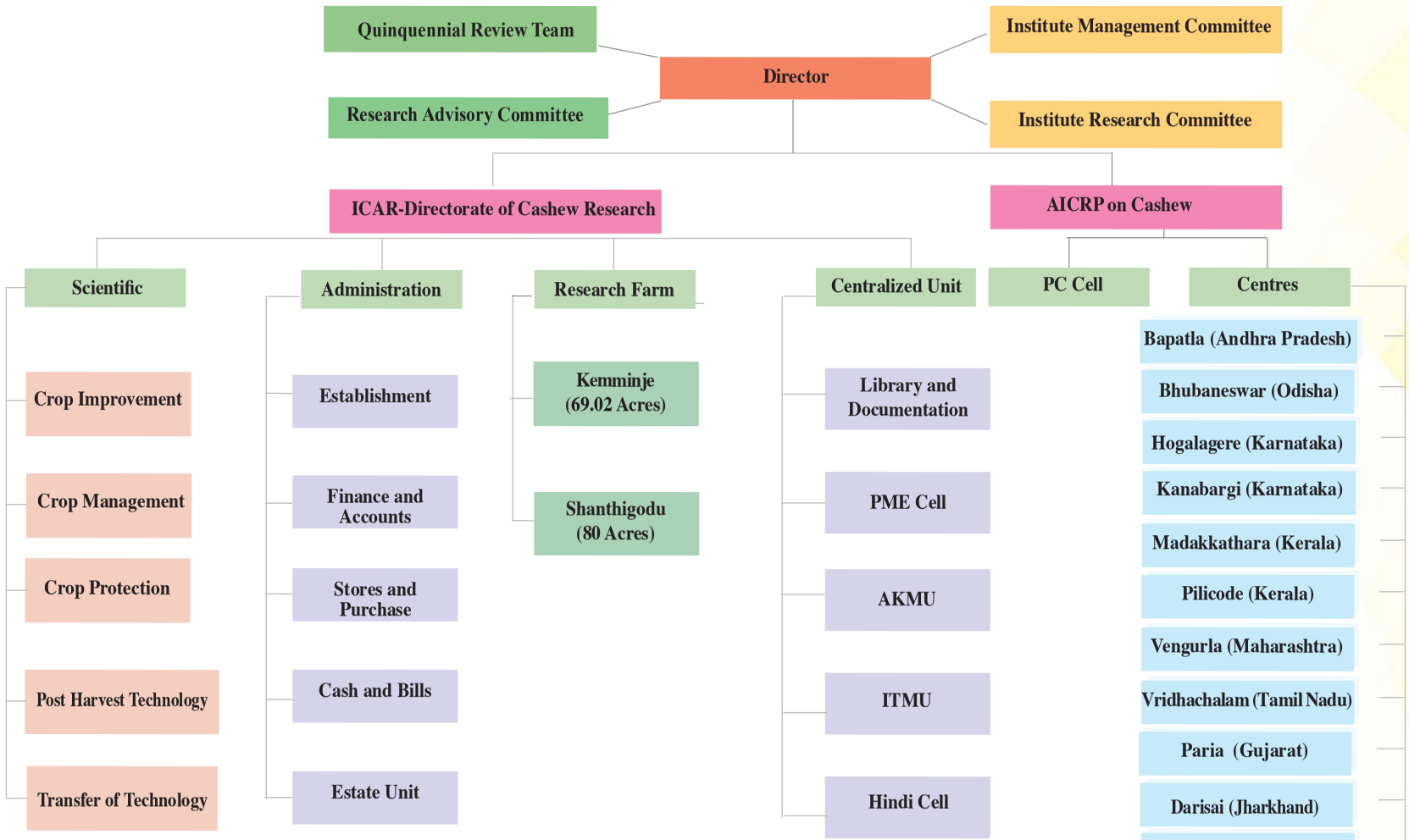


PME - Priority Setting, Monitoring and Evaluation
AKMU - Agricultural Knowledge Management Unit
ITMU - Institute Technology Management Unit
PC Cell - Project Coordinator Cell

Fig. 2.1. Organisational structure of ICAR-DCR, Puttur

3. RESEARCH ACHIEVEMENTS

3.1. CROP IMPROVEMENT

3.1.1. Management of genetic resources in cashew

Cashew germplasm database enrichment

The online cashew germplasm database management system developed for 478 accessions of cashew (https://cashew.icar.gov.in/dcr) was enriched with 700 images of morphological characters of 80 germplasm accessions.

Maintenance of core collections

The core collections of 61 cashew germplasm accessions established during 2017 were maintained following the recommended agronomic practices and shape pruning (Fig. 3.1.1).

Fig. 3.1.1. A view of cashew core accessions field

3.1.2. Screening of cashew germplasm for apple and nut characters

Identification and evaluation of cashew genotypes for cashew nut shell liquid content (CNSL)

During 2019, the CNSL content for twenty accessions was estimated (Table 3.1.1). Since the beginning of the project in 2015, the CNSL content of 321 cashew accessions has been estimated. The work is under progress to evaluate remaining germplasm accessions for CNSL content.

Table 3.1.1. CNSL content of 20 cashew germplasm accessions analysed during the year 2019

Sl. No.	Accession No.	CNSL (%)
1.	NRC-170	30.42
2.	NRC-129	22.43
3.	NRC-144	26.12
4.	NRC-397	30.89
5.	NRC-330	20.10
6.	NRC-162	23.91

Sl. No.	Accession No.	CNSL (%)
7.	NRC-11	20.57
8.	NRC-140	22.13
9.	NRC-4	21.25
10.	NRC-9	19.85
11.	NRC-3	19.50
12.	NRC-148	21.08
13.	NRC-158	29.09

Sl. No.	Accession No.	CNSL (%)
14.	NRC-253	17.98
15.	NRC-251	17.77
16.	NRC-159	24.76
17.	NRC-168	26.96
18.	NRC-157	19.54
19.	NRC-222	20.80
20.	NRC-167	26.25

Evaluation of cashew germplasm accessions for fat content

The fat content in cashew kernels of 17 cashew germplasm accessions was estimated (Table 3.1.2). The work is under progress to analyse for contents of cashew kernels in the entire germplasms.

Table 3.1.2. Fat content of cashew kernels in 17 cashew accessions

Sl. No.	Accession No.	Fat content (%)
1.	NRC-14	22.12±0.03
2.	NRC-41	26.67±0.49
3.	NRC-66	25.35±0.24
4.	NRC-79	22.72±0.21
5.	NRC-90	25.77±0.44
6.	NRC-102	25.53±0.40
7.	NRC-103	22.28±0.55
8.	NRC-192	28.45±0.13
9.	NRC-201	26.76±0.57

Sl. No.	Accession No.	Fat content (%)
10.	NRC-203	27.56±0.09
11.	NRC-206	24.15±0.25
12.	NRC-215	24.34±0.04
13.	NRC-218	22.87±0.62
14.	NRC-340	27.73±0.16
15.	NRC-344	23.36±0.42
16.	NRC-384	29.28±0.06
17.	NRC-467	22.82±0.10

3.1.3. Evaluation of cashew germplasm for cashew apple yield and quality traits

Cashew apple morphology and yield

Among the accessions evaluated during 2019, NRC-301 had the longest (9.33 cm) and heaviest apples (188.80 g), and NRC-389 had the broadest apple (7.09 cm) (Table 3.1.3).

Table 3.1.3. Cashew apple morphology and nut weight

Sl. No.	Accession No.	Apple characters			Cashewnut weight (g)
		Weight (g)	Length (cm)	Breadth (cm)	
1.	NRC-75	91.58	7.17	3.57	9.44
2.	NRC-111	121.91	8.17	4.55	13.71
3.	NRC-112	133.48	8.08	4.93	60.23

4.	NRC-120	107.59	6.43	4.50	10.26
5.	NRC-140	132.01	8.92	4.47	9.02
6.	NRC-144	110.79	7.58	4.57	10.05
7.	NRC-175	70.39	5.70	3.83	6.91
8.	NRC-176	64.39	5.52	3.74	7.63
9.	NRC-183	119.80	8.20	4.73	14.55
10.	NRC-189	98.20	6.41	4.63	10.65
11.	NRC-270	97.73	6.00	6.81	10.74
12.	NRC-301	188.8	9.33	5.31	11.24
13.	NRC-389	107.00	6.45	7.09	9.63
14.	NRC-493	101.17	8.99	3.88	13.21
15.	Vengurla-8	73.50	5.92	3.67	8.90
16.	Mean	107.89	7.26	4.68	13.74
SEm		18.74	1.24	0.85	1.81
CD (0.05)		3.84	2.53	1.74	3.71
CV (%)		17.54	16.04	15.99	16.95

Incidence of insect pest on cashew accessions

During 2019, heavy incidence of tea mosquito bug (TMB) was recorded on all the accessions. Population of TMB and also leaf-feeding caterpillars started during October - November. During November, the incidence of inflorescence caterpillars was also noticed, but in less intensity (0.5-2.0%). At the end of December, TMB adults were seen in large numbers. Among the accessions evaluated, higher mean damage grade was recorded in NRC-75 (2.01) followed by NRC-493 (1.97) and NRC-144 (1.79). Mean damage grade was low in Vengurla-8 (0.21) and NRC-111 (0.72). Observations showed that damage by cashew stem and root borer (CSRB) was more in NRC-120 followed by NRC-111 and NRC-112 (Table 3.1.4). Spraying of λ-cyhalothrin @ 0.6 ml L^{-1} was taken up, to reduce the foliar and flower pest population, and the trees infested with CSRB were given post grub extraction prophylactic treatment.

Table 3.1.4. Grading of TMB damage

Sl. No.	Accession No.	Mean	Range
1.	NRC-75	2.01	1.46-3.04
2.	NRC-111	0.72	0.04-1.23
3.	NRC-112	1.06	0.42-1.38
4.	NRC-120	1.06	0.50-1.96
5.	NRC-140	1.31	0.08-2.96
6.	NRC-144	1.79	0.19-3.73
7.	NRC-175	0.75	0.27-1.81
8.	NRC-176	1.34	0.50-2.69
9.	NRC-183	1.09	0.38-2.77
10.	NRC-189	1.73	0.77-3.08
11.	NRC-270	0.80	0.12-1.31
12.	NRC-301	0.93	0.08-2.27
13.	NRC-389	1.05	0.04-3.08
14.	NRC-493	1.97	0.65-2.62
15.	Vengurla-8	0.21	0.00-1.00

3.1.4. Development of dwarf and compact cashew hybrids

Direct and reciprocal crosses

Breeding efforts are being continued to develop dwarf and compact cashew hybrids. Seven trees were selected from the 27 selections made in 2018 for further yield observations. In addition, during the year 2019, seven more trees were selected based on fruit bearing making a total of 14 promising selections. The details of the selections along with growth and yield observations are provided in Table 3.1.5. Two hybrids viz., Tree No. 102 (Madakkathara-2 x NRC-492) and Tree No. 5 (Vengurla-4 x Thaliparamba-1) recorded the higher annual nut yield of 6.41 kg and 5.53 kg with cumulative nut yield of 11.10 kg and 10.86 kg, respectively, over the last four years. The cumulative nut yield of these two hybrids was slightly higher than the cumulative nut yield of local check Bhaskara which recorded 10.74 kg over the last four years. Another promising Tree No. 8 (Dhana x NRC-492) was selected during the year 2019 as it was found semi-tall with 4.3 m height and 5.4 m average tree spread (Fig 3.1.2). Besides, it also recorded 2.27 kg of nut yield of during 6th year of planting and it bears bold nuts in clusters with an average nut weight of 8.30 g.

Fig. 3.1.2. Tree No. 8 with semi-tall stature derived from Dhana x NRC-492 and its cluster bearing nature

Table 3.1.5. Promising selections with their growth parameters and nut yield developed through direct and reciprocal crosses

Sl. No.	Cross	Tree No.	Girth (cm)	Height (m)	Spread (m)	Nut weight (g)	Nut yield (kg tree^{-1})	Cumulative nut yield (4 yrs) (kg tree^{-1})
Selections in 2018								
1.	Vengurla-4 x NRC-492	28	63.0	6.30	5.60	5.50	3.20	9.60
2.		65	55.5	5.10	5.55	7.50	5.11	10.66
3.		87	64.0	6.10	5.85	6.50	2.61	7.50
4.	Vengurla-4 x Thaliparamba-1	5	65.0	4.80	6.85	6.00	5.53	10.86
5.	Priyanka x NRC-492	3	71.5	6.80	6.40	6.50	5.52	10.42
6.	Madakkathara-2 x NRC-492	149	63.0	6.10	6.30	6.00	3.53	8.01
7.	NRC-492 x Madakathara- 2	102	64.0	5.90	5.90	5.00	6.41	11.08
Selections in 2019								
1.	Dhana x NRC-492 (Semi tall)	8	52.0	4.30	5.40	8.30	2.27	4.96
2.	NRC-492 x Dhana	49	56.0	5.50	6.55	8.04	3.56	6.57
3.		51	65.5	4.9	6.75	8.15	4.51	7.72
4.		53	61.5	4.7	5.50	5.90	3.26	5.93
5.	Madakkathara-2 x NRC-492	13	74.5	6.0	6.35	6.00	4.97	8.26
6.		117	66.0	6.7	4.95	5.00	4.83	8.24
7.		99	79.0	6.6	6.13	5.00	3.33	6.19

Backcrosses

In the backcross selection, one more promising accession (BDB-626-58) was added to the list of promising progenies during the year 2019, making a total of 16 promising progenies (Fig. 3.1.3, Table 3.1.6). The tree height of BDB-626-58 during the year 2019 was 2.80 m and girth was 41 cm. The cumulative nut yields of three harvests were 8.01 kg tree^{-1} (Table 3.1.6). However, overall cumulative yield of three harvests was more in BDB-626-97 which yielded 8.16 kg tree^{-1}. All these promising accessions will be further evaluated for their growth characteristics and yield along with other progenies in the back cross selection.

Fig. 3.1.3. Panicle of promising accession of cashew BDB-626-58

Table 3.1.6. Growth and yield characters of promising progenies in back cross population

Sl. No.	Plant No.	Height (m)	Spread (m) EW	Spread (m) NS	Girth (m)	Nut yield (kg tree^{-1})	Cumulative nut yield [3 harvests] (kg tree^{-1})
1.	BDB-372 -4	4.25	2.50	3.00	34.00	0.46	2.74
2.	BDB-372 -23	4.50	4.50	6.25	60.50	2.62	5.22
3.	BDB-372 -36	4.25	4.25	3.25	42.00	0.81	3.22
4.	BDB-372 -37	4.75	4.75	4.25	53.50	2.56	5.97
5.	BDB-372 -46	4.30	4.30	3.30	49.00	1.02	3.91
6.	BDB-372 -60	4.80	4.50	4.25	36.00	3.03	7.97
7.	BDB-372 -61	5.00	7.25	4.75	54.00	2.42	6.17
8.	BDB-372 -84	4.40	5.25	4.40	71.50	2.91	7.34
9.	BDB-372 -90	4.75	7.75	5.75	49.00	1.39	4.68
10.	BDB-626 -49	4.75	4.50	4.75	55.50	2.96	5.41
11.	BDB-626-58	2.80	4.75	3.50	41.00	4.78	8.01
12.	BDB-626 -97	3.60	4.60	4.50	46.00	4.66	8.16
13.	BDB-626 -113	5.75	4.60	4.40	42.00	3.37	5.72
14.	BDB-626 -114	4.50	5.50	5.00	46.50	1.07	2.67
15.	BDB-626 -122	3.70	4.40	4.25	48.00	3.00	5.95
16.	UDU-577 -85	4.10	4.60	4.25	44.00	1.53	3.99

3.1.5. Mutation breeding and interspecific hybridization in cashew for Tea Mosquito Bug (TMB) tolerance with high yield

Two approaches were followed to develop TMB tolerant varieties of cashew viz. Mutation breeding and Interspecific hybridization.

Mutation breeding

In mutation breeding, 113 plants derived from the γ-rays treated seeds and scion sticks of two popular varieties i.e. Bhaskara and Ullal-3 were planted during the year 2018 and maintained following the recommended agronomic practices (Fig. 3.1.4). Variations such as puckering of leaves, dwarfness and excessive branching were seen in some seedlings as observed in the previous year. Further, out of 50 seeds each from Bhaskara, H-130 and Ullal-3 varieties exposed to γ-rays of dosage 700 Gray and sown in the nursery, only one seed could germinate and the seedling is planted in the main field. The next generation seedlings (M_2) from all these trees will be screened for TMB tolerance in the nursery.

Fig. 3.1.4. View of M_1 progenies planted in the field

3.1.6. Breeding for improvement of nut size in cluster bearing genotypes

To improve the nut size in the cluster bearing genotypes with small and medium-sized nuts, 15 crosses were made between cluster bearing types x bold nut types. Among them, 247 seedlings of nine crosses between cluster bearing types x bold nut types were planted in the field in an augmented block design. Besides, another set of 161 seedlings of six crosses made between cluster bearing x bold nut and bold x bold nut types were also planted in the field. All these seedlings were planted during October 2018 along with check varieties viz., Bhaskara and NRCC Selection-2 at spacing of 4 m x 4 m (Fig. 3.1.5). The details of the crosses and plants are presented in Table 3.1.7. During the post rainy season of 2019, shape pruning in all these plants was carried out and plants are being maintained in the field with proper care.

Fig. 3.1.5. Seedlings of medium x bold nut and bold x bold nut types planted along with checks

Table 3.1.7. Plants available in crosses between cluster bearing x bold, bold x bold and bold x medium nut types

Sl. No.	Crosses	No. of plants
Cluster bearing x bold nut crosses		
1.	Ullal-2 x H-130	29
2.	H-130 x Ullal-2	30
3.	NRC-493 x Ullal-2	27
4.	Ullal-2 x NRC-493	22
5.	Bhaskara x NRC-493	10
6.	NRCC Sel-2 x Bhaskara	45
7.	Ullal-3 x H-130	20
8.	Madakkathara-2 x H-130	26
9.	Vengurla- 4 x H-130	38
	Total	**247**

Sl. No.	Crosses	No. of plants
Bold x bold nut and bold x medium nut crosses		
1.	H-130 x NRC-493	25
2.	NRC-493 x H-130	20
3.	H-130 x Ullal-4	43
4.	Vengurla-7 x H-130	25
5.	Priyanka x NRC-493	21
6.	VRI-3 x H-130	27
	Total	**161**

3.1.7. *De-novo* genome assembly, linkage analysis and population structure studies in cashew

Draft genome sequence and bioinformatics analysis in cashew

The cashew is an outcrossing diploid tree species with 2n=42 and is heterozygous in nature. Molecular breeding approaches have attained great importance for enhancing the speed of genetic improvement in perennial tree crops. Compared to the major fruit tree crops like apple, the application of genomics or marker-assisted breeding in cashew is lagging due to lack of genomic sequence resources, candidate genes and molecular markers. The recent advances in sequencing technologies have enhanced the pace and affordability of large scale genome sequencing experiments even in non-model crop species. However, the genome assembly of eukaryotic genomes presents a great challenge due to repetitive sequences and genomic heterozygosity. Recently, the hybrid approach is followed for enhancing the fidelity of assembly of complex genomes which involves a combination of short read but accurate second-generation sequencing data (i.e. from IonTorrent, Illumina) with long read but less accurate third-generation sequencing data (i.e. from PacBio RS, Oxford Nanopore) to overcome long repetitive and heterozygous genomic regions.

In this study, a draft genome sequence of the popular Indian cashew cultivar Bhaskara was generated using the hybrid genome assembly approach. The total cashew genome assembled is 38,49,79,184 bp i.e. approximately 385 Mb (92%) of the cashew genome is arranged in 4981 scaffolds, with a scaffold N50 of 2.55 Mb.

Gene prediction and annotation

The gene annotation and gene prediction of the assembled genome showed a total of 40,264 protein-coding genes, of which 32,194 were annotated proteins and 8,070 were unannotated proteins. Further, the gene ontology analysis showed that the annotated proteins play roles in different biological processes, molecular functions and cellular compartments (Fig. 3.1.6).

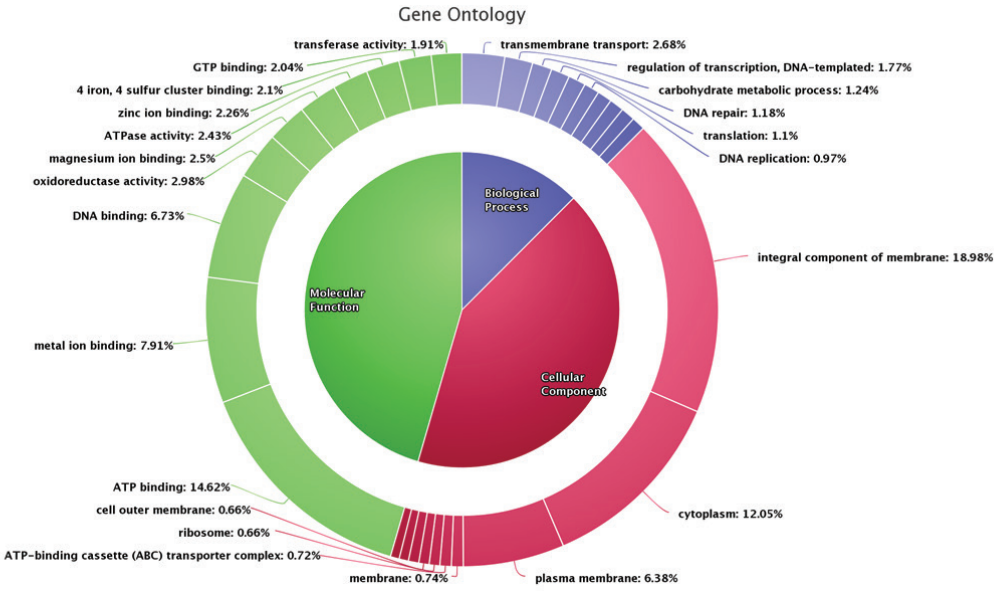


Fig. 3.1.6. Gene ontology (GO) analysis in cashew

Identification and designing of Simple sequence repeat (SSR) markers

The analysis of 385 Mb of the cashew genome sequence for microsatellite or Simple Sequence Repeats (SSRs) showed a total of 47,646 SSRs. Further, analysis of SSR repeat types showed 59% of di-repeats followed by 24.4% tri-nucleotide, 3.6% of tetra-nucleotide, 1% of penta-nucleotide, and 0.8% of hexa-nucleotide repeats and 11.1% complex SSR motifs.

Genotyping of core accessions with Cashew SSRs (CSSR)

In the current year, five more polymorphic cashew SSRs were used for genotyping the core accessions of cashew (Fig. 3.1.7). With the completion of cashew draft genome assembly, novel SSRs have been designed and will be tested for polymorphism detection and genetic diversity analysis.

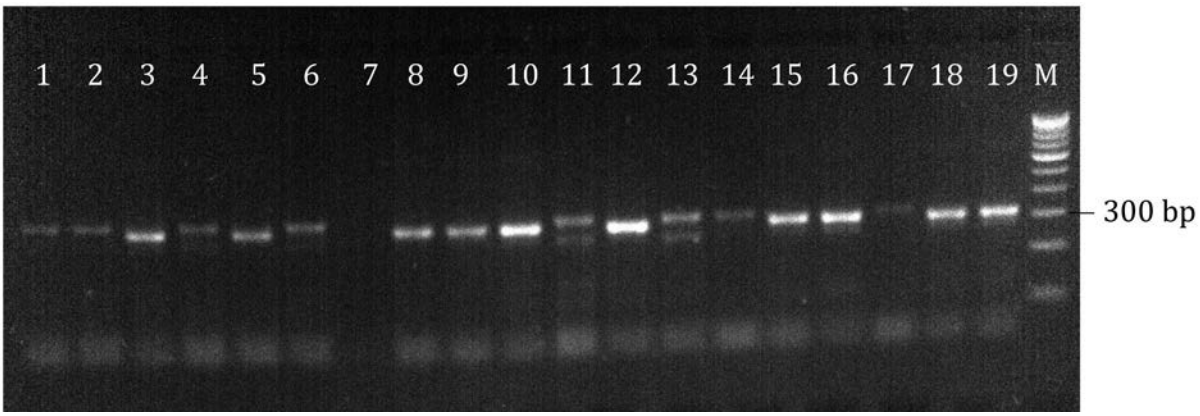


Fig. 3.1.7. Amplification profile of CSSR10 markers in cashew core accessions

3.1.8. Genetic dissection of QTLs governing nut yield and cashew nut shell liquid (CNSL) content in cashew

Seed nut and seedling growth characters analysis of F_1 population

In the current year, the nuts derived from the seven types of crossings viz. Bhaskara x H-130 (UV), Bhaskara x NRC-188, NRC-492 (Dwarf) x H-130, NRC-492 (Dwarf) x Thaliparamba, NRC-492 (Dwarf) x Vengurla-7, Vengurla-7 x NRC-116 and Vengurla-7 x NRC-492 (Dwarf) made during 2018-19 were sown and the seedlings were raised in the nursery (Fig. 3.1.8).

Observations were recorded for the seed nut characters such as length, breadth and width before sowing. A total of 1167 seed nuts of all the crosses were sown in the nursery bag with a potting mixture containing soil, sand and FYM in the ratio of 1:1:1. The germination per centages ranged from 84-100% and final surviving plants ranged from 66-96% among the seven crosses.

Observations were also recorded for the seedling growth characteristics such as height, number of leaves, last leaf length and last leaf width in 12 plants of each cross at 45 and 90 days after sowing. The statistical analysis of the data was carried out and the results are presented in Fig. 3.1.9.

Fig. 3.1.8. The growth features of the seven different crosses of cashew developed in the study

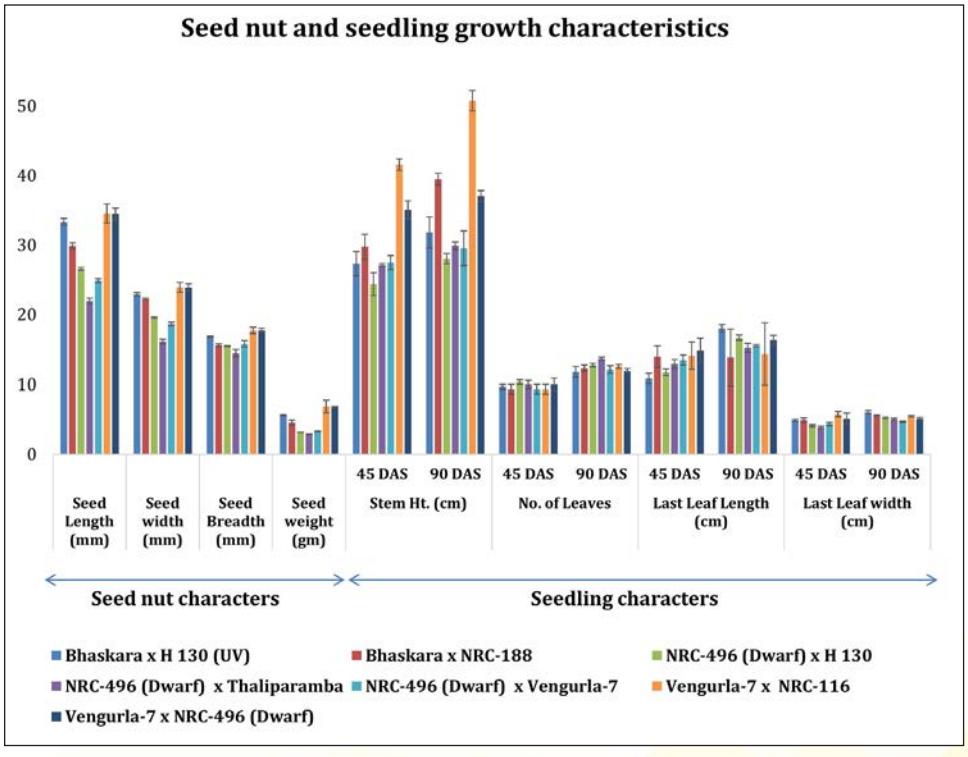


Fig 3.1.9. Analyses of growth traits in the crosses of cashew developed in the study

3.1.9. Future areas of thrust for research in cashew crop improvement

- Survey for identification and collection of unique types of cashew or related species of cashew.
- Development of Tea mosquito bug (TMB) tolerant varieties, dwarf and high yielding varieties for ultra-high density planting and salt and cold-tolerant varieties.
- Development and utility of genomics/omics resources and tools for application of molecular breeding to improve productivity, quality and stresses tolerance in cashew.

3.2. CROP MANAGEMENT

3.2.1. Studies on pruning and phenology in cashew

Influence of time of fertilizer application on the phenology of cashew cultivars Bhaskara and Ullal-3

The influence of time of recommended dose of fertilizer (RDF) application was carried out in cashew cultivars Ullal-3 and Bhaskara. The RDF of fertilizer was applied in the months of July, August and September and the observations for different phenological growth stages were recorded twice a month from October 2019 onwards. The study showed that the buds were at 010 stage (dormant stage) till first forth night of October 2019 and this was invariable to cultivars and time of fertilizer application. The different phenological stages obeserved in cashew cultivars Bhaskara and Ullal-3 are presented in the table 3.2.1.

Table 3.2.1. (A) Different phenological stages in cashew cultivars influenced by time of fertilizer application

Time of application	Phenological observation (in BBCH code)													
	Bhaskara							Ullal-3						
	October		November		December		January	October		November		December		January
	1st	2nd	1st	2nd	1st	2nd	1st	1st	2nd	1st	2nd	1st	2nd	1st
Control	010	019	313	317	511	516	613	010	017	313	513	513	611	613
July	010	019	313	513	613	711	713	010	017	313	117	516	517	611
August	010	019	313	511	511	516	613	010	017	313	516	516	611	613
September	010	019	313	317	511	517	517	010	017	313	516	613	711	713

Table 3.2.1. (B) Description of the BBCH codes of different phenological stages of cashew

Code	Description
010	Dormant stage: buds covered with brown or brownish-green scales
019	End of bud break: leaf tip visible above the bud scales
117	More leaves unfolded: slightly expanded, the appearance of coppery shades on leaves
313	Shoots at 30% maturity: shoots about 30% of final maturity, light green colour, smooth texture, flexible shoots, leaf are dark copper green
317	Shoots at 70% maturity: shoots about 70% of final maturity, brownish green and smooth shoots, leaves are dark green and leathery

511	Beginning of reproductive bud swelling: Inflorescence bud visible
516	Separation of sub laterals: sub laterals start separating from main laterals, keel leaf green in colour and intact
517	More sub laterals separated: about 80% of sub laterals separated and elongated, keel leaf dried and withered
611	Beginning of flowering: Up to 10% of flowers opened, newly opened flowers are white and older flowers are pink in colour
613	Early flowering: About 30% of flowers opened
711	The nut at 10% of the final developmental stage: nut at about 10% of the final developmental size, soft and spongy, style is attached, 90% of the nut cavity is empty Apple: about 2.5% of the final cultivar apple size
713	The nut at 30% of the final developmental stage: about 30% of the final developmental stage size, soft and spongy, about 50% of the nut cavity is filled, visible kernel, nutshell grows rapidly compared kernel and testa Apple: about 5% of the final cultivar apple size

Influence of pruning in Bhaskara

The pruning treatments were imposed on 8 year old Bhaskara trees in the months of June, July, August and September. The range of new shoot production varied among the treatments. The shoot number ranged from 45 to 80 in un-pruned trees. The pruned trees recorded a higher number of new shoots (Table 3.2.2).

Table 3.2.2. Effect of pruning on the production of new shoots in Bhaskara variety

Sl. No.	Treatment	Shoot number
1.	June @25% leader	62-90
2.	June @50% leader	22-102
3.	June@25% lateral	92-152
4.	June@50% lateral	79-150
5.	August @25% leader	120-232
6.	August @50% leader	121-125
7.	August @25% lateral	92-98
8.	August @50% lateral	89-94
9.	Sep @25% leader	54-120
10.	Sep @50% leader	40-130
11.	Sep @25% lateral	45-126
12.	Sep @50% lateral	62-130
13.	Control	45-80

3.2.2. Optimization of mineral nutrition to cashew under high/ultra density planting

High/ultra density planting (HDP) is a technique which is capable of increasing the productivity per unit area by accommodating more number of plants per unit area. Conventionally cashew is planted at 7.5 m × 7.5 m which accommodates 177 plants per hectare and the plants takes 7-8 years to cover the allotted space and to give potential yields of 2 tonnes per hectare with proper management practices. Therefore, high density or ultra density planting appears to be the most appropriate solution to overcome the low productivity and initial long waiting period for early returns. Under the high density systems, the plants being placed adjacent to each other compete for nutrients. Proper nutritional management is important for realizing higher productivity from high density orchards. No information is available for the nutrient requirement and fertilizer schedule for high density planting. This work is undertaken to assess the nutrient requirement of cashew under high density planting. The work also aims to develop a fertilizer nutrient management package for HDP/UDP in cashew.

Experimental details and soil characteristics

To standardise the fertiliser recommendation under ultra density planting in cashew, the experiments were carried out in the existing ultra high density plots of ICAR-DCR in which plants are planted at 2.5 x 2.5 m spacing. The plantation was established during the year 2013. As per the response surface function approach of statistical analysis, 20 treatments comprising different combinations of N, P_2O_5 and K_2O were imposed. The analysis of initial soil samples showed that soil pH ranged from 5.5 to 5.92, electrical conductivity from 0.053 to 0.056 dSm^{-1}, organic carbon from 0.59 to 0.69% in the surface 0 to 30 cm layer. The available nitrogen content in the surface layer varied from 275 to 325 kg ha^{-1}. In the subsurface layers, the soil pH decreased (5.66 at 30-60 cm layer and 5.62 at 60-90 cm layer). Similarly, there was a depth-wise decrease in electrical conductivity, soil organic carbon and available nitrogen content. The treatments were designed following response surface methodology and the fertilizer nutrients applied as per the treatments. The treatment wise plant samples were collected and processed for analysis.

3.2.3. Future areas of thrust for research in the cashew crop management

- Crop management based on phenological stages.
- Standardization of leaf nutrient-based nutrient management for cashew
- Estimating the carbon sequestration capabilities of cashew plantations, and carbon and nutrient cycling.

3.3. CROP PROTECTION

3.3.1. Investigations on semiochemicals for management of Tea Mosquito Bug (TMB) and Cashew Stem and Root Borer (CSRB)

To confirm the age of virgin females during which the maximum pheromone activity occurs, the freshly emerged TMB virgin females were used as bait in the modified cylindrical traps (Fig. 3.3.1). It was confirmed that the maximum attraction of males to the TMB females was during the 4th to 5th day after emergence (DAE). Hence, the virgin TMB females of this age group only were used for the preparation of the whole body extracts (WBE) in di-chloromethane. The WBE so prepared was stored in a deep freezer for future evaluations. The WBE (2 Nos/0.5 ml) was used as bait in the cylindrical traps and could attract TMB within 5.0 minutes after installation of traps (i.e. after puncturing of the Eppendorf vials containing the WBE). It was noticed that the maximum number of TMB males trapped in the WBE baited cylindrical traps was 44/ trap within an hour of installation.

Fig. 3.3.1. TMB males trapped in WBE baited traps

The maximum number of TMB males trapped was the highest (58/trap) during November 2019 in the morning hours viz., 9.00 am to 11.00 am and reduced gradually thereafter, & again a slightly higher catch was found during the late afternoon hours viz., 3.00 pm to 4.00 pm (Fig. 3.3.2).

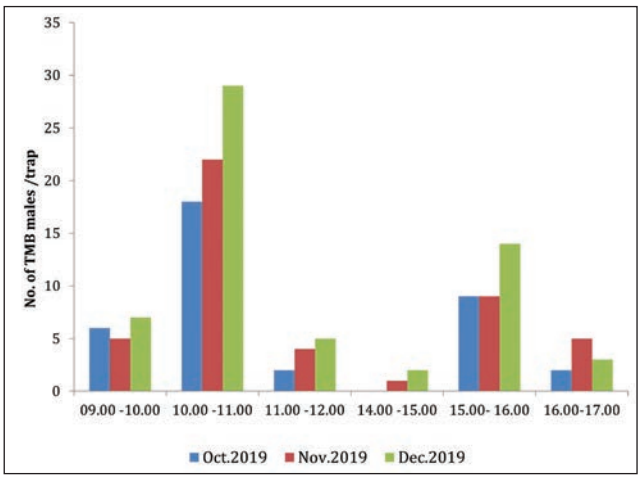


Fig. 3.3.2. TMB catches per day

3.3.2. Evaluation of alternative insecticides/ products for the management of tea mosquito bug (TMB) and cashew stem and root borers (CSRB)

The alternate test insecticides comprising of neonicotinoids; carbamates; pyrazoles; synthetic pyrethroids and an Insect Growth Hormone (IGH) were evaluated for their efficacy against the major pests of cashew viz., TMB and CSRB. The test insecticides - thiamethoxam (0.1g L^{-1} & 0.2 g L^{-1}), acetamiprid (0.5 g L^{-1}), carbosulfan (2.0 ml L^{-1}), buprofezin (2.0 ml L^{-1}) and check L-cyhalothrin (0.6 ml L^{-1}) were evaluated against TMB while fipronil (2.0 ml L^{-1}), imidacloprid (2.0 ml L^{-1}) and chlorpyriphos (10 ml L^{-1}) as check were evaluated against CSRB.

The treatments were imposed on the labelled cashew trees, by using a pneumatic hand sprayer and the shoots were collected 15 days after treatment (DAT) for evaluating the feeding deterrence induced by different treatments. Five TMB (nymphs or adults) were released and allowed for feeding for 6 h and later these were removed.

The feeding damage induced was scored after 24 h as per the damage score scale of 0-4 (Fig. 3.3.3). It was noticed that only thiamethoxam (0.2 g L^{-1}) and L-cyhalothrin (0.6 ml L^{-1}) could result in a damage score below 0.5, 15 DAT treatment and even these promising insecticides could not lead to damage scores lower than 0.5, 30 DAT. None of the test insecticides could lead to damage scores lower than 2.0 at 45 DAT under laboratory evaluation.

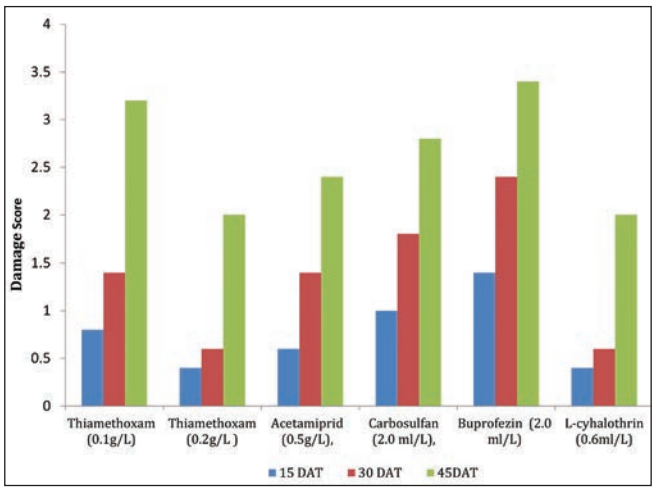


Fig. 3.3.3. Damage scores of TMB

3.3.3. Nest occupancy by *Braunsapis picitarsus* in the artificial bee nests

The artificial bee nests comprised of small wooden blocks with 1,400 drilled holes of 7-8 cm length and of five different diameters installed during September 2017 were examined for the occupancy by the abundant cashew pollinator, *Braunsapis picitarsus*. The percentage of nests occupied by the bees gradually increased over time, since its installation. The small-sized (2.00 mm diameter) nests were occupied initially by the tiny mud wasps. The bigger sized holes (3.5 and 4 mm) were also occupied by the mud wasps, stingless bees (*Tetragonula* sp.) etc. But, it was observed that those nests were also occupied by *B. picitarsus* subsequently (Fig. 3.3.4). Observations revealed that bees occupy the same nests *i.e.,* reuse of occupied ones. The percentage of nests occupied by *B. picitarsus* during August 2018 and August 2019 is given in Fig. 3.3.5. Among the different nest diameter, the nests of 2.5 mm and 3.0 mm diameter were highly preferred by the bees, and the percent occupancy was 39.8% and 55.2%, respectively during August 2019. Hence for successful occupation of artificial nests by *B. picitarsus*, the diameter of the nest hole is standardized as 3.00 mm.

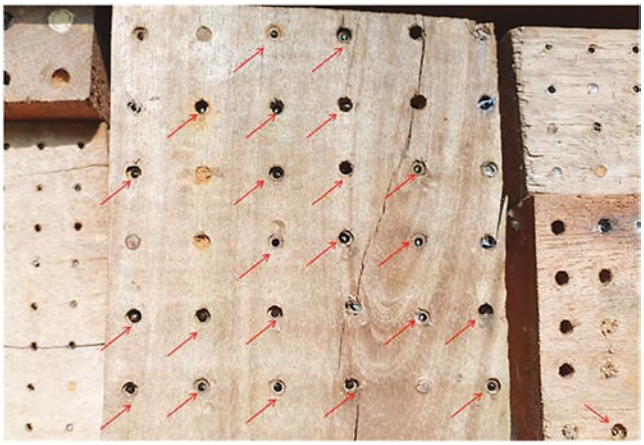


Fig. 3.3.4. Occupancy of artificial nests by *B. picitarsus*

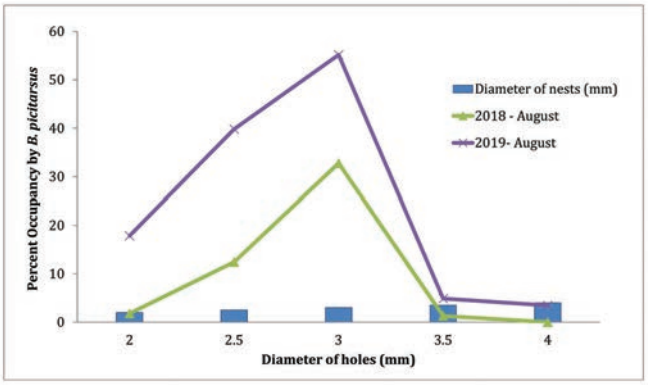


Fig. 3.3.5. Occupancy of artificial nests by *B. picitarsus*

3.3.4. Investigations on inflorescence pests of cashew and their management

During 2019, initiation of inflorescence pests including TMB and lepidopterans was noticed during November first week and a heavy infestation was recorded during the third week of November. As there was delayed flushing this season, few flower eating caterpillars like *Oenospila flavifusata, Penicillaria jacosatrix* were observed to feed on flower buds as well (Fig. 3.3.6). Spraying of lambda cyhalothrin @ 0.6 ml L^{-1} was effective in bringing down the pest population. Pests were noticed again during December and higher infestation by TMB (20-30%) and complex of flower caterpillars (25-35%) were noticed in few plots. Up to three caterpillars especially flower webbers were recorded per inflorescence. Besides, feeding damage by a green Pentatomid bug (*Nezara* sp.) resulted in shrivelling and premature fall of developing nuts. Among the natural enemies, *Eocanthecona furcellata* (Pentatomidae), praying mantises (*Euantissa pulchra, Leptomantella* sp., *Hierodulla* sp.) Neuropterans (Crysopidae), mantispid flies, reduviids (*Sycanus* sp, *Panthous* sp.), spiders were commonly encountered on the inflorescences.

Fig. 3.3.6. Damage of flowers by *O. flavifusata* and flower webbers (unidentified)

3.3.5. Future areas of thrust for research in the field of crop protection

- Studies on TMB and CSRB management through pheromone and kairomone technologies, respectively, shall be intensified for synthesis, characterization and evaluation of sex pheromones/kairamones.
- Studies on Cashew-TMB interactions and defensive responses.
- Influence of major pollinators on pollination and fruit set in cashew.

3.4. POST HARVEST TECHNOLOGY

3.4.1. Design and development of moisture meter for raw cashewnuts

Calibration of moisture meter for raw cashewnuts, unpeeled and peeled cashew kernels

Capacitance based moisture meter is developed by a private firm M/s EMCON, Kochi for predicting moisture content of raw cashewnuts and unpeeled and peeled cashew kernels. The calibration of the moisture meter was done by the Directorate. The instrument consists of a signal conditioning circuit, a microcontroller interfaced with a computer for display and sinusoidal function generator. Function generator produces an AC current with variable magnitude and frequency. The produced sine signal is fed to the capacitive sensor and the output signal from the sensor is sent to the signal conditioning circuit. The final output voltage is measured by Analog to dital converter (ADC) and the capacitance and dielectric constant of sample is computed by a microcontroller and the results are displayed. Based on the experimental values observed for different varieties of freshly harvested raw cashewnuts viz., Bhaskara, Ullal-3, VTH-30-4, Ullal-4, NRCC Selection-1, Vengurla-7, K-22-1, Ullal-3, Ullal-1, Vengurla-4, mixed nuts (Farm) and mixed nuts collected from processing units at ICAR-Directorate of Cashew Research, necessary changes were incorporated in the developed moisture meter by M/s EMCON, Kochi. Calibration curve for naturally filled raw cashewnuts in the moisture meter was found to be on par with compactly filled suggesting the effect of degree of compaction is negligible (Fig. 3.4.1 and Fig. 3.4.2). The validity of moisture meter, thus developed was checked for raw cashewnuts at industrial sites and ICAR-DCR, Puttur. The coefficient of correlation computed, found to be in the range of 0.93 to 0.97.

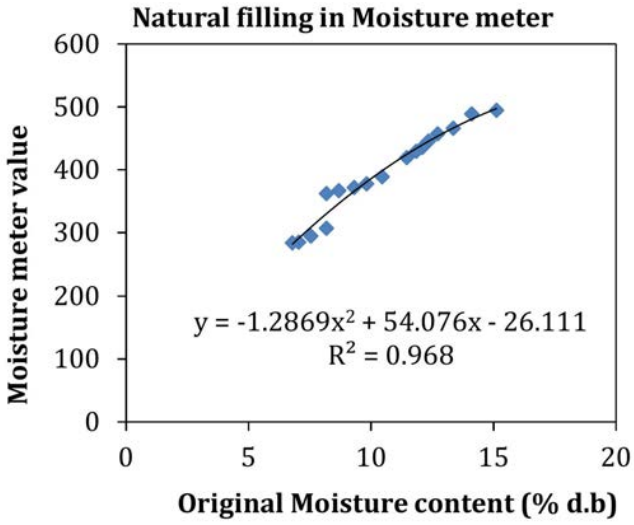


Fig. 3.4.1. Calibration curve for raw cashewnuts for moisture meter with natural filling

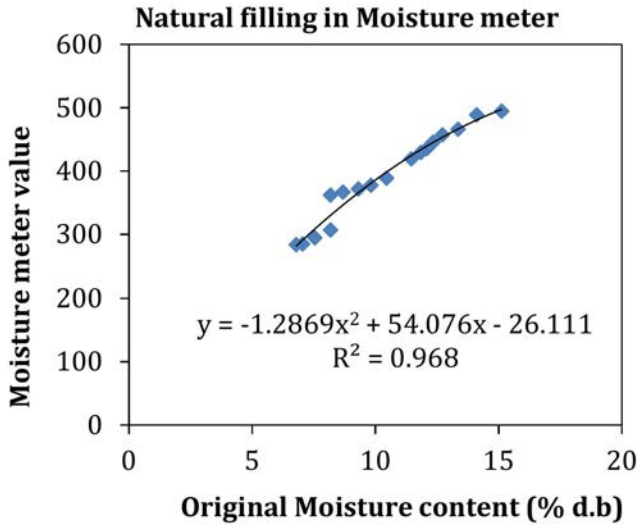


Fig. 3.4.2. Calibration curve for raw cashewnuts for moisture meter with compact filling

The developed moisture meter was also tested to make the moisture meter suitable for unpeeled and peeled cashew kernels which aids in optimizing processing parameters at various stages while processing to obtain better white whole kernels recovery. Correlation analysis showed that the second order polynomial model is the best fit for the experimental data of moisture meter value and original moisture content. A quadratic relationship of $y=8.7482\ x^2-36.67\ x+117.8$ could be used as a predictive model for assessing moisture content of unpeeled cashew kernels with a correlation coefficient of 0.965 (Fig. 3.4.3).

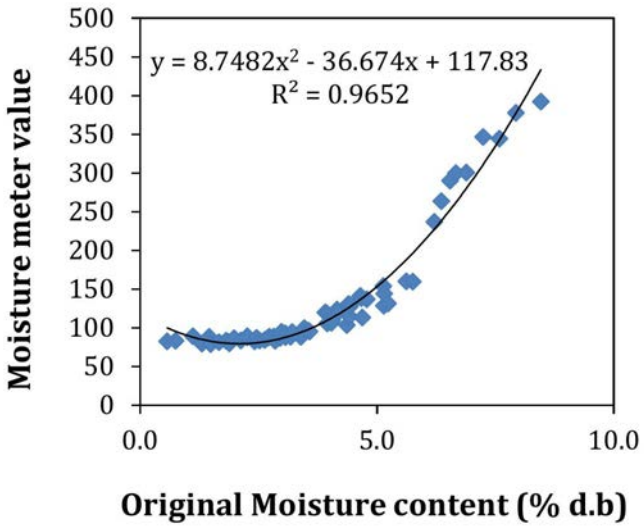


Fig. 3.4.3. Claibration curve for unpeeled cashew kernels (UPK) using moisture meter

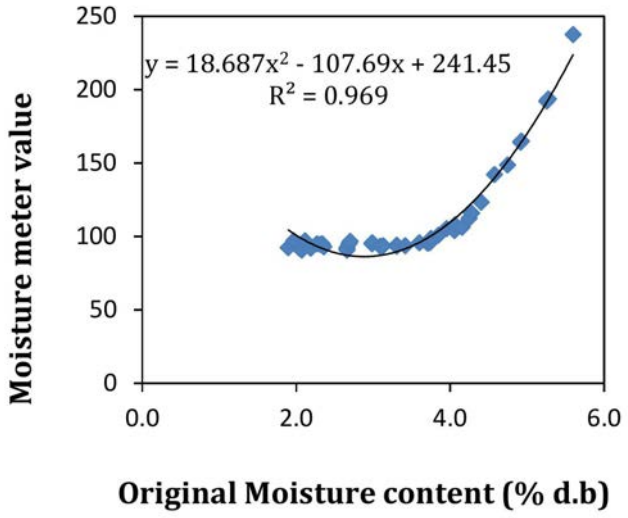


Fig. 3.4.4. Claibration curve for peeled cashew kernls (PK) using moisture meter

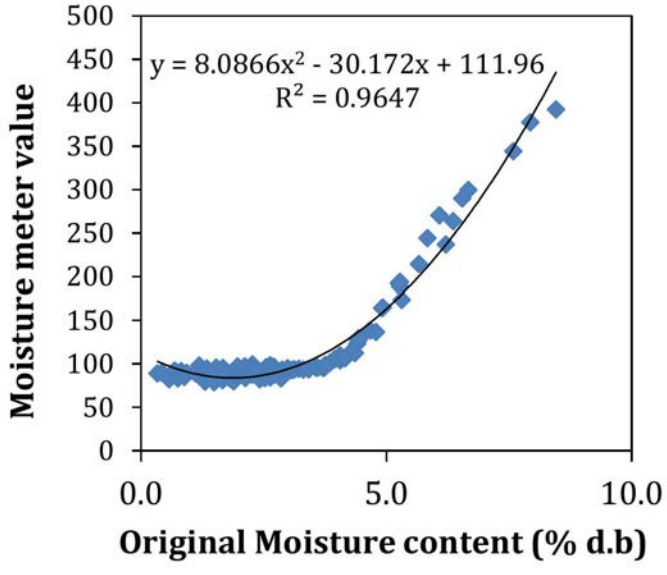


Fig. 3.4.5. Claibration curve for combined cashew kernels (UPK and PK) using moisture meter

In the same manner, the moisture meter is tested for peeled cashew kernels after conditioning. Data analysis revealed that a polynomial fit of $y=18.68x^2-107.6x+241.4$ representing peeled cashew kernels towards predicting moisture content with accuracy of R^2 value equal to 0.969 (Fig.3.4.4). To simplify the instrument with the minimal operation, in view of size, shape and moisture-holding capacity of testa layer, a pooled data correlation analysis carried out for both peeled and unpeeled cashew kernels and represented in Fig. 3.4.5. A polynomial predictive model of $y=8.086x^2-30.17x+111.9$ with R^2 value of 0.964 confirmed that moisture meter could be simplified to assess the moisture content of both peeled and unpeeled cashew kernels with a single operation.

3.4.2. Studying the comparative performance of cashewnut processing systems in India

Diagnostic investigations carried out in cashewnut processing units located in three different states of varied category viz., manual, semi-mechanized and fully mechanized revealed that cost of processing varied from Rs. 1280 to Rs. 3000 per bag. Processing cost found to be higher in the case of labour oriented processing system primarily due to lower rate of production, higher wages and overhead charges. Production rate observed to be 2.5 tonnes per day (TPD) under labour oriented processing units whereas it is up to 12 TPD in two shifts under a fully mechanized category. Qualitative efficiency of the processing is influenced by several factors which include the skill level of the labourer, the efficiency of the machines, material handling system, material parameters i.e. size, moisture, freshness and maturity, adopted processing parameters etc. Majority of the semi-mechanized and fully mechanized units are in compliance with ISO standards pertaining to quality and safety. Problems identified in the cashewnut processing system and probable measures are listed in Table 3.4.1.

Table 3.4.1. Problems identified and probable measures in the performances of cashewnut processing units

Sl. No.	Problems statement	Probable measures
1.	Quality assessment of raw cashewnut is not carried out. Nut moisture is not at all considered while processing and rely on private agencies.	The empirical relationship developed could be used to assess the quality. Moisture meter developed could be utilized for assessing moisture content.
2.	Improper grading of raw nuts leading to kernel breakage in mechanized de-shelling process and decreased production rate in labour oriented mode of processing.	Raw cashewnuts need to be graded using appropriate sieve sizes and blades have to be set for graded raw cashewnuts.
3.	Comparative evaluation of static and rotary steam boilers.	Need to be carried out towards better whole kernel yield in shelling and higher thermal efficiency.
4.	Kernel contamination due to CNSL during the mechanised deshelling process.	Developing appropriate technology to obtain CNSL free kernels extraction.

5.	Enhancing whole kernel recovery after shelling for graded raw cashewnut.	Processing parameters need to be optimized for the combination of steaming and shelling machines.
6.	Improving white whole kernel recovery after peeling operation.	Processing parameters need to be optimized for the combination of dryer, humidifier and peeling machines.
7.	Evaluation of size and colour sorters.	Performance evaluation needs to be conducted to quantify production rate and efficiency.
8.	Necessity of IR dryer in the line of processing.	Microbiological aspects of cashew kernels need to be investigated to confirm its usage.
9.	Watermark on cashew kernels while packaging.	Final moisture in kernels in relation to packaging parameters needs to be investigated.
10.	The shelf life of value added products is unknown.	Storage studies on various value-added products have to be investigated.
11.	Quality and safety of cashew processing system is not followed.	Awareness of ISO standards to all mode of processing is essential.

3.4.3. Design and development of mechanized slicer for cashew apple

Development of mechanized slicer and its performance evaluation

The major aim in developing the slicer is to reduce the size of the cashew apple fruits by mechanical means without change in chemical properties of the material and uniformity in size and shape to prepare diversified food products. It is also to ease the process of drying, the size reduced materials towards pulverization to prepare cashew apple powder based food products. To enhance the performance of earlier developed mechanized cashew apple slicer, it is modified (Fig. 3.4.6) by i) increasing the number of rotary disc blades with a bevel angle of 15^0 for better shearing; ii) Enlarged diameter of the blade to make it suitable for bigger size apples; iii) provided slotted plate with specific curvature at the feed end for complete slicing and ejection without breakage in slices and iv) conveyer belt to transfer singulated fruit to slicing end. An independent drive is coupled to belt conveyer for its operation as high torque is required to move the apples in a given orientation for slicing.

Fig. 3.4.6. Mechanized cashew apple slicer

Performance trials were conducted at Regional Research Station, Tamil Nadu Agricultural University (TNAU), Vridhachalam, Tamil Nadu, and was the operational capacity was observed to be 108 kg h^{-1} depending upon the size of the apples and the whole slice recovery recorded was more than 80%. This mechanical slicer needs to be refined for improving its performance in terms of quantitative and qualitative efficiency. Accordingly, suitable design for singulating cashew apples and regulating the cashew apples in a longitudinal orientation to slice it by the rotary disc blades of required thickness is prepared and the fabrication is under progress.

Vacuum frying of cashew apple slices

Vacuum frying is a reasonably new technology which uses lower pressure and temperature rather than atmospheric deep-fat frying to improve the quality attributes of food products. Exploring the possibility of preparing crispy snack food, batch vacuum frying of cashew apple slices was carried out at M/s Orbello Agro Foods Private Limited, Sangli, Maharashtra. Initially, cashew apples were cleaned off adhering dirt, and sliced manually into 3-4 mm thickness and subjected to preliminary treatment for 180 minutes in order to harden the slices. Depending on the moisture content, slice thickness, composition and hardness, parameters for frying cashew apple slices were arbitrarily fixed. Hardened cashew apple slices were placed in the basket inside the frying chamber, but suspended above the hot oil. The pressure inside the vacuum frying chamber was reduced to the required level and the sample was lowered into the oil for certain duration. Later the basket was raised above the oil and centrifuged separately to drain the surface oil. To check the quality of fried slices, the process of vacuum frying was stopped for a while for every 5 minutes and after testing its crispy texture, it is continued. Care was taken to avoid exposing the material in an ambient environment as it would lead to darkening of slices due to the oxidation process. The final product of vacuum fried cashew apple slices were found to be crispy, retaining its colour and flavour. Affirmatively, vacuum frying of size reduced cashew apples is quite possible, but retaining its quality and crucial parameters need to be optimized to obtain better food product with minimal astringency.

Fig. 3.4.7. Vacuum frying unit

Fig. 3.4.8. Vacuum fried cashew apple slices

Extruded product using cashew apple powder

Extrusion is a high-temperature short-time cooking technique used to produce a variety of products from different food ingredients. During the process of high-pressure operation that provides sudden expansion of the processed product with porous and crunchy texture while leaving the die opening at the outlet. The present investigation was carried out to explore the possibility of utilizing cashew apples, one of the byproducts of the cashew industry in preparing crispy snack food. In this connection, fully ripened cashew apples were cleaned, pre-treated, cut into slices and dried under hygienic environment. Exposing slices in forced convection ease the drying process in a shorter duration and make it amenable for pulverization. Cashew apples in amorphous form finally sieved through the pore size of 425 nm to obtain uniform size particles to blend as an ingredient with corn and sorghum on account of its nutritional composition. A laboratory ribbon blender mixer was used to blend the raw materials homogeneously and moisture to be added computed based on the initial moisture content of the Cashew Apple Powder (CAP). A co-rotating extruder was used for the preparation of extrudate having 16:1 Length to Diameter (L/D) ratio of extrusion screws and die diameter of 3 mm.

Selectively various parameters influencing the extrusion process viz., the composition of the blend (Maize proportion at 60%, Sorghum at 25%, 30% and 35%, CAP at 5%, 10% and 15%), moisture content of the blend (12%, 14% and 16% d.b), screw speed (30, 32.5 and 35 Hz) were followed based on the preliminary investigations. Response Surface Methodology (RSM) was used to optimize the experimental design and accordingly, a total of 14 combinations were conducted to save time, energy and cost (Table 3.4.2). After 5 min of the initial run, the extrudate was collected and dried in convection dryer maintained at an air temperature of 120 ^{0}C for 15 min. Polythene laminated pouches were used to store the extrudate for further analysis. Extrudate properties of the snack food prepared viz., physical property, expansion ratio (ER), true density (TD), rehydration ratio (RR), water absorption index (WAI), water solubility index (WSI), oil absorption capacity (OAC) and texture profile analysis (TPA) in terms of compression force and cutting strength were assessed following standard technical procedures.

Dimension analysis of the extrudate prepared using CAP as ingredient showed that average diameter ranged between 8.32 to 13.05 mm for the various combinations of material and machine parameters. Expansion takes place due to sudden exit of molten mass from the restricted die from very high pressure to atmosphere giving improved texture to the extrudate. The expansion ratio (ER) of extrudate ranged from 2.81 to 4.10. The highest value of ER was observed at a moisture content of 12% (w.b) and a screw speed of 30.0 Hz. Lower expansion ratio may be attributed to the presence of higher fibre content which leads to rupture causing a reduction in expansion. The true density of the extrudate varied between 117.25 to 361.04 g cc^{-1} with an average value of 191.70 g cc^{-1}, which plays an important role in packaging and further value addition.

Extrudate products are mostly consumed as ready to serve snack foods or used as base ingredients of many beverages as well as gruels and weaning foods. The solubility of the material as a result of extrusion as well as its water holding capacity, therefore, becomes important physical properties. The response of Water Absorption Index (WAI) on feed composition and extrusion condition indicated that its value ranged from 7.76 to 12.41 ml g^{-1}. Maximum WAI was recorded for the CAP proportion of 15% with a moisture content of 14% w.b. It is also observed that the WAI increased with increased screw speed owing to a lower shear rate of blend due to the hydrophilic property it binds more water molecules. Water solubility Index (WSI) can be used as an indicator for measuring the degree of starch conversion and degradation of molecular compounds during the extrusion process. Values of CAP blend extrudate ranged from 0.13 to 0.30% showing the effect of composition on CAP primarily cellulose, lignin and hemicelluloses on WSI of the extrudate.

Table 3.4.2. RSM experimental design for the preparation of CAP based extrudate

Treatment	Proportion of blend (%)			Moisture content (% w.b)	Screw speed (Hz)
	Maize	Sorghum	CAP		
T1	60	25	15.0	14.0	35.0
T2	60	30	5.0	12.0	32.5
T3	60	35	5.0	14.0	30.0
T4	60	30	10.0	16.0	35.0
T5	60	35	5.0	16.0	32.5
T6	60	30	10.0	14.0	32.5
T7	60	25	15.0	12.0	32.5
T8	60	25	15.0	16.0	32.5
T9	60	30	10.0	12.0	30.0
T10	60	35	5.0	14.0	35.0
T11	60	30	10.0	16.0	30.0
T12	60	30	10.0	12.0	35.0
T13	60	30	10.0	14.0	35.0
T14	60	25	15.0	14.0	30.0

CAP: Cashew Apple Powder; w.b: wet basis; Hz: Hertz

Oil Absorption Capacity (OAC) denotes how much oil is bound to the matrices in a particular food system, which could be used as an index of hydrophobicity of the food. OAC of CAP blended extrudate varied between 141 to 304 g g^{-1} (d.b) which was highly influenced by the moisture content and screw speed. The texture of the extrudate is a very important physical property for ready to eat snack products, which largely depends on the composition of the raw material of the mix used for extrusion. Textural Profile Analysis (TPA) especially breaking strength and compressive force was determined using TA-XT2 texture analyzer equipped with 500 N load cell using 2 mm diameter cylinder. Care was taken to avoid moisture sorption during storage or the time taken from extrusion to texture analysis. Breaking strength of extrudate fluctuated between 1.87 to 14.88 N indicating the influence of moisture content and screw speed on structural integrity and desirable extruded snack food.

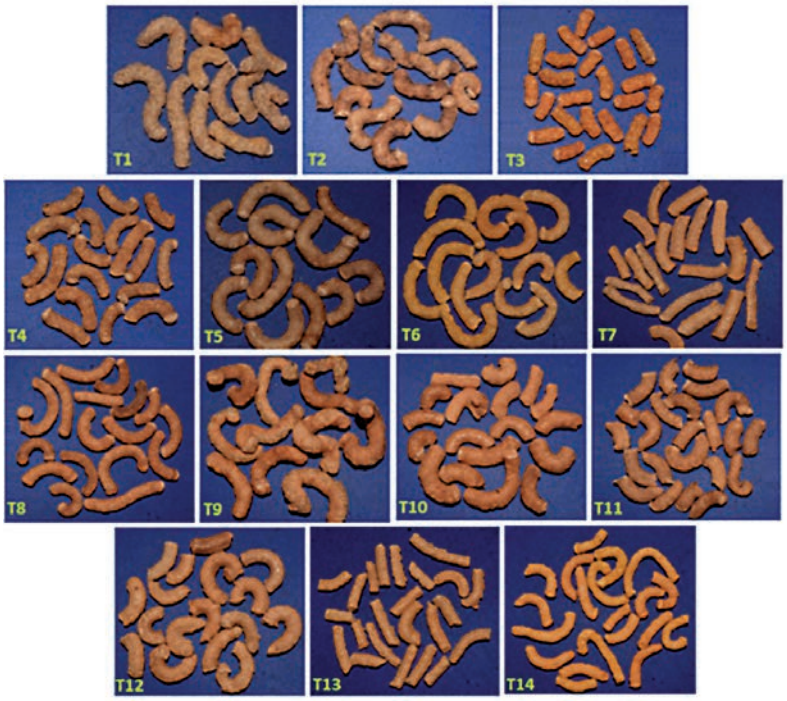


Fig. 3.4.9. Cashew apple powder-based extruded product

3.4.4. Development of dehydrated products from cashew apple and sprouts

Cashew apple chew

Well ripened firm and freshly harvested cashew apples were washed and air-dried for 5 to 10 min. Cashew apples (500 g) are cut into cubes of desirable size and mixed thoroughly with a spice mixture made of cumin, clove, cardomom, cinnamon and sugar. The mixture was spread as a single layer over a clean dry stainless steel tray for dehydration using cabinet dryer at a temperature of 40-45°C for 6-7 h or 28-30°C for 3-4 days for moisture removal. Frequent stirring or turning of sliced cashew apples is essential to avoid microbial infection. The sweet spice mixture acts as an osmolyte and the released aqueous solution from cashew apple is again impregnated into spice coated cashew slice to increase the retention of Vitamin C. This can be taken as such like a mouth freshener or along with betel leaves (Fig. 3.4.10).

Cashew apple fig

Whole fresh and firm uniform-sized cashew apples are selected and washed in running water. The apple base and distal end are removed by chopping and soaked in sugar solution of concentrations ranging from 50-70°Brix and 0.6% potassium metabisulphate (KMS) as a preservative. If the whole apple is used, gentle slits are made on four sides of cashew apple using a bamboo splint or stainless steel knife to encourage osmosis. The sugar solution concentration should be maintained at 60°Brix for at least 3-4 days. The apple slices in solution should be frequently stirred to ensure complete immersion, to avoid microbial infestation. After 3-4 days, the sugar solution is drained off and the separated cashew apples are dehydrated using cabinet dryer at 40-45°C temperature for 7-8 h (Fig. 3.4.11). The quality and physical parameters of the cashew apple chew and fig are given in Table 3.4.3.

Table 3.4.3. Quality and physical parameters of the cashew apple chew and fig

Sl. No.	Quality parameters	Cashew apple chew	Cashew apple fig
1.	Ascorbic acid (mg 100 g^{-1})	35.32	15.83
2.	Protein (%)	2.73	2.33
3.	Starch (%)	13.55	13.23
4.	Reducing sugars (%)	10.70	10.40
5.	Total phenols (% catechol equivalents)	0.69	1.20
6.	Water absorption index (%)	2.21	1.76

Fig. 3.4.10. Cashew apple chew

Fig. 3.4.11. Cashew apple fig

Cashew apple sauce

Cashew apple sauce is an important product made out of well ripe and less firm cashew apples. The cashew apple pulp is removed as lumps and added with ingredients such as onion powder, garlic powder, red chilli powder, salt and vinegar. The ingredients are mixed thoroughly with cashew pulp and cooked until it reached sauce consistency (Fig. 3.4.12). The consistency can be confirmed with a drop test method. The mineral content of cashew apple sauce is given in Table 3.4.4.

Fig. 3.4.12. Cashew apple sauce

Table 3.4.4. Mineral content in cashew apple sauce

Sl. No.	Minerals	Content
1.	Phosphorous (ppm)	0.005
2.	Potassium (%)	1.94
3.	Calcium (%)	6.01
4.	Sodium (%)	3.52
5.	Magnesium (%)	4.87
6.	Manganese (ppm)	9.46
7.	Zinc (ppm)	20.36
8.	Copper (ppm)	208.8
9.	Boron (%)	0.12
10.	Iron (ppm)	113

Cashew apple crisp

Cashew apple crisp is an important extruded product prepared out of cashew apple pomace powder. The methodology for the preparation of cashew apple pomace powder has been standardized by ICAR-DCR, Puttur. By converting the perishable cashew apple pomace to powder form is helpful to store the raw material for diversified uses during offseason. Corn flour (CF) and rice flour (RF) are the major ingredients in extruded product preparation. These ingredients are predominantly poor in minerals, proteins and fibre. Hence, to enrich the product with biominerals, protein and fibre, cashew apple pomace powder (CAPP) was added as one of the ingredients along with commercially available corn flour and rice flour. The optimised quantity of cashew apple pomace powder ranged from 5-25% (Fig. 3.4.13) for the successful exit of extruded products. The research work was carried out at Agro-processing complex, ICAR-CPCRI, Kasaragod.

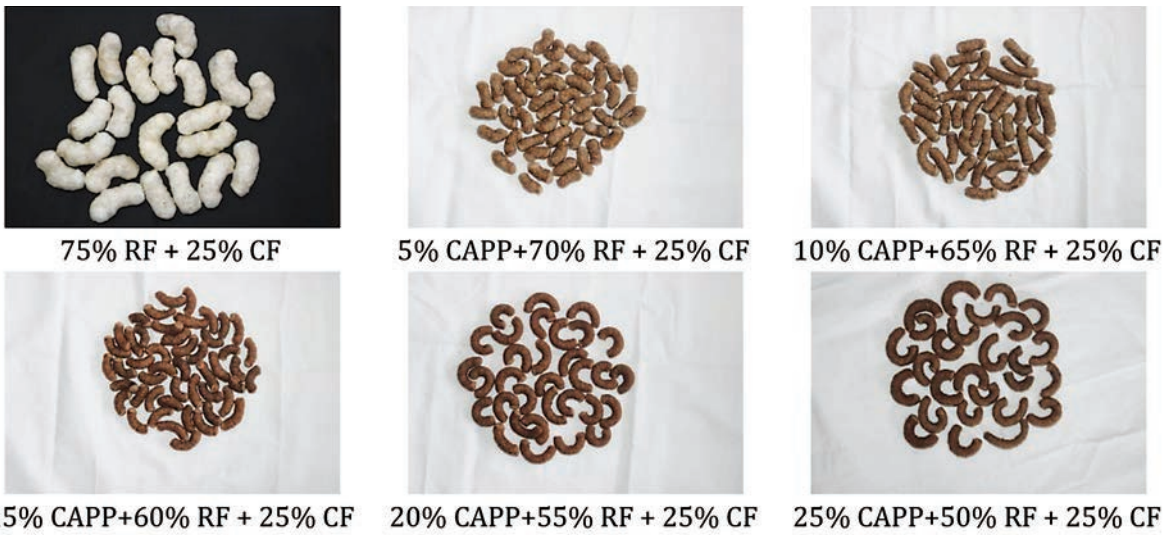


Fig. 3.4.13. Cashew apple crisp prepared using different proportions of cashew apple pomace powder (CAPP), rice flour (RF) and corn flour (CF)

3.4.6. Future areas of thrust for research in cashew Post harvest technology

- Optimization of technical parameters at various stages of cashewnut processing to improve whole kernel recovery for better cost economics.
- Innovative approaches to minimize the contamination of cashew kernels in mechanized shelling.
- Value addition of cashew apple and kernels to produce nutritious novel food products

3.5. CONCLUDED PROJECTS

3.5.1. Developing quality standards for raw cashewnuts

Principal Investigator	Dr. D. Balasubramanian
Co-Principal Investigator	Dr. K. Vanitha
Project code	4.1.1
Project duration	10/2014 – 09/2018

Introduction

Basic hindrance in establishing a suitable agency to the understand collection and marketing of raw cashewnuts is the absence of a standard system to assess its quality. Standards for raw cashewnuts and their application will be instrumental in i) Developing a culture of quality in raw cashewnut trade; ii) Assuring safety; iii) Expediting trade by serving as a common procedure and basis for pricing; iv) Ensuring success in the pooled marketing from associations of small farmers; v) Adopting appropriate systems and applying technologies to meet market expectations and requirements, and vi) Enhancing the image of the cashew enterprises as reliable suppliers of quality products. Developing methodology to assess the quality of raw cashewnuts with measurable parameters in the form of empirical relationship representing the contribution of each parameter towards quality can aid in formulating price. In view of this, the current project was formulated with the following objectives.

Objectives

- To conduct a detailed survey on prevailing quality standards for raw cashewnuts in India
- To study qualitative variables of raw cashewnuts during maturity
- To study the influence of pest attack on quality attributes of raw cashewnuts
- To develop standard methods for determining the moisture content of raw cashewnuts
- To develop inter-relationship between grading and qualitative variables of raw cashewnut
- Developing quality standards for raw cashewnuts and its validation

Materials and methods

Sampling: Storing raw cashewnuts in a sisal or gunny bags of 80 kg capacity is a regular practice. Representative samples were collected from different bags randomly depending on the quantity. The quantity of 'test sample' was conveniently made as one kg. Test samples of raw cashewnuts after cleaning the foreign matter was transferred to a vessel containing water and stirred continuously. Allowing nuts to settle down, floating (Floaters) and sunken nuts (Sinkers) are separated to confirm the magnitude of superior quality nuts. Normally nuts turn greyish brown or greenish-brown at the time of harvest indicating its maturity. Dark brown indicates the long term stored nuts and green or grey colour indicate immaturity of nuts. These indicative tests ascertain the proportion of good and inferior quality nuts in a lot.

Foreign Matter: All materials other than raw cashewnut in the lot are considered as the foreign matter which includes cashew apple residue, stones, dirt, glass, metal, straw, sticks, plastic, hair, paper, threads etc.

Nut count and spatial dimension: Nut count indicates the size of the nuts. Sample of nuts, say one kg, need to be counted and represented as the number of nuts per unit weight. The physical dimension of the nuts viz., nut length (L), nut width (W), effective width (EW), nut thickness (T) have to be measured using micrometer and nut weight

using calibrated weighing scale with Least Count (LC) of 0.01g. In the same manner, kernels of corresponding nuts need to be carefully extracted using a hand cum pedal-operated shelling machine or a hand cutting tool and its spatial dimensions viz., length (l), width (w), effective width (ew), thickness (t) and weight (Kw) have to be measured.

Quantitative analysis: Random sample of raw cashewnuts are subjected to 'cutting tests' to analyze useful kernels. It is called as 'Outturn (OT)' or 'Kernel Output Ratio (KOR)' at the stakeholders' level. One kg of raw cashewnuts are exposed to sun or convective drying (air temperature should not exceed 65^0C) till it reaches a moisture content of 8% d.b. Sample of uniform moisture is shelled open to extract kernels. As a prerequisite, unpeeled cashew kernels are graded as good, shrivelled/speckled, dotted, brown patched, oily and spoiled kernels. Quantity of useful kernels can be calculated as a summation of good kernels (100%) and shriveled/ speckled, dotted, brown patched kernels (50%). Quantitative analysis is represented as 'Outturn' and it is calculated as

$$\text{OT or KOR} = \frac{(\text{Weight of useful kernels (g)})}{(\text{Weight of nut sample (kg)})} \times \frac{1}{0.454} \times \frac{1}{1000 \times 80}$$

Shrivelled kernels: Is complete withering of the kernels that distorts its characteristic shape.

Spotted kernels: Visible black spots on the surface of cashew kernels.

Brown patched kernels: Visible brown patches on the surface of cashew kernels.

Oil stained: Oil stained kernels.

Spoiled or deteriorated or rejected kernels: Kernels are visibly spoiled partially or fully with or without foul smell and unsuitable for consumption.

Qualitative analysis: In continuation of quantitative analysis, unpeeled kernels are exposed to convective drying (air temperature should not exceed 85^0C for 2-3 h) to facilitate peeling of testa. Once the kernels are peeled off, it can be segregated into good kernels, shrivelled/speckled kernels, dotted kernels, oily kernels, brown-patched kernels and spoiled kernels. The commercial value of graded kernels is computed by 'Product value method'. In this method, whole kernel value could be found out by the total weight of good kernels irrespective of its wholesomeness i.e. whether whole or broken kernels, by its count. Depending upon its nearest value, it can be classified under 180(2.52)/ 210(2.16)/ 240(1.89)/ 320(1.42)/ 450(1.01)/ 520(0.87) grades and corresponding market price can be accounted for working out its product value. Similarly, the product value of shrivelled, dotted, brown-patched kernels can be worked based on the market price for Scorched Whole (SW), Scorched Seconds Whole (SSW), Desert Whole (DW), Oily Whole (OW) and spoiled or reject kernels. Summation of all these will yield 'Product value' of the sample.

Determination of moisture content (Chemical distillation method): Toluene (b.p. 110°C), a entraining solvent which is immiscible in water is used to determine the moisture content of raw cashewnuts. Distillation apparatus is cleaned with potassium dichromate/sulphuric acid solution to minimize the adherence of water droplets to the sides of the condenser or receiver. The nut is cut along the suture line with a scalpel and then across it into quarters. The material is weighed immediately at least to the nearest 0.1 g and transferred to the distillation flask. Sufficient toluene is added to cover the sample and the mixture is swirled. The temperature is maintained in such a way that about 170-190 drops of distillate are collected per minute. After the receiver cooled to room temperature, the volume of water collected is noted. The moisture

content is calculated as the ratio between the volume of water collected (ml) to the weight of the sample (g). Finally, the moisture content is converted into a dry basis for all practical purposes.

Influence of pest infestation on kernel quality: Random samples of raw cashewnuts (RCN) were collected from a bulk to investigate the nature of pest infestation on RCN. Nuts samples were examined visually for insect infestation (Fig. 3.5.1) i.e. healthy nuts without any insect infestation, infestation by tea mosquito bug (TMB) having clear sunken spots, infestation by apple and nut borer (ANB) having surface damage showing rough shell portions with or without holes at the scar region of nuts, by thrips having corky patches with or without shrivelling and malformation, and other kinds of damage i.e. nuts with malformation without pest damage, immature nuts, physical damage.

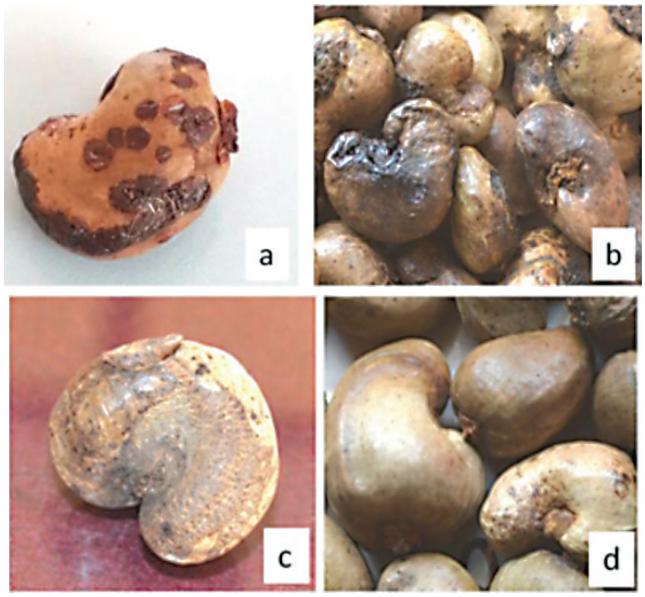


Fig. 3.5.1. Pest infestation on RCN damaged by (a) TMB; (b) apple and nut borer nd (c) thrips. (d) Healthy nuts without any pest infestation

To find out the degree of pest infestation on kernel quality, thrips infested nuts were further segregated as G1, G2, G3 and G4 based on visual observation on the degree of symptoms as G1 representing <25% corky surface; G2 as 26- 50%, G3 as 51-75% and G4 as >75% malformed. Similarly, ANB infested nuts were segregated as A1, A2 and A3 based on damage score, where A1 indicates 25% surface damage, A2 as 25-50% surface damage without holes, A3 as >50% damage with holes. Resultant kernels were segregated into kernels with shrivelling, brown patches, black spots, spoiled, oily kernels. The proportion of each kernel type was worked out and correlation analysis was performed to find out the influence of pest infestation on kernel quality.

Regression analysis to compute quality index: 'Product value' estimated for raw cashewnuts is influenced by various parameters of raw cashewnuts and its kernels viz. spatial dimension, nut count (NC), outturn (OT) and moisture content (M). Therefore, stepwise regression analysis has to be run to develop an empirical relationship of all the above-mentioned parameters to estimate its contribution for the best quality index ($P \leq 0.01$).

Results and discussions

Heterogeneity in raw cashewnuts

The spatial dimension of raw cashewnuts such as length, width, thickness representing the size and weight of nuts of certain varieties viz., Vengurla-1, Vengurla-3, Vengurla-4, Ullal-3, Bhaskara, Dhana and VTH-174, harvested from cashew farm (ICAR-DCR), Puttur were determined and depicted in Fig. 3.5.2. It is confirmed from resultant data that there was no strong correlation between nut and kernels characters for all the varieties examined except weight which is having a correlation coefficient of 0.76. The same trend is observed for the nuts imported from Africa viz., CDJKL zone, Guinea Bissau, Gambia, Ivory Coast, Indonesia and Tanzania (Fig. 3.5.3).

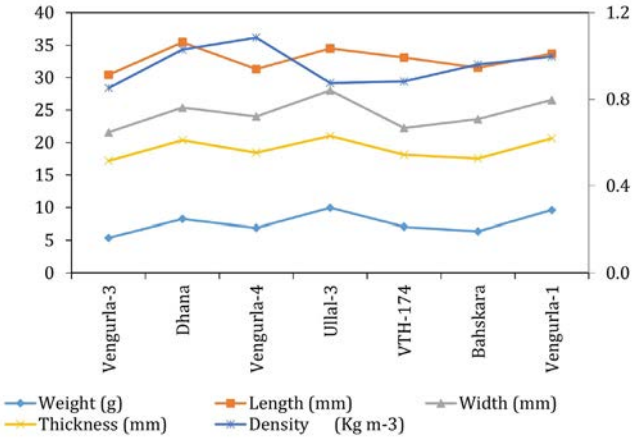


Fig. 3.5.2. Heterogeneity in the spatial dimension of raw cashewnuts (Domestic)

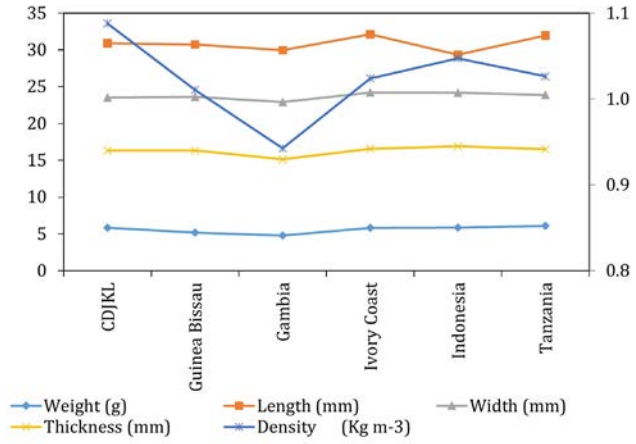


Fig. 3.5.3. Heterogeneity in the spatial dimension of raw cashewnuts (Imported)

This indicates that heterogeneity exists in raw cashewnuts even for the nuts grown in the same region. Significant difference observed in density with all other physical parameters assessed and it may not be used as a quality indicator. Therefore, a floating test which is in vogue to assess the quality should serve as a preliminary indicator and not a confirmatory test. As per the recommendations of the Institute Research Committee (IRC), developing quality standards for raw cashewnuts was restricted to domestically produced nuts only.

Quality assessment based on nut counts

Nut count is one of the techniques followed to assess the quality of raw cashewnuts in terms of size/weight. Random samples of raw cashewnuts obtained from different origins viz., Burkino Faso (Two samples imported during different periods), Benin (Two samples imported during different periods), Ivory Coast, Tanzania and Zambia were segregated into small, medium, large and very large based on its effective width using rotary sieve grader. Nuts, thus graded were counted and expressed per unit weight (Fig. 3.5.4). In the

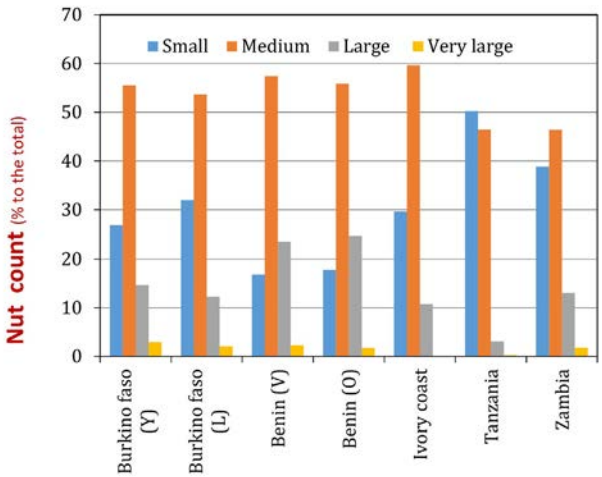


Fig. 3.5.4. Quality of raw cashewnuts based on nut count

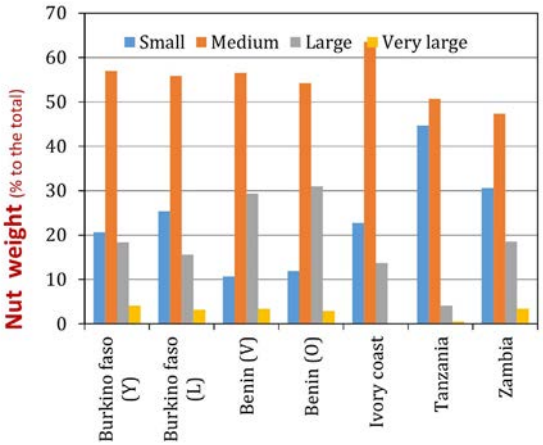


Fig. 3.5.5. Quality of raw cashewnuts based on nut weight

same manner, graded nuts were also weighed and expressed to the total quantity analyzed (Fig. 3.5.5). It is evident from the bar charts depicted on nut count and corresponding weight that there was no significant difference, indicating nut size has a high correlation with its weight. Majority of the nuts of imported origin showed that proportion of the medium size nuts representing W240 and W320 grades of the kernel as end product i.e. edible kernel quality had higher proportion followed by small, large and very large irrespective of the nuts count or weight. Probably, this could be the underlying factor for considering W320 as benchmark grade to assess the quality which is in vogue. Therefore, nut size or nut weight could a serve as technique to assess the quality of the nuts at the preliminary level. In this regard, grading gadget suitable for grading samples size of one kg is essential.

Influence of pest infestation on kernel quality

The moisture content of all the samples varied between 5.0 and 7.0% d.b. Samples collected from Kemminje farm indicated that mean per cent infestation of thrips (26.8%) was more compared to Tea Mosquito Bugs (TMB) (2.1%) and Apple and Nut Borer (ANB) (5.9%). Similarly, the mean per cent infestation was 17.6%, 8.3%, 5.9% for thrips, TMB and ANB, respectively, for samples collected from Shanthigodu farm. While assessing the quality in terms of kernels characteristics, it was observed that shrivelling, brown patches and black spots were found also on kernels of healthy cashewnuts. Hence, these characteristics could not be solely attributed to pest infestation. Further, black spots were not found in the kernels in the TMB infested RCN. Pooled data analysis of three harvests and varieties revealed that per centage of healthy nuts was more (71.4%) followed by thrips infested (21.1%), ANB (5.8%) and TMB (1.0%) infested nuts. Among the three pests, thrips infestation was more pronounced followed by ANB. Varied levels of pest infestation resulted in a difference in surface quality characteristics of kernels. But the presence of shrivelling, brown patches, black spots on kernels of healthy raw cashewnuts without visible signs of pest infestation indicates the involvement of factors other than insects. In the late harvest nuts, brown patches and spoiled nuts were more, which might be due to the climatic factors prevailed during the maturity period of raw nuts. However, it needs to be ascertained. A lower level of damages on raw nuts by thrips, ANB and TMB had no much influence on the kernel physical quality and highly significant correlations arrived with good kernel recovery.

Dimension analysis of Indigenous raw cashewnuts

Raw nuts collected from cashew growing regions in both East and West coasts were graded using mechanized concentric drum type rotary sieve grader. The proportion of graded nuts viz., Very Large (VL), Large (L), Medium (M) and Small (S) based on the effective width, which plays important role in shelling process is presented in Table 3.5.1.

Distribution of various sizes of nuts in the sample indicated that certain varieties had a higher proportion of very large sizes of nuts yielding better economic values viz., Indira caju, Jhargram-2, Balabhadra and Jaganatha in the East coast and Vengurla -6, Vengurla -7, Vengurla -8 and Vengurla -9 in the West coast. Spatial dimension and nut quality in terms of nut count and outturn for 40 samples collected from AICRP Centres of cashew revealed

Table 3.5.1. Changes in the size of the raw cashewnuts (Weight in gram)

Sl. No.	Variety	Very large	Large	Medium	Small
1.	VRI-2	0	0	483	517
2.	VRI-3	0	20	877	103
3.	VRI-4	0	0	487	513
4.	VRI-Cw	0	111	829	60
5.	BPP-1	0	41	594	366
6.	BPP-2	0	0	487	513
7.	BPP-3	0	103	683	214
8.	BPP-4	0	7	143	850
9.	BPP-5	0	0	487	513
10.	BPP-6	0	22	505	473
11.	BPP-8	28	553	419	0
12.	BPP-9	18	386	588	7
13.	Jagannatha (BH-6)	26	344	553	77
14.	Bhuvaneshwar-1	0	8	414	579
15.	Balabhadra (BH-85)	68	274	639	20
16.	Indira caju	114	742	144	0
17.	Jhargram-1	0	0	458	542
18.	Jhargram-2	10	648	342	0
19.	Anagha	0	8	13	979
20.	K-22-1	0	23	646	331
21.	Dhana	0	238	608	154
22.	Priyanka	0	107	487	406
23.	Poornima	0	175	507	319
24.	Maddakkathara-1	0	7	104	889
25.	Maddakkathara-2	0	28	685	287
26.	Raghav	0	300	630	70
27.	Damador	0	17	299	684
28	Amrutha	0	13	361	626
29.	Dharasree	11	179	332	478
30.	Bhaskara	0	150	826	24
31.	Vengurla-1	0	0	720	280
32.	Vengurla-2	0	46	703	250
33.	Vengurla-3	66	682	252	0
34.	Vengurla-4	39	787	174	0
35.	Vengurla-5	0	0	0	1000
36.	Vengurla-6	190	783	28	0
37.	Vengurla-7	793	207	0	0
38.	Vengurla-8	364	636	0	0
39.	Vengurla-9	468	532	0	0

VL: Very large; L: Large; M: Medium; S: Small

that dimension in major, minor and intermediate axes were found to be in the range of 25.8-39.5, 19.3-28.8 and 14.2-21.3 mm respectively. Average values of sphericity and equivalent diameter of these nuts ranged from 18.87 to 27.69 and 0.82 to 0.88 respectively. There was no strong correlation observed between nut and kernel characters except weight (0.76). Among the varieties, nut count found to be lesser for 'Vengurla-7' (91 nuts) whereas 'Anagha' registered higher value of 250 nuts per kg. As far as outturn is concerned, 'VRI-Cw' (62%) recorded the highest and in 'Raghav' (45.4%) it was found to be the lowest. It was observed that nut size has a strong correlation with nut weight. The proportion of medium size nuts found to be the highest among the graded nuts. After processing, this particular size turns out to be 'W320' grade and hence, this grade is considered as benchmark for price computation.

Empirical relationship representing quality

A simple empirical relationship was developed to represent quality by considering the proportion of graded raw cashewnuts, the prevailing market price for cashew kernels, count-based nut weight and yield of good kernels and other fractions. This quality index suggests that the value between 0.08 and 1.0, wherein the lowest value represents completely spoiled kernels as the final yield and a highest value indicating 100% good kernels.

$$Y = \sum_{i=1}^{n} \frac{A_i X_i}{(AX)_{Max}}$$

Where Y is the quality index (1.0<Y<0.1); A is the grade of cashew kernel; X is the assigned value for the grade, i representing various grades of cashew kernels.

This methodology is quite suitable for preliminary assessment with the assumption that 72% of the processing cost is incurred on raw cashewnuts, kernel per centage recovery of 23% the nuts are graded into VL, L, M and S based on effective width yielding W180, W210 and W240, W320 and W450 and W520 respectively and the prevailing market price.

This Product value method has not incorporated moisture content, which has a strong bearing on the quality of raw cashewnuts as far as its shelf life is concerned. Hence, it needs to be modified with a provision to determine the moisture content instantaneously. 'Product Value' estimated for raw cashewnuts is influenced by various parameters of raw cashewnuts and its kernels viz., their spatial dimensions, nut count (NC), outturn (OT) and moisture content (M). Therefore, stepwise regression analysis was followed for the basic data generated in 40 different varieties collected from the AICRP Centres. An empirical relationship is developed in terms of 'Quality index' to estimate its contribution towards the quality of raw cashewnuts ($P \leq 0.01$) and conveniently it can be utilized at different stakeholders' level.

Quality index = 64.48-0.161 NC + 4.56 OT – 3.85 M with (Multiple R value of 0.88)

Where NC – Nut count; M – Moisture content of in-shell cashewnuts; OT – Outturn

Validation of empirical model with locally available raw cashewnuts

The quality index developed was validated for raw cashewnuts gathered from ICAR-DCR farm viz., VTH-30/4, Ullal-4, Bhaskara, Ullal-3 and NRCC Selection-1 and freshly harvested local nuts i.e. Bellare and Sullia. Moreover, in order verify the influence of stored nuts, both freshly harvested nuts and one year old nuts of accession H-126 were assessed for its quality using the empirical relationship developed in terms of 'Quality Index' (Table 3.5.2).

Table 3.5.2. Validation of quality index developed for raw cashewnuts

Variety / origin	NC	M	OT	Original Yield	Yield using QI
Varieties (cashew farm)					
VTH-30-4	166	9.75	57.51	270.9	262.5
Ullal-4	156	8.88	60.11	280.2	279.3
Baskara	169	7.63	62.07	298.0	291.0
Ullal-3	138	10.23	55.88	260.2	257.7
NRCC Sel-1	142	7.40	58.77	292.8	281.1
Locally collected nuts				**R^2**	**0.96**
Bellare	184	14.00	57.63	243.04	243.7
Sullia	155	13.25	54.09	230.79	235.2
Stored nuts				**R^2**	**1.00**
H-126 Fresh	70	9.96	50.43	236.2	244.8
H-126 Old	85	5.75	55.26	278.9	280.6
Fresh / Old nuts of H-126				**R^2**	**1.00**

NC - Nut Count ; M - Moisture content of Inshell Cashewnuts ; OT - Outturn.

3.5.2. Screening of cashew varieties to specify the use of cashew apple in value-added products

Principal Investigator	Mr. R. A. Dagadkhair
Co-Principal Investigators	Dr. Ramkesh Meena (11/2014 to 12/2015)
	Dr. M.V. Sajeev (10/2015 to 03/2017
	Dr. P. Preethi (09/2017 to 06/2018)
Project code	4.19
Project duration	10/2014 – 06/2018

Introduction

India is one of the leading countries in cashew cultivation and production with 10.27 lakh ha area under cashew cultivation and 7.25 lakh tonnes of production of raw cashew nuts (DCCD 2020). A unit of the cashew apple is eight times heavier than a nut, considering this thumb rule we are producing 58.24 lakh tonnes of cashew apple every year. In the majority of cases, the cashew apples are not utilized and left to rot in the field.

Because cashew apples are harvested over a period of 4 -5 months during a year, its use as a raw material for a variety of fruit-based products can trigger a revolution in the cashew industry. Cashew apple can be processed as wine, gin, brandy, syrup, vinegar and jam and some of these products are being produced on a commercial scale in Brazil, India and Mozambique.

Cashew apple juice is sweet and nutritious, but it has astringency due to the presence of phenolic compounds, which makes it less palatable. Hence, it was decided to undertake the research for improving the palatability and quality of the cashew apple by converting it into juice and by blending with other fruit juices and spices for the preparation of Ready-to-Serve (RTS) beverage, cider, jams and jelly etc. Cashew apple obtained from different varieties has different physicochemical properties. The range of the products so far developed from cashew apple in India is seen to be failed either in the early stage of industrial development or at consumer level due to lack of quality. The important reason behind this sorry status of processed products of the cashew apple is nonuniformity of the raw material and unawareness about variety-specific product preparations. Therefore, it was highly essential to screen the cashew varieties based on their suitability for specific product preparation from the cashew apple.

Objectives

1. To judge the right stage of development of cashew apple suitable for specific product preparation.
2. To determine the chemical composition of cashew apple at different stages of development.
3. To specify varietal suitability for fresh consumption and value addition of cashew apple.
4. To evaluate the shelf life of raw cashew apple and its processed products.

Research Findings

Physicochemical properties of cashew apple at different stages of its development

Five different stages of the physiological development of cashew apple were recognized (Fig. 3.5.6) and fruits were tested for their physicochemical properties (Table 3.5.3). The fifth stage of the physiological development of cashew apple was found to be suitable for preparation of RTS, cider, jam, jelly and pulp.

Fig. 3.5.6. Stages of development of cashew apple

Table 3.5.3. Physicochemical properties of cashew apple at five different stages of development

Apple stages	Bhaskara			Ullal-3		
	Tannin (%)	Phenols (µg 100 mg^{-1})	Reducing sugars (%)	Tannin (%)	Phenols (µg 100 mg^{-1})	Reducing sugars (%)
1.	0.048	6.081	0.378	0.062	5.331	0.468
2.	0.030	2.324	0.408	0.043	2.675	0.624
3.	0.022	1.864	0.418	0.044	1.143	0.797
4.	0.023	1.396	0.732	0.022	1.256	0.924
5.	0.018	3.323	1.195	0.016	3.879	1.834
CD (5%)	0.053	5.32	0.58	0.051	4.63	0.61

Apple stages	Bhaskara		Ullal 3	
	DPPH scavenging activity (µ mols 15 min 100 mg^{-1})		DPPH scavenging activity (µ mols 15 min 100 mg^{-1})	
	Methanol extract	Phenols fraction	Methanol extract	Phenols fraction
1.	0.511	0.073	0.634	0.089
2.	0.356	0.216	0.482	0.368
3.	0.288	0.311	0.335	0.487
4.	0.263	0.202	0.298	0.456
5.	0.167	0.226	0.211	0.379
CD (5%)	0.59	0.611	0.62	0.632

Screening of varieties

Every processed product has its raw material requirement to stand excellent as far as its quality is concerned. Keeping that in view, one germplasm accession and ten released varieties have been analysed for their physicochemical parameters (Table 3.5.4).

Table 3.5.4. Screening of cashew apple varieties based on their biochemical composition

Sl. No.	Variety	Colour	Apple weight (g)	Juice content (%)	TSS (°Bx)	Tannin (mg g^{-1})	Vit-C (mg 100 g^{-1})	Acidity (g 100 ml^{-1})
1.	Bhaskara	Red	68.5	61.5	8.5	0.60	73.24	0.43
2.	Madakkathara-2	Red	79.0	63.5	10.0	0.51	NA	0.59
3.	Ullal-3	Red	70.0	60.0	10.5	0.39	NA	0.29
4.	Vengurla-4	Red	73.5	58.0	9.5	0.48	NA	0.37
5.	NRCC-301	Red	132.0	69.5	9.0	0.50	NA	0.27
6.	NRCC Selection-2	Red	71.0	65.0	11.0	0.68	63.80	0.48
7.	Dhana	Yellow	73.0	61.0	9.0	0.63	59.72	0.40
8.	Priyanka	Yellow	113.0	69.0	10.5	0.39	87.37	0.41
9.	VTH-174	Yellow	79.0	48.0	11.5	0.66	NA	0.52
10.	Kanaka	Yellow	63.0	50.0	12.0	0.58	63.28	0.39
11.	Vengurla-3	Yellow	72.0	56.0	10.5	0.41	----	0.40

(n=3, NA= not analyzed)

Cashew apple pulp

Studies on the long time storage of cashew apple in the form of pulp were taken up. Freshly collected cashew apples were ground into a slurry consistency without the addition of water or any other ingredient. This pulp was packed in the High-density polyethylene (HDPE) bags and stored at below -10°C (Fig. 3.5.7). The study revealed that except 16% reduction in Vitamin C content (338 to 282 mg 100 ml^{-1}), the other components such as tannins, phenolics and total soluble solids remained without significant changes even up to 6 months of storage.

Fig. 3.5.7. Frozen Cashew apple pulp

The effect of pulp blanching on its storage behaviour was studied in comparison with the unblanched sample. Though heating of pulp at about 100°C for 1-2 minutes resulted in depletion of few heat-labile nutrients like Vitamin C (343 mg 100 ml^{-1}) over unblanched sample (368 mg 100 ml^{-1}), the inactivation of enzymes due to blanching resulted in retention of maximum nutrients (TSS-9°Bx, Vitamin C (Vit-C) 273 mg 100 ml^{-1}, Tannins 148 mg 100 ml^{-1}, Total Phenolic Contents (TPC) 236 mg 100 ml^{-1}, CUPRAC Assay 863 mg 100 $ml^{-1}$and FRAP Assay 463 mg 100 ml^{-1} during the storage compared to the unblanched samples (TSS-8.8°Bx, Vit-C 251 mg 100 ml^{-1}, Tannins 140 mg 100 ml^{-1}, TPC 230 mg 100 ml^{-1}, CUPRAC Assay 803 mg 100 ml^{-1} and FRAP Assay 426 mg 100 ml^{-1}). The colour of the blanched pulp at the end of twelve months frozen storage was better than unblanched samples.

CASHLIME: Cashew apple lime blend RTS nectar

Cashew apple juice is sweet and nutritious but has astringency due to the presence of tannins (0.2-0.3%), which makes it less palatable at the same time limits processing and marketability of its value-added processed products. To overcome this problem attempts were made by compatibly blending the cashew apple juice with lime juice and water. The threshold value for the sensation of astringency of tannins is 0.1%. Below this concentration astringency cannot be sensed. The concentration of cashew apple juice in the "Cashlime" is so adjusted that it will contribute maximum to the nutritional value of the product and also bring down the concentration of tannins below threshold value through optimum dilution with water. Blending with lime juice resulted into delightful and delicious beverages with improved organoleptic quality and nutritive value. Keeping in view the nutritive and health benefits of cashew apple and lime, the present technology is developed where lime possess bland taste and cashew apple can serve as the best functional food by blending with lemon as taste improver. The product falls in the category of "Ready to Serve Nectar" (RTS Nectar) beverage in food technological terms as the fresh fruit juice content of the beverage is more than 20%.

Out of eleven varieties selected for study, five varieties viz., Vengurla-3, Accession-301, Dhana, Bhaskara and Ullal-3 were found to be suitable for the preparation of RTS beverage in terms of overall acceptability through organoleptic evaluation and biochemical composition.

Fig. 3.5.8. "Cashlime" a cashew apple and lemon juice blended RTS beverage

Comparative nutritional value and functional properties of the CA-Lime blend RTS and commercial lime RTS is presented in Table 3.5.5. It is clearly understood that the blended RTS prepared from the selected combination of juices found to be superior to RTS prepared using only cashew apple juice or commercially available lime-based RTS. The product could retain a maximum of ascorbic acid (75.9 mg $100ml^{-1}$) and total phenolics (0.06%). The tannin content (86.62 mg $100ml^{-1}$) of the product was found to be below the threshold level of the sensation of astringency (≤0.1%).

Table 3.5.5. Nutritional value and functional properties of the product compared with fresh juice and RTS without lime juice

Sl. No.	Parameter	Raw cashew apple Juice	RTS without lime Juice	Cashew apple-lime blend RTS	Commercial lime RTS (Nimbooz)
1.	TSS (°Bx)	11.5	10.0	10.0	10.0
2.	Ascorbic acid (mg $100ml^{-1}$)	330.0	68.0	75.9	13.2
3.	Tannin (mg $100ml^{-1}$)	289.0	90.86	86.62	3.7
4.	Total phenol (%)	0.28.0	0.04	0.06	0.02
5.	DPPH Scavenging Activity (µmoles $15min^{-1}$ 100 μl^{-1} juice)	1184.2	203.8	281.6	117.0
6.	Acidity (%)	0.48	0.33	0.38	0.46
7.	Carbohydrates (%)	14.05	13.02	13.06	13.0
8.	Sugars (%)	12.04	11.04	12.06	12.02
9.	Protein (%)	0.18	----	----	----
10.	Fat (%)	0.09	----	----	----
11.	Energy (kcal $100ml^{-1}$)	51	47	51	50

Microbial evaluation of Cashlime

The prepared beverage formulation was studied for the microbial load. The total microbial load was calculated by Standard plate count method. The standard plate count was done according to the method described in "Recommended method for the microbiological examination of food". The microbial analysis of the cashew apple-lemon blend RTS Nectar was performed at the interval of 30, 60, 90, 120, 150 and 180 days after storage (DAS) at room temperature and refrigerated storage (10°C) with and without the addition of permitted chemical preservative. The preparation with 70 ppm potassium metabisulphite (KMS) at room temperature remained safe for 60 days over the one without added KMS (30 DAS). The significant improvement in the shelf life of the beverage i.e. 150 DAS was recorded over the one stored at refrigeration temperature without KMS (90 DAS) which can be attributed to the synergistic effect of 70 ppm of KMS and refrigerated condition during storage.

Cashew apple cider

Cashew apple cider is prepared from four different varieties separately and also from mixed variety cashew apple juice through anaerobic fermentation at room temperature by yeast *Saccharomyces cerevisiae.* The pH of 4.2-4.4 was identified and maintained for efficient fermentation using suitable buffers at different stages of fermentation. The sugar is added to the tune of 1-2% if the TSS of fresh juice is below 10°Bx. The alcohol content of the product is in the range of 3.5-6.0% (v/v). Based on the preliminary sensory evaluation, the cider prepared from mixed juices of different varieties was found to be better than the individual varieties. The product was analyzed for its functional nutrients. The concentration of antioxidants in the fresh product was found to be 65-100 mg $100ml^{-1}$ trolox equivalent by CUPRAC method. The beverage is rich in Vitamin C (150-220 mg 100 ml^{-1}) and phenolics content (150-180

mg 100ml^{-1}). The cider prepared was observed for its stability with respect to biochemical changes (TSS, Vit- C, total phenols and antioxidants activity) occurred during storage. The preparation is highly stable even at room temperature (>6 months), whereas at refrigerated temperatures, the product was found to be stable for more than twelve months (Fig. 3.5.9, Table 3.5.6).

Fig. 3.5.9. Antioxidant rich cashew apple cider

Table 3.5.6. Nutritional value and functional properties of cashew apple cider

Sl. No.	Parameter	Value
1.	TSS (°Bx)	1.0-1.5
2.	Ascorbic acid (mg 100ml^{-1})	150-220
3.	Tannin (mg 100ml^{-1})	112-186
4.	Total phenol (mg 100ml^{-1})	140-205
5.	Antioxidant activity (CUPRAC) (mg 100ml)	65-100
6.	Antioxidant activity FRAP (mg 100ml)	250-400
7.	Carbohydrates (%)	1.5-2.0
8.	Sugars (%)	1.0-1.5
9.	Ethanol (%)	3.5-6.0
10.	Protein (%)	---
11.	Fat (%)	---
12.	Energy (kcal 100ml^{-1})	40-50

Cashew apple jam

Out of eleven varieties screened, three (Bhaskara, VTH-174 and NRC-301) were found to be suitable for jam preparation due to their high pectin content compared to other varieties. Moreover, the product can be prepared from other varieties also by the addition of commercial pectin or natural source of pectin at the rate of 0.1 to 0.5% (depending upon the original pectin content of cashew apple). Cashew apple jam (68°Bx) preparation was standardized by using a natural source of pectin. Different concentrations of the dried orange peel powder (boiled) extract was added and a suitable concentration for setting a quality jam was identified. Cashew apple jam was analyzed for its functional nutrients and it was found to be rich in Vitamin C (120 mg 100g^{-1}), total phenolics (134 mg 100g^{-1}), and antioxidants (403 mg 100g^{-1} by CUPRAC and 200 mg 10g^{-1} by FRAP assay). The product was checked for its shelf life based on the effect of storage temperature on biochemical composition of the preparation and it was found that the product was high in sugar and remained stable up to six months. The nutritional content of cashew apple jam is given in Table 3.5.7.

Fig. 3.5.10. Antioxidant rich cashew apple jam

Table 3.5.7. Nutritional value and functional properties of cashew apple jam and jelly

Sl. No.	Parameter	Cashew apple jam	Cashew apple jelly
1.	TSS (°Bx)	68.5	65.0
2.	Ascorbic acid (mg $100ml^{-1}$)	121.0	142.0
3.	Tannin (mg $100ml^{-1}$)	112.0	93.0
4.	Total phenol (mg $100ml^{-1}$)	134.0	117.0
5.	Antioxidant activity (CUPRAC) (mg $100ml^{-1}$)	403.0	316.0
6.	Antioxidant activity FRAP (mg $100ml^{-1}$)	200.0	152.0
7.	% DPPH assay	68.30	66.0
8.	Sugars (%)	64.30	65.5
9.	Dietary fiber (%)	1.60	Traces
10.	Protein (%)	0.17	0.06
11.	Fat (%)	0.12	0.08
12.	Energy (kcal $100g^{-1}$)	277	261

Cashew apple jelly

Out of eleven varieties screened, three (Bhaskara, VTH-174 and NRC-301) were found suitable for jelly preparation due to their high pectin content compared to other varieties. The product can also be prepared from any other varieties with the addition of commercial pectin or natural source of pectin at the rate of 0.1 to 0.5% (depending upon the original pectin content of cashew apple) more than the selected varieties. Cashew apple jelly (65°Bx) preparation was standardized where the use of commercial pectin is reduced by using a natural source of pectin. The cooked guava (unripe/firm) pulp extract was added at a different levels of concentration and a suitable concentration was fixed to set a quality jelly. Cashew apple jelly was analyzed for its functional nutrients and was found to be rich in Vitamin C (142 mg $10g^{-1}$), total phenolics (117 mg $10g^{-1}$), antioxidants (316 mg $10g^{-1}$ by CUPRAC and 152 mg $10g^{-1}$ by FRAP assay). The product is checked for its shelf life based on the effect of storage temperature on biochemical composition of the preparation and it was observed that the product was high in sugar and remained stable up to six months.

Fig. 3.5.11. Antioxidant rich cashew apple jelly

4. TRANSFER OF TECHNOLOGY AND EDUCATION

4.1. Farmer participatory soil and plant health management – An attempt for improving the livelihood of cashew farmers of coastal Karnataka under RKVY-RAFTAAR

Cashew is usually grown as rainfed crop along the West and East coasts in soils that are generally poor in fertility status. Poor soil fertility and limited attention to nutrient management is one of the major constraints in realizing the potential yield from cashew. Timely management of pest and diseases is also important for improving the yield and net returns from cashew orchards. Under this background, a project funded by RKVY-RAFTAAR was initiated to create a state of art laboratory facilities and demonstration plots to showcase the usefulness of improved technologies to realize higher yield and income to the cashew growers of Karnataka in particular and other regions in general. The demonstration with farmer's participation is expected to allow the growers to realize the impact of technologies in the field.

On-farm demonstration

For establishing a demonstration plot on improved production technology for the visiting farmers, an additional plot area of 4.5 acres with cashew variety Bhaskara was developed in the Kemminje campus. Of the 4.5 acres, 3 acres was planted at normal density (7.5 m x 7.5 m spacing) with the contents Bhaskara, and 1.5 acres under high density planting at a spacing of 4 m x 4 m with the variety H-130. To demonstrate the usefulness of water management and irrigation under precision agricultural practices, a drip irrigation system was installed (Fig. 4.1.1).


Fig. 4.1.1. Field preparation, planting and drip system laying activities for establishing thebdemonstration plot

Front line demonstration (FLD) in the farmers' field and training

Farmers fields in the coastal districts of Karnataka viz. Udupi, Dakshina Kannada and Uttara Kannada were surveyed and need-based advice on cashew cultivation was given. Farmers meetings were carried out in all the three districts. Based on exploratory survey 60 farmers were selected for conducting adaptive research trials and front line demonstrations. Of the 60 farmers contacted, 59 farmers took up the farmer's participatory research and demonstration and carried out activities on improved plant health management. Soil health cards were also distributed to these farmers.

Cashew plant health clinic museum

Cashew is a seasonal crop which flowers and fruits in a definite season. To illustrate different aspects of cashew cultivation throughout the year to the visiting farmers and others, a museum was proposed to be established under the project. During the financial year 2018-19, the phase-I activities of the museum have been completed. This includes the development of models, showcases and interactive kiosks. The phase II will cover wall panelling, designer ceiling, wall painting, wooden flooring, lighting, making glass enclosures, making special frames, fascia gate, murals, digital printing, digital translates with backlit, digital printing of foldable rollup banners, press button information board, storytelling board, LED flow sheets/move signs display, hologram fan display and standing translites.

4.2. Exhibitions

Krishi Yantra Mela-2019: ICAR-DCR, Puttur participated in 'Krishi Yantra Mela-2019' conducted at Vivekananda College of Engineering and Technology (VCET), Puttur, Karnataka during 23-25 February 2019 and exhibited commercialisable technologies of the Directorate.

Kisan Mela and Agri-Expo-2019: A team from ICAR-DCR exhibited a stall of the Directorate in Kisan Mela and Agri-Expo during 12-13 October 2019 at ICAR- Central Plantation Crops Research Institute

(CPCRI), Research Station, Kidu. In this event, 500 farmers visited the DCR stall and extension leaflets on cashew cultivation aspects were distributed to needy farmers along with an explanation.

Jal Sakthi Abhiyan-2019: ICAR-DCR, Puttur participated in Jal Sakthi Abhiyan-2019 conducted at ICAR-Central Plantation Crops Research Institute (CPCRI), Kasaragod on 2 October 2019. An exhibition stall showing the technologies related to cashew production, soil and water conservation technologies developed by the directorate was put and it was visited by 1000 people such as farmers of Karnataka and Kerala, students, researchers, processors and the general public.

4.3. Farmers visit/field day at ICAR-DCR

Sl. No.	Details	Date	Co-ordinator
1.	Field day/exposure visit to DCR experimental fields and section was arranged to 50 farmers of Farmers Producers Organization, KVK Tiptur, Tumkur district of Karnataka.	22 January 2019	Eradasappa, E.
2.	Field day/exposure visit to DCR experimental fields and section was arranged to 25 farmers from Vengara block, Malappuram ATMA programme.	22 January 2019	Shamsudheen Managalassery
3.	Field day/exposure visit to DCR experimental fields and section was arranged to 30 farmers of Haveri district, Karnataka.	1 March 2019	Siddanna Savadi
4.	Field day/exposure visit to DCR experimental fields and section was arranged to 30 farmers from ATMA, Raigad, Maharashtra.	7 March 2019	Shamsudheen Managalassery

5.	Field day/exposure visit to DCR experimental fields and section was arranged to 45 farmers from ATMA, Wayanad.	23 March 2019	Shamsudheen Managalassery
6.	Field day/exposure visit to DCR experimental fields and section was arranged to 33 farmers and 7 officials from the office of the Asst. Director of Agriculture, Thiruvalla, Pathanamthitta, Malapuram district of Kerala under ATMA programme.	25 May 2019	Eradasappa, E.
7.	Visit of five cashew farmers from Sagar for cashew apple processing – Prakruti foods, Mangalore and Madhu Multiples, Kavu, Puttur and ICAR-DCR, Puttur.	18–19 June 2019	Mohana, G.S.

4.4. Diagnostic field visits/monitoring of field trials/demonstration by scientist

Dr. Shamsudheen Mangalassery, [Senior Scientist (Soil Science)] conducted diagnostic visit in a farmer's field in Gokak, Belagavi on 7 November 2019 and suggestions were given based on the field visit and after soil and plant sample analysis.

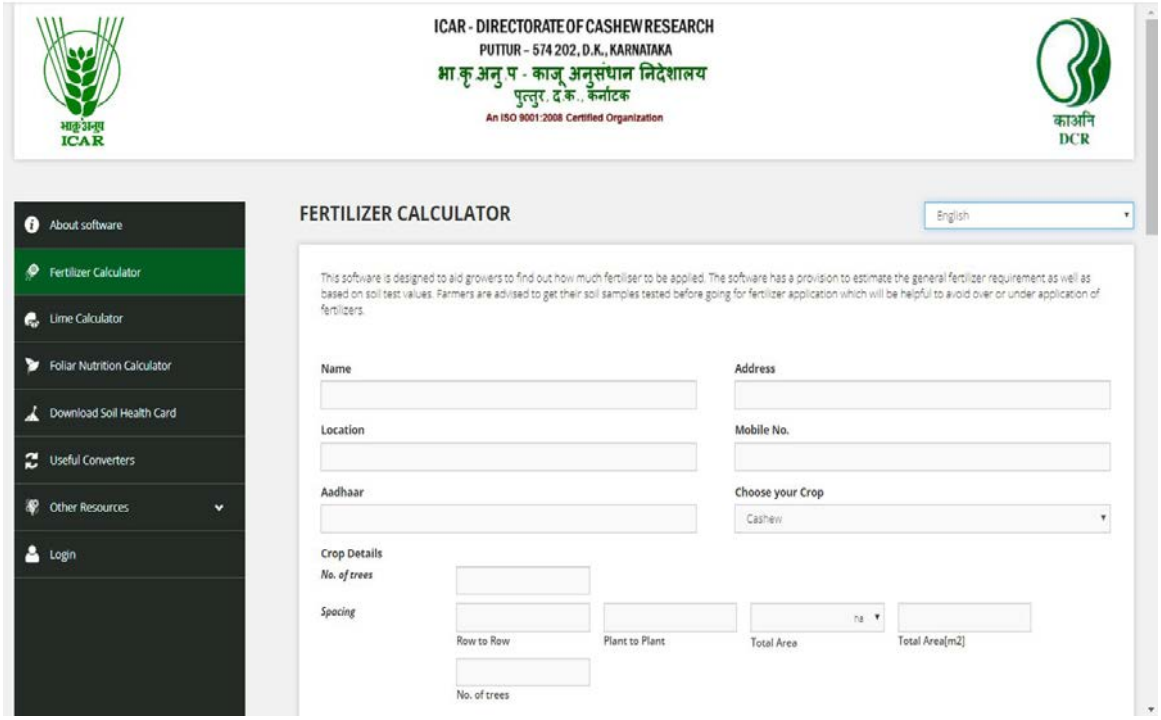
4.5. E-extension through social media / mobile app/website

Nutrient management software and mobile app

One of the major constraints in realizing the potential yield in cashew is the limited attention given by growers on nutrient management in cashew. The application of the right quantity of required fertilizer at the right time is vital for the judicious management of resources and for achieving the maximum benefit and income. Due to the wide variability in field conditions, and availability and choice of fertilisers, the farmers cannot correctly determine the right quantity of fertiliser to be applied and they may have to depend on scientists and extension personnel to get information on the correct doses. For empowering the farmers to take an informed decision by themselves, a software and a mobile App for nutrient management in cashew were developed under the project funded by RKVY-RAFTAAR at ICAR-DCR, Puttur. Under the same project, another offline soil health card generator in both English and Kannada was prepared to generate the soil health card from analytical data.

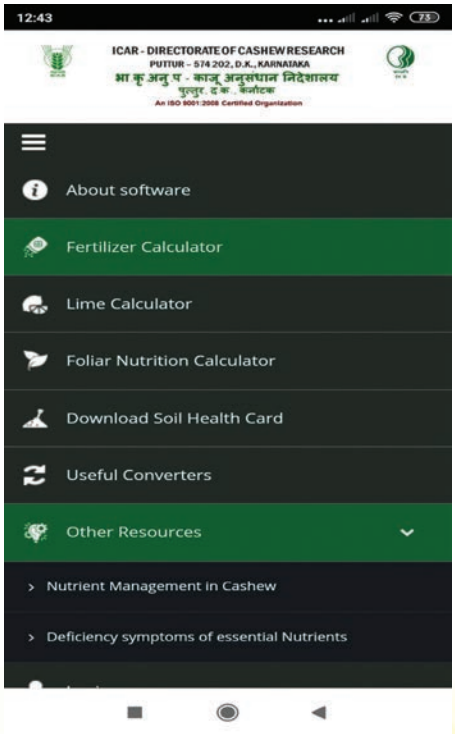
Software on Cashew nutrient manager

This software is available in both English and Kannada. It is available on the ICAR-DCR website for calculating fertilizer requirement, lime requirement, foliar application of major and micronutrients. The deficiency symptoms of major and micronutrients commonly observed in the field also included in the software. The farmers can click on the images and understand the symptoms and find out the options to correct the deficiency. The software also lets the farmers download the soil health card issued by ICAR-DCR, Puttur. The link to the software is at https://cashew.icar.gov.in/soil.



Mobile App on cashew nutrient manager

The mobile app version of the software on the cashew nutrient manager was developed. The App has got bilingual functionality (English and Kannada). The app can be downloaded from the Google play store at https://play.google.com/store/apps/details?id=com.icarcashew.dcr_cashewnutrientmanager.



Soil health card generator

Offline software in both English and Kannada was prepared to generate the soil health card. It enables to generate error-free soil health card from the analytical results as single and multiple pdf files. For using the software, the laboratory staff need to upload the analytical data in excel sheet format specified and choose single or multiple pdf option available in the software. The single pdf files can be used to issue the electronic copy of the soil health card to the individual farmer or to upload on the website which can be downloaded by the farmer by providing information such as Adhaar card number and year from ICAR-DCR, website. The multiple pdf in single file option can be used when the soil health cards are to be printed for distribution to the farmers. The software was developed with funding support from RKVY-RAFTAAR, Govt. of Karnataka.

Digital Soil Health Card

Farmers who tested their soil at ICAR-DCR, Puttur can download their soil health card any time anywhere from DCR web page or Mobile App on Cashew Nutrient Manager by inputting the information such as Aadhar card number and year.

4.6 Websites

Mohana, G.S. (AKMU In-charge) and Muthuraju R. (Technical officer, AKMU) maintained and update the following websites:

- The webpage of AICRP on cashew www.cashew.icar.gov.in/aicrpc
- The Cashew phenology webpage www.cashew.icar.gov.in/phenology
- The website of ICAR-Directorate of Cashew Research https://cashew.icar.gov.in/

4.7 Radio/TV talk/Lectures

M.G. Nayak	TV talk and discussion on "Cashew cultivation practices" on DD1.	28 January 2019
Eradasappa, E.	Participated as a resource person and delivered a talk on 'Cashew cultivation practices' in the Agri and Horticulture Farmer's Mela at Alike, Bantwal Taluk, Dakshina Kannada organized by KAMPU Agriculture and Horticulture Crop Producer Company Limited, Vittal, Bantwal, Dakshina Kannada, Karnataka.	26 February 2019
D. Balasubramanian	Attended on the meeting during Inter-Institute-Industry meeting conducted by Karnataka Cashew Manufacturers Association (KCMA) at Mangaluru.	26 April 2019
Eradasappa, E.	Participated as a resource person and delivered a talk on 'Cashew cultivation practices' in Farmer's Field School organized by SKDRDP at Mundoor Village, Puttur Taluk, Dakshina Kannada.	4 July 2019
Mohana, G.S.	Delivered a talk on "Cashew cultivation practices" at Punacha Cooperative society Hall at Punacha village, Dakshina Kannada. The program was organised by IFFCO, Bangalore, Punacha Cooperative Society, Punacha and Directorate of Cashew Research, Puttur.	18 July 2019
Eradasappa, E.	Delivered a talk on "Institutional services available at ICAR-DCR for the input dealers, farmers and other stakeholders" to the students of Diploma in Agricultural Extension Services at KVK, Mangaluru.	7 September 2019
Mohana G.S.	Participated and made a presentation on "Role of media in science communication" in Science communication workshop at CFTRI, Mysuru.	20-21 September 2019
M.G. Nayak	TV talk on "Modern cashew cultivation practices" on DD	19 October 2019
M.G. Nayak	Radio talk on "High density orcharding in cashew" recorded by All India Radio (AIR), Mangaluru.	5 November 2019
Eradasappa, E.	Participated in an interview in Kisan Vani programme on "Varietal Improvement in Cashew" at All India Radio (AIR), Mangaluru.	11 November 2019
T.N. Raviprasad	Participated in an interview in Kannada on "Integrated Pest Management in Cashew" in Kisan Vani from All India Radio (AIR), Mangaluru.	20 November 2019

4.8. Teaching/Training/Guiding of Students

Dr. Siddanna Savadi

- Supervised the 2 M.Sc. (Biotechnology) students' research and thesis writing on the topics "Orthology based gene amplification for plant stature, CNSL and flowering traits and genetic diversity analysis in cashew accessions" of Ms. Akhila S.N., Mangalore University and "Orthology based gene amplification for compactness and purple pigmentation and genetic diversity analysis in cashew accessions" of Ms. Jyothishree K.M., Mangalore University from 01.06.2019 to 31.07.2019.

Dr. Preethi, P.

- Supervised 3 M.Sc. (Food Science and Nutrition) students' research and thesis writing on the topics 'Storage behaviour of cashew sprout under brine condition' by Ms. K. Sushmitha, 'Development extruded product from cashew apple pomace powder' by Ms. K. Shradha, and 'Development of extruded products from cashew sprout powder' by Ms. K. Tanushree of Mangalore University, Mangalore for their project work from 01.06.2019 to 31.07.2019.

Dr. Shamsudheen Mangalassery

- Supervised one M.Sc. (Microbiology) student's research and thesis writing on the topic 'Impact of organic farming in cashew on rhizosphere microbial populations and soil enzymes' by Ms. Navyashri, P. of Mangalore University, Mangalore for her project work from 01.06.2019 to 31.07.2019.

5. AICRP / Co-ordination Unit

5.1. Annual Group Meeting (AGM) of AICRP on Cashew

The Annual Group Meeting (AGM) of Scientists of AICRP on Cashew was organized at the University of Horticultural Sciences, Bagalkot from 13-14 December 2019. Dr. Indiresh. K.M., Hon'ble Vice Chancellor of UHS, Bagalkote, Dr. N. Basavaraj, Director of Research, UHS, Bagalkote, Dr. W.S. Dhillon, ADG (Hort. Sci.), ICAR, New Delhi, Dr. M.G. Nayak, Director (Acting), ICAR-DCR, Puttur had participated in the AGM. About 75 delegates including the scientists from the Coordinating Centres of AICRP-Cashew, and ICAR-DCR, Invitees, UHS Staff, Press and Media persons participated in the meeting. The welcome address was delivered by Dr. N. Basavaraj, Director of Research, UHS, Bagalkot. The Presidential address was delivered by Dr. K.M. Indiresh, Vice Chancellor, UHS Bagalkot, wherein he mentioned the scope of cashew cultivation over other plantation and fruit crops in non-traditional areas of Karnataka and the requirement of transfer of technology to the enterprunering farmers. Dr. W. S. Dillion, ADG (HS), ICAR, New Delhi narrated about the latest developments in the horticultural sector in India. He emphasized on the need to adopt innovative technologies for increasing the productivity of cashew. He also focused on undertaking studies on cashew rootstocks suitable for drought and salinity stress.

The Project Coordinator's report was presented by Dr. M.G. Nayak, Director (Acting) wherein he highlighted the activities taken up by 14 AICRP Cashew Centres. He said that the centres are maintaining 1557 accessions, and 27 new

accessions have been collected by different AICRP Cashew centres during the year 2018-19 with respect to the yield and yield attributing characters. He also mentioned that a new trial on the evaluation of promising bold nut, bigger size apple types and high yielding cashew genotypes was initiated in the centres. In addition to the trial on hybridization and selection, another trial on rapid clonal hybrid evaluation which aims at bringing desirable characters from promising germplasm accessions is under progress at Bhubaneshwar, Madakkathara, Vridhachalam and Vengurla centres. During the year 2018-19, around 3.61 lakh cashew grafts were produced and supplied to farmers. He also mentioned that the AICRP centres are also playing a major role in the transfer of technologies for cashew cultivation and more than 49 training/awareness camps on different aspect of cashew cultivation and management practices have been taken up in which around 1000 farmers had participated.

On this occasion, five publications from Horticultural Research and Extension Centre (HREC), Hogalagere, Karnataka; Cashew Research Station (CRS), Bhubaneswar, Odisha, and Regional Research Station, (BCKV), Jhargram, West Bengal were released. Later, the technical session on 'Crop Improvement' chaired by Dr. N. Basavaraj, Director of Research, UHS, Bagalkot, and the session on 'Crop Management' chaired by Dr. D.R. Patil, Assoc. Director of Research & Extension, UHS, Bagalkot was held on 13 December 2019. The session on 'Crop Protection" was held on 14 December 2019 followed by "Interaction Session with farmers, scientists, processors and officials from development departments chaired by Dr. S.I. Hanamashetti, Department of Plantation, Spices, Medicinal and Aromatic Crops, College of Horticulture, Bagalkot and co-chaired by Dr. Venkatesh N. Hubballi, Director, DCCD, Kochi. The problems and suggestions of farmers regarding cashew were also discussed at length and the AGM was concluded with the plenary session.

6. AWARDS / RECOGNITIONS

6.1. Institutional awards

- The cashew variety of ICAR-DCR, Puttur named Bhaskara has been granted the registration number 207 of 2019 on 6 December 2019 by the Protection of Plant Varieties and Farmers Rights Authority, New Delhi.
- The planting material nursery of ICAR-DCR, Puttur has been granted the IV star rating (Certificate No. KNCAPU4919) by the Directorate of Cashewnut and Cocoa Development, Kochi with effect from 13 October 2019.

6.2. Individual awards

Dr. J.D. Adiga

- Received the Pomologist Award-2019 in the International Conference of Scicon series on "In Sync-with Next Generation Biosciences (SciCon INGB)- 2019" held at Goa, during 6-8 November 2019.

Dr. Shamsudheen Mangalassery

- Received the Outstanding best paper award of the Novel Research Academy, Puducherry on 31 May 2019, for the research paper entitled "Effect of inorganic fertilisers and organic amendments on soil aggregation and biochemical characteristics in a weathered tropical soil", authored by S. Mangalassery, D. Kalaivanan and Prabha S. Philip published in Soil and Tillage Research Vol. 187.
- Received the Highly Cited Researcher Award 2018 of the Novel Research Academy, Puducherry on 31 May 2019.

Dr. K. Vanitha

- Received Young Achiever Award - 2018 by the Society for Advancement of Human and Nature (SADHNA), Dr. Y.S. Parmar University of Horticulture and Forestry, Solan, Himachal Pradesh.

Mr. Muralidhara, B.M.

- Received "Young Scientist Award-2019" from Agriculture Technology Development Society (ATDS), Ghaziabad, Uttar Pradesh, India for outstanding contribution and recognition in the field of Horticulture on the occasion of 3rd International conference on global initiatives in agriculture and applied sciences for the eco-friendly environment (GIASE-2019) held on 16-18 June 2019 at Tribhuvan University Kathmandu, Nepal.

Dr. Siddanna Savadi

- Received the "Young Scientist Award-2019" by Society for Biotic and Environmental Research (SBER) on 27 July 2019 during the national conference held at Sona College, Salem, Tamil Nadu.
- Received the second position in the Memory test competition on the Hindi language held on the occasion of Hindi Sapthah-2019 organized by TOLIC, Puttur on 21 September 2019.

6.3. Recognitions

Dr. M.G. Nayak

- Participated in Indian Caju Fest as a penalist – A Global Event during 13-15 February 2019.
- Participated as Guest of Honour in the national conference on cashew organised by DCCD, Kochi at Vijayawada during 22-23 February 2019 and delivered a lecture on 'Recent advances in cashew research'.
- Acted as a member of the Standing Committee, PLACROSYM XIII held during 6-8 March 2019 at Chikkamagaluru.
- Participated as chief guest in the inaugural session of the short course on Farming Systems at UAHS, Shivamogga on 11 March 2019.
- Participated in the national steering committee meeting on cashew chaired by secretary of Agriculture (GoI) on 14 June 2019 at Krishi Bhawan, New Delhi.
- Participated in the meeting of price fixing committee for cashew grafts organized by DCCD, Kochi at Brahmavar on 12 July 2019.
- Participated in National training programme as guest of honorn and delivered lecture on Varieties & HDP at at Brahmavar, D.K. on 31 July 2019.
- Participated in Regional committee meeting Region VIII which was chaired by Secretary, DARE & DG, ICAR at IIHR, Bengaluru on 6-7 September 2019.
- Participated in Krishi Mela of CPCRI, Regional Center, Kidu as guest of honor on 12 October 2019.
- Participated in Kisan Mela of ZAHRS, Brahmavar on 19 October 2019 and delivered talk on cashew varieties and high density orcharding.

Dr. D. Balasubramanian

- Selected as Member of Executive Committee, Indian Society of Plantation Crops (ISPC) for the period 2018-20.
- Selected and participated as Member of 'National Technical Committee' for resolving problems of cashewnut drum roasting process and related pollution at Cashew Export Promotion Council of India (CEPCI), Kollam on 18 September 2019.

Dr. K. Vanitha

- Recognized as PG Teacher in the Discipline of Agricultural Entomology at University of Horticultural Sciences, Bagalkot, Karnataka w.e.f. 7 July 2019.

6.4. Resource person/lecture

Mohana, G.S.	Delivered a talk on Cashew production technologies at Sasaravalli village, Sagar Taluk	15 April 2019
Mohana, G.S.	Gave a talk on Cashew production technologies at Neechadi village, Sagar Taluk	12 May 2019
D. Balasubramanian	Participated in 'National training on Cashew' and delivered a lecture on 'Advanced technologies in Cashewnut processing' conducted by Directorate of Cashew and Cocoa Development (DCCD) at Brahmavar, Karnataka.	1 August 2019
D. Balasubramanian	Acted as a resource person during 'Interactive meeting on cashewnut processing' conducted at Cashew Export Promotion Council of India (CEPCI), Kollam.	18 September 2019
D. Balasubramanian	Delivered lecture on "Small Scale Cashewnut Processing by Kudumbashree (SHG): A Success story" during training program on 'Entrepreneurship development through agro/food processing centres' conducted by ICAR-Central Institute of Agricultural Engineering, Regional Centre, Coimbatore, Tamilnadu.	18 December 2019

7. PUBLICATIONS

7.1. Research / Review articles

Babli Mog., Janani, P., Nayak, M.G., Adiga, J.D. and Meena, R.K. 2019. Manipulation of vegetative growth and improvement of yield potential of cashew by paclobutrazol. *Scientia Horticulturae,* 257: 108748, 1-10. [http://krishi.icar.gov.in/jspui/handle/123456789/33836].

Eradasappa, E. and Mohana, G.S. 2019. Investigations on self-compatibility and extent of self and cross-pollination in cashew. *Journal of Plantation Crops,* 47: 72-81. [http://krishi.icar.gov.in/jspui/handle/123456789/36573]

Mangalassery, S., Rejani, R., Singh, V., Adiga, J.D., Kalaivanan, D., Rupa, T.R. and Philip, P.S. 2019. Impact of different irrigation regimes under varied planting density on growth, yield and economic return of cashew (*Anacardium occidentale* L.). *Irrigation Science*, 37:483-494. [http://krishi.icar.gov.in/jspui/handle/123456789/22674].

Nayak, M.G., Mangalassery, S. and Preethi, P. 2019. Innovative production technologies to enhance productivity and income of cashew farmers. *The Cashew & Cocoa Journal* 8:8-18. [http://krishi.icar.gov.in/jspui/handle/123456789/24330].

Pandiselvam, R, Manikantan, M.R., Subhashree, N., Mathew, A.C., Balasubramanian, D., Shameena Beegum, P.P., Ramesh, S.V., Niral, V., Ranjini T.N. and Hebbar, K.B. 2019. Correlation and principal component analysis of physical properties of tender coconut (*Cocos nucifera* L.) in relation to the development of trimming machine. *Journal of Food Process Engineering,* 42: e13217. [http://krishi.icar.gov.in/jspui/handle/123456789/36609]

Pandiselvam, R., Manikantan, M.R., Balasubramanian, D., Shameena Beegum, P.P., Mathew, A. C., Ramesh, S.V., Hebbar, K. B., Niral, V. 2019. Mechanical properties of tender coconut (*Cocos nucifera* L.): implications for the design of processing machineries. *Journal of Food Process Engineering,* 43: e13349. [http://krishi.icar.gov.in/jspui/handle/123456789/23771]

Vanitha, K. 2019. Nest structure, development and natural enemies of *Ceratina hieroglyphica* Smith, a stem nesting bee colonizing cashew trees in hilly terrains. *Journal of Apicultural Science*, 63:223-232. [http://krishi.icar.gov.in/jspui/handle/123456789/33838].

Vanitha, K. and Raviprasad, T.N. 2019. Pollinator's diversity, abundance and their foraging behaviour in cashew. *Agricultural Research* 8:197–206. [http://krishi.icar.gov.in/jspui/handle/123456789/33846].

7.2. Abstracts / Chapters in Symposia /Workshops / Seminars

Mangalassery, S., Nayak, M.G. and Prabha, P.S. 2019. Delineation of soil nutrient constraints of cashew orchards in India and management alternatives. 2nd International Conference on Recent Advances in Agricultural, Environmental and Applied Science for Global Development (RAAEASGD-2019), 27-29 September 2019. Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan, H.P., India organized by Agro-Environmental Development Society (AEDS), Majhar Ghat, Rampur, UP, India: pp. 218. [http://krishi.icar.gov.in/jspui/handle/123456789/24325].

Raviprasad, T.N., Vanitha, K., Shivarama Bhat, P. and Srikumar, K.K. 2019. Existence of female sex pheromone in tea mosquito bug, *Helopeltis antonii* Sign. (Hemiptera: Miridae)– Prospects and Perspective. International Conference on Plant Protection in Horticulture: Advances and Challenges, 24-27 July, ICAR-Indian Institute of Horticultural Research, Bengaluru, India. p. 184. [http://krishi.icar.gov.in/jspui/handle/123456789/36280].

Vanitha, K. 2019. Diversity of insect pollinators and the means of conservation. National conference on current trends in Entomology and insect-plant interaction during 11-12 September 2019 at St. Aloysius College (Autonomous), Mangaluru organized by Department of Zoology and Department of Botany, St. Aloysius college, and Department of Biotechnology, GOI, New Delhi. pp. 16-20. [http://krishi.icar.gov.in/jspui/handle/123456789/36191].

7.3. Technical Reports / Compendia

Annual Report, 2018-19. All India Co-ordinated Research Project on Cashew. ICAR-Directorate of Cashew Research (DCR), Puttur, p. 172 (Eds. Mohana, G.S and Nayak, M.G.). [http://krishi.icar.gov.in/jspui/handle/123456789/36468].

Annual Report, 2018-19. ICAR-Directorate of Cashew Research (DCR), Puttur, p. 104 (Eds. Shamsudheen M., Savadi, S. and Mohana, G.S.). [http://krishi.icar.gov.in/jspui/handle/123456789/22681].

Annual Report, 2018-19 (Hindi). ICAR-Directorate of Cashew Research (DCR), Puttur, p. 104 (Eds. Shamsudheen M., Savadi, S. and Mohana, G.S.). [http://krishi.icar.gov.in/jspui/handle/123456789/24326].

Cashew News, 2019. ICAR-Directorate of Cashew Research, Puttur, Vol. 24 (1), p. 12 (Eds. Vanitha, K, Siddanna Savadi and Mohana, G.S.). [http://krishi.icar.gov.in/jspui/handle/123456789/31902].

Cashew News, 2019. ICAR-Directorate of Cashew Research, Puttur, Vol. 24 (2), p. 12 (Eds. Vanitha, K., Siddanna Savadi and Mohana, G.S.). [http://krishi.icar.gov.in/jspui/handle/123456789/31888.

7.4. Extension Bulletins / Pamphlets

Muralidhara, B.M., Savadi, S., Nayak, M.G., Adiga J.D., Preethi P. and Shamsudheen, M. 2019. Geru beleyalli poshakanshagala nirvahane. ICAR-Directorate of Cashew Research, Puttur, Karnataka, India [Kannada]. [http://krishi.icar.gov.in/jspui/handle/123456789/23247].

Muralidhara, B.M., Savadi, S., Nayak, M.G., Adiga, J.D and Shamsudheen, M. 2019. Yerehulu gobbara mattu yerejala tayarike vidhana mattu krishiyalli ivugala balake. ICAR-Directorate of Cashew Research, Puttur, Karnataka, India [Kannada]. [http://krishi.icar.gov.in/jspui/handle/123456789/23248].

Muralidhara, B.M., Savadi, S., Nayak, M.G., Adiga, J.D., Preethi, P. and Shamsudheen, M. 2019. Geru thotagalalli poshakanshagala nirvahanege mannu mattu yele madari tegeyuva vidhana. ICAR-Directorate of Cashew Research, Puttur, Karnataka, India [Kannada]. [http://krishi.icar.gov.in/jspui/

handle/123456789/23256].

Shamsudheen, M., Manikandan, N. and Muralikrishna, K. 2019. Kasumavu-krishireethikal. ICAR-Directorate of Cashew Research, Puttur, Karnataka, India [Malayalam]. [http://krishi.icar.gov.in/jspui/handle/123456789/31869].

Shamsudheen, M., Nayak, M.G., Adiga, J.D., Preethi, P. and Muralidhara, B.M. 2019. Nutrient management in cashew. ICAR-Directorate of Cashew Research, Puttur, Karnataka, India [English]. [http://krishi.icar.gov.in/jspui/handle/123456789/23257].

Shamsudheen, M., Nayak, M.G., Adiga, J.D., Preethi, P. and Muralidhara, B.M. 2019. Soil and leaf sampling for nutritional management in cashew orchards. ICAR-Directorate of Cashew Research, Puttur, Karnataka, India [English]. [http://krishi.icar.gov.in/jspui/handle/ 123456789/23258].

Nayak, M.G., Preethi, P., Muralidhara, B.M. and Shamsudheen, M., 2019. Training, pruning and aftercare in cashew. ICAR-Directorate of Cashew Research, Puttur, Karnataka, India [Extension leaflet-English]. September 2019. [http://krishi.icar.gov.in/jspui/handle/123456789/23259].

7.5. Technical bulletins

Mangalassery, S., Nayak, M.G., Adiga, J.D., Preethi, P. and Mualidhara, B.M. 2019. Nutrient management in cashew. Technical Bulletin No. 1/2019. ICAR-Directorate of Cashew Research, Puttur, Karnataka, India, pp. 28. [http://krishi.icar.gov.in/jspui/handle/123456789/22683].

Preethi, P., Rajkumar, A.D., Mangalassery, S. and Nayak, M.G. 2019. Prospects of cashew apple-a compilation report, Technical Bulletin No. 2/2019. ICAR-Directorate of Cashew Research, Puttur, Karnataka, India, pp. 28. [http://krishi.icar.gov.in/jspui/handle/123456789/22682].

Vanitha, K. and Raviprasad, T.N. 2019. Pollinators of cashew, their foraging behaviour and conservation measures. ICAR-DCR Technical Bulletin No. 30, ICAR-Directorate of Cashew Research, Puttur, Karnataka. pp. 33. [http://krishi.icar.gov.in/jspui/handle/123456789/33387].

7.6. Popular Articles

Babli Mog and Nayak, M.G. 2019. Enhancement of quality planting material production in cashew through soft wood grafting. *Agriculture & Food:* e-Newsletter, 1(5), 96-102. [http://krishi.icar.gov.in/jspui/handle/123456789/36312].

Babli Mog and Prabha, M. 2019. Physiology of cashew under salinity stress. *Agriculture & Food: e-Newsletter,* e-ISSN : 2581 – 8317. Babli Mog and Prabha, M. 2019. Soil and water conservation measures in Cashew: An approach to maximize crop productivity. *Agriculture & Food:* e-Newsletter, 1, 23-26. [http://krishi.icar.gov.in/jspui/handle/123456789/36314].

Babli Mog, Nayak, M.G. and Shashibhushan, N.B. 2019. High density planting of Cashew: A tool to achieve higher crop productivity. *Biomolecule Reports,* ISSN:2456-8759. [http://krishi.icar.gov.in/jspui/handle/123456789/36282].

Babli Mog and Nayak, M.G. 2019. Utility of canopy management in cashew nut production. Biomolecule Reports - An International eNewsletter, ISSN:2456-8759. [http://krishi.icar.gov.in/jspui/handle/123456789/33837].

Babli Mog, Prabha, M. and Mawlong, I. 2019. Germination and seedling establishment in cashew: Key factors for enhancing productivity. *Agriculture & Food: e-Newsletter, 1, 403-406.* [http://krishi.icar.gov.in/jspui/handle/123456789/36317] .

Babli Mog, Shamsudheen, M. and Prabha, M. 2019. Nutrient management in cashew. *Agriculture & Food: E-News letter,* 1, 50-52. [http://krishi.icar.gov.in/jspui/handle/123456789/36318].

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Babli Mog. 2019. Ultra high density planting: A new approach for yield enhancement in cashew. *Agriculture & Food:* e-Newsletter, ISSN: 2581-8317. [http://krishi.icar.gov.in/jspui/handle/123456789/36320].

Preethi, P. and Shamsudheen, M. 2019. Cashew apple products and cashew sprout. Cashew News, 24(1): 2-5. [http://krishi.icar.gov.in/jspui/handle/123456789/33850].

Vanitha, K. and Raviprasad, T.N. 2019. Native bees–potential pollinators of cashew. *ICAR News,* 25 (3): 8-9. [http://krishi.icar.gov.in/jspui/handle/123456789/33845].

Mangalassery, S., Nayak, M.G., Adiga, J.D., Preethi, P. and Muralidhara, B.M. 2019. Offline software on soil health card generator. *Cashew News,* 24(2): 3-4. [http://krishi.icar.gov.in/jspui/handle/123456789/33847].

7.7. E-Publications

Babli Mog, Savadi, S., Prabha, M., Mawlong, I. and Nayak, M.G. 2019. Cashew - a tree crop of choice for future. *Kerala Karshakan,* 5: 7. [http://krishi.icar.gov.in/jspui/handle/123456789/33839].

Babli Mog, Nayak, M.G., Mawlong, I., Sujith Kumar, M.S. and Prabha, M. 2019. Manipulation of tree physiology in cashew: paclobutrazol as paradigm. *Kerala Karshakan*, 7: 2. [http://krishi.icar.gov.in/jspui/handle/123456789/33852].

Savadi, S., Mullia, S., Babli Mog, Muralidhara, B.M., Mangalassery, S. 2019. The saga of cashew: From a soil conservation tree to a prominent commercial crop of India. *Kerala Karshakan,* 7 (5): 40-42. [http://krishi.icar.gov.in/jspui/handle/123456789/33851].

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Vanitha, K. 2019. Mimicry in insects and spiders-an introduction to ant mimicry. *Kerala karshakan,* 7: 13-15. [http://krishi.icar.gov.in/jspui/handle/123456789/33849].

7.8. Customised instruction materials

Mangalassery, S., Preethi, P., Savadi, S. and Muralidhara, B.M. 2019. The use of software on nutrient management in cashew,

Customised instruction material No. 1/2019 (15 August 2019). ICAR-Directorate of Cashew Research, Puttur, Karnataka, India, pp. 10. [http://krishi.icar.gov.in/jspui/handle/123456789/34855].

Mangalassery, S., Preethi, P., Savadi, S. and Muralidhara, B.M. 2019. The use of mobile App "Cashew nutrient manager", Customised instruction material No. 2/2019 (15 August 2019). ICAR-Directorate of Cashew Research, Puttur, Karnataka, India, pp. 10. [http://krishi.icar.gov.in/jspui/handle/123456789/34856].

8. LINKAGES / COLLABORATION

Organization	Area of collaboration
ICAR-National Bureau of Agricultural Insect Resources (ICAR-NBAIR), Bengaluru	Identification of kairomones/ pheromones of major pests of cashew
ICAR-Indian Institute of Horticultural Research (IIHR), Bengaluru	Biosystematics of tea mosquito bug and natural enemies
	Biotechnology Department for SSR marker analysis in cashew
University of Agricultural Sciences (UAS), GKVK, Bengaluru	Identification of arthropod fauna associated with cashew
ICAR-Indian Agricultural Research Institute (IARI), New Delhi	
Directorate of Cashewnut and Cocoa Development (DCCD), Kochi	Training programmes for farmers and frontline demonstrations
ICAR-Central Institute of Agricultural Engineering (ICAR-CIAE), Bhopal	Development of postharvest technology machinery
Department of Horticulture, Karnataka. Horticultural Research Station, Ullal, Mangaluru Zonal Agricultural Research Station, Brahmavar, Udupi district, Karnataka.	Training programmes for farmers and Krishi Melas
KVK, Mangaluru Achal Industries, Mangaluru UAHS, Shivamogga KCMA, Mangaluru	Transfer of technology
AICRP-Cashew Centres located in SAUs / ICAR institutes	Multilocational testing, exchange of research findings/germplasm/planting material.
ICAR-Central Plantation Crops Research Institute, Kasaragod, Kerala	Evaluation of EPN species in cashew ecosystem value addition and post harvest product development

ICAR-Directorate of Medicinal and Aromatic Plants Research, Anand, Gujarat	Identification and synthesis of organic components in the Whole Body Extracts (WBE) of virgin females of TMB.
M/s Environment, Measurement and Control, (EMCON), Kochi, Kerala	Development of moisture meter for cashew in Public-Private-Partnership (PPP) mode
Kerala State Agency for the expansion of Cashew Cultivation (KSACC), Kollam	For large scale distribution of planting material and area expansion in cashew
All India Cashew Growers Association, Puttur	Facilitated its formation and provided technical advice to the association

9. HUMAN RESOURCE DEVELOPMENT / TRAINING AND CAPACITY BUILDING

Participants	Details	Date
K. Murali Krishna	Capacity building and skill up-gradation programme on Farm Management at ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut, UP.	13-19 February 2019
Siddanna Savadi	DBT funded training programme on "Bioinformatics for metagenome data analysis" (NGSDAT 2019) at ICAR-Indian Institute of Spices Research (ICAR-IISR), Kozhikode, Kerala.	18-22 March 2019
N. Manikandan	Training programme on Hospitality management at ICAR-NAARM, Hyderabad (In collaboration with Institute of Hospitality Management, Catering technology), Telangana.	26 June - 2 July 2019
N. Manikandan	Pesticide application techniques and safety measures at NIPHM, Hyderabad.	16-20 September 2019
Preethi, P.	Winter school on "Hi-tech approaches for production and value addition of horticultural crops in arid and semiarid regions" at SKRA University, Beechwal, Rajasthan.	7 -27 November 2019

Status of budget for training and capacity building (2019-20)

Allocation : Rs. 1.00 lakhs

Utilization : Rs. 0.70 lakhs

10. PARTICIPATION IN SYMPOSIA/ CONFERENCES/ SEMINARS/MEETINGS

Participants	Details	Date
T.N. Raviprasad	National Symposium on Sustainable Management of Pests and Diseases in Augmenting Food and Nutritional Security at Navsari Agricultural University, Navasari, Gujarat.	22-24 January 2019
Eradasappa, E.	Indian Plant Science Congress at SRMIST, Kattankulathur, Chennai.	23-25 January 2019
M.G. Nayak	Indian Caju Fest – a Global Event organized at New Delhi by CEPCI, Kollam.	13-15 February 2019
M.G. Nayak	National Conference on Cashew organized by DCCD, Kochi at Vijayawada.	22-23 February 2019
M.G. Nayak D. Balasubramanian Mohana, G.S. Eradasappa, E. J.D. Adiga	PLACROSYM-XXIII Conducted by the Indian Society of Plantation Crops at Central Coffee Research Institute, Chikkamagaluru, Karnataka	6-8 March 2019
K. Vanitha	National conference on current trends in Entomology and insect-plant interaction conducted at St. Aloysius College (Autonomous).	11-12 September 2019
Preethi, P.	Brainstorming workshop on "HortiMillets" at ICAR- Indian Institute of Millets Research, Rajendra Nagar, Hyderabad.	13 September 2019
Mohana, G.S.	Science communication workshop at CFTRI, Mysuru.	20-21 September 2019
Raghurama Kukkude	National Conference of agricultural libraries and user community (NCALUC-2019) on Role of agricultural libraries in network digital environment at Navsari Agricultural University, Navasari, Gujarat.	25-27 September 2019

Shamsudheen Mangalassery	2nd International Conference on Recent Advances in Agricultural, Environmental and Applied Science for Global Development (RAAEASGD-2019) at Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan, HP, India, organized by Agro-Environmental Development Society (AEDS), Majhar Ghat, Rampur, UP, India.	27-29 September 2019
Preethi, P.	Fourth national workshop of officer In-charge, data management (ICAR research data repository for knowledge management) organized by ICAR-IASRI at A.P. Shinde symposium hall, NASC Complex, New Delhi.	10-11 December 2019
M.G. Nayak Mohana, G.S. J.D. Adiga Shamsudheen Mangalassery	Annual Group Meeting of All India Coordinated Research Project on Cashew at University of Horticultural Sciences, Bagalkot.	13-15 December 2019
Mohana, G.S.	Anveshana Agri Tinkering fest organized by Vivekananda Vidyavardhaka Sangha, Puttur.	11 December 2019

11. ONGOING AND CONCLUDED RESEARCH PROJECTS

Ongoing Projects

Sl. No.	Project	PI	Co-PIs
Crop Improvement			
1.1.	**Management of cashew germplasm resources**		
1.	1.1.1. Management of genetic resources in cashew [1986 - Long term]	M.G. Nayak	Mohana, G.S. K. Vanitha Eradasappa, E. *Muralidhara, B.M.
2.	1.1.2. Screening of cashew germplasm for apple and nut characters [03/2016 - 03/2024]	Mohana, G.S.	D. Balasubramanian Preethi, P. *Muralidhara, B.M.
3.	1.1.3. Evaluation of big cashew apple genotypes for apple yield and quality [10/2013 - 06/2021]	Preethi, P.	K. Vanitha Eradasappa, E.
1.2.	**Genetic improvement of cashew**		
4.	1.2.1 Genetic improvement of cashew for yield and quality traits [1986 - Long Term]	J.D. Adiga	Mohana, G.S. M.G. Nayak Eradasappa, E. Siddanna Savadi *Muralidhara, B.M.
5.	1.2.2 Development of dwarf and compact cashew hybrids [06/2012 - 05/2027]	Eradasappa, E.	Mohana, G.S. J.D. Adiga
6.	1.2.3 Breeding for improvement of nut size in cluster bearing genotypes [06/2018 – 05/2024]	Eradasappa, E.	Mohana, G.S. M.G. Nayak
7.	1.2.4 Breeding approaches for developing TMB tolerance [09/2017 - 08/2030]	Mohana, G.S.	Eradasappa, E. K. Vanitha
8.	1.2.5 *De novo* genome assembly, linkage analysis and population structure studies in cashew (*Anacardium occidentale* L.) [09/2017 – 08/2020]	Siddanna Savadi	Mohana, G.S. J.D. Adiga

9.	1.2.6 Genetic dissection of QTLs governing nut yield and cashew nut shell liquid (CNSL) content in cashew [06/2018 - 05/2025]	Siddanna Savadi	Eradasappa, E. Mohana, G.S.
10.	1.2.7 Generation mean analysis in cashew to understand the nature of gene action for important traits [05/2019 – 04/2025]	Eradasappa, E.	Mohana, G.S.
11.	1.2.8 Breeding for reduced tannin content in cashew apples of hybrids of popular cultivars [05/2019 – 04/2025]	Eradasappa, E.	Mohana, G.S. J.D. Adiga Preethi, P.
12.	***Externally Funded Project:*** Development of morphological descriptors and DUS test guidelines for cashew Funded by: Protection of Plant Varieties and Farmers' Rights Authority (PPV&FRA), New Delhi Budget: Rs. 10 Lakhs [04/2015 - 03/2020]	M.G. Nayak	Mohana, G.S.
Crop Management			
13.	2.1.1 Studies on pruning and phenology in cashew [09/2017 - 08/2020]	J.D. Adiga	Preethi, P. Siddanna Savadi *Muralidhara, B.M.
14.	2.1.3 Optimisation of mineral nutrition to cashew under high density planting [06/2018 – 05/2021]	Shamsudheen Mangalassery	M.G. Nayak Preethi, P. Babli Mog
15.	2.1.4 Characterization of physiological responses of cashew (*A. occidentale* L.) accessions to salt and drought stresses [10/2015 - 09/2020]	Babli Mog	-
16.	2.1.6 In-vitro pollen germination and pollen tube growth of cashew varieties in response to high temperature stress [05/2019 – 04/2021]	Babli Mog	Shamsudheen Mangalassery Eradasappa, E. K.B. Hebbar

17.	***Externally Funded Project:***		
	Farmer participatory soil and plant health management – An attempt for improving the livelihood of cashew farmers of coastal Karnataka Funded by: RKVY-FAFTAAR, Government of Karnataka Budget: Rs. 1.89 Crores [04/2018 to 03/2020]	Shamsudheen Mangalassery	M.G. Nayak J.D. Adiga Preethi, P. *Muralidhara, B.M.
Crop Protection			
3.1.	**Management of Insect Pests of Cashew**		
18.	3.1.1 Investigations on semiochemicals for management of TMB and CSRB [10/2014 - 10/2020]	T.N. Raviprasad	K. Vanitha Bakthavatsalam, N. (ICAR-NBAIR) Gajbhiye, N. (ICAR-DMAPR)
19.	3.1.2 Investigations on inflorescence insect pests of cashew and their management [10/2016 - 09/2020]	K. Vanitha	T.N. Raviprasad
20.	3.1.3 Evaluation of alternative insecticides/ products for the management of tea mosquito bug (TMB) and cashew stem and root borers (CSRB) [10/2016 - 10/2020]	T.N. Raviprasad	K. Vanitha
21.	3.1.4 Standardization of IPM involving EPN and *Metarhizium anisopliae* for management of CSRB [09/2017 - 10/2021]	T.N. Raviprasad	Rajkumar (ICAR-CPCRI)
22.	3.1.5 Cashew tea mosquito bug interactions and the defensive responses [05/2019 – 04/2023]	K. Vanitha	T.N. Raviprasad Preethi, P.
3.2.	**Arthropod Bio-diversity and Pollinator Activity in Cashew**		
23.	3.2.3 Influence of *Apis cerana* and *Braunsapis picitarsis* on pollination and fruit set of cashew [05/2019 – 04/2023]	K. Vanitha	-

Post Harvest Technology			
4.1.	**Improving performance of cashewnut processing**		
24.	4.1.2 Design and development of moisture meter for raw cashewnuts [07/2018 - 06/2020]	D. Balasubramanian	Sreejith (M/s EMCON, Kerala)
25.	4.1.3 Studying comparative performance of cashewnut processing systems in India [10/2017 - 09/2019]	D. Balasubramanian	-
4.2.	**By-product utilization and product diversification**		
26.	4.2.1 Design and development of mechanized slicer for cashew apple [10/2014 – 06/2020]	D. Balasubramanian	Ravindra Naik (ICAR-CIAE)
27.	4.2.3 Development of dehydrated products from cashew apple and sprouts [06/2018 - 05/2021]	Preethi, P.	Shamsudheen Mangalassery
Transfer of Technology			
28.	***Externally Funded Project:*** Development of an exclusive android application for cashew cultivation Funding: Directorate of Cashewnut and Cocoa Development (DCCD), Kochi Budget: Rs. 5.0 Lakhs [09/2017 - 09/2019]	Mohana, G.S.	M.G. Nayak

Concluded projects

Sl. No.	Project	PI	Co-PIs
Post Harvest Technology			
1.	4.1.1 Developing quality standards for raw cashew nuts [10/2014 – 09/2018]	D. Balasubramanian	K. Vanitha
2.	4.2.2 Screening of cashew varieties to specify the use of cashew apple in value-added products [10/2014 – 06/2018]	*Rajkumar, A.D.	Preethi, P.

*On study leave

12. CONSULTANCY, PATENTS AND COMMERCIALISATION OF TECHNOLOGY

12.1. Commercialisation of technologies by ITMU

Technologies developed by ICAR-DCR, Puttur were commercialized to private cashew machine manufactures on non-exclusive licensing. License to fabricate Dual-mode dryer for raw cashewnuts was given to M/s Newtech Industries, Mangaluru by signing MoU on 12 March 2019. Likewise, five more technologies developed at this Directorate viz. Radial arm type cashew kernel extracting machine, Rotating drum roasting machine, Hydraulic juice extractor for cashew apples, Concentric drum type rotary sieve grader and Cashew shell cake based updraft gasifier were licensed to M/s Rotex Transmission, Pune by signing MoU with ICAR-DCR on 4 April 2019.

Signing MoU between ICAR-DCR, and M/s Newtech Industries, Mangaluru

Signing MoU between ICAR-DCR, and M/s Rotex Transmission, Pune

12.2. Efforts to popularise commercialisable technologies

The Institute Technology Management Unit (ITMU), which shoulders the responsibility of commercialization of technologies developed at the Directorate, steered commercialization of 6 cashew processing machinery technologies to the private firms. ITMU unit is regularly following up the status of the patent application filed at the patent office, Chennai. Mr. Sandesh M.S., Research associate, ITMU visited the Gujarat state to explore the potential licensees for the technologies developed at the Directorate.

12.3. Consultancy services

Dr. Shamsudheen Mangalassery, Senior Scientist (Soil Science), and Mr. K. Muralikrishna, [Chief Technical Officer & Farm Superintendent] undertook an advisory/consultancy visit on the request of the district administration to cashew plantations under Karnataka Cashew Development Corporation near Aryapu, Puttur taluk, Dakshina Kannada for assessing the condition of rainwater harvesting activities undertaken by the corporation on 3 December 2019 and its impact, and submitted the report to Deputy Commissioner & District Magistrate, Dakshina Kannada district, Karnataka.

13. QRT/RAC / IRC / IMC / IJSC MEETINGS

13.1. Quinquennial Review Team (QRT)

The final meeting of the Sixth Quinquennial Review Team (QRT) of ICAR-DCR and AICRP for the period 2018-19 was held on 6-8 February 2019 at ICAR-DCR, Puttur to interact with IMC members and developmental departments. After this meeting, QRT report was prepared and the final report was submitted to DG, ICAR on 12 February 2019. The Council's comments on recommendations of the 6th QRT report received on 1 November 2019 along with the time frame were circulated among the scientists identified/responsible to implement the salient recommendations of QRT. An ATR on action initiated/ongoing/planned to implement the recommendations of QRT was prepared and sent to the council by 8 November 2019. The composition of the QRT is given below.

Sl. No.	Name and Address	Status
1.	Dr. S.P. Ghosh, Former DDG (Hort.), ICAR, New Delhi	Chairman
2.	Dr. M.G. Bhat, Former Director, ICAR-DCR, Puttur	Member
3.	Dr. K.R.M. Swamy, Former Head, Vegetable Science, ICAR-IIHR, Bengaluru	Member
4.	Dr. J.C. Bhatt, Former Director, ICAR-VPKAS, Almora	Member
5.	Dr. George V. Thomas, Former Director, ICAR-CPCRI, Kasaragod	Member
6.	Dr. A.K. Mehta, Former ADG (Agri. Extension), ICAR, New Delhi	Member
7.	Dr. T.N. Raviprasad, Principal Scientist (Agril. Entomology), ICAR-DCR, Puttur	Member Secretary

13.2. Research Advisory Committee (RAC)

The second meeting of 8th RAC was held during 26-27 April 2019. The Chairman of RAC, Dr. D.S. Rathore discussed about recent QRT recommendations and global trends in cashew research and felt the need to align the research programmes with QRT recommendations too. Dr. P.C. Lenka, member, RAC, felt the need to devise moisture meter for cashew. The other two members, Dr. Subhash Chander and Dr. K.B. Hebbar, also made introductory remarks about various research needs. This was followed by a presentation about the Action Taken Report on the previous RAC recommendations by Dr. J. Dinakara Adiga, Member Secretary, 8th RAC. Thereafter, presentations on the progress of research in Crop Improvement, Crop Management, Crop Protection, Post Harvest Technology, and Transfer of Technology were made by the scientists of DCR. After the completion of deliberations under different sections, the

Chairman discussed at length about feedbacks from scientists, farmers, processors and consumers concerned to future needs of cashew research. Prior to the meeting, visit to processing factories in Mangaluru was undertaken in the afternoon of 25 April 2019 and field visits to progressive farmers fields in the forenoon of 26 April 2019. Based on the presentations and discussions, the RAC made recommendations for different research programmes. The composition of RAC is given below.

Sl. No.	Name and Address	Status
1.	Dr. D.S. Rathore, Former ADG (Hort.), ICAR and Ex-Vice Chancellor, Himachal Pradesh Agriculture University, Palampur, Himachal Pradesh	Chairman
2.	Dr. P.C. Lenka, Former Dean, OUAT, Odisha	Member
3.	Dr. A.N. Ganeshmurthy, Head, Division of Soil Science & Agricultural Chemistry, ICAR-IIHR, Bengaluru	Member
4.	Dr. Subhash Chander, Principal Scientist, (Entomology), Division of Entomology, ICAR-IARI, New Delhi	Member
5.	Dr. K.B. Hebbar, Head, Division of Crop Physiology & Biochemistry & Post Harvest Technology, ICAR-CPCRI, Kasaragod	Member
6.	Dr. S.N. Ojha Principal Scientist, ICAR- Central Institute of Fisheries Education (CIFE), Mumbai	Member
7.	Dr. M. Gangadhara Nayak, Director (Acting), ICAR-DCR, Puttur	Member
8.	Dr. W.S. Dhillon, ADG (HS-I), ICAR, KAB-II, Pusa, New Delhi	Member
9.	Dr. J.D. Adiga, Principal Scientist (Horticulture), ICAR-Directorate of Cashew Research, Puttur	Member Secretary

13.3. Institute Research Committee (IRC)

The 32nd Institute Research Committee (IRC) meeting of ICAR-DCR, Puttur was held during 15-16 May 2019. There were four technical sessions chaired by experts of the field. Dr. A. Mohan Rao, Professor, Department of Genetics and Plant Breeding, UAS, GKVK, Bengaluru was the resource person for the technical session on 'Crop Improvement'. Dr. Ravi Bhat, Head, Division of Crop Production, ICAR-CPCRI, Kasaragod was the resource person for 'Crop Management'. For Crop Protection and Post Harvest Technology sessions, Dr. Kamala Jayanti, Principal Scientist, Division of Entomology and Nematology, IIHR, Bengaluru and Dr. Harinder Singh Oberoi, Head, Division of Post Harvest Technology, IIHR, Bengaluru were the resource persons, respectively. In each session, the results of various ongoing projects were presented along with new project proposals by the scientists of DCR and the details were deliberated. New project proposals included, Generation mean analysis in cashew to understand the nature of gene action for important traits, Breeding for reduced tannin content in cashew apples of popular cultivars, *In vitro* pollen germination and pollen tube growth of cashew varieties in response to high temperature stress, Cashew - tea mosquito bug interactions and the defensive responses, and Influence of *Apis cerana* and *Braunsapis* sp. on pollination and fruit set of cashew. Accordingly, the technical programme of the projects for the year 2019-20 was also finalized.

13.4. Institute Management Committee (IMC)

The 48th meeting of IMC was held on 7 February 2019 wherein IMC members interacted with QRT. The composition of IMC is as follows:

Sl. No.	Name and Address	Status
1.	Dr. M.G. Nayak, Director (Acting), ICAR-DCR, Puttur , Karnataka	Chairman
2.	The Joint Director of Horticulture, Directorate of Horticulture, Govt. of Karnataka, Lalbagh, Bengaluru	Member
3.	Dr. Mahabaleshwar Hegde, Registrar, UAS, GKVK, Bengaluru	Member
4.	The Special Officer (Cashew), Aravind Chambers, Mundakkal West, Near DCC Office, Kollam, Kerala	Member
5.	Dr. D.V.S. Reddy, Principal Scientist, ICAR-Agricultural Technology Application Research Institute (ICAR-ATARI), Zone VIII, MRS, H.A. Farm, P.O. Hebbal, Bengaluru	Member
6.	Dr. K. Bhanu Prakash, Principal Scientist, ICAR- Indian Institute of Horticultural Research (ICAR-IIHR), Bengaluru	Member
7.	Dr. N. Vijaya Kumari, Principal Scientist, ICAR-Central Citrus Research Institute (ICAR-CCRI), Nagpur	Member
8.	Dr. Ravi Bhat, Head, Crop Production, ICAR-CPCRI, Kasaragod, Kerala	Member
9.	The Finance and Accounts Officer, ICAR-CPCRI, Kasaragod, Kerala	Member
10.	The Administrative Officer, ICAR-DCR, Puttur, Karnataka	Member Secretary

13.5. Institute Joint Staff Council (IJSC)

The IJSC meeting was held on 29 March 2019 under the chairmanship of Director (Acting), ICAR-DCR, Puttur at Kemminje campus of DCR and the agenda items were discussed for the benefit of DCR staff members.

Sl. No.	Name	Status
1.	Dr. M.G. Nayak	Chairman, IJSC
2.	Dr. Shamsudheen Mangalassery	Member (Official side)
3.	Dr. Babli Mog	Secretary (Official side)
4.	Shri. P. Abdulla	Member (Official side)
5.	Shri. R. Arulmony	Member (Official side)
6.	Smt. Leela, M.	Member (Staff side)
7.	Smt. Reshma, K.	Secretary (Staff side)
8.	Shri. Ravishankar Prasad	Member (Staff side)
9.	Shri. Gopala Krishna	Member (Staff side)
10.	Shri. T. Padmanabha	Member (Staff side)
11.	Shri. Bhojappa Gowda	Member (Staff side)

14. WORKSHOPS, SEMINARS, TRAINING, FARMERS DAYS AND OTHER EVENTS ORGANISED

14.1. Programmes organized

Annual cashew day – 2019

The annual cashew day was celebrated on 22 January 2019 at ICAR-Directorate of Cashew Research, Puttur, Dakshina Kannada. The cashew day was inaugurated by Smt. J. Mercykutty Amma, Hon'ble minister for fisheries, harbour engineering and cashew Industry, Government of Kerala. On the occasion, she released the first cashew hybrid H-130 developed by ICAR-DCR by distributing it to Horticultural department officials from Karnataka and Kerala. She said that there is a shortage of

raw cashewnuts for processing in Kerala and different parts of the country. There is an urgent need to increase the production and productivity of cashew. During the programme, the guest of honour, Mr. Shirish, K., Special Officer (Cashew) and Managing Director, Kerala State Agency for Expansion of Cashew Cultivation opined that cashew planting material is of utmost importance in the present condition to expand the cashew cultivation in Kerala. Dr. Anitha Karun, Director (Acting), ICAR-Central Plantation Crops Research Institute, Kasaragod lauded the efforts of ICAR-DCR in developing modern technologies for improved cashew cultivation. On this occasion, Dr. M.G. Nayak, Director (Acting), ICAR-DCR, Puttur announced the formation of Cashew Growers Association of India. In the event, more than 200 cashew farmers participated besides nurserymen, representatives of KVK, development departments and scientists.

Inaugural programme of PM-KISAN scheme

The inauguration of Pradhan Mantri Kisan Samman Nidhi (PM-KISAN) scheme by Honorable Prime Minister of India, Shri. Narendra Modi at Gorakhpur, Uttar Pradesh was webcasted by organizing a farmers' fair at ICAR-Directorate of Cashew Research, Puttur, on 24 February 2019. On this occasion, Shri. Parshottam Rupala, Union Minister of State for Agriculture and Farmer's Welfare, Shri. Amitabh Gautam, Joint Secretary,

Department of Agriculture Cooperation and Farmers Welfare, Shri. Nalin Kumar Kateel, Member of Parliament (MP) and Shri. Sanjeeva Matandoor,

Member of Legislative Assembly (MLA), Puttur Karnataka were present. The programme started with the welcome speech by Dr. M.G. Nayak, Acting Director, ICAR-DCR, Puttur who welcomed all the guests and audience present in the programme. Then the importance of PM-KISAN, its features and benefits to farmers were explained in Kannada by Dr. T.N. Raviprasad, Principal Scientist, ICAR-DCR, Puttur. M.P., M.L.A. and the Minister present on the occasion talked about the motive of this unique programme i.e. welfare of farmers. Then about 11.00 A.M. the Mann Ki Bath programme of PM was webcasted to the assembled audience. It was followed by web telecasting of the inauguration of PM-KISAN scheme and laying foundations for the Kanga (Gujarat)-Gorakhpur (Uttar Pradesh) gas pipeline connection project. In the interaction session, PM interacted with Shri. Janardhana Bhat, Puttur, a farmer identified by ICAR-DCR, Puttur. It was followed by a short film on PM-KISAN scheme and the speech of PM who spoke at length about the importance of this scheme and how it is going to benefit 12 crores farmers of the country. The total attendance of the gathering was 430.

International women's day

The International women's day was celebrated on 8 March 2019 at ICAR-Directorate of Cashew Research, Puttur. Dr. M.G. Nayak, Director (Acting), Women and other staffs of this Directorate participated in the event. Dr. Babli Mog, Scientist & Chairperson Women's Cell gave the welcome address. Dr. M.G. Nayak, the Director (Acting), addressed the gathering with warm wishes and also praised particularly the women staff of this Directorate for their contribution to the development of this Institution. Dr. Babli Mog, Chairperson addressed the gathering with a talk on the theme "Think Equal, Build Smart & Innovate for Change". In her talk, she highlighted the way the girls and women have grown up in the society

and the achievements they have made in all fields. Web telecast of Hon'ble PM's address was arranged on the occasion of International women's day and mass interaction was held among the women staff for the betterment in the working place and other places of interest.

Foundation day, Farmers' meet and SCSP launching programme

ICAR-DCR, Puttur celebrated its 33rd Foundation day along with the Farmers' meet and Scheduled Caste Sub-Plan (SCSP) launching programme on 18 June 2019. In the beginning, Dr. M.G. Nayak, Director (Acting) welcomed the dignitaries, farmers and other participants. It was followed by launching of SCSP programme by Chief Guest of the programme Shri. Sanjeeva Matandoor, Member of Legislative Assembly (MLA), Puttur. In the introductory speech, MLA talked about the role of agriculture in Indian society and changing agriculture scenario in the country. Guest of Honour, Shri. Venkatesh N. Hubballi, Director, Directorate of Cashewnut and Cocoa Development

(DCCD), Kochi, talked about programmes of DCCD for the popularisation of cashew and its area expansion to non-traditional cashew growing regions. Guest of Honour, Shri. Prakash Natelkar, Managing Director, KCDC, Karnataka congratulated the Directorate for the achievements made over the years for improving cashew production. On the

occasion, six publications on cashew cultivation and related aspects were released. It was followed by felicitation of Shri. K. Nagaraja, a progressive farmer growing Cashew in Kolar district for producing very high levels of cashew yields by following scientific cashew cultivation practices. The resource person of the programme Mr. S. Ramesh delivered a lecture on "Role of NABARD in the formation of Farmers Producer Organizations (FPOs)". It was supplemented by Shri. Ramkishore Manchi, Director, Pingara FPO, who shared his experiences of formation and running an FPO. Shri. Shiva Prakash, Department of Horticulture, Beltangadi talked about state horticulture department incentives to the farmers for staring the FPOs. The Progressive farmer felicitated on the occasion shared his success story with other farmers. The programme was attended by 200 participants.

Hindi week

Hindi week-2019 organised under the auspice of Puttur Town Official Language Implementation Committee, was inaugurated on 13 September 2019 at ICAR-DCR Puttur. Smt Kusuma Vasanth, Hindi Lecturer, Govt Women's College, Puttur was the Chief Guest. Sri Chinnaya Chary, Manager SBI, Puttur was the Guest of Honor. Students who secured highest marks in Dakshin Bharat Hindi Prachar Sabha Exams were honoured on the occasion. Hindi competitions were conducted for the students and staff members on the occasion.

Vigilance awareness week

ICAR-Directorate of Cashew Research, Puttur celebrated the Vigilance Awareness Week - 2019. A week-long programme was conducted by the institute from 28 October 2019 to 2 November 2019. The valedictory function was held on 2 November 2019. In the inaugural address, Sri. Rudolph Peirera, Hon'ble 5th Additional District & Session Judge, Puttur stressed the importance of integrity in human life and requested all to do the right things in any situation. Sri. Manjunatha, Hon'ble Principal Senior Civil Judge & ACJM and

Chairman, Taluk Legal Services Committee, Puttur was the Guest of Honour for the programme. Sri. Suresh Rai Paddmbailu, Vice President, Bar Association, Puttur, Smt. Mamatha Suvarna, Joint Secretary, Bar Association, Puttur and Sri. Bhaskara Kodimbala, Ex-President, Bar Association, Puttur were also present in the programme.

During the function, resource person Sri Suryanarayana, N.K., Advocate, Puttur gave a talk on *"Integrity-A way of Life".* The programme was attended by about 150 people.

Swacchata pakhwada

Swacchata Pakhwada was organised at ICAR-DCR, Puttur from 15 to 31 December 2019 to create awareness amongst the staff and their family members on the necessity of maintaining cleanliness. The activities conducted included cleanliness and sanitation drive in Ammunja village by removing the weeds and litter in the village. The villagers were apprised about the importance of sanitation for a healthy life and safe environment. Similarly, cleanliness drive was taken up at the residential area of ICAR-DCR, wherein family members actively participated in removal and disposal of waste materials including plastic items. A cleanliness campaign was also done in the Shantigodu campus wherein staff members cleared the debris and other waste in the office premises. In order to make the staff aware about composting kitchen and home waste materials, a demonstration was done to generate valuable compost using the biodegradable kitchen and household wastes by segregating waste as dry/wet and biodegradable/ non-biodegradable. Farmers' day was conducted for farmers from Hatyadka village of Belthangadi taluk, D.K. to sensitise about the cleanliness and the need for reducing the use of plastics. A presentation on "Ancient and Modern Agriculture" was arranged exclusively for students of Government Higher Primary School, Mottethadka. Also, a quiz competition was held for students which included

interesting questions on both Swachha Bharat Mission and the Indian Constitution. The students enthusiastically took part in the competition. The valedictory function and prize distribution were conducted on the final day of the Swacchata Pakhwada.

Constitution day

The Constitution day was celebrated at ICAR-DCR, Puttur in collaboration with District Legal Services Authority, Mangalore; Taluk Legal Services Committee, Puttur; Bar Association, Puttur; Government First Grade Women Degree College,

Puttur and Vivekananda Law College, Puttur on 26 November 2019. Dr. M.G. Nayak, Director (Acting), ICAR-DCR, Puttur welcomed the guests and audience. Mr. Manjunath, Hon'ble Principal Sr. Civil Judge & ACJM, Chairman, Taluk Legal Services Committee, Puttur, D.K., set the tone for the function with his inaugural speech on the general aspects of the constitution and its present scenario in India. Then the pledge on 'Preamble' of Indian constitution was administered to the audience. Guests of Honour, Mr. Udayashankar Shetty, Advocate & Member, District Legal Services Authority, Mangalore; Sri. Manohar K.V., President, Bar Association, Puttur and Mr. Xavier D'Souza, Principal, Government First Grade College for Women, Puttur briefly spoke on the occasion highlighting the importance of the Indian Constitution.

The resource person for the function Dr. B. K. Ravindra, Director of Legal Studies, Vivekananda Law College, Puttur spoke at length on the topic, "Significance of Indian constitution and citizens' duties". The programme was attended by 160 participants including the Officials of Bar Association, Puttur, Press, students and staff of Government First Grade College for Women, Vivekananda Law College, the staff of ICAR-DCR, Puttur and general public.

Quiz competitions on constitution day

A quiz competition was held as part of the Swachhata Pakhwada and Constitution awareness by ICAR-DCR, Puttur on 27 December 2019. The Students of Government Primary school, Mottethadka, Puttur took part in the quiz competition for the students, juniors (1^{st}-5^{th} standard) and seniors (6^{th}-8^{th} standard). The quiz

included three rounds of questions and the students enthusiastically took part in the competition and enjoyed it. In the programme, along with students and teachers of Primary school, the DCR staff was also present. On 31 December 2019, a quiz programme was organized separately for the staff of ICAR-DCR, Puttur to mark the importance of Indian constitution and also to create awareness on the contributions made by different persons to make India, a Republic country.

14.2. Training/Workshop

Hindi workshop

Hindi workshop for the staff members of the Directorate and members of the Puttur Town Official Language Implementation Committee (TOLIC) was conducted on 25 July 2019. Sri. Avanish Kumar, Sr. Manager (OL), Corporation Bank, Mangaluru and Sri. Manesh Mohan, OL officer, Circle office, Canara

Bank were the resource persons. The 36th Half Yearly meeting of the Puttur Town Official Language Implementation Committee (TOLIC) was organized in the afternoon of 27 July 2019. Representative Officers from different member organizations of Puttur TOLIC participated in the programme.

Training on cashewnut processing

A five days training programme on cashew nut processing was conducted during 23 to 27 September 2019 at the Directorate for the five participants including two each from Tamil Nadu and Karnataka and one from Kerala. The training programme was coordinated by Dr. Eradasappa, E., Scientist (Plant Breeding) & I/c Extension. The training programme covered all aspects of cashew processing including cashew cultivation. Participants were given hands-on training on various aspects of cashew processing and were taken to two cashew processing units viz., Sree Venkateshwara Cashew Processors, Vittal, which is a semi-mechanised unit and Kalbhavi Cashew Processors, Mangalore, which is a fully mechanized unit. Resource persons for the training programme encompassed Dr. D. Balasubramanian, Principal Scientist (AS&PE), Dr. J.D. Adiga, Principal Scientist (Horticulture), Dr. P. Preethi, Scientist (Fruit science) of ICAR-DCR, Puttur and Mr. Subraya Pai, Shree Venkateshwara Cashew Processors, Vittal.

15. राजभाषा कार्यान्वयन एवं प्रगति

राजभाषा कार्यान्वयन समिति

1.	डा. एम.जी. नायक	अध्यक्ष
2.	डा. षंसुधीन यम.	सदस्य
3.	डा. ईरदासप्पा, ई	सदस्य
4.	श्री पी अब्दुल्ला	सदस्य
5.	श्रीमती रत्न रंजिनि	सदस्य
6.	श्रीमति लीला एम.	सदस्य
7.	श्री रघुराम कुकडे	सदस्य
8.	श्री उमाशंकर	सदस्य
9.	श्री प्रकाश जी. भट्	सदस्य सचिव

राजभाषा विभाग, गृह मंत्रालय और भारतीय कृषि अनुसंधान परिषद की ओर से जारी किए जा रहे राजभाषा कार्यान्वयन संबंधी दिशानिर्देश और भारत सरकार की राजभाषा नीति के अनुपालन के संबंध में राजभाषा विभाग द्वारा निर्धारित वार्षिक कार्यक्रम में उल्लिखित लक्ष्यों की पूर्ति तथा राजभाषा हिंदी के उत्तरोत्तर प्रगति हेतु राजभाषा कार्यान्वयन के सभी पहलुओं पर इस निदेशालय में प्रयास किया जा रहा है।

राजभाषा विभाग एवं भारतीय कृषि अनुसंधान परिषद के निर्देश एवं आदेशों के अनुपालन एवं राजभाषा कार्यान्वयन की प्रगति की समीक्षा हेतु इस निदेशालय में निदेशक महोदय की अध्यक्षता में गठित राजभाषा कार्यान्वयन समिति की बैठक नियमित रूप से आयोजित की जा रही है। इस बैठक को हर तिमाही में एक बार आयोजन की जा रही है।

इस समिति में राजभाषा विभाग के वार्षिक कार्यक्रम के अनुसार राजभाषा कार्यान्वयन प्रगति तथा भारतीय कृषि अनुसंधान परिषद के आदेशों के अनुपालन पर चर्चा एवं समीक्षा की जाती है। इस निदेशालय के प्रशासनिक अधिकारी, विभिन्न अनुभागों के छः कर्मचारी इस समिति के सदस्य हैं।

प्रत्येक बैठक के कार्यवृत्त की समीक्षा निदेशक (राजभाषा) भारतीय कृषि अनुसंधान परिषद की ओर से की जाती है और तदनुसार अगली बैठक में चर्चा कर निदेशक महोदय की अनुमति से पुष्टि की जाती है।

राजभाषा अधिनियम 1963 धारा 3(3) के अनुपालन का अधिकाधिक प्रयास किया जाता है। तदनुसार निदेशालय की ओर से जारी किए जा रहे प्रपत्रों को द्विभाषीकरण कर नियम का अनुपालन सुनिश्चित किया जाता है। वार्षिक प्रतिवेदनों को पूर्णरूप से हिंदी में भी तैयार कर अधिनियम का अनुपालन किया जा रहा है।

राजभाषा के प्रति जागरुकता पैदा कराने हेतु राजभाषा विभाग की ओर से जारी किए गए वार्षिक कार्यक्रम के अनुसार इस निदेशालय में 14 सितंबर से 22 तक हिंदी सप्ताह समारोह आयोजन किया गया। इस अवसर पर कर्मचारियों के लिए विभिन्न प्रतियोगिताओं जैसे हिंदी निबंध लेखन, प्रारूप, टिप्पण एवं मसौदा लेखन प्रतियोगिता, क्विझ प्रतियोगिता आदी आयोजित की गई है। प्रतियोगिताओं के विजेताओं को सप्ताह के समापन समारोह में पुरस्कार भी वितरण किया गया है। इसके अतिरिक्त सरकारी काम काज में हिंदी का अधिकाधिक प्रयोग करनेवाले अधिकारियों एवं कर्मचारियों को इस अवसर पर मुख्य अतिथि द्वारा प्रोत्साहन योजना के अधीन नकद पुरस्कार वितरण किया गया है।

इस वर्ष हिन्दी सप्ताह समारोह के अवसर पर श्रीमती कुसुमा, हिन्दी प्राध्यपिक, सरकारी महिला कालेज, पुत्तूर विशेष अतिथि थे।

दिनांक 18.12.2019 को भा.कृ.अनु.प. मुख्यालय, नई दिल्ली से आए श्री पी.के. गुप्ता, उप निदेशक (राजभाषा) और श्री मनोज कुमार सीटीओ, निदाशालय में उपस्थित थे। उन्होंने निदेशालय के राजभाषा गतिविधियों की निरीक्षण किए और उसे सुधारने के लिए जरूरी सूचना दिये। इस अवसर पर निदेशक, प्रशासन अधिकारी एवं हिन्दी समिति के सदस्य उपस्थित थे।

राजभाषा नियम 1976 नियम 11 के अनुपालन हेतु आवश्यक सामग्रियों जैसे प्रपत्र, रबड़ की मोहरें, नाम पट्ट आवश्यकतानुसार द्विभाषी में तैयार कर समय समय पर मार्गनिर्देश दिया जाता है। सम्मेलनों का बैनर एवं निमंत्रण पत्र द्विभाषा में ही प्रदर्शित किया जाता है।

हिंदी पत्रों की आवति के लिए प्रत्येक रजिस्टर रखकर राजभाषा नियम 1976 नियम 5 का अनुपालन पूर्ण रूप से शत प्रतिशत किया जाता है।

वेबसाइट का प्रदर्शन

निदेशालय की वेबसाइट संपूर्ण द्विभाषा में प्रदर्शित किया गया है। राजभाषा से संबंधित सभी गतिविधियों का विवरण वेबसाइट पर दिया जाता है।

हिंदी कार्यशाला

सरकारी काम काज में हिंदी का प्रयोग बढ़ाने एवं हिंदी कार्य का उपयोगी ज्ञान प्राप्त कराने हेतु निदेशालय में कुल चार कार्यशालाओं को आयोजन किया जा रहा है। इस वर्ष भी अनुभवी मार्गदर्शकों की मार्गदर्शन में मसौदा लेखन, टिप्पण, अनुवाद एवं राजभाषा नियम, अधिनियम पर हिंदी कार्यशाला आयोजित की गई और उन्हें अभ्यास भी कराया गया है।

उपर्युक्त कार्यशालाओं में निदेशालय के अधिकारियों तथा नगर राजभाषा कार्यान्वयन समिति के सदस्य कार्यालयों के अधिकारियों एवं कर्मचारियों को भी उपस्थित होने का सुअवसर प्रदान किया गया।

पुत्तूर नगर राजभाषा कार्यान्वयन समिति

पुत्तूर नगर और आस पास के केन्द्र सरकारी कार्यलयों में राजभाषा हिन्दी का कार्यान्वयन सुनिश्चित करने की दृष्टी से पुत्तूर और विट्टल में स्थित केंद्रीय सरकार के कार्यालय, उपक्रम, बैंक सहित 18 सदस्य कार्यालय सम्मिलित नगर राजभाषा कार्यान्वयन समिति (नराकास) का घटन किया गया है। पुत्तूर नराकास की 36वीं अर्धवार्षिक बैठक दिनांक 25.07.2019 को निदेशक महोदय की अध्यक्षता में आयोजित की गई।

बैठक में सदस्य कार्यालयों से राजभाषा कार्यान्वयन से संबंधित अर्धवार्षिक प्रगति रिपोर्ट की समीक्षा की गई । काजू अनुसंधान निदेशालय की ओर से आयोजित हिंदी कार्यशाला और प्रशिक्षण में नराकास के सदस्य कार्यालयों को भी आमंत्रित किया गया और संयुक्त रूप से आयोजन किया गया।

निदेशालय में निम्नलिखित रिपोर्ट हिंदी में प्रकाशित किया गए:

1. निदेशालय का वार्षिक प्रतिवेदन (वर्ष 2018-19) पूर्ण रूप से हिंदी में।
2. अखिल भारतीय समन्वित काजू अनुसंधान परियोजना की वार्षिक प्रतिवेदन सारांश (वर्ष 2018-19)।
3. अर्ध वार्षिक, पत्रिका 'काजू समाचार' में हिंदी समिती की गतिविधियों के बारे में प्रतिवेदन।
4. दैनंदिन प्रयोग में आने वाले प्रपत्रों का हिंदी रूपान्तरण।

निदेशालय के सभी वैज्ञानिक, अधिकारी एवं कर्मचारी संस्थान के काम में राजभाषा हिंदी के कार्यान्वयन के लिए अपनी प्रतिबद्धता दोहराते हैं।

16. DISTINGUISHED VISITORS

Name	Address	Date of visit
Shri. S.N. Bhat Kandige	Vice President CAMPCO, Puttur	20 January 2019
Shri. G. Chandra Sekar	Scientist, DRDO, Hyderabad	20 January 2019
Shri. J. Mercykutty Amma	Minister for Fisheries, Harbor Engineering & Cashew Industry, Govt. of Kerala	22 January 2019
Dr. S.P. Ghosh	Former DDG (Hort.), ICAR, New Delhi	5-8 February 2019
Dr. J.C. Bhat	Former Director, ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan (VPKAS), Almora, Uttar Pradesh	5-8 February 2019
Dr. M.G. Bhat	Former Director, ICAR-DCR, Puttur	5-8 February 2019
Dr. A.K. Mehta	Former ADG (Extension), ICAR, New Delhi	5-8 February 2019
Dr. Abraham Verghese	Former Director CPCRI, Kasaragod	5-8 February 2019
Dr. K.R.M. Swamy	Former Principal Scientist, ICAR-DCR, Puttur	5-8 February 2019
Dr. V.N. Hubbali	Director, Directorate of Cashewnut and Cocoa Development (DCCD), Kochi	7 February 2019
Shri. Prakash Kalbhavi	M/s Kalbhavi Cashew Processor, Mangaluru	7 February 2019
Shri. Subraya Pai	Chairman, Karnataka Cashew Manufacturer Association, Mangaluru	7 February 2019
Shri. Sudhakar Kamath	Former Chairman, Karnataka Cashew Manufacturer Association, Bengaluru	7 February 2019
Shri. Sreenivas Reddy	ICAR-Agricultural Technology Application Research Institute, Bengaluru	7 February 2019
Dr. Ravi Bhat	Principal Scientist, CPCRI, Kasaragod	7 February 2019
Shri. Parashottam Rupala	Union Minister of State for Agriculture and Farmers Welfare, Govt. of India	24 February 2019
Shri. Amitabh Gautam	Joint Secretary, Department of Agriculture, Cooperation and Farmers Welfare, Govt. of India	24 February 2019
Shri. Nalin Kumar Kateel	Member of Parliament, D.K., Mangaluru	24 February 2019
Shri. Sanjeeva Matandoor	Member of Legislative Assembly, Puttur	24 February 2019
Shri, Krishnappa	Former MLA, Bannur, Mysore, Karnataka	25 February 2019
Shri. Chandrakanta Bellad	Former Member of Legislative Assembly, Dharwad	4 March 2019
Shri. Basavaraja Vibbhura	Progressive Farmer, Dharwad	4 March 2019
Dr. S. Rajam	Former ADG (Horticulture)., ICAR, New Delhi	25 March 2019
Dr. G. K. Mukunda	Professor of Horticulture, UAS, Bengaluru	25 March 2019

Shri. B. Ramanatha Rai	Former Minister of Forests & Environment, Govt. of Karnataka	27 June 2019
Dr. K.V. Peter	Former Vice Chancellor, Kerala Agricultural University	9 December 2019
Dr. Jagadish Rane	Director (Acting), ICAR-National Institute of Abiotic Stress Management (NIASM), Baramati, Maharashtra	9 December 2019
Dr. K.S. Shivashankar	Principal Scientist, IIHR, Bengaluru	9 December 2019
Dr. Kanhaiya Singh	Principal Scientist, IARI, New Delhi	9 December 2019 & 28 December 2019
Dr. S.B. Dandin	Former Vice-Chancellor, University of Horticultural Sciences, Bagalkot	9 December 2019 & 28 December 2019
Dr. N.K. Krishnakumar	Former DDG (Hort.) and Chairman Bioversity International, New Delhi	9 December 2019 & 10 December 2019
Dr. Akshaya Talukdar	Principal Scientist, IARI, New Delhi	9 December 2019
Dr. P.S. Bhat	Principal Scientist, IIHR, Bengaluru	10 December 2019
Dr. Vikramaditya Pandey	Principal Scientist (Hort. Division), ICAR KAB-II, New Delhi	10 December 2019
Dr. Reju M. Kurian	Principal Scientist, IIHR, Bengaluru	10 December 2019
Dr. N. Bakthavatsalam	Principal Scientist, NBAIR, Bengaluru	10 December 2019
Dr. M.K. Rajesh	Principal Scientist, ICAR-CPCRI, Kasaragod	28 December 2019
Dr. Selvi, A.	Principal Scientist, ICAR-Sugarcane Breeding Institute, Coimbatore	28 December 2019

17. PERSONNEL

Research Management Position		
1.	Dr. M.G. Nayak	Director (Acting)
Scientific		
1.	Dr. T.N. Raviprasad	Principal Scientist (Agricultural Entomology)
2.	Dr. D. Balasubramanian	Principal Scientist (Agricultural Structures and Processing Engineering)
3.	Dr. J.D. Adiga	Principal Scientist (Horticulture)
4.	Dr. Mohana, G.S.	Senior Scientist (Genetics & Cytogenetics)
5.	Dr. Shamsudheen Mangalassery	Senior Scientist (Soil Science)
6.	Dr. Eradasappa, E.	Scientist (Plant Breeding)
7.	Dr. K. Vanitha	Scientist (Agricultural Entomology)
8.	Shri. Rajkumar Arjun Dagadkhair	Scientist (Food Technology) [On study leave from 29 March 2018 to 20 March 2021]
9.	Dr. Babli Mog	Scientist (Plant Physiology)
10.	Dr. Preethi, P.	Scientist (Fruit Science)
11.	Shri. Muralidhara, B.M.	Scientist (Fruit Science) [On study leave from 20 September 2018 to 19 September 2021]
12.	Dr. Siddanna Savadi	Scientist (Agricultural Biotechnology)
Technical		
1.	Shri. K. Muralikrishna	Chief Technical Officer
2.	Shri. P. Abdulla	Chief Technical Officer
3.	Shri. R. Arulmony	Chief Technical Officer
4.	Shri. Prakash G. Bhat	Chief Technical Officer
5.	Shri. N. Manikandan	Sr. Technical Officer
6.	Shri. Raghurama Kukude	Sr. Technical Officer
7.	Shri. K.V. Ramesh Babu	Sr. Technical Officer
8.	Shri. R. Muthuraju	Sr. Technical Officer
9.	Shri. M. Bhojappa Gowda	Technical Officer
10.	Shri. Ravishankar Prasad	Sr. Technical Assistant
11.	Shri. Honnappa Naik, P.	Sr. Technician

Administration		
1.	Shri. T. E. Janardhanan	Administrative Officer (on additional charge from 30.12.2019)
2.	Smt. M. Rathna Ranjini	Assistant Administrative Officer
3.	Shri. O.G. Varghese	Private Secretary
4.	Smt. Reshma, K	Personal Assistant
5.	Ms. Winnie Lobo	Assistant
6.	Smt. M. Leela	Assistant
7.	Shri. Umashankar	Upper Division Clerk
8.	Smt. K. Padminikutty	Upper Division Clerk

Skilled Supporting Staff

Sl. No.	Name	Sl. No.	Name
1.	Sri. K. Shiva	10.	Sri. K. Narayana
2.	Sri. N. Narayana Naik	11.	Sri. B. Narayana Poojari
3.	Sri. Vijaya Achari	12.	Sri. B. Kushalappa
4.	Sri. Veerappa	13	Sri. B. Babu Gowda
5.	Sri. K. Annu	14.	Sri. T. Padmanabha
6.	Sri. Krishnappa Naik	15.	Sri. S. Monappa
7.	Sri. V. Sundara	16.	Sri. B. Seetharama
8.	Sri. C.H. Hariya Naik	17.	Sri. K. Gopalakrishna
9.	Sri. K. Umanath Shetty	18.	Smt. S. Kasturi

Retirement

- Shri. K. Babu Poojari, Senior Technical Assistant superannuated on 31 January 2019
- Shri. Surendra Kumar Indra, Coffee/Tea maker superannuated on 28 February 2019
- Shri. Jayarama Naik K.M., Administrative Officer superannuated on 31 March 2019
- Shri. Honappa Gowda, supporting staff superannuated on 30 September 2019

Promotion

- Dr. Shamsudheen Mangalassery, Scientist (Soil Science) has been promoted to Senior Scientist (Soil Science) w.e.f. 8 January 2017.

18. METEOROLOGICAL DATA (2019)

Month	Temperature (°C)		Humidity (%)		Rainy days	Rainfall (mm)	Mean wind velocity (km/h)	Sunshine hours (h)	Pan evaporation (mm)
	Max.	Min.	FN	AN					
January	32.77	18.80	74.69	35.89	0	0.00	2.09	256.30	5.82
February	33.20	19.96	63.86	37.57	0	0.00	2.24	244.60	3.91
March	37.27	21.46	74.60	44.14	0	0.00	2.68	221.50	4.44
April	35.40	24.91	73.23	49.14	5	43.70	3.01	227.90	4.37
May	33.63	24.13	78.21	64.68	15	493.10	2.57	122.50	4.84
June	27.46	22.57	88.25	86.14	30	1217.40	2.52	54.90	2.00
July	28.43	22.94	91.09	82.51	29	1239.30	3.50	55.90	1.90
August	28.96	23.36	91.18	80.61	29	842.90	3.50	55.10	2.40
September	32.14	23.18	86.82	57.93	7	161.90	2.22	135.10	2.70
October	33.23	23.36	81.60	55.60	11	187.20	1.81	245.00	2.50
November	32.73	22.15	77.04	51.86	2	57.10	1.64	212.80	3.10
December	33.00	22.18	81.57	46.86	1	3.30	1.60	188.30	3.50
Annual Average	**32.35**	**22.42**	**80.18**	**57.74**	**-**	**-**	**2.45**	**168.33**	**3.46**
Annual Total	**-**	**-**	**-**	**-**	**129**	**4246**	**-**	**-**	**-**

Rainfall, rainy days and sunshine hours are monthly total; other parameters are monthly mean values.

19. PUBLICATIONS FOR SALE

Sl. No.	Publication	Price (Rs.)
1.	Cashew production technology (Revised)	60.00
2.	Softwood grafting and nursery management in cashew (Revised)	45.00
3.	Catalogue of minimum descriptors of cashew	
4.	Germplasm accessions - I	165.00
5.	Germplasm accessions - II	125.00
6.	Germplasm accessions - III	128.00
7.	Germplasm accessions – IV	--
8.	Germplasm accessions - V	--
9.	Process catalogue on development of economically viable on-farm cashewnut processing	45.00
10.	Annotated bibliography on cashew (1995-2007)	205.00
11.	Soil and water management in cashew plantations	30.00
12.	Biochemical characterization of released varieties of cashew	85.00
13.	Pruning and canopy architecturing in cashew	40.00
14.	Development of dual-mode dryer for raw cashewnuts	90.00
15.	Alternate energy utilization of cashew shell cake for thermal application	90.00
16.	Cashew cultivation practices (Pamphlet)	*
17.	Status of cashew germplasm collection in India (Booklet)	*
18.	Cashew nutritive value (Revised) (Brochure)	*
19.	Insect pests of cashew	*

Price indicated above does not include postage.

Address your enquiries to the Director, ICAR-Directorate of Cashew Research, Puttur-574 202, Dakshina Kannada, Karnataka.

* Free of cost.

20. MAJOR ABBREVIATIONS USED

Abbreviation	Expansion
%	Percentage
°Bx	Degrees Brix
°C	Degree Celsius
ADC	Analog to Digital Converter
ADG	Assistant Director General
AGM	Annual Group Meeting
AICRP	All India Coordinated Research Project
AICS and CIP	All India Coordinated Spices and Cashew Improvement Project
AIIMS	All India Institute of Medical Sciences
AKMU	Agricultural Knowledge Management Unit
AN	Afternoon
ANB	Apple and Nut Borer
ATARI	Agricultural Technology Application Research Institute
ATMA	Agricultural Technology Management Agency
B	Boron
b.p	Boiling Point
BBCH	Biologische Bundesantalt Bundessortenamt und Chemische Industrie
Ca	Calcium
CAP	Cashew Apple Powder
CEPCI	Cashew Export Promotion Council of India
CIAE	Central Institute of Agricultural Engineering
cm	Centimetre
CNSL	Cashew Nut Shell Liquid
CPCRI	Central Plantation Crops Research Institute

Abbreviation	Expansion
CRS	Cashew Research Station
CSRB	Cashew Stem and Root Borer
CSSR	Cashew Simple Sequence Repeats
Cu	Copper
CUPRAC	Cupric Reducing Antioxidant Capacity
CVC	Central Vigilance Commission
d.b	Dry basis
D.K.	Dakshina Kannada
DAE	Days After Emergence
DARE	Department of Agricultural Research and Education
DAT	Days After Treatment
DCCD	Directorate of Cashewnut and Cocoa Development
DCR	Directorate of Cashew Research
DDG	Deputy Director General
DG	Director General
DMAPR	Directorate of Medicinal and Aromatic Plants Research
DPPH	2, 2-diphenyle-1-picryl-hydrazyl-hydrate
DUS	Distinctness, Uniformity and Stability
DW	Desert Whole
EPN	Entomopathogenic Nematodes
F_1	the first Filial generation
Fe	Iron
FN	Forenoon
g	Gram
GC-MS	Gas Chromatography–Mass Spectrometry
GIA	Grant-in-Aid
h	Hours
ha	hectare

Abbreviation	Expansion
HDPE	High-density polyethylene
Hz	Hertz
IARI	Indian Agricultural Research Institute
ICAR	Indian Council of Agricultural Research
IGH	Insect Growth Hormone
IIHR	Indian Institute of Horticultural Research
IISR	Indian Institute of Spices Research
IJSC	Institute Joint Staff Council
IMC	Institute Management Committee
IPGRI	International Plant Genetic Resources Institute
IPR	Intellectual Property Rights
IRC	Institute Research Committee
ISO	International Standards Organization
ISPC	Indian Society for Plantation Crops
ITMU	Institute Technology Management Unit
K	Potassium
KAB	Krishi Anusandhan Bhawan
KAU	Kerala Agricultural University
KCDC	Karnataka Cashew Development Corporation
KCMA	Karnataka Cashew Manufacturers Association
kg	Kilogram
KPR	Kernel Percent Recovery
KSACC	Kerala State Agency for the expansion of Cashew Cultivation

Abbreviation	Expansion
KVK	Krishi Vigyan Kendra
L	Litre
LC	Least Count
L/D ratio	Length to Diameter ratio
M/S EMCON	M/S Environment, Measurement and Controls
Max.	Maximum
Mg	Mangnesium
min	Minute
Min.	Minimum
MIT ADT	Maharashtra Institute of Technology Arts, Design and Technology
ml	Millilitre
mm	Millimetre
Mn	Manganese
Mo	Molybdenum
MoU	Memorandum of Understanding
MP-AES	Micro-wave Plasma Atomic Emission Spectrometer
MSL	Mean Sea Level
N	Nitrogen
NASC	National Agriculture Science Complex
NBAIR	National Bureau of Agricultural Insect Resources
NGS	Next Generation Sequencing
NRCC	National Research Centre for Cashew
OUAT	Odisha University of Agriculture and Technology
OW	Oily Whole
P	Phosphorus
PLACROSYM	Plantation Crops Symposium

Abbreviation	Expansion
PME	Priority setting, Monitoring and Evaluation
PM-KISAN	Pradhan Mantri Kisan Samman Nidhi
ppm	Parts per million
PPP	Public-Private-Partnership
PPV&FRA	Protection of Plant Varieties and Farmers' Rights Authority
QRT	Quinquennial Review Team
QTL	Quantitative Trait Locus
RAC	Research Advisory Committee
RKVY-RAFTAAR	Rashtriya Krishi Vikas Yojana – Remunerative Approaches for Agriculture and Allied Sector Rejuvenation
RMP	Research Management Position
RTS	Ready-To-Serve
s	Seconds
S	Sulphur
SADHNA	Society for the Advancement of Human and Nature
SD	Standard Deviation
SEm	Standard error of means
sp.	Species
SPPU	Savitribai Phule Pune University
SSW	Scorched Whole Second
SW	Scorched Whole
TMB	Tea Mosquito Bug
TNAU	Tamil Nadu Agricultural University
TOLIC	Town Official Language Implementation Committee
TPC	Total Phenolic Contents
TPD	tonnes per day
UAHS	University of Agricultural and Horticultural Sciences
UAS	University of Agricultural Sciences
UHS	University of Horticultural Sciences
UNESCO	United Nations Educational, Scientific and Cultural Organization
UP	Uttar Pradesh
UV	Ultra Violet rays
v/v	Volume by volume
VCET	Vivekananda College of Engineering and Technology
VPKAS	Vivekananda Parvatiya Krishi Anusandhan Sansthan
WBE	Whole Body Extracts
W/b	Wet Basis
WKR	Whole Kernel Recovery
Zn	Zinc

NOTE

NOTE

Release of publication of ICAR-DCR, Puttur by Smt. J. Mercykutty Amma, Hon'ble Minister for Fisheries, Harbour Engineering and Cashew Industry, Government of Kerala on 22 January 2019

Visit of Shri. B. Ramanatha Rai, Former Minister of Forests & Environment, Govt. of Karnataka to ICAR-DCR, Puttur on 27 June 2019

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