वार्षिक प्रतिवेदन
ANNUAL REPORT
2018-19

भा.कृ.अनु.प. – काजू अनुसंधान निदेशालय
(आई.एस.ओ. 9001:2008)
पुत्तूर – 574 202, कर्नाटक, भारत
ICAR-Directorate of Cashew Research
(ISO 9001:2008)
Puttur - 574 202, Karnataka, India

ICAR-Directorate of Cashew Research Annual Report 2018-19

Visit of Shri. Parshottam Rupala, Union Minister of State for Agriculture and Farmer's Welfare to cashew nursey of ICAR-DCR, Puttur on 24 February 2019

Visit of Smt. J. Mercykutty Amma, Minister for Fisheries, Harbour Engineering and Cashew Industry, Government of Kerala to the experimental fields of ICAR-DCR, Puttur on 22 January 2019

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Front Cover : Along the side: Insect pollinators in cashew [From top to bottom: *Apis cerana indica*, *Braunsapis picitarsus*, *Tetragonula* sp., *Pseudapis oxybeloides* and *Ceratina hieroglyphica*]; Centre: Cashewnut along with cashew apple of a bold nut genotype

Back Cover : Android mobile apps developed by ICAR-DCR (i) Cashew Cultivation, and (ii) Cashew Nutrient Manager
On Top: Dwarf cashew tree

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प्राक्कथन

मुझे, भा.कृ.अनु.प. - काजू अनुसंधान निदेशालय (ICAR-DCR), पुत्तूर का वार्षिक प्रतिवेधन 2018-19 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 संभाग के तहत चलाई गई प्रमुख अनुसंधान उपलब्धियों में शामिल है: उच्च उपजशील किस्मों तथा बौनी किस्मों एवं सुगठित काजू संकरों का विकास करने में प्रजनन प्रयास करना, वृद्धि एवं उपज गुणों के लिए जननद्रव्य प्राप्तियों का लक्षणवर्णन करना, टी मॉस्किेटों बग् (TMB) सहिष्णुता वाले अंतर-विशिष्ट संकर की पहचान करना, काजू की व्यावसायिक किस्म भास्कर के मसौदा जीनोम अनुक्रम का विकास करना और अंतर-विशिष्ट संकरों की आनुवंशिक शुद्धता का आमापन करने के लिए आण्विक मार्करों की पहचान करना। फसल प्रबंध संभाग में चलाई गई अनुसंधान गतिविधियों का फोकस इस प्रकार था : BBCH स्केल के अनुसार काजू में फीनोलॉजीकल वृद्धि अवस्थाओं की पहचान एवं कोडिफिकेशन, लोकप्रिय किस्म भास्कर में प्रूनिंग का मानकीकरण करने का प्रयास, काजू की खेती करने वाले क्षेत्रों की पोषण स्थिति का वर्णन तथा पोषक तत्व नैदानिकी मानकों का विकास करना। फसल सुरक्षा संभाग में TMB के लिए सिंथेटिक फिरोमॉन ट्रैप की डिजाइनिंग की दिशा में अभ्यर्थी सेमियो-केमीकल्स की पहचान करने तथा काजू के दो प्रमुख नाशीजीवों की रोकथाम के लिए वैकल्पिक रसायनों के रूप में नए कीटनाशकों की पहचान करने की दिशा में प्रयास किए गए। फसलोत्तर पहलुओं के तहत, कच्ची काजू गिरी की गुणवत्ता का आकलन करने के लिए अनुभवजन्य मॉडल्स का विकास करने, काजू गिरी में नमी की मात्रा का पता लगाने के लिए नमी मीटर का विकास एवं मापांकन करने, काजू गिरी अंकुरों एवं काजू फल से निर्जलीकृत उत्पादों का विकास करने में सफलता हासिल की गई।

इसके अलावा, संसाधन द्वारा विकसित काजू उत्पादन एवं प्रसंस्करण प्रौद्योगिकियों का हस्तांतरण सभी हिलधारकों को करने के प्रयास किए गए। रिपोर्टाधीन अवधि के दौरान, किसानों व विकास एजेन्सियों को काजू की लगभग एक लाख गुणवत्ता रोपण सामग्री की आपूर्ति की गई। RKVY-RAFTAAR द्वारा वित्त पोषित परियोजना में, किसानों को काजू उत्पादन प्रौद्योगिकियों का प्रभावी तरीके से हस्तांतरण करने हेतु किसान भागीदारी खेत अनुसंधान प्रदर्शनी, काजू म्यूजियम का विकास एवं एंड्राइड मोबाइल ऐप्स का विकास किया गया। इसके अलावा, निदेशालय की मृदा विज्ञान प्रयोगिशाला को RKVY-RAFTAAR परियोजना के तहत आधुनिक उपकरणों की स्थापना करके प्रोन्नत किया गया। रिपोर्टाधीन वर्ष के दौरान, संस्थान प्रौद्योगिकी प्रबंध इकाई (ITMU) द्वारा इस निदेशालय में विकासित प्रौद्योगिकी शीर्षक ''कच्ची काजू गिरी के लिए ड्यूल मोड ड्रायर'' की नॉन-एक्सक्लूसिव लाइसेन्सिंग की सुविधा प्रदान की गई और मैसर्स न्यूटेक इंडस्ट्रीज, कर्नाटक के साथ एक समझौता ज्ञापन पर हस्ताक्षर किए गए।

निदेशालय द्वारा अनेक कार्यक्रमों को आयोजन किए गए जैसे कि स्थापना दिवस समारोह, अंतर्राष्ट्रीय योग दिवस, स्वच्छता ही सेवा अभियान, सतर्कता जागरुकता सप्ताह, विश्व मृदा दिवस, प्रधान मंत्री किसान सम्मान निधि (PM-KISAN) के शुभारंभ समारोह की वेब्कास्टिंग तथा महिला दिवस। भाकृअनुप - काजू निदेशालय (ICAR-DCR), पुत्तूर द्वारा बौद्धिक सम्पदा अधिकार पर एक कार्यशाला और किसानों, प्रसंस्करणकर्ताओं, निर्यातकों एवं राज्य विभाग के अधिकारियों के साथ दो इन्टरफेस बैठकें आयोजित की गई। रिपोर्टाधीन वर्ष में संस्थान के वैज्ञानिकों ने अनेक पुरस्कार एवं सम्मान हासिल किए और उनके कई अनुसंधान लेख, सम्मेलन सारांश, लोकप्रिय लेख तथा पुस्तक अध्याय प्रकाशित हुए तथा साथ ही अर्धवार्षिक समाचार पत्र एवं वार्षिक रिपोर्ट का प्रकाशन भी किया गया।

अपना सतत 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. ढिल्लोन, सहायक महानिदेशक (बागवानी विज्ञान), भाकृअनुप का अत्यंत आभारी हूँ। निदेशालय द्वारा की गई प्रगति में अपना महत्वपूर्ण योगदान देने के लिए मैं संस्थान के सभी वैज्ञानिकों एवं अन्य स्टाफ सदस्यों को धन्यवाद देता हूँ। इस वार्षिक प्रतिवेदन के प्रभावी संकलन में सम्पादन एवं प्रकाशन समिति के सदस्यों द्वारा किए गए सार्थक प्रयासों के प्रति मैं अपना आभार व्यक्त करता हूँ।

स्थान : भाकृअनुप - डीसीआर, पुत्तूर

दिनांक : 15 जून 2019

(एम.गंगाधर नायक)

निदेशक (प्रभारी)

PREFACE

It gives me immense pleasure to present the Annual Report 2018-19 of ICAR-Directorate of Cashew Research (ICAR-DCR), Puttur. It highlights the significant research achievements made during the period in the areas of Crop Improvement, Crop Management, Crop Protection, Post Harvest Technology and Transfer of Technology along with the institutional activities.

The major research activities undertaken in the crop improvement include breeding efforts to develop high yielding cultivars and dwarf and compact cashew hybrids, characterization of germplasm accessions for growth and yield traits, identification of interspecific hybrid with Tea Mosquito Bug (TMB) tolerance, development of a draft genome sequence of cashew cv. Bhaskara and identification of molecular markers for assaying genetic purity of interspecific hybrids. The research activities in crop management focused on identification and codification of phenological growth stages in cashew according to the BBCH scale, efforts to standardize pruning in the popular cultivar Bhaskara, delineation of nutrient status of cashew growing areas and developing nutrient diagnostic norms. In the crop protection, identification of candidate semiochemicals towards designing of synthetic pheromone traps for TMB and identification of new insecticides as alternative chemicals for control of the two major pests of cashew were attempted. In the post harvest aspects, development of empirical models for assessing the quality of raw cashewnuts, calibration of moisture meter developed in collaboration with M/S EMCON, Kochi for estimation of moisture content in cashewnuts and development of dehydrated products from cashewnut sprouts and the cashew apple were achieved.

Besides, efforts were made for transferring the cashew production and processing technologies developed by the institute to all the stakeholders. About 1 lakh quality planting material of cashew was supplied to the farmers and developmental agencies. In the project funded by RKVY-RAFTAAR, farmer-participatory field research demonstrations, development of cashew museum and development of Android mobile apps were undertaken to effectively transfer the cashew production technologies to the farmers. In addition, the Soil Science laboratory of the Directorate was upgraded with the installation of modern instruments under RKVY-RAFTAAR project.

During the year, Institute Technology Management Unit (ITMU) facilitated non-exclusive licensing of technology entitled "Dual mode dryer for raw cashewnuts" developed at this Directorate and a Memorandum of Understanding was signed with M/S Newtech Industries, Karnataka.

The Directorate organized various events such as Foundation day, International day of yoga, Swachhata Hi Sewa campaign, Vigilance awareness week, World soil day, webcasting of launching ceremony of Pradhan Mantri Kisan Samman Nidhi (PM-KISAN) and International Women's day. The Directorate conducted one workshop on intellectual property rights and two interface meetings with farmers, processors, exporters and officials of state departments. During the reported year, Scientists of this Institute have won several awards and honours and have published a number of research articles, conference abstracts, popular articles and book chapters besides bi-annual newsletters and annual report.

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 important 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 of the Annual Report.

Place : ICAR-DCR, Puttur
Date : 15 June 2019

(M. Gangadhara Nayak)
Director (Acting)

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कार्यकारी सारांश

भाकृअनुप - काजू अनुसंधान निदेशालय (ICAR-DCR), पुत्तूर के अधिदेशों में काजू पर अनुसंधान एवं प्रसार गतिविधियों को चलाना शामिल है। वर्ष 2018-19 के दौरान, पांच प्रमुख कार्यक्रमों यथा आनुवंशिक संसाधनों का प्रबंध, फसल सुधार, फसल प्रबंध, फसल सुरक्षा और फसलोत्तर प्रौद्योगिकी के अंतर्गत अनुसंधान गतिविधियां चलाई गई। इस निदेशालय में संस्थान की कुल 21 परियोजनाएं और 3 बाह्य वित्त पोषित अनुसंधान परियोजनाएं चलाई जा रही हैं और इस वर्ष के दौरान संस्थान की 3 परियोजनाओं को पूर्ण किया गया।

काजू जननद्रव्य पर निर्णय समर्थित प्रणाली के उपयोगकर्ताओं को बेहतर रूप से सुसज्जित करने हेतु 80 जननद्रव्य प्राप्तियों से जुड़े 700 चित्रों के साथ काजू जननद्रव्य डाटाबेस को समृद्ध बनाया गया। काजू संकरों का मूल्यांकन करने पर 7वीं तुड़ाई के दौरान, गिरी उपज (6 से 8.5 किग्रा. / वृक्ष) के लिए दो संकर तथा गिरी उपज (4.60 किग्रा./ वृक्ष) एवं काजू फल गुणवत्ता (10°Bx) दोनों के लिए एक संकर आशाजनक पाया गया। बड़ी गिरी वाले जीन प्ररूपों का मूल्यांकन करने पर प्रदर्शित हुआ कि अधिकतम उपजशील जीन प्ररूप (वीटीएच - 30/4 का एक पौधा सेलेक्शन) में उच्च उपज तथा मीठा फल (16°Bx) पाया गया। काजू की व्यावसायिक किस्म भास्कर का मसौदा जीनोम अनुक्रम विकसित किया गया। क्रास यथा एन.आर.सी.-492 x वेंगुरला-7, वेंगुरला-7 x एन.आर.सी.-492, एन.आर.सी.-492 x एच-130 तथा एन.आर.सी.-492 x थालीपरम्बा तैयार किए जा सके। गिरी उपज तथा काजू गिरी छिलका तरल (CNSL) मात्रा के लिए मानचित्र संख्या विकसित करने हेतु भास्कर - एनआरसी 188 एवं वेंगरला - 7 x एनआरसी 116 के बीच क्रास कराए गए और कुल 632 एवं 366 स्यूडो - F_1 गिरी उत्पन्न की गई। बौने और सुगठित संकरों का विकास करने वाले प्रजनन परीक्षणों में, धना x एनआरसी 492 के बीच हुए क्रास में 4.3 मीटर ऊंचाई और 5.4 मीटर औसत कैनोपी अथवा वितान विस्तार के साथ एक अर्ध-लंबी संतति उत्पन्न हुई। बैकक्रास संततियों का रोपण करने के बाद 5वें वर्ष में, उपज और क्लस्टर धारण करने की क्षमता के संबंध में 16 पौधे आशाजनक पाए गए। अंतर - विशिष्ट संकरण (उलाल-1 x *ए.माइक्रोकार्पम*) में, एक संतति लगातार टी मॉस्किटो बग् नुकसान से बची रही। बड़े आकार की गिरी टाइप के साथ क्लस्टर धारण करने वाली किस्मों के साथ संकरण कराकर क्लस्टर धारण करने वाले जीनप्ररूपों में गिरी आकार में सुधार करने की दिशा में प्रयास किया जा रहा है ? उच्च गिरी उपज और बड़े तथा बेहतर फल गुणों के लिए कुल 14 काजू जननद्रव्य प्राप्तियों का मूल्यांकन किया गया जिसमें प्रदर्शित हुआ कि बड़ा फल एनआरसी 389 में था जब कि कहीं अधिक आकर्षक रंग और महक वाले फल एन.आर.सी.-301 में पाए गए। कुल 39 बहुरूपीय प्राइमरों की पहचान के लिए पैतृकों उलाल-3 तथा एन.आर.सी. 492 में कुल 138 एसएसआर प्राइमरों (काजू एवं संबंधित वृक्षों से) की छंटाई की गई लेकिन ये सम्बद्ध विश्लेशण करने में अपर्याप्त पाए गए। आनुवंशिक विविधता अध्ययन में, काजू की 48 कोर प्राप्तियों की जीनोटाइपिंग करने के लिए आठ बहुरूपीय काजू एसएसआर (CSSRs) का उपयोग किया गया। तीन CSSRs, यथा CSSR5, CSSR8 एवं CSSR18 में पैतृक बहुरूपिता प्रदर्शित हुई और अंतर विशिष्ट संकरों की आनुवंशिक शुद्धता की पहचान की जा सकी। नव विकसित MiEST-SSRs का स्थानान्तरण क्षमता की दर की सीमा *ए माइक्रोकार्पम* में 24.2 प्रतिशत से *ए. प्यूमिलम* में 69.7 प्रतिशत तक पाई गई।

काजू के घटनाविज्ञान अध्ययनों में, सात प्रमुख प्रधान घटनाविज्ञान अवस्थाओं की पहचान की गई और इनका वर्णन Biologische Bundesantalt Bundessortenamt und Chemische Industrie (BBCH) स्केल का उपयोग करके किया गया तथा साथ ही पर्णीय नाशीजीव प्रकोप में संवेदनशील अवस्थाओं का निरूपण किया गया। काजू के प्रमुख खेती क्षेत्रों यथा पुत्तूर, वेंगुरला, भुवनेश्वर, बापटला, पिलिकोड तथा वृदाचलम में प्रमुख एवं सूक्ष्म पोषक तत्वों के संबंध में मृदा की पोषक तत्व स्थिति का मूल्यांकन किया गया जिसमें पता चला मृदा में नाइट्रोजन और फॉस्फोरस की कम मात्रा और पोटसियम की मध्यम से कम मात्र थी। पुन: जिंक और कॉपर के लिए

सूक्ष्म पोषक तत्व की कमी देखने को मिली। रोग का पता लगाकर अथवा निदान एवं संसतुत एकीकृत प्रणाली (DRIS) का उपयोग करके काजू के लिए नैदानिकी मानक स्थापित किए गए। उच्च सघनता रोपण के तहत पोषक तत्व की आवश्यकता का पता लगाने के लिए एक नई परियोजना प्रारंभ की गई।

भाकृअनुप – औषधीय एवं सुगंधीय पादप अनुसंधानव निदेशलय (ICAR-DMAPR), आनंद गुजरात में जीसी–एमएस के माध्यम से TMB द्वारा छोडा गया मादा लिंग फिरोमॉन के रासायनिक संयोजन की पहचान की गई। C-DAC कोलकाता में काजू तना तथा जड़ वेधक (CSRB) ग्रब की फीडिंग ध्वनियों का विश्लेषण करने पर पता चला कि ध्वनियां अनियमित एवं कमजोर हैं जिससे उच्चतर संवेदनशीलता के साथ सेंसर की जरूरत का पता चलता है ताकि CSRB प्रबंधन के लिए फीडिंग ग्रब का सटीकता से पता लगाया जा सके। काजू के पुष्पक्रम कीट नाशीजीवों में, अज्ञात मिरिड की दो प्रजातियों और अज्ञात पुष्प भृंग की दो प्रजातियों को बाह्य दलपुंज का नुकसान करने वाली और पराग पर पलने वाली पाया गया जिनकी कि पहचान करने की जरूरत है। नाशीजीव, TMB की मृत्यूदर को उत्प्रेरित करने में 0.2 ग्राम प्रति लिटर की दर पर थिआमिथोक्सम का छिड़काव करना संस्तुत कीटनाशक λ–साइहैलोथ्रिन के समतुल्य प्रभावी पाया गया जिसकी सिफारिश TMB की रोकथाम के लिए एक वैकल्पिक कीटनाशक के रूप में की जा सकती है। रासायनिक तरीकों से CSRB की रोकथाम करने हेतु काजू वृक्ष के तने पर फिप्रोनिल (2.0 मिलि. प्रति लिटर) के साथ पुचारा करना अथवा साफ करना, संसतुत कीटनाशक क्लोरपायरीफॉस (10.0 मिलि. प्रति लिटर) का उपयोग करने के समतुल्य प्रभावी पाया गया और CSRB की रोकथाम के लिए इसकी सिफारिश की जा सकती है। इसके अलावा, दो कीटरोगजनक सूत्रकृमि (EPN) यथा *हीटरोरैबडिटिस* तथा *स्टाइनरनिमा* जिनके द्वारा CSRB ग्रब में मृत्युदर उत्प्रेरित की गई, छायादार पारिस्थितिकी प्रणाली में 150 दिनों तक उत्तरजीवी पाए गए और इनमें उग्रता बनी रही।

कच्ची काजू गिरी की गुणवत्ता का आकलन करने के लिए उत्पादन मात्रा, नमी मात्रा और गिरी की गणना के संबंध में छिलका प्रतिशत को शामिल करके अनुभवजन्य मॉडल तैयार किए गए। भा.कृ.अ.प. – केन्द्रीय कृषि अभियंत्रिकी संस्थान के सहयोग से, काजू फल का प्रसंस्करण करने के लिए संशोधित वर्टिकल रोटरी डिस्क ब्लेड और क्षैतिज रोटरी डिस्क मैकेनिकल स्लाइसर विकसित किए गए और इनके प्रदर्शन का मूल्यांकन किया गया। मैसर्स इनवायरनमेन्ट मीजरमेन्ट एंड कंट्रोल (EMCON) कोच्चि, के सहयोग से, घरेलू किस्मों की कच्ची काजू गिरी में नमी की मात्रा के ऑन–साइट मापन के लिए एक नॉन – डिस्ट्रक्टिव नमी मीटर विकसित किया गया और उसका मापांकन किया गया। काजू गिरी प्रसंस्करण उद्योग के नैदानिकी अन्वेषण से पता चला कि प्रसंस्करण की मात्रा, यांत्रिकीकरण की डिग्री, गुठली प्रतिशत वसूली और समग्र गुठली वसूली (KPR तथा WKR) के साथ प्रसंस्करण की लागत यथा पैकेजिंग, श्रम मजदूरी और परिलब्धियों में भी भिन्नता देखने को मिली और इन उद्योगों की सफलता के लिए प्रसंस्करण की सभी अवस्थाओं में तकनीकी पैरामीटरों का इष्टतमीकरण करने की जरूरत है। अंकुरण की विभिन्न अवस्थाओं में अंकुरों में गुणवत्ता पैरामीटरों का विश्लेषण करने पर पता चला कि बुवाई के 8–10 दिन बाद (बीजपत्र जिन्हें आसानी से अलग किया जा सकता है, में क्लोरोफिल गठन से तुरंत पहले) काजू अंकुरों में काजू गुठली की तुलना में बढ़ी हुई रेशा मात्रा, कुल फिनोल मात्रा और कैल्सियम, आयरन, मैंग्नीज, जिंक तथा कॉपर जैसे खनिज की मात्रा तथा कमतर वसा मात्रा दर्ज की गई। काजू डंठल से एक मौथ फ्रेशनर तैयार किया गया और इसका मूल्यांकन जैव रसायन विशेषताओं तथा लंबी अवधि की भण्डारण के लिए किया जा रहा है।

RKVY-RAFTAAR द्वारा वित्त पोषित परियोजना के अंतर्गत, कर्नाटक के तीन जिलों यथा दक्षिण कन्नड, उडुपी तथा उत्तर कन्नड में 59 किसान भागीदारी खेत अनुसंधान परीक्षण / प्रदर्शन आयोजित किए गए और किसानों को प्रशिक्षण प्रदान किया गया तथा प्रदर्शन प्लॉटों में खेत अवसर दौरे कराये गये। रिपोर्टाधीन वर्ष के दौरान, भाकृअनुप – काजू अनुसंधान निदेशालय, पुत्तूर ने भाकृअनुप – केंद्रिय रोपण फसल अनुसंघान संस्थान के क्षेत्रीय केंद्र, किडु में आयोजित कृषि मेला एवं कृषि प्रदर्शनी 2018 में भाग लिया और विवेकानंद कॉलेज ऑफ इंजीनियरिंग एंड टैक्नोलॉजी, कर्नाटक में आयोजित यंत्र मेला

2019 में भी अपनी भागीदारी दर्ज कराई। निदेशालय का दौरा करने वाले किसानों को भाकृअनुप – काजू अनुसंधान निदेशालय, पुत्तूर की विभिन्न गतिविधियों की जानकारी दी गई और उन्हें संस्थान के खेत एवं नर्सरी का दौरा कराया गया। ''काजू की खेती'' पर एक एंड्राइड मोबाइल ऐप का विकास काजू एवं कोको विकास निदेशालय, कोच्चि के वित्तीय सहयोग से किया जा रहा है। पोषक तत्व प्रबंध पर एक सॉफ्टवेयर और मोबाइल ऐप का विकास किया गया और उसे RKVY-RAFTAAR के वित्तीय सहयोग से प्रारंभ किया गया। मृदा स्वास्थ्य कार्ड तैयार करने पर ऑफ–लाइन सॉफ्टवेयर भी विकसित किया गया। काजू उत्पादन एवं प्रसंस्करण में उन्नत प्रौद्योगिकियों को अगन्तुक किसानों के समक्ष प्रदर्शित करने के लिए RKVY-RAFTAAR के वित्तीय सहयोग से एक आधुनिक म्यूजियम विकसित किया जा रहा है और वर्ष 2018–19 के दौरान इसके पहले चरण का कार्य पूरा कर लिया गया। रिपोर्टाधीन वर्ष में चार M.Sc. के छात्रों को मार्गदर्शन दिया गया। अखिल भारतीय समन्वित काजू अनुसंधान परियोजना के वैज्ञानिकों की वार्षिक समूह बैठक (AGM) का आयोजन ओडिशा कृषि एवं प्रौद्योगिकी विश्वविद्यालय (OUAT), भुवनेश्वर में दिनांक 6 से 8 दिसंबर, 2018 की अवधि में किया गया।

इस निदेशालय में विकसित ''कच्ची काजू गिरी के लिए ड्यूल मोड ड्रायर'' प्रौद्योगिकी के व्यावसायीकरण के लिए नॉन – एक्सक्लूसिव लाइसेंस प्रदान किया गया। कच्चे काजू के नमी मापन के लिए नमी मीटर का विकास करने हेतु मैसर्स इनवायरनमेन्ट मीजरमेन्ट एंड कंट्रोल (EMCON), कोच्चि, केरल के साथ एक सहयोगात्मक अनुसंधान प्रारंभ किया गया।

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 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, विश्व मृदा दिवस, पधानमंत्री किसान सम्मान निधि (PM-KISAN) तथा महिला दिवस का आयोजन किया गया। भाकृअनुप – काजू अनुसंधान निदेशालय, पुत्तूर द्वारा बैद्धिक सम्पदा अधिकार पर एक कार्यशाला और वैज्ञानिकों, किसानों, विभाग के अधिकारियों एवं काजू निर्यातकों के साथ दो इन्टरफेस बैठकों 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।

रिपोर्टाधीन वर्ष के दौरान, निदेशालय द्वारा कुल रुपये 141.23 लाख का राजस्व सृजित किया गया और किसानों को एक लाख काजू कलम की आपूर्ति की गई। निदेशालय की मृदा विज्ञान प्रयोगशाला को आधुनिक उपकरणों यथा माइक्रो वेव प्लाज्मा एटॉमिक इमीशन स्पेक्ट्रोमीटर (MP-AES, Agilent 4210), यूवी विजीबल स्पेक्ट्रोफोटोमीटर, (Shimadzu, UV-1900) तथा आठ गौण उपकरणों की खरीद व स्थापना करके प्रोन्नत बनाया गया।

1. EXECUTIVE SUMMARY

ICAR-Directorate of Cashew Research, Puttur has the mandate to carry out research and extension activities on cashew. During 2018-19, the research activities were carried out under five major programmes i.e. management of genetic resources, crop improvement, crop management, crop protection and post harvest technology. A total of 21 institute projects and three externally funded research projects are being undertaken at this directorate and three institute projects were concluded during the year.

The cashew germplasm database was enriched with 700 images belonging to 80 germplasm accessions to better equip the users of decision support system on cashew germplasms. Under the evaluation of cashew hybrids, 2 hybrids were found promising for nut yield (6 to 8.5 kg tree^{-1}) and one hybrid for both nut yield (4.60 kg tree^{-1}) and apple quality (10°Bx) during 7th harvest. The evaluation of bold nut genotypes showed that a seedling selection of VTH-30/4 had high yield and sweeter apples (16°Bx). A draft genome sequence of cashew cv. Bhaskara has been developed. Crosses viz. NRC-492 × Vengurla-7, Vengurla-7 × NRC-492, NRC-492 × H-130, and NRC-492 × Taliparamba were made to develop populations to assay the potential utility of the new molecular markers being developed. To develop mapping populations for nut yield and Cashew Nut Shell Liquid (CNSL) content, crosses between Bhaskara × NRC-188 and Vengurla-7 × NRC-116 were made and a total 632 and 366 pseudo-F_1 nuts were produced. In the breeding trials to develop dwarf and compact hybrids, the lowest height was observed in the cross between Dhana × NRC-492 with 4.3 m height and 5.4 m average canopy spread. At 5th year after planting of back cross progenies, 16 plants found to be promising with respect to yield and cluster bearing ability. In interspecific hybridization (Ullal-1 x *A. microcarpum*), one of the progeny was found to be consistently escaping Tea Mosquito Bug (TMB) damage. An effort is being made to improve the nut size in cluster bearing genotypes by crossing cluster bearing cultivars with the bold nut types. The evaluation of 14 cashew germplasm accessions for high nut yield and larger and better apple characteristics showed that larger apple was in NRC-389 and the apples with more appealing colour and fragrance were found in NRC-301.

A total of 138 SSR primers (from cashew and related trees) were screened in parents Ullal-3 and NRC-492 for identification of 39 polymorphic primers but were found insufficient to carry out the association analysis. In the genetic diversity study, eight polymorphic cashew SSRs (CSSRs) were used for genotyping 48 core accessions of cashew. Further, three of the CSSRs *viz.* CSSR5, CSSR8, and CSSR18 showed parental polymorphism and could identify the genetic purity of the interspecific hybrids. The rate of transferability of the newly designed MiEST-SSRs ranged from 24.2% in *A. microcarpum* to 69.7% in *A. pumilum.*

In phenological studies of cashew, seven major principal phenological stages were identified and described using Biologische Bundesantalt Bundessortenamt und Chemische Industrie (BBCH) scale and susceptible stages to foliar pest attack were delineated. The evaluation of soil nutrient status with respect to major and micronutrients in major cashew growing regions *viz.* Puttur, Vengurla, Bhubaneswar, Bapatla, Pilicode and Vridachalam showed the soils were low in nitrogen and phosphorus, medium to low in potassium. Further,

micronutrient deficiencies were observed for zinc and copper. Diagnostic norms were established for cashew using Diagnosis and Recommendation Integrated System (DRIS). A new project was initiated to assess the nutrient requirement under high density planting.

The chemical composition of female sex pheromone released by TMB has been identified through GC-MS at ICAR-Directorate of Medicinal and Aromatic Plants Research (ICAR-DMAPR), Anand. The analysis of feeding sounds of Cashew Stem and Root Borer (CSRB) grubs at C-DAC, Kolkata showed that the sounds are discontinuous and feeble indicating the need for sensors with higher sensitivity to precisely locate feeding grubs for CSRB management. Among inflorescence insect pests of cashew, two species of unidentified mirids and two species of unidentified flower beetles were observed to damage the calyx and feed on the pollen, which needs to be identified. Spraying Thiamethoxam at the rate of 0.2 g L^{-1} was on par with the recommended insecticide, λ-cyhalothrin in inducing mortality of the pest, TMB, which can be recommended as an alternate insecticide for the management of TMB. To control CSRB through chemical means, swabbing with fipronil (2.0 ml L^{-1}) on the cashew tree trunk was on par with the recommended insecticide chlorpyriphos (10.0 ml L^{-1}) and can be recommended for the management of CSRB. In addition, the two entomopathogenic nematodes (EPN) *viz. Heterorhabditis* and *Steinernema* which induce mortality in the CSRB grubs were found to survive up to 150 days in the shaded ecosystem and maintained the virulence.

Empirical models were developed involving shelling percentage in terms of outturn, moisture content and nut count to assess the quality of raw cashewnuts. Modified vertical rotary disc blade and horizontal rotary disc mechanical slicers were developed in association with ICAR-Central Institute of Agricultural Engineering, Bhopal for processing the cashew apples, and its performance was evaluated. A non-destructive moisture meter was developed in collaboration with M/S Environment Measurement and Control, Kochi, and calibrated for the on-site measurement of moisture content in raw cashewnuts of domestic varieties. Diagnostic investigation of cashewnut processing industries indicated that the cost of processing varied with the quantum of processing, degree of mechanization, Kernel Percent Recovery and Whole Kernel Recovery (KPR and WKR) in packaging, labour wages and perks, and optimization of technical parameters at all stages of processing is needed for the success of these industries. The analysis of quality parameters in the sprouts at different stages of germination showed that the cashew sprouts 8-10 days after sowing (i.e. just before the chlorophyll formation in the cotyledons and which are easily separable) recorded increased fibre, total phenols and minerals such as calcium, iron, manganese, zinc and copper, and lower fat content compared to the cashew kernel. A mouth freshener was prepared from cashew apple and is being evaluated for biochemical characteristics, acceptance and storage life.

Under the project funded by RKVY-RAFTAAR, fifty-nine farmer participatory field research trials/ demonstrations were conducted in three districts of Karnataka *viz.* Dakshina Kannada, Udupi and Uttara Kannada and training and field exposure visits to the demonstration plots were undertaken. During the year DCR participated in Krishi Mela and Agri Expo – 2018 conducted at ICAR-Central Plantation Crops Research Institute, Regional Centre, Kidu and 'Yantra Mela-2019' conducted at Vivekananda College of Engineering and Technology (VCET), Puttur, Karnataka. Farmers visiting the Directorate

were given exposure to activities of different sections of ICAR- DCR and field and nursery visits were arranged. An android mobile app on "Cashew Cultivation" is being developed with funding support from Directorate of Cashewnut and Cocoa Development, Kochi. A software and mobile app on nutrient management were developed and launched with funding support from RKVY-RAFTAAR. Offline software on soil health card generator was also developed. To showcase the advanced technologies in cashew production and processing to visiting farmers a modern museum is being developed with funding support from RKVY-RAFTAAR and phase I work was completed during 2018-19. During the year four M.Sc. students' projects were guided. The Annual Group Meeting (AGM) of Scientists of AICRP on Cashew was organized at the Odisha University of Agriculture and Technology (OUAT), Bhubaneswar from 6 to 8 December 2018.

The technology "Dual mode dryer for raw cashewnuts" developed at this Directorate was given non-exclusive licensing for commercialisation. Collaborative research was initiated with M/S Environment Measurement and Controls (EMCON), Kochi, Kerala for developing moisture meter for cashew.

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. The Directorate organised various events such as Foundation day, International day of yoga, Swachhata Hi Sewa campaign, Vigilance awareness week, World soil day, Annual cashew day, Webcasting of *Mann Ki Bath* and launching of Pradhan Mantri Kisan Samman Nidhi (PM-KISAN) and International women's day. The Directorate conducted one workshop on intellectual property rights and two interface meetings with scientists, farmers, officials of the department and exporters of cashew. The Hindi cell of the Directorate conducted Hindi week and also quarterly and half-yearly Hindi workshops.

During the year, the Directorate generated Rs. 141.23 Lakhs revenue and supplied 1 lakh cashew grafts to farmers. The Soil Science laboratory of the Directorate was upgraded with purchase and 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

Research on cashew 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 and CIP) with its headquarters located at CPCRI, Kasaragod. The CPCRI Regional Station, Vittal (Karnataka) was given the mandate to carry out research work on cashew while four Centres under Universities (Bapatla, Vridhachalam, Anakkayam and Vengurla) were assigned the research component on cashew under AICS and CIP. During the V and VI plan periods, three more Centres (Bhubaneswar, Jhargram and Chintamani) came under the fold of AICS and 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, 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 which was later upgraded and renamed by ICAR on 23 March 2009 under XI Plan as **ICAR-Directorate of Cashew Research (ICAR-DCR).** Subsequent to the bifurcation of AICS and CIP, the Headquarters of All India Coordinated Research Project on Cashew was shifted to ICAR-DCR, Puttur. At present, this Coordinated Research Project is operating at 14 Centres distributed in major cashew growing areas of the country.

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 68 ha with field experiments and Laboratory-cum-Administrative Block. Experimental Station at Shantigodu, which also forms part of the Directorate is 13 km away from the main campus and has an area of 80 ha. The institute is conducting and coordinating research on all aspects of cashew germplasm collection, conservation and improvement, production, protection, post harvest technology and transfer of technology.

2.3. Vision, Mission and Mandates

Vision

- Accomplishing self-sufficiency in raw cashewnut production and maintaining 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 (Fig. 2.1). The research and extension on various aspects of cashew are conducted in five divisions, namely, 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 Post Harvest Technology. The other facilities available at the directorate include Audio Visual Laboratory, PME Cell, ITMU, AKMU and Museum. The Directorate also functions as headquarter for the All India Coordinated Research Project on Cashew.

2.5. Library

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.

2.6. Staff

The Institute has a sanctioned strength of 17 scientific, 19 technicals, 15 administrative, 38 skilled support staff and 1 canteen staff, of which 13 scientists, 11 technicals, 9 administrative and 19 skilled support staff are in position and the remaining positions are vaccant (Table 2.1).

Table 2.1. Staff position as on 31.3.2019

Category	Sanctioned	Filled	Vacant
Director (RMP)	1	-	1
Scientific	17	13	4
Technical	19	11	8
Administrative	15	9	6
Canteen staff	1	-	1
Skilled support staff	38	19	19
Total	**91**	**52**	**39**

2.7. Budget

During 2018-19, the total budget allotted to the Directorate was Rs. 1306.41 Lakhs of which Rs. 1287.11 Lakhs were utilised (Table 2.2). Under externally funded projects, the total receipts were Rs. 106.5 Lakhs, of which Rs. 86.82 Lakhs was utilised (Table 2.3). The revenue generation during 2018-19 was Rs. 141.23 Lakhs (Table 2.4).

Table 2.2. Budget and expenditure details of DCR for the FY 2018-19 (Rs. in Lakhs)

Particulars	Allocation	Utilization
GIA capital	324.00	324.00
GIA salary	601.00	595.46
Pension	94.00	80.11
GIA general	287.41	287.54
Total	**1306.41**	**1287.11**

Table 2.3. Receipts and expenditure under externally funded schemes at DCR for the FY 2018-19 (Rs. in Lakhs)

Particulars	Allocation	Utilization
RKVY-RAFTAAR, Govt. of Karnataka	96.00	84.67
PPV&FRA, New Delhi	5.50	2.15
DCCD, Kochi	5.0	0
Total	**106.5**	**86.82**

Table 2.4. Revenue generation at ICAR-DCR during 2018-19 (Rs. in Lakhs)

Particulars	Revenue generation
DCR	141.23

2.8. Production of planting materials

ICAR-DCR has cashew nurseries at both of its campuses: Kemminje and Shantigodu, accredited by National Horticulture Board (NHB) 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, Dhana etc. are produced in the two nurseries between June and August every year for supplying to the farmers. During the year 2018-19, about 1 lakh cashew grafts (61,952 from Kemminje campus and 38,052 from Shantigodu campus) were supplied to farmers.

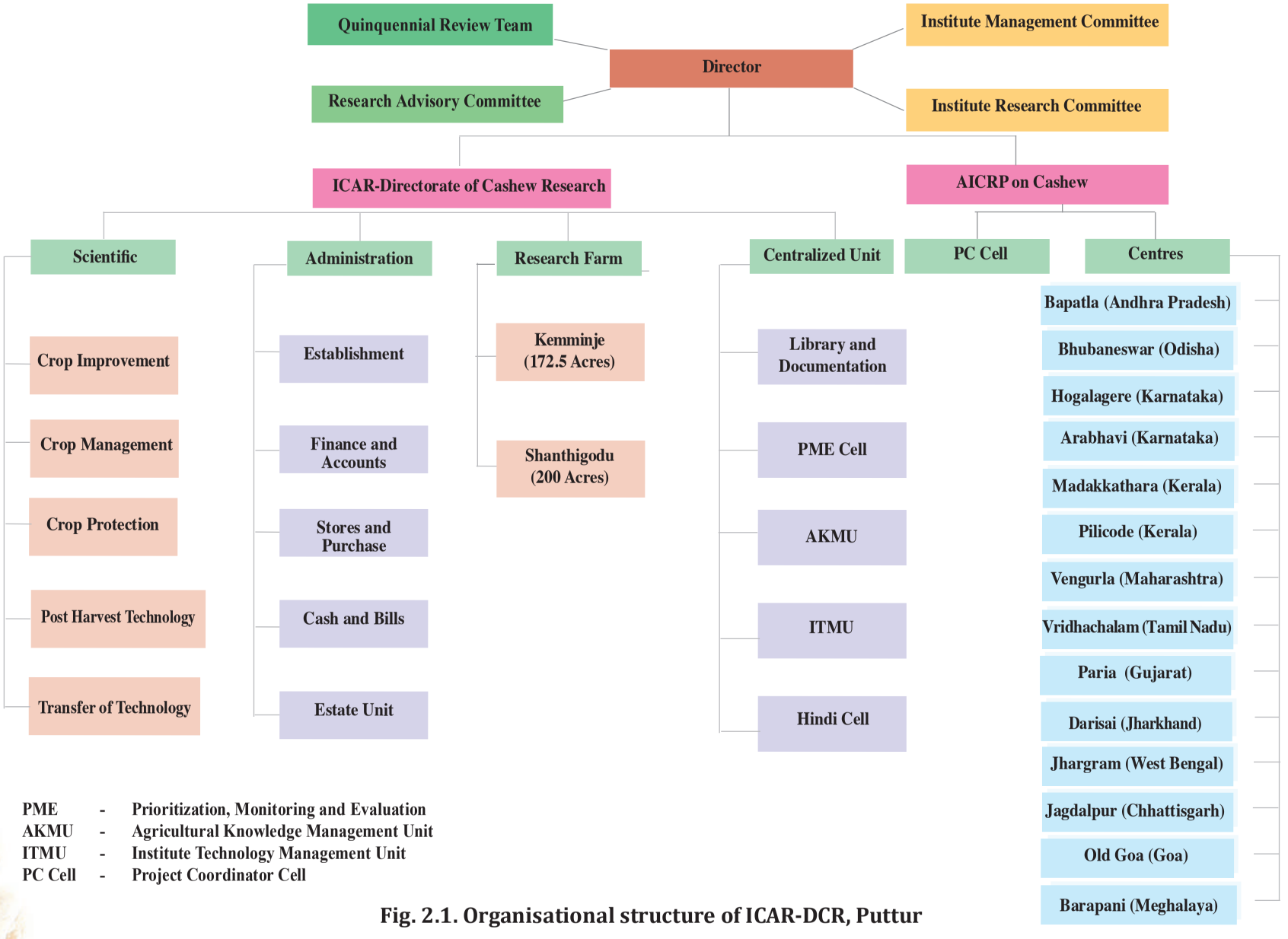
2.9. Infrastructure and assets

The major infrastructures developed during 2018-19 are provided in Table 2.5. During the period, instrumental facilities of the Soil Science section was strengthened with the purchase of modern equipments through the project funded by RKVY.

Table 2.5. Infrastructure and assets developed during 2018-19

Sl. No.	Infrastructure/ Assets/ Equipment name	Amount (Rs. in Lakhs)	Budget head
1.	Museum (Phase I)	19.13	RKVY-RAFTAAR
2.	Field store room cum retiring room	4.45	RKVY-RAFTAAR
3.	Microwave Plasma Atomic Emission Spectrometer (MP-AES, Agilent 4210)	29.75	RKVY-RAFTAAR
4.	UV-Visible Spectrophotometer (Shimadzu, UV-1900)	5.20	RKVY-RAFTAAR
5.	Minor equipment: Electronic balance, Motorised sprayer, Tree pruner, Earth auger, GPS, Camera, Refrigerator	3.23	RKVY-RAFTAAR
6.	Toilets in farm complex, Kemminje campus	4.29	Institute
7.	Watchman shed near residential campus	1.68	Institute

ICAR-Directorate of Cashew Research



PME - Prioritization, 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

Germplasm conservation

A new block of unique germplasm types has been established (Fig. 3.1.1) and four unique types *viz.* purple mutant, H-130 and two wild relatives of *Semecarpus pranuii* have been planted and grafts of some more unique types have been prepared.

Fig. 3.1.1. New block of unique germplasm types of cashew

Germplasm evaluation

Thirteen germplasm accessions planted during 2007-08 were evaluated for vegetative characters and grouped as per IPGRI descriptors during the season (Table 3.1.1). Among them, 11 accessions have upright and open canopy with extensive branching behaviour and two have spreading and intensive branching pattern. All the accessions are mid-season flowering types. One accession has red coloured new flushes, eight have yellow red and four have green red new flushes. All the 13 accessions have oblong leaf shape.

Table 3.1.1. Details of accessions characterized during the fruiting season in the year 2018

Data field	Descriptor	Descriptor state	No. of accessions
7	Tree habit	3 Upright and compact	0
		5 Upright and open	11
		7 Spreading	2
9	Leaf shape	1 Oblong	13
		2 Obovate (Club-shaped)	0
		3 Oval	0
16	Branching pattern	1 Extensive	11
		2 Intensive	2
19	Colour of young leaves	1 Red	1
		2 Yellow red	8
		3 Green yellow	4
		4 Purple	0
28	Season of flowering	3 Early (Nov-Dec)	0
		5 Mid (Dec-Jan)	13
		7 Late (Jan-Feb)	0

Germplasm database enrichment

The cashew germplasm database (https://cashew.icar.gov.in/dcr) was enriched with 700 images belonging to 80 germplasm accessions. The database has been visited 565 times from April 2018 to March 2019.

Maintenance of core collections

The core collection of 61 cashew germplasm accessions established during 2017 was maintained following the recommended agronomic practices.

3.1.2. Genetic improvement of cashew for yield and quality traits

Evaluation of cashew hybrids from the closely planted block for growth characters

Among the hybrids selected from the closely planted block, 2 hybrids were found promising with respect to yield and nut weight. Among them, the tree number 130 (NRC-100 × NRC-185) recorded the highest raw cashewnut yield of 8.5 kg followed by No.163 (NRC-240 × NRC-194) which recorded 6 kg nut yield (Table 3.1.2) during 7th harvest. Another hybrid (tree No. 186) (NRC-239 × VTH-711/4) with good apple character of good edible quality was also identified. The hybrid produced big apples (90-100 g) which were sweet (10°Bx) and juicy (80% juice content). The big apple hybrid also produced bigger nuts (9.68 g). The yield of this hybrid was estimated at 4.60 kg tree^{-1}. The apples were free from astringency, rich in pulp content with less fibrous matter which makes the apples highly palatable as table fruit (Fig. 3.1.2).

Table 3.1.2. Performance of promising hybrids from the closely planted block for yield and shelling percentage

Tree No.	Cross combination	Annual yield (kg tree^{-1})	Average yield of 7 harvests (kg tree^{-1})	Nut weight (g)	Shelling (%)
130	NRC-100 × NRC-185	8.50	5.00	7.86	29.64
163	NRC-240 × NRC-194	6.00	4.40	8.57	29.17

Fig. 3.1.2. Comparison of the apple of H-186 (middle) with VTH-174 genotype (left and right)

Evaluation of bold nut genotypes for their performance

Among the different genotypes, the highest annual nut yield of 4.23 kg tree^{-1} was recorded in the 4-year old plants of tree no. 480 (a seedling selection of VTH-30/4). This genotype also recorded high shelling percentage of 30.85%. The apples of this tree recorded 16°Bx which was higher compared to other cashew genotypes. The yield of H-32/4 was 0.69 kg tree^{-1}, while the yield of NRC-493 was 0.56 kg tree^{-1} which was below the yield of the local check. The lowest yield (0.42 kg tree^{-1}) was recorded by the accession no. NRC-270.

3.1.3. Development of dwarf and compact cashew hybrids

Out of 27 trees selected in the previous year, seven trees were shortlisted for further observations. During the fruiting season of 2018-19, seven trees were selected based on fruit bearing. Observations such as stem girth, tree height, tree spread and yield per tree were recorded in the selected trees. The list of selections and observations is given in Table 3.1.3. Tree no. 29 belonging to Dhana x NRC-492 was found semi-tall with 4.3 m height and 5.4 m average tree spread (Fig. 3.1.3-A). Yield observations for this year are under progress in selected trees. However, tree no. 122 of the cross Vengurla-4 x NRC-492 and tree no. 102 of the cross Madakathara-2 x NRC-492 appears to the promising with their nut-bearing potential (Fig. 3.1.3-B).

Table 3.1.3. Growth characters of promising selections in direct and reciprocal crosses

Sl. No.	Cross	Tree No.	Girth (cm)	Height (m)	Spread (m)	
					E-W	N-S
Selections in 2018						
1	Vengurla-4 x NRC-492	28	63	6.3	6.8	5.0
2		65	55.5	5.1	5.5	5.6
3		87	64	6.1	6.1	5.6
4	Vengurla-4 x Taliparamba-1	122	65	4.8	6.9	6.8
5	Priyanka x NRC-492	3	71.5	6.8	5.8	7.0
6	Madakkathara-2 x NRC-492	102	63	6.1	5.2	6.2
7	NRC-492 x Madakathara-2	149	64	5.9	5.2	6.6
Selections in 2019						
1	Dhana x NRC-492	29	52	4.3	6.3	4.5
2	NRC-492 x Dhana	49	56	5.5	6.3	6.8
3		51	65.5	4.9	6.8	6.6
4		53	61.5	4.7	6.0	5.0
5	Madakkathara-2 x NRC-492	13	74.5	6.0	5.6	7.1
6		117	66.0	6.7	4.7	5.2
7		99	79.0	6.6	6.7	5.5

Fig. 3.1.3-A. Semi tall selection in Dhana × NRC-492

A promising selection in Vengurla-4 × NRC-492

Promising selection in Madakathara-2 × NRC-492

Fig. 3.1.3-B. Promising selections

Backcrosses

This year, a 5-year old tree *viz.* BDB-626-58 was selected in addition to the 15 trees selected during the previous years which appears to be promising with cluster bearing ability (Fig. 3.1.4). Observations such as stem girth, tree height, tree spread and yield per tree were recorded in the selected trees (Table 3.1.4). Yield observations for this year are under progress.

Fig. 3.1.4. Promising backcross selection BDB-626-58 with cluster bearing

Table 3.1.4. Growth characters of promising selections in backcross hybrids

Tree No.	Height (m)	Canopy spread (m)		Girth (cm)
		E-W	N-S	
BDB-372 -4	4.25	2.50	3.00	53.0
BDB-372 -23	4.50	4.50	6.25	60.5
BDB-372 -36	4.25	4.25	3.25	42.0
BDB-372 -37	4.75	4.75	4.25	53.5
BDB-372 -46	4.30	4.30	3.30	49.0
BDB-372 -60	4.80	4.50	4.25	36.0
BDB-372 -61	5.00	7.25	4.75	54.0
BDB-372 -84	4.40	5.25	5.30	71.5
BDB-372 -90	4.75	7.75	5.75	49.0
BDB-626 -49	4.75	4.50	4.75	55.5
BDB-626-58	2.80	4.75	3.50	41.0
BDB-626 -97	3.60	4.60	4.50	46.0
BDB-626 -113	5.75	4.60	4.40	42.0
BDB-626 -114	4.50	5.50	5.00	46.5
BDB-626 -122	3.70	4.40	4.25	48.0
UDU-577 -85	4.10	4.60	4.25	44.0

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

The objective of this project is to identify promising accessions with very high and low CNSL content. The CNSL extraction with hexane solvent was done for 192 accessions during 2015-18. During 2018-19, the CNSL content of 128 accessions has been estimated. The work is under progress to evaluate remaining germplasm accessions. The CNSL content of the genotypes assayed during the year ranged from 0 to 36.48% (Table 3.1.5).

Table 3.1.5. CNSL content of 129 cashew germplasm accessions

Sl. No.	Acc. No.	CNSL (%)	Sl. No.	Acc. No	CNSL (%)	Sl. No.	Accession No.	CNSL (%)	Sl. No.	Acc. No.	CNSL (%)
1.	NRC-11	17.73	33.	NRC-102	19.57	65.	NRC-188	0	97.	NRC-307	31.84
2.	NRC-13	13.41	34.	NRC-103	34.61	66.	NRC-191	10.5	98.	NRC-311	22.75
3.	NRC-14	14.35	35.	NRC-104	15.15	67.	NRC-192	16.03	99.	NRC-314	22.82
4.	NRC-24	17.36	36.	NRC-106	19.91	68.	NRC-197	10.94	100.	NRC-323	15.98
5.	NRC-28	12.27	37.	NRC-111	15.33	69.	NRC-201	12.63	101.	NRC-344	18.61
6.	NRC-37	11.84	38.	NRC-114	27.22	70.	NRC-203	24.33	102.	NRC-347	28.01
7.	NRC-38	12.72	39.	NRC-115	12.77	71.	NRC-204	13.82	103.	NRC-356	25.72
8.	NRC-41	13.32	40.	NRC-116	16.17	72.	NRC-206	20.18	104.	NRC-357	21.95
9.	NRC-46	16.42	41.	NRC-117	15.79	73.	NRC-207	20.53	105.	NRC-360	19.35
10.	NRC-47	16.74	42.	NRC-121	15.39	74.	NRC-212	17.66	106.	NRC-369	19.22
11.	NRC-49	24.83	43.	NRC-123	21.06	75.	NRC-213	19.83	107.	NRC-372	16.63
12.	NRC-50	26.05	44.	NRC-125	7.88	76.	NRC-214	24.02	108.	NRC-373	13.41
13.	NRC-52	23.38	45.	NRC-126	14.87	77.	NRC-215	22.74	109.	NRC-374	16.9
14.	NRC-53	17.73	46.	NRC-127	19.61	78.	NRC-216	21.7	110.	NRC-376	18.1
15.	NRC-54	11.24	47.	NRC-129	22.43	79.	NRC-217	17.58	111.	NRC-377	21.49
16.	NRC-57	12.96	48.	NRC-131	18.06	80.	NRC-218	11.95	112.	NRC-378	23
17.	NRC-58	26.35	49.	NRC-139	25.96	81.	NRC-219	12.7	113.	NRC-380	19.92
18.	NRC-60	16.43	50.	NRC-140	18.33	82.	NRC-220	18.99	114.	NRC-381	18.41
19.	NRC-62	14.99	51.	NRC-141	20.22	83.	NRC-224	27.42	115.	NRC-383	36.48
20.	NRC-64	16.81	52.	NRC-143	22.76	84.	NRC-225	19.86	116.	NRC-384	27.2

21.	NRC-66	14.42
22.	NRC-70	16.54
23.	NRC-71	16.06
24.	NRC-75	18.82
25.	NRC-79	14.26
26.	NRC-82	16.43
27.	NRC-84	16.42
28.	NRC-90	19.53
29.	NRC-93	17.62
30.	NRC-94	13.33
31.	NRC-96	24.77
32.	NRC-101	20.76

53.	NRC-144	26.12
54.	NRC-149	26.78
55.	NRC-151	22.6
56.	NRC-152	27.52
57.	NRC-153	12
58.	NRC-154	21.54
59.	NRC-156	7.54
60.	NRC-162	20.5
61.	NRC-165	20.09
62.	NRC-170	30.42
63.	NRC-178	24.9
64.	NRC-182	9.69

85.	NRC-233	21.89
86.	NRC-234	18.02
87.	NRC-236	19.76
88.	NRC-238	19.08
89.	NRC-242	15.01
90.	NRC-248	15.09
91.	NRC-249	18.07
92.	NRC-256	15.57
93.	NRC-273	19.8
94.	NRC-289	15.03
95.	NRC-296	22.41
96.	NRC-298	12.22

117.	NRC-386	15.57
118.	NRC-387	20.36
119.	NRC-388	29.69
120.	NRC-389	22.84
121.	NRC-394	11.7
122.	NRC-396	22.31
123.	NRC-397	30.89
124.	NRC-398	24.91
125.	NRC-404	27.54
126.	NRC-421	19.63
127.	NRC-422	21.25
128.	NRC-425	17.26

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

Mutation Breeding

One hundred and thirteen seedlings and grafts (from gamma-ray treated seeds and scion sticks) of two popular varieties i.e. Bhaskara and Ullal-3 were field planted during the year. In sum of these seedlings, variations such as puckering of leaves, dwarfness and excessive branching were seen (Fig. 3.1.5 and 3.1.6). Further, 50 seeds each from Bhaskara, H-130 and Ullal-3 varieties were exposed to gamma rays of dosage 700 Gray (more than the LD-50 dose i.e. 600 Gray) and sown in the nursery. The seedlings will be planted and the next generation seedlings (M_2) from all these trees will be screened for TMB tolerance in the nursery.

Fig. 3.1.5. Leaf puckering in one of the M_1 progenies

Fig. 3.1.6. View of M_1 progenies planted in the field

Fig 3.1.7. Progeny of Ullal-1 x *A. microcarpum*

Interspecific hybridization

A progeny of the Ullal-1 x *A. microcarpum* cross has been observed for two years and found to be almost free from TMB damage in inter-specific progeny plot at the Directorate (Fig. 3.1.7). This location is a hotspot for TMB occurrence. The TMB damage score was recorded on this particular progeny during the year by taking the TMB damage score on 8 lateral shoots each in four directions. The data on TMB damage recorded on 32 shoots is given in Table 3.1.6. It is observed that the progeny which seem to be tolerant to TMB has recorded an average damage score of 0.06 compared to Ullal-3 and Vengurla-4 which recorded the damage score of 1.22 and 1.38 respectively. This shows that the progeny seems to be tolerant to TMB and hence, can be utilized in breeding programmes. Accordingly, this tolerant tree was used as male to cross with Vengurla-4 to generate 79 progenies, and with Ullal-3 to generate 17 progenies. These progenies will be subjected to TMB tolerance screening in the nursery and promising ones will be planted in the field during the next season.

Table 3.1.6. TMB damage score on interspecfic progeny and varieties

Twig No.	TMBT*	Ullal-3			Vengurla-4		
	T. No.1	T. No.1	T. No.2	T. No.3	T. No.1	T. No.2	T. No.3
1	2	0	4	0	0	0	4
2	0	0	4	0	0	4	4
3	0	0	0	0	0	3	0
4	0	4	4	0	0	4	1
5	0	0	0	0	0	0	4
6	0	0	0	4	0	0	3
7	0	0	4	0	0	0	0

8	0	0	0	4	0	2	3
9	0	2	0	4	0	0	0
10	0	0	0	0	0	3	2
11	0	0	0	0	4	1	0
12	0	0	0	0	4	0	0
13	0	0	0	0	0	2	0
14	0	4	4	0	0	0	0
15	0	4	4	4	0	0	0
16	0	0	0	0	0	0	4
17	0	0	0	4	2	4	1
18	0	4	0	4	0	3	0
19	0	0	0	4	0	2	0
20	0	0	4	0	0	4	4
21	0	0	4	0	0	4	4
22	0	0	0	0	0	0	0
23	0	0	0	0	0	1	0
24	0	3	0	1	0	3	4
25	0	4	4	0	2	0	0
26	0	0	4	0	0	3	3
27	0	0	4	0	0	0	3
28	0	0	4	0	1	0	0
29	0	0	0	4	1	4	4
30	0	0	1	0	4	0	0
31	0	0	0	4	4	0	4
32	0	0	2	4	4	3	4
Average	**0.06**		**1.22**			**1.38**	

*TMBT: TMB Tolerant ; T. No. : Tree Number

TMB Tolerance on scale:- Resistant 0.0-1.0; Moderately resistant 1.1-2.0, Moderatly susceptible 2.1 -3.0 and Susceptible 3.1-4.0.

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

A total of 274 seedlings of nine crosses made between cluster bearing and bold nut types were planted in the field in augmented block design. Among them, 254 seedlings were established in the field and 20 seedlings failed to survive due to transplanting shock, low vigour and high temperature (Table 3.1.7). In addition, 183 seedlings of six crosses including medium × bold nut types and bold x bold types were planted in the field. Among them, 161 seedlings were established in the field.

Table 3.1.7. Establishment of seedlings of crosses between cluster bearing x bold nut types and bold nut x bold nut and bold nut x medium nut types

Sl. No.	Cross	No. of seedlings planted	No. of survived seedlings
Cluster bearing × Bold nut crosses planted in Augmented Design			
1	Ullal-2 × H-130	34	29
2	H-130 × Ullal-2	33	31
3	NRC-493 × Ullal-2	34	30
4	Ullal-2 × NRC-493	23	22
5	Bhaskara × NRC-493	10	10
6	NRCCSel-2 × Bhaskara	51	46
7	Ullal-3 × H-130	22	21
8	Madakkathara-2 × H-130	27	27
9	Vengurla-4 × H-130	40	38
	Total	**274**	**254**
Bold x Bold nut and Bold × Medium nut crosses			
1	H-130 × NRC-493	31	25
2	NRC-493 × H-130	22	20
3	H-130 × Ullal-4	46	43
4	Vengurla-7 × H-130	28	25
5	Priyanka × NRC-493	23	21
6	VRI-3 × H-130	33	27
	Total	**183**	**161**

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

Cashew apple morphology and nut yield

Among the 14 accessions along with check under evaluation, 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) during 2018-19 (Table 3.1.8). The observation on cashew apple and nut yield are under progress.

Table 3.1.8. Cashew apple morphology and nut weight

Accession No.	Cashew apple characters			Cashewnut weight (g)
	Weight (g)	Length (cm)	Breadth (cm)	
NRC-75	91.58	7.17	3.57	9.44
NRC-111	121.91	8.17	4.55	13.71
NRC-112	133.48	8.08	4.93	60.23
NRC-120	107.59	6.43	4.50	10.26
NRC-140	132.01	8.92	4.47	9.02
NRC-144	110.79	7.58	4.57	10.05
NRC-175	70.39	5.70	3.83	6.91
NRC-176	64.39	5.52	3.74	7.63
NRC-183	119.80	8.20	4.73	14.55
NRC-189	98.20	6.41	4.63	10.65
NRC-270	97.73	6.00	6.81	10.74
NRC-301	188.80	9.33	5.31	11.24
NRC-389	107.00	6.45	7.09	9.63
NRC-493	101.17	8.99	3.88	13.21
Vengurla-8	73.50	5.92	3.67	8.90
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

Morphological characterization of different cashew accessions

Among the fourteen cashew accessions along with the check (Vengurla-8), the maximum mean height was recorded in NRC-493 (4.91 m), while minimum height was recorded in Vengurla-8 (2.9 m) (Table 3.1.9). The mean height ranged from 2.9 to 4.9 m, however, the difference was not significant. The mean tree girth among the accessions was the highest in NRC-389 (73.97 cm). The check Vengurla-8 recorded the least plant girth (43.9 cm). The maximum canopy spread was recorded in NRC-301 (6.6 m) across North-South, while NRC-112 recorded maximum canopy spread across East-West direction (6.76 m).

Table 3.1.9. Morphometric parameters of different cashew accessions in 2018-19

Acc. No.	Growth parameters			
	Height (m)	Girth (cm)	Canopy spread (m)	
			North-South	East-West
NRC-75	4.2	50.1	6.1	5.4
NRC-111	3.8	54.8	5.3	5.2
NRC-112	3.4	58.5	6.2	6.8
NRC-120	3.7	46.1	5.3	5.3
NRC-140	3.8	54.6	5.7	6.0
NRC-144	4.4	48.5	5.2	4.9
NRC-175	4.0	60.7	4.6	4.7
NRC-176	3.6	56.0	5.2	4.8
NRC-183	3.8	61.3	3.5	5.0
NRC-189	4.7	61.0	4.8	5.1
NRC-270	3.9	69.7	4.4	4.9
NRC-301	4.3	65.4	6.6	5.5
NRC-389	3.9	74.0	6.4	5.9
NRC-493	4.9	65.9	5.7	5.4
Vengurla 8	2.9	43.9	3.6	3.5
Mean	4.0	54.0	5.2	5.2
SEm	0.35	3.53	3.55	0.60
CD (0.05)	NS	1.54	NS	NS
CV (%)	14.68	17.01	17.45	17.33

Organoleptic evaluation of fresh cashew apple

The organoleptic evaluation of fresh cashew apples was carried out using 9 point hedonic scale. The cashew apples of NRC-301 were appealing based on colour and fragrance, and the overall acceptability of this accession was found better, while the check Vengurla-8 scored the highest reading with respect to overall acceptability (Table 3.1.10).

Table 3.1.10. Hedonic scale evaluation of fresh cashew apples

Accession No.	Colour & Fragrance	Flavour	Texture	Taste	Over all acceptability
NRC-75	4.5	4.5	4.0	4.5	4.0
NRC-111	7.2	4.8	5.8	5.0	5.6
NRC-112	5.2	4.6	4.6	4.2	4.4
NRC-120	3.0	2.4	2.4	2.2	2.0
NRC-140	4.0	3.5	4.5	3.5	3.5
NRC-144	5.0	4.0	5.0	4.0	3.5
NRC-175	5.0	5.2	5.2	5.6	5.6
NRC-176	5.8	5.0	5.5	4.8	5.3
NRC-183	6.0	6.0	6.4	6.0	5.8
NRC-189	3.0	4.0	4.0	4.0	4.0
NRC-270	5.8	5.5	5.8	5.5	5.5
NRC-301	7.8	5.8	5.5	5.0	6.3
NRC-389	5.0	5.5	6.0	5.5	5.5
NRC-493	6.0	5.3	6.0	4.8	5.3
Vengurla-8	6.3	6.5	6.5	6.3	6.8

3.1.8. Development of morphological descriptors and DUS test guidelines for cashew

A plot of thirty reference varieties of cashew established for the purpose of DUS testing was maintained during 2018.

3.1.9. Development of microsatellite markers, linkage analysis and population structure studies in cashew

De novo genome and transcriptome sequencing

A draft genome sequence of cashew cv. Bhaskara was generated using the Nanopore and Illumina sequencing technologies. Currently, efforts are being made to make a hybrid assembly using both the long and short reads generated by the two next-generation sequencing (NGS) technologies. Further, the transcriptome sequencing of cashew shoot of Bhaskara (tall genotype) and NRC-492 (dwarf genotype) and developing nuts of H-130 (bold nut and high Cashew Nut Shell Liquid (CNSL) genotype) and NRC-188 (medium size nut and CNSL free genotype) is being carried out to identify the gene-based markers and to investigate the molecular mechanisms and key genes governing the traits like tree height and CNSL content. In addition, crosses between NRC-492 × Vengurla-7, Vengurla-7 × NRC-492, NRC-492 × H-130, and NRC-492 × Taliparamba were made to develop populations needed for assaying the potential utility of the new molecular markers being developed in this study for

selection of tree height and yield traits in cashew. A total of 146 pseudo-F_1 nuts were harvested in these crosses and more of these crosses are planned during the next flowering season.

Transferability of 60 Mango EST-SSRs (MiEST-SSRs) in cashew and related species of *Anacardium*

The newly designed MiEST-SSRs were evaluated for the transferability in cashew and its three related species. The rate of cross-species amplification of MiEST-SSRs varied from 24.2% in *A. microcarpum* to 69.7% in *A. pumilum*. The utility of these MiEST-SSRs as genetic markers need to be evaluated.

Genotyping of core accessions with Cashew SSRs (CSSR)

Eight polymorphic cashew SSRs were used for genotyping 48 core accessions of cashew (Fig. 3.1.8). With the completion of cashew draft genome assembly, novel SSRs would be designed and tested for polymorphism detection and genetic diversity analysis.

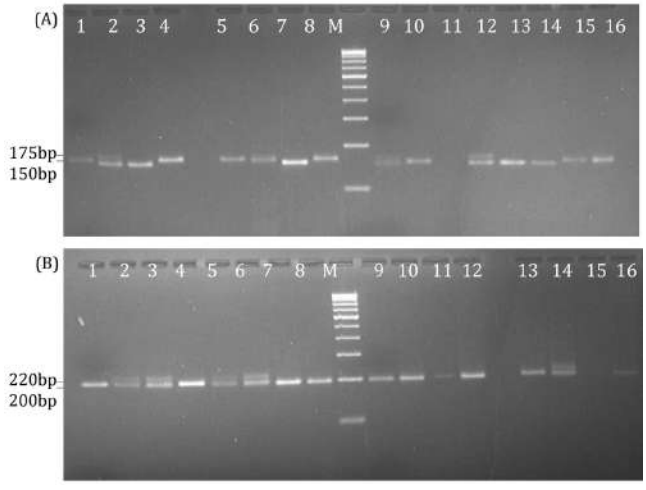


Fig. 3.1.8. Amplification profile of CSSR13 (A), and CSSR14 (B) markers in cashew germplasm accessions

Identification of SSR markers for testing genetic purity of interspecific hybrids of cashew

A total of 21 cashew SSRs (CSSRs) were screened for polymorphism detection in the parents of interspecific hybrids (ISH). Three of these SSRs viz., CSSR5, CSSR8, and CSSR18 showed parental polymorphism and could identify the true hybridity. CSSR5 could identify true hybridity of ISH816 derived from *A. occidentale* cv. Bhaskara × *A. microcarpum* cross (Fig. 3.1.9). Another SSR marker, CSSR13, could identify true hybridity of ISH706 derived from *A. occidentale* cv. Ullal-3 × *A. microcarpum* cross and ISH794 derived from *A. microcarpum* × *A. occidentale* cv. Ullal-3 crosses. Further, CSSR18 could identify true hybridity of ISH816 derived from *A. occidentale* cv. Bhaskara × *A. microcarpum* cross.

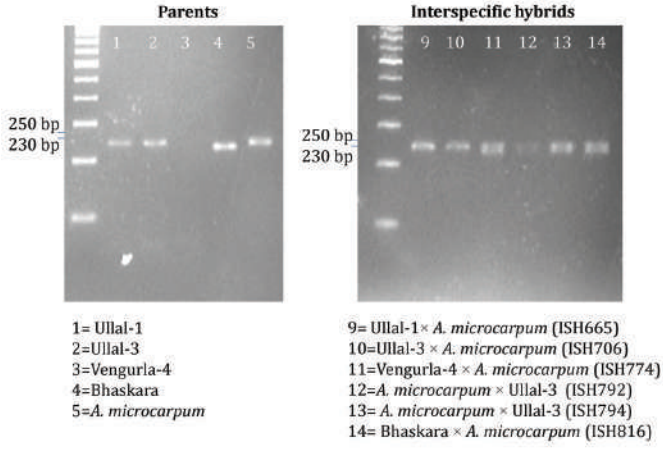


Fig. 3.1.9. Parental polymorphism and genetic purity of hybrids detected by CSSR5 marker

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

Development of mapping populations for nut yield and CNSL content

In this study, two crosses *viz.,* Bhaskara × NRC-188 and Vengurla-7 × NRC-116 were made for developing two mapping populations. The two female parents used in the crosses are high nut yielders with high levels of CNSL, whereas the male parents are low nut yielders and CNSL free types. In the cross Bhaskara × NRC-188, a total of 1720 flowers were cross-pollinated and 632 pseudo-F_1 nuts were produced which accounts for 36.7% nut set. Likewise, in the cross Vengurla-7 × NRC-116, a total of 1154 flowers were cross-pollinated and 368 pseudo-F_1 nuts were produced which accounts for 31.9% nut set. The cross-pollinated nuts will be sown and mapping population will be raised.

Evaluation of CNSL content of parents

CNSL contents in the nuts belonging to the eight phenological stages of nut development and maturity (stages between 701-819 of recently developed cashew specific BBCH scale) collected from 6 cashew genotypes (which included 4 parents used in the crossings of this study) were evaluated (Fig. 3.1.10A). In four of the cashew genotypes assayed, the CNSL content in the nuts increased with the passing of phenological stages, whereas in two CNSL free genotypes, NRC-116 and NRC-188, no CNSL was found confirming the true to type for CNSL free trait (Fig. 3.1.10B). Further, in the CNSL containing genotypes, significantly higher CNSL content was detected at the 70% nut development stage (BBCH scale: 707) and later stages of nut development suggesting that the CNSL biosynthesis in cashewnuts appears to be in the log phase after 50% nut development stage i.e. 705 (Fig. 3.1.10B). However, the rate of CNSL biosynthesis decreases after the 90% nut development stage (709). Among the assayed genotypes, the maximum CNSL content of 35% was observed in the cashew hybrid, H-130. In the cashewnut shell, the CNSL is present in the spongy pith having honeycomb-like structures. The cross-section evaluation of cashewnut shell showed that the honeycomb-like structures in the spongy pith were large and filled with shiny liquid in H-130, a high CNSL containing genotype, whereas, in NRC-188, a CNSL free genotype, the honeycomb-like structures were relatively smaller and compact without shiny liquid (Fig. 3.1.11).

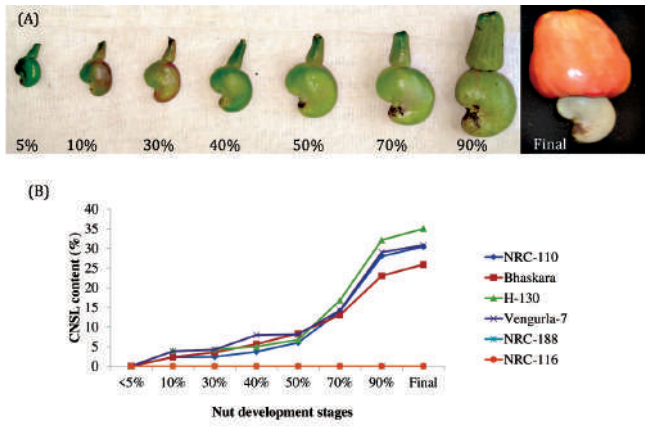


Fig. 3.1.10. Different nut development stages identified (A) and the CNSL content in the identified nut development stages (B)

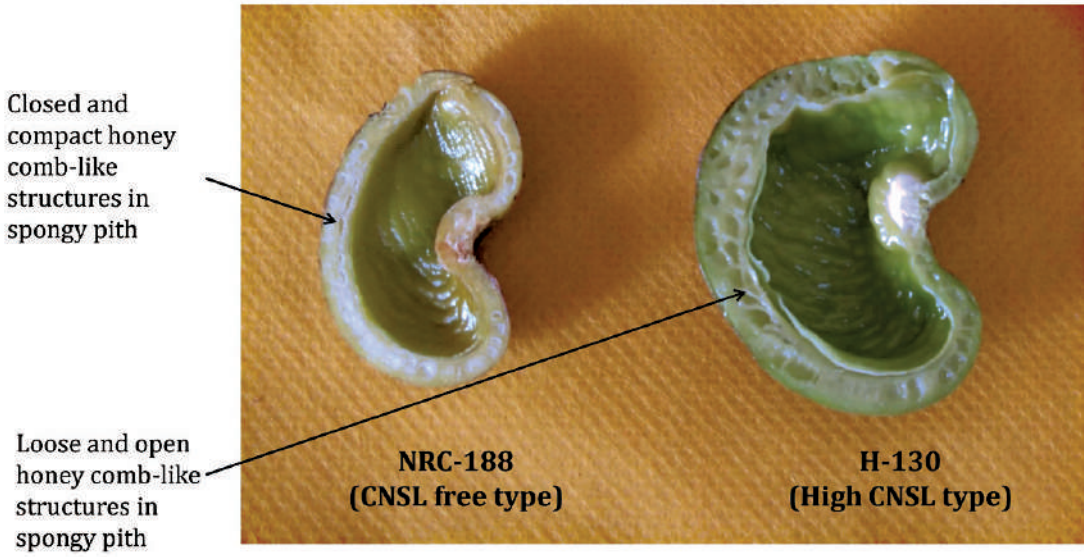


Fig. 3.1.11. Comparison of CNSL containing spongy tissues structures present in the cashewnut shell of CNSL free type and high CNSL containing cashew genotypes

3.1.11. Future areas of thrust for research in the field of crop improvement

- Survey for identification and collection of unique types of cashew or related species of cashew.
- Development of Tea mosquito bug 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

Principal phenological stages and their characteristics in cashew

The phenological studies were carried out using Biologische Bundesantalt Bundessortenamt und Chemische Industrie (BBCH) scale. The phenological stages exhibited a similar trend as that of the previous year. One stage, senescence stage was dropped based on extended BBCH scale guidelines. The principal phenological stages and their characteristics are given Table 3.2.1.

Table 3.2.1. Principal phenological stages and their characteristics in cashew

Sl. No.	Principal phenological stages and their characteristics
1.	**Principal growth stage 0: Vegetative bud development** After a quiscent phase, the vegetative buds start swelling and burst to form leaf primordia which differentiate into leaves through a series of developmental stages. The bud initiation starts after the rainy season (September – October). However, the flushes occur two or more times during the annual growth of cashew.
2.	**Principal growth stage 1: Leaf development** Leaf primordia visible after withering of bud scales develop into leaves by passing through sequential developmental stages. Further, leaf development occurs parallel to the shoot development. Distinct shoot visibility occurs towards the end of the leaf development.
3.	**Principal growth stage 3: Shoot development** Shoot elongation and development continues along with leaf development. Finally, the leaves turn into leathery green and shoot become woody in 5-7 weeks.
4.	**Principal growth stage 5: Inflorescence development** In cashew, inflorescence emerges terminally from current season shoots during winter. Reproductive buds develop into inflorescence. During inflorescence development, panicle expansion occurs with the formation of laterals and sub-laterals in a sequential manner to form a complete panicle in 4-6 weeks. Shoot development continues in parallel with inflorescence development (BBCH code: 311-317). The inflorescence emergence begins in November and more than 80% inflorescences emerge between the third week of November and the third week of December. The inflorescence development stages were redefined with codes 516A, 517A and 519 A for better clarity in defining stages with codes (Fig. 3.2.1).

5.	**Principal growth stage 6: Flowering** Flowering begins in the second week of November and the peak flowering occurs during January and February months. In cashew, two types of flowers are found *viz.,* hermaphrodite and staminate flowers. The freshly opened flowers are white in colour and turn into pink after a few hours of opening. The Inflorescence development also continues with flowering and in a panicle, about 600-800 flower buds formed and opened sequentially. The secondary flowering stages were defined on the basis of percentage of flowers opened *viz.,* 10% of flowers opened and so on till 90% flower opened. The flowering stages were redefined with codes 610A, 611A, 613 A, 615A, 617A and 619A for better clarity in defining stages with codes (Fig. 3.2.2).
6.	**Principal growth stage 7: Nut and apple development** In cashew, along with true fruit (cashewnut), flower pedicel swells and develops into the false fruit called 'cashew apple'. In the initial phase, nut develops at a faster rate and attains the maximum size whereas apple develops slowly and attains about 10% of its final size by the end of nut development. After fertilization, the nut develops slowly up to 30% of its final size (i.e. lag phase) and later grows rapidly (log phase of growth) to attain the maximum size. Both nut and apple developments follow a simple sigmoidal growth pattern. For describing the secondary stages, growth characteristics of both nut and apple (percentages of final size) were taken into account.
7.	**Principal growth stage 8: Nut and apple maturity** After nut attaining the maximum size, nut undergoes desiccation and shrinks and colour changes from dark green to grey in 8-10 days. At the same time, apple rapidly develops to reach the final size and reaches maturity. The secondary stages of nut and apple maturity were assigned taking into account the growth (size in percentages) and maturity (colour changes) characteristics of both.

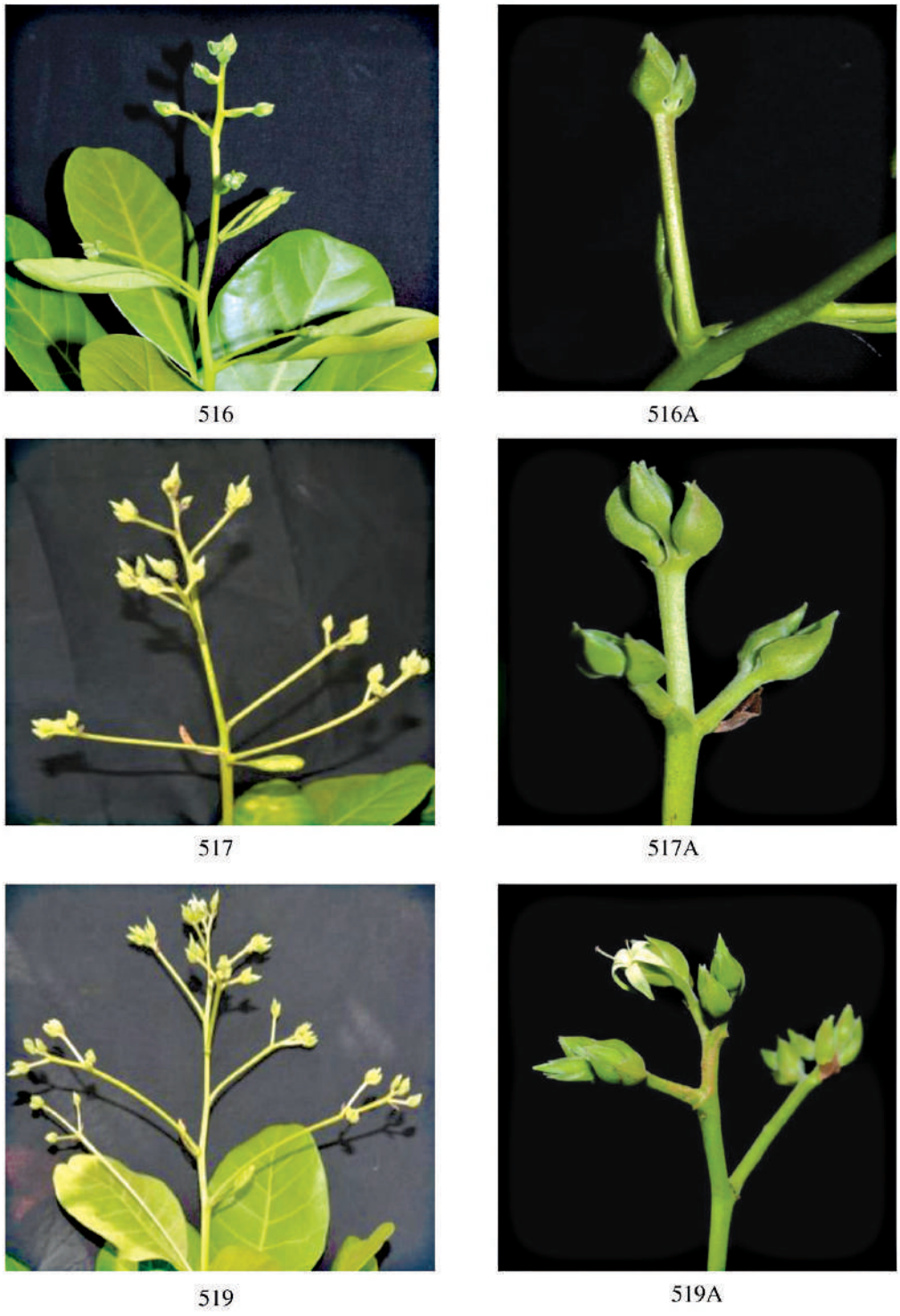


Fig. 3.2.1. Principal growth stage 5: Inflorescence development stages

610

610 A

611

611A

613

613A

Fig. 3.2.2. Principal growth stage 6: Flowering stages

Phenological stages susceptible to pest attack

It was found that the tender shoots (110 to 313), developing panicles (511 to 519) and flowering (611 to 615) are highly susceptible to Tea Mosquito Bug (*Helopeltis antonii*) attack, whereas expanding tender leaves (119 to 313) are susceptible to leaf miner (*Acrocercops syngramma*) attack, and developing nuts and apples (715 to 811) are more susceptible to apple and nut borer (*Thylocoptila paurosema*) attack (Table 3.2.2).

Table 3.2.2. The phenological stages identified as critical for pest attack in cashew

Stage code	Pest
110-313 (Tender shoots)	Tea mosquito bug
511-519 (Developing panicles)	Tea mosquito bug
611-615 (Flowering stages)	Tea mosquito bug
119-313 (Expanding tender leaves)	Leaf miner
715-811 (Nut and apple development stages)	Apple and nut borer

The response of cashew variety Bhaskara to pruning

The pruning treatments were imposed on 8 year old Bhaskara trees in the months of June, July, August and September. The pruning response of Bhaskara was better when pruning was done in September (Table 3.2.3). Pruning of laterals @25% level led to the production of the highest number of panicles per tree (80.5) leading to highest raw nut yield (6.76 kg tree^{-1}), closely followed by pruning of laterals at @50% level (71.5 panicles and raw nut yield of 6.01 kg tree^{-1}).

Table 3.2.3. Effect of pruning on flowering and yield in Bhaskara variety

Treatment	No. of panicles tree^{-1}	Cashewnut yield (kg tree^{-1})
June@25% leader	0	0
June@50% leader	0	0
June@25% lateral	44.0	3.7
June@50% lateral	21.0	1.8
July@25% leader	29.5	2.5
July@50% leader	6.5	0.6
July@25% lateral	23.5	2.0
July@50%lateral	17.0	1.4
August@25% leader	18.0	1.5
August@50% leader	36.0	3.0
August@25% lateral	23.5	2.0

August@50%lateral	53.0	4.5
September@25% leader	38.0	3.2
September@50% leader	25.0	2.1
September@25% lateral	80.5	6.8
September@50%lateral	71.5	6.0
Control	47.5	4.0
CD at 5%	37.1	3.1

3.2.2. Optimisation of mineral nutrition to cashew under high density planting

High 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 completes 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 project is undertaken to assess the nutrient requirement of cashew under high density planting. The project also aims to develop a fertilizer nutrient management package for HDP in cashew.

Experimental details and soil characteristics

To standardise the fertiliser recommendation under high 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 depthwise decrease in electrical conductivity, soil organic carbon and available nitrogen content. The treatmentwise plant samples were collected and processed for analysis. The cashewnut yield is being monitored.

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

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

3.3. CROP PROTECTION

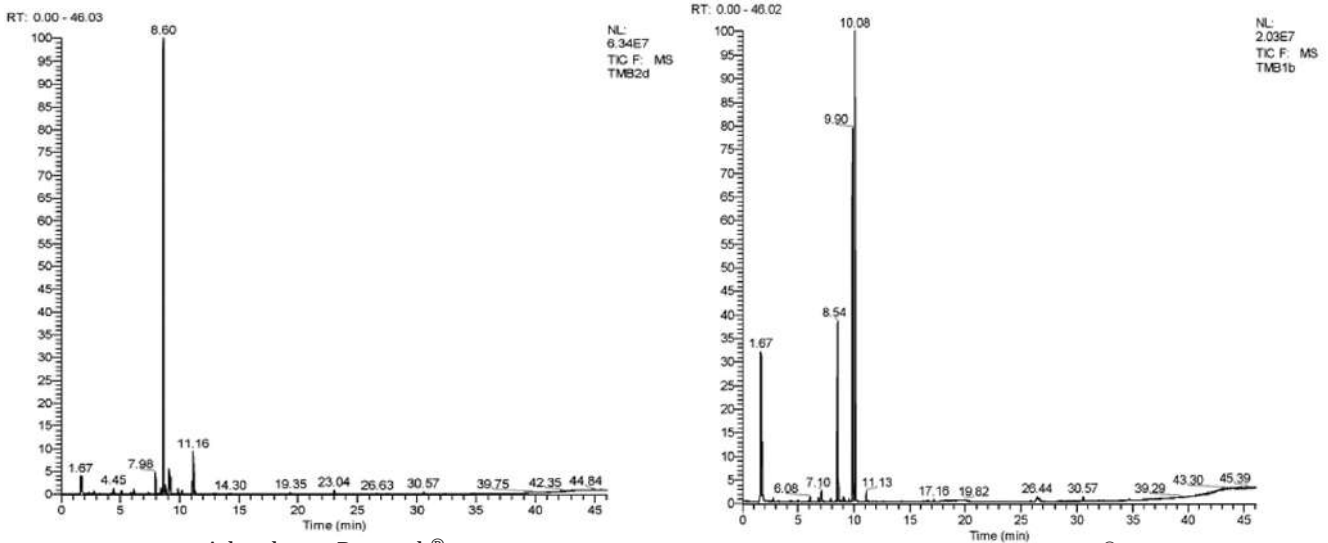
3.3.1. Investigations on semiochemicals for management of Tea Mosquito Bug (TMB) and Cashew Stem and Root Borer (CSRB)

Sex pheromone trials for TMB

The project envisages the identification of semiochemical activity of sex pheromone volatiles through in-vivo evaluation followed by GC-MS analysis, with the objective of developing sex-pheromone traps for monitoring and decimating the pest populations of TMB in the field situations.

Earlier studies indicated that live virgin females of TMB, as well as whole body extracts (WBE) of live virgin females, could elicit field response from males of TMB. However, the WBE when analysed at ICAR-Directorate of Medicinal and Aromatic Plants Research (ICAR-DMAPR), Anand, Gujarat indicated significant contamination of body compounds, especially lipids in the extracts, thereby making it difficult to segregate the sex pheromone compounds. Hence, an alternate method of volatile collection i.e. use of adsorbents was adopted to trap the volatiles from virgin TMB females under laboratory conditions. The laboratory-reared populations of TMB were utilized for the collection of sex pheromone volatiles, using effective and universally accepted adsorbents *viz.,* Porapak® and Tenax®. The live virgin females of TMB aged 4 to 5 days after emergence were placed in a net cage and secured in the field and the calling females were later transferred to a glass desiccator (wiped well internally with di-chloromethane) containing 0.5 to 0.6 mg of the activated adsorbents placed in an autoclaved watch glass.

The females were allowed for 8 to 12 h in the set-up and the adsorbents were later transferred to glass stopper vials. The same were evaluated for their chemical composition at ICAR-DMAPR in the GC-MS with EAD; the results were compared to the GC library and the chemicals having >90% matching were recorded. The elution peaks indicated that all samples had similar and consistent elution time peaks between 8.2 to 10.5 min after sample injection (Fig. 3.3.1). The possible group of organic compounds in the samples were identified as carenes, diethyl-esters, pthalic acid derivatives, naptha derivatives, pinenes, acetophenones etc.



Adsorbent: Porapak® Adsorbent: Tenax®

Fig. 3.3.1. GC-MS elution graphs of adsorbed female sex pheromone volatiles of TMB

During 2018-19, the maximum number of TMB males trapped by a single female was 51 males/trap when a 4 days old virgin female TMB was used as bait and 43 males/trap when a 5 days old virgin female TMB was used as live bait (Table 3.3.1).

Table 3.3.1. Mean TMB male catches using live virgin TMB females as bait

Days after emergence (DAE)		Mean number of TMB males trap^{-1} day^{-1}						
		Sep. 2018	Oct. 2018	Nov. 2018	Dec. 2018	Jan. 2019	Feb. 2019	Mar. 2019
4 DAE	AM	-	22	51	31	19	8	-
	PM	-	31	49	-	26	-	-
5DAE	AM	-	29	33	43	20	11	-
	PM	-	27	19	22	18	-	-
6DAE	AM	-	16	22	28	24	12	4
	PM	-	11	17	19	17	4	-
7DAE	AM	-	15	20	23	22	10	-
	PM	-	13	15	16	12	5	-
8DAE	AM	-	9	10	11	-	-	-
	PM	-	4	6	5	-	-	-

Evaluation of fresh frass extract- synthetic baits for CSRB

As the attraction of CSRB females and males to the fresh frass in infested trees was confirmed earlier, the fresh frass was collected and extracted. The components of fresh frass from CSRB infested cashew trees, *viz.,* phenols, ketones, polyphenols, naptha-derivatives and aldehydes were identified and formulated using synthetic formulations. Later synthetic baits prepared from the identified chemical components were provided by ICAR-National Bureau of Agricultural Insect Resources (ICAR-NBAIR), Bengaluru, for field evaluation. These compounds were tested by placing them in a physical trap that has been designed and fabricated at this Directorate (Fig. 3.3.2). However, no trap catches were obtained either due to non-attraction by synthetic frass formulation or escape of attracted CSRB beetles. Further trials are being planned in collaboration with ICAR-NBAIR, Bengaluru.

Fig. 3.3.2. Physical traps designed for evaluating kairomone blends for CSRB

Investigations on acoustic tracking of CSRB grub feeding sounds

It was observed through field trials that tracing the location of the CSRB grubs in infested trees is a big hurdle in the physical removal of the pest stages. In this context, it was contemplated to record the feeding sounds through acoustic sensors to locate the grub position inside the tree. For this purpose, the laboratory-reared CSRB grubs aged <45 Days After Emergence (DAE), 45-90 DAE, 90-120 DAE and >120 DAE were tracked for their feeding sound through acoustic sensors at C-DAC, Kolkata in a soundproof chamber. It was noticed that the sound produced by the feeding CSRB grubs was not continuous and feeble necessitating future testing with sensor-devices having enhanced sensitivity levels.

3.3.2. Evaluation of newer molecules for their efficacy against Tea Mosquito Bug (TMB) and Cashew Stem and Root Borers (CSRB)

Keeping in view of the need for alternate insecticides which were ecologically safer and not harmful to the non-target organisms; this study was envisaged to evaluate the efficacy of neonicotinoids, carbamates, pyrazoles, synthetic pyrethroids and an Insect Growth Hormone (IGH) against the two major pests of cashew *viz.,* TMB and CSRB.

The following parameters *viz.,* a) mortality and b) feeding deterrence have been recorded using the test insecticides, namely, thiamethoxam (0.1 g/L & 0.2 g/L), acetamiprid (0.5 g/L), carbosulfan (2.0 ml/L) and buprofezin (2.0 ml/L), with L-cyhalothrin (0.6 ml/L) as check for TMB. For CSRB, the nascent grub mortality has been recorded with test insecticides; fipronil (2.0 ml/L) and imidacloprid (2.0 ml/L), with chlorpyriphos (10 ml/L) as a check.

Laboratory and field evaluation of test insecticides versus TMB

The tender shoots of cashew were collected and placed in glass vials containing water to maintain their turgidity. The test insecticides were initially sprayed on all the shoots as a fine mist with no dripping. These were later air-dried and used at different intervals after spraying for testing the efficacy against the TMB adults and nymphs. The lab trials were done for up to 5 DAT (Days After Treatment). As the tender cashew shoots did not retain their turgidity after 5 days the residual toxicity of the test insecticides beyond 5 DAT was done by spraying the test insecticide onto tagged flushing branches and evaluating those treated tender cashew shoots at regular intervals of 10 DAT, 15 DAT and 30 DAT. Five insects of TMB either adults or nymphs were allowed on the treated

cashew shoots and the mortality and damage score were recorded after 12 h and analysed.

It was observed that thiamethoxam (0.2 g/L) was on par with the recommended insecticide, L-cyhalothrin in inducing mortality of TMB as well as feeding deterrence, and it was closely followed by acetamiprid (0.5 g/L) (Fig. 3.3.3 and 3.3.4). Buprofezin did not induce mortality of TMB nymphs or adults even on 1DAT.

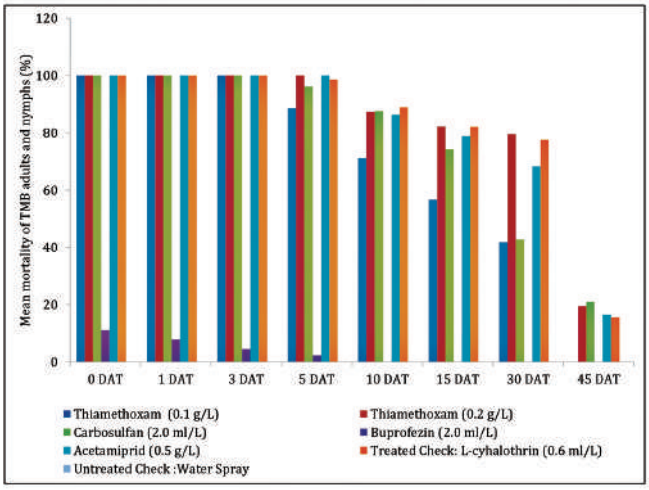


Fig. 3.3.3. Mean mortality (%) of TMB adults & nymphs in different treatments

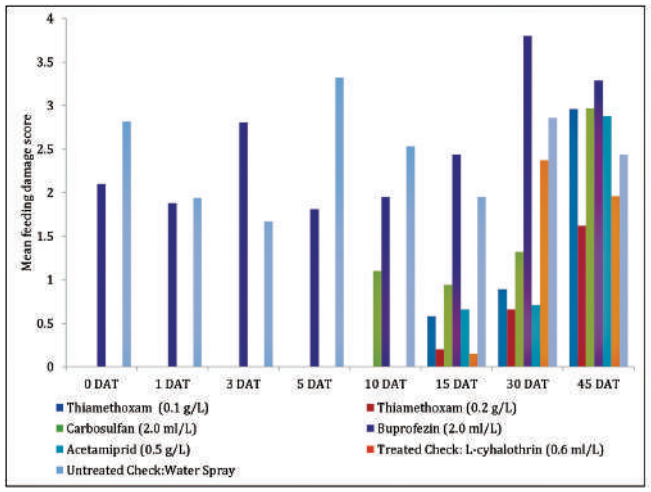


Fig. 3.3.4. Mean feeding damage score by TMB adults and nymphs in different treatments

Laboratory and field evaluation of insecticides against CSRB

For laboratory evaluation, the stout twigs of cashew were collected and sprayed with test insecticides till they were well drenched and these were shade-dried. Later a soft cotton tape (2 cm wide) was snugly wound around them. Well developed fertile eggs of CSRB, collected from laboratory cultures were placed below the tape while winding. The hatching of the eggs and entry of the nascent grub into the bark were recorded 7 days after release. Fine powdery frass exudation indicated the successful entry of the nascent CSRB grub into the twig; while the nascent grubs which died on nibbling the bark did not show any frass exudation (Fig. 3.3.5).

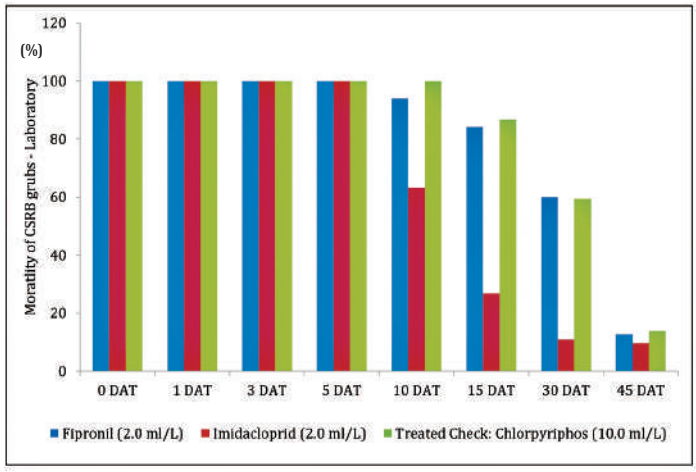


Fig. 3.3.5. Mortality of CSRB nascent grubs - under laboratory trials (%)

Similarly, field evaluation of these test insecticides was also done by placing the eggs by slight scooping of the outer bark of the treated branch. The eggs of CSRB were protected with a cotton tape covered by cellophane strip. The hatching and mortality of the CSRB grubs were recorded on the 7th day after egg placement. The same branch was utilized for residual toxicity for 3 DAT, 5 DAT, 10 DAT, 15 DAT, 30 DAT AND 45 DAT. The details were later statistically analyzed to find the most effective insecticide which induced mortality of the nascent CSRB grubs before damage was inflicted.

The mortality percentage of nascent grubs of CSRB indicated that fipronil (2.0 ml/L) was on par with the recommended insecticide chlorpyriphos; but induced lesser mortality of nascent CSRB larvae (Fig. 3.3.6).

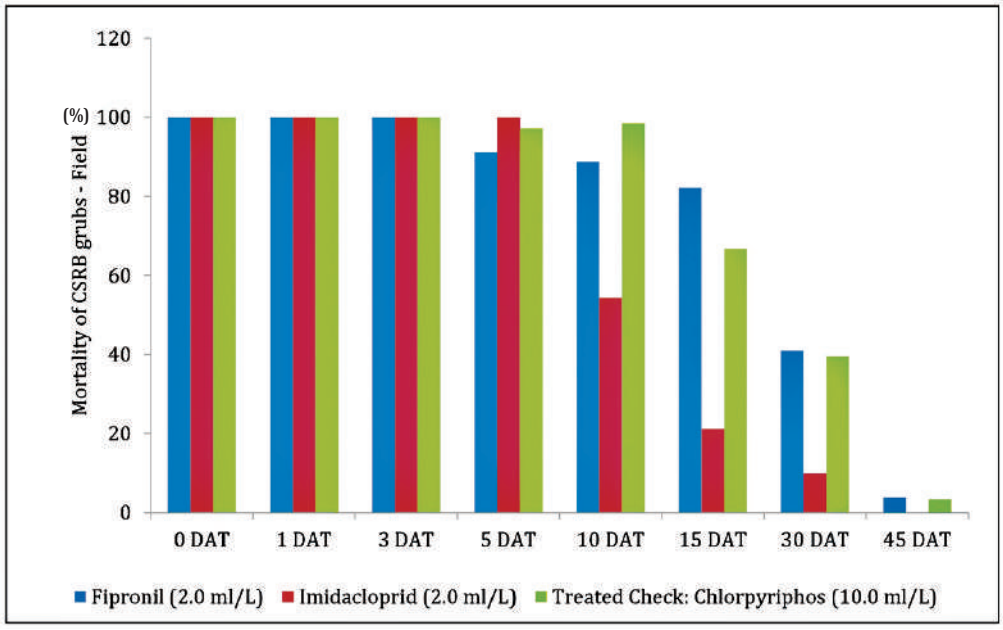


Fig. 3.3.6. Mortality of CSRB nascent grubs - under field trials (%)

3.3.3. Investigations on inflorescence pests of cashew and their management

Hitherto, the inflorescence pests were considered as minor pests of cashew. However, the incidence of inflorescence pests considerably reduces the total nut yield. During the current cropping season the populations of semi-loopers, Apple and Nut Borer (ANB) caterpillars, mirid bugs and thrips was comparatively lower than the previous years. Two species of unidentified mirids and two species of unidentified flower beetles were noticed to damage the calyx region and feed on pollen, which needs further studies in relation to flower drying. The occurrence of inflorescence pest on different cashew varieties is illustrated in Fig. 3.3.7. The commonly observed micro-lepidopterans pest of cashew inflorescence are *Gyrtona* sp. (Family: Noctuidae), *Eublemma versicolor* (Family: Erebidae), *Nanaguna* sp. (Family: Nolidae), *Ascotis scenario* (Family: Geometridae), *Pleuroptya balteata* (Family: Crambidae) and several species of Tortricidae.

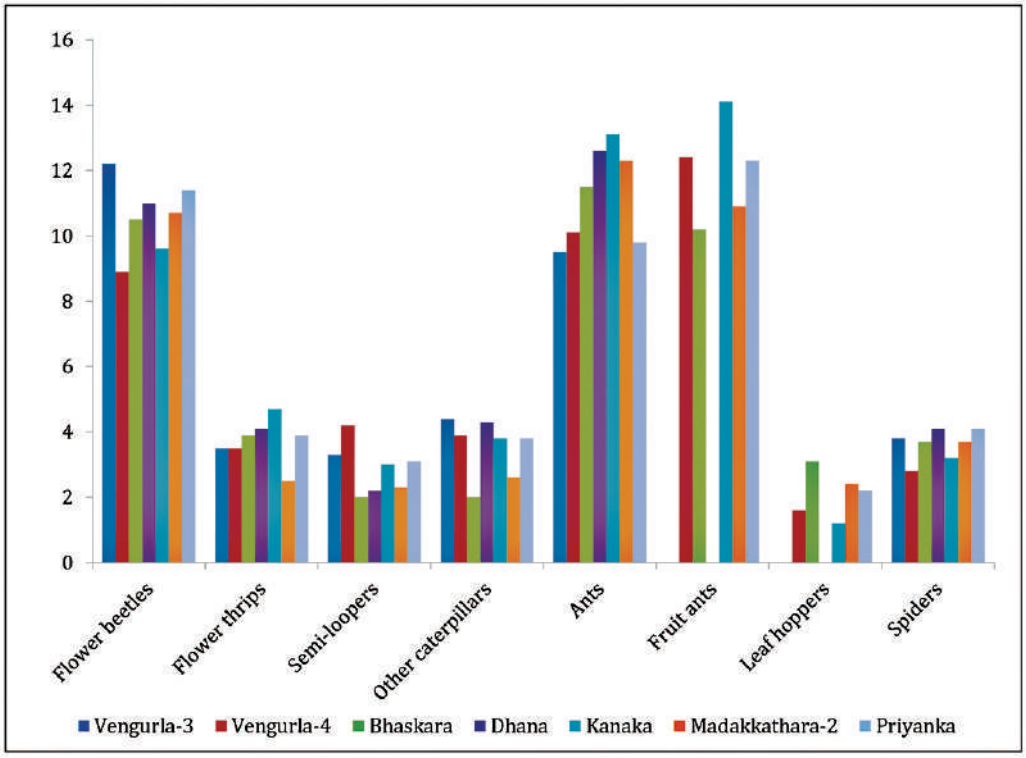


Fig. 3.3.7. Occurrence of inflorescence pests and other Fauna in different cashew varieties (Nos per observation)

3.3.4. Standardization of pest management practices involving EPN and *Metarhizium anisopliae* for management of CSRB

The two entomopathogenic nematodes (EPN) *viz., Heterorhabditis* and *Steinernema* were maintained in aerated aqueous medium and regularly cultured on *Galleria mellonella* (greater wax moth larvae); and were utilized for the field evaluations. The few cashew trees having initial incidence of CSRB have been treated in the experimental plots at ICAR-DCR, with *M.anisopliae* spawn 250 g/tree and 500 g/tree and identified strains of EPN i.e., *Steinernema* and *Heterorhabditis* @10 Larvel equivalents (LE)/infested tree and @ 10 LE/healthy tree in comparison with treated check i.e., chlorpyriphos 0.2%. The survival of the infective juveniles (IJs) of these EPN has been confirmed up to 150 days in the shaded ecosystem and they maintained their virulence and could also induce mortality in the CSRB grubs. None of the treated healthy cashew trees showed any signs of reinfestation by the pest and did not have any residual infestation of CSRB.

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

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

3.4. POST HARVEST TECHNOLOGY

3.4.1. Developing quality standards for raw cashewnuts

Developing an empirical model for assessing the quality of raw cashewnuts

A protocol has been developed to assess the quality of raw cashewnuts. Major factors considered for the development of empirical relationship are i) shelling % in terms of out turn (OT), ii) nut count (NC), iii) moisture content (MC), iv) spatial dimensions of raw cashewnuts *viz.,* nut length (RL), nut width (RW), nut effective width (REW), nut thickness (RT), v) nut weight (NW), vi) sinkers count (SC) and sinkers weight (SW). On the other hand, kernel quality is assessed based on its surface characteristics such as i) good kernel, ii) shrivelled kernel, iii) speckled or black spotted kernel, iv) oily kernels, v) kernel with brown patches and vi) rejected kernels. Its yield is calculated accounting ruling price for specific grades. Basic data generated for raw cashewnut samples of 34 varieties were subjected to multiple linear regression analysis to develop an empirical relationship. An empirical model, thus developed expresses quality index i.e. the kernel yield in terms of nut count, moisture content and outturn. Another model also worked out involving a spatial dimension of the raw cashewnuts *viz.,* length (L) and width (W), nut count (NC), sinkers (S), moisture (MC) and outturn (OT) with higher R^2 value. These models aids in assessing the quality and fix up the price based on the market value of cashew kernels.

Validation of empirical model with locally available raw cashewnuts

Developed empirical models have been validated with freshly harvested nuts of different varieties *viz.,* VTH-30/4, Ullal-4, Bhaskara, Ullal-1, NRCC Sel-1, K-22-1, and H-126 and the correlation coefficient between model values and computed values found to be in the range of 0.92 to 0.94.

3.4.2. Design and development of mechanized slicer for cashew apple

Incorporating modification in the developed slicer and evaluating its performance

Multi-string slicing of cashew apples leads to improper shearing due to the presence of waxy coat (0.2 mm thick) surrounding the fruit and blunt edges of the string. Alternatively, staggered disc blades slicer designed, but encountered the problem of positioning the halves of the cashew apples after first slicing and distortion of cut apples. Later, a modified multi-blade rotary mechanical slicer was developed and its performance was evaluated. Certain modifications in the present design are to be incorporated to overcome the problems of fracture in the cut slices, optimum rotational speed to guide the cut slices into an outlet, increasing the strength of support plate with grooves for complete slicing, change in the size of the disc blade and its bevel angle. Although juice loss is minimized, due to increased centrifugal force, cut slices struck the arrestor, converting slices into pieces. Trials conducted with a prototype of vertical feed rotary slicer and the resultant data indicated that the operational capacity ranged between 60-72 kg h^{-1} and the whole slice recovery was in the range of 75-78%. The major problem associated with this mechanized slicer was the accumulation of fibrous pulpy materials in the space between the curved blade and peripheral end of the disc.

Studying drying characteristics of cashew apple slices in a vacuum dryer

Experiments carried out at the University of Agricultural Sciences (UAS), GKVK, Bengaluru indicated that cashew apple slices of ~2 mm size could be dried under vacuum environment maintained at 40°C, retained its original colour and nutrients, requiring 6-7 h amenable for grinding. Its drying effect has been tested by rehydration technique and found to regain original size. Besides, the drying of cashew apple carried out using radial flow convection dryer indicated that it could be dehydrated within 12 h with air temperature maintained at 40°C.

3.4.3. Calibration of moisture meter for raw cashewnuts

A moisture meter based on parallel plate capacitance principle has been designed and developed accounting the spatial dimensions of the raw cashewnuts, range of moisture in whole nut and irregular shape of the nuts. It is developed by M/S Environment Measurement and Control (EMCON), Kochi. It is a non-destructive moisture meter for onsite measurement of moisture content in cashewnuts. Two moisture meters have been developed for different nut holding capacities. Due to non-availability of the nuts (off-season), moisture infused raw cashewnuts were used for its development and its calibration. Later on, moisture meter was calibrated with freshly harvested raw cashewnuts of specific variety representing the size and moisture level and mixed variety nuts. Data analyzed and moisture meter refined for more accuracy and repeatability. Coefficient of correlation found to be in the range of 0.92 to 0.94 between meter reading and original moisture in the nuts. This technology is ready for commercial utility.

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

Industry oriented technical problems were identified based on the diagnostic study conducted with two units representing labour oriented and semi-mechanized mode of processing. Optimization of processing parameters influencing the quality of the end product found to be the prime issue of the industry. Efficient utilization of human, thermal and electrical energy is the secondary issue to be tackled to minimize the cost.

Stage-wise problems have been identified in the line of fully mechanized processing and probable solutions suggested. Contamination of cashew kernels with CNSL during shelling is one of the major problems to be addressed. As the moisture plays a vital role at all stages of processing, moisture based technique need to be optimized for better qualitative and quantitative efficiency. Accounting labour wages, cost of raw materials and overhead charges in the highly energy intensive processing, cost of production found to be lower in fully mechanized mode than labour oriented system.

3.4.5. Development of dehydrated products from cashew apple and sprouts

Physical modulation during sprouting of cashewnuts

The cashewnuts of different varieties were sprouted under the protected condition to assess the biochemical and micronutrient status of cashew sprouts of different stages. Five stages of sprouts were identified to create baseline data on suitable drying temperature, biochemical and nutritional status (Fig. 3.4.1). The physical modulation of cashew sprouts was also recorded (Table 3.4.1). As the sprouting progressed, the weight, moisture content, length of plumule and radical increased gradually.

Table 3.4.1. Physical modulation of cashewnut during sprouting

Stages of sprouting		1	2	3	4	5
Nut weight (g)		6.02	6.43	7.18	9.13	9.53
Moisture content (%)		52.96	68.60	69.95	71.15	74.74
Radicle	Length (mm)	6.36	8.57	8.83	9.13	9.53
	Girth (mm)	6.25	6.34	6.18	5.87	5.33
Plumule	Length (mm)	3.82	5.12	6.23	9.11	11.39
	Girth (mm)	0.28	3.361	4.16	3.47	3.52

Fig. 3.4.1. Five different stages of sprouting in cashew

Moisture loss pattern of cashew sprouts at different temperatures

The cashew sprouts are exposed to different temperature (45°C, 55°C and 65°C) to find out the suitable drying temperature. The moisture loss pattern indicated significant moisture loss during the initial four hours of drying irrespective of drying temperature (Fig. 3.4.2).

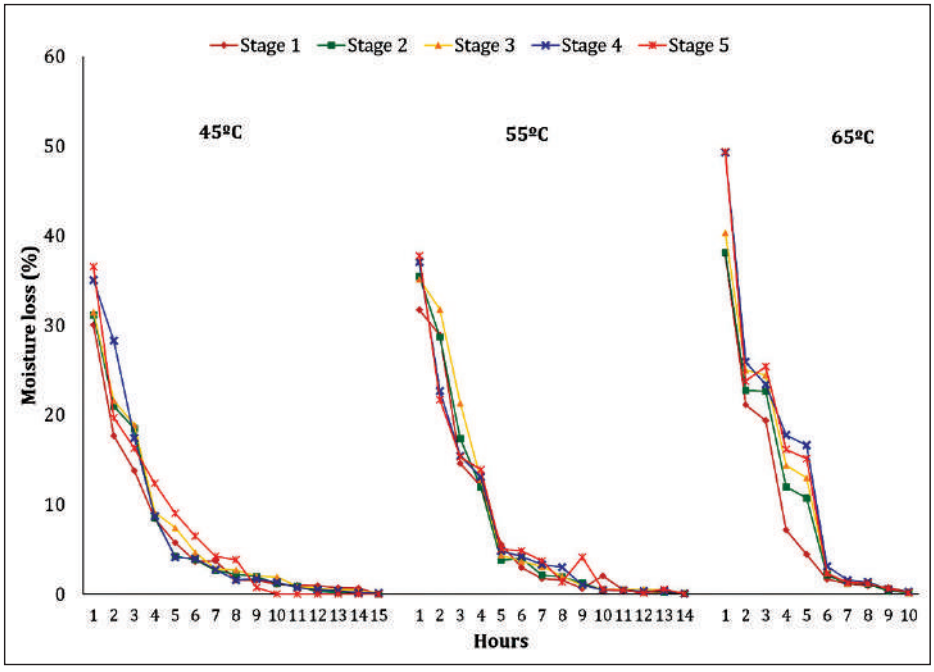


Fig. 3.4.2. Moisture loss pattern during different stages of sprouting of cashewnuts at 45°C, 55°C and 65°C

Quality parameters of cashew sprout and cashew kernel

The micronutrient contents of sprouts dried under different temperature did not differ significantly. However, sprouted nuts showed increased contents of mineral nutrients compared to the cashew kernel (Table 3.4.2).

Table 3.4.2. Micronutrient status of cashew sprouts and cashew kernel

Temperature	Stages of sprouting	K (%)	Ca (%)	Mg (%)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)
45°C	1	0.85	0.06	0.14	203.63	2.32	60.62	9.80
	2	0.76	0.03	0.14	189.52	2.55	51.91	12.41
	3	0.85	0.04	0.15	203.16	3.45	57.95	12.88
	4	0.84	0.04	0.16	238.58	2.19	65.00	10.79
	5	0.84	0.05	0.16	297.45	9.76	59.23	11.19
55°C	1	0.86	0.03	0.15	219.84	2.00	52.71	11.36
	2	0.82	0.03	0.13	290.45	3.08	61.73	8.88
	3	0.91	0.05	0.15	217.01	4.23	58.48	12.69
	4	0.85	0.04	0.14	183.28	6.74	52.97	11.45
	5	0.89	0.04	0.14	206.56	4.77	53.33	10.23
65°C	1	0.84	0.04	0.16	147.49	2.04	53.83	12.44
	2	0.93	0.04	0.15	173.03	1.86	59.68	13.29
	3	0.76	0.04	0.14	147.84	2.70	45.53	9.44
	4	0.85	0.04	0.14	177.35	1.92	52.61	10.26
	5	0.91	0.04	0.15	202.19	8.29	55.12	13.67
Root		1.90	0.06	0.17	1150.94	2.09	67.59	34.97
Mix stages		0.71	0.04	0.15	100.01	3.90	48.95	2.75
Sprout milk		0.51	0.07	0.12	208.87	2.13	49.73	19.50
Sprout pomace		1.22	0.04	0.20	192.21	10.27	80.45	35.37
Cashew kernel		0.85	0.03	0.03	27.04	0.10	0.91	0.66
SEm		0.27	0.02	0.04	2.25	3.65	16.05	8.32
CD (0.05)		0.17	NS	0.04	1.45	4.93	10.87	3.91

The quality parameters of stage 1 cashew (the cashew sprouts 8-10 days after sowing, just before the chlorophyll formation in the cotyledons and are easily separable) were compared with cashew kernel for biochemical and other quality parameters. The fat content was drastically reduced by 45-50% in sprouted cashew kernel compared to the content in cashew kernel, whereas the fibre content was increased by 24% in sprouted kernel compared to cashew kernels. Similarly, the total phenolic content was also increased by 50% in sprouted kernel compared to cashew kernels. Minerals such as calcium, iron, manganese, zinc and copper were increased during the process of sprouting (Table 3.4.3).

Table 3.4.3. Biochemical and nutritive status of cashew sprouts (stage 1) compared with cashew kernel

Parameters	Cashew sprout	Cashew kernel
Weight (Dry Weight Basis)	2.4-3.0 g / sprout	3-4 g / kernel
Weight (Wet Weight Basis)	6-7 g / sprout	4-6 g / kernel
Fat content	19-22%	42-48%
Fibre content	4.3%	3.3%
Total sugars	2%	8%
Total Phenols	472 mg/100 g	210 mg/100 g
Free Amino acids	1.06%	0.48%
Essential minerals		
Potassium	0.85%	0.85%
Calcium	0.58%	0.03%
Magnesium	0.14%	0.03%
Iron	336.94 ppm	30.4 ppm
Manganese	10.1 ppm	2.32 ppm
Zinc	60.62 ppm	9.1 ppm
Copper	9.80 ppm	0.66 ppm
		

Mouth freshener from cashew apple

Well-ripened freshly harvested cashew apples were washed and air dried for 5 to 10 min. Cashew apples (500 g) were cut into 0.5 cm^3 sized slices and mixed thoroughly with spice mixture (cumin – 40 g, clove – 4 Nos, cardamom – 5 Nos, cinnamon – small piece) and sugar (50 g). The mixture was kept under 28-30°C for 3-4 days for moisture removal (Fig. 3.4.3). The products are to be subjected to biochemical analysis and storage life assessment under ambient and refrigerated storage.

Fig. 3.4.3. Mouth freshener from cashew apple

3.4.6. Future areas of thrust for research in the field of 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.

3.5. CONCLUDED PROJECTS

3.5.1. Genetic analysis of mapping population through molecular markers for important traits in cashew

Principal Investigator	Dr. Mohana, G.S.
Co-Principal Investigators	Dr. Eradasappa, E.
	Dr. Siddanna Savadi (Since November 2017)
	Dr. J.D. Adiga (Since September 2017)
	Dr. M.G. Nayak (Till September 2017)
Project code	1.8
Project duration	2012-2018

Introduction

Rapid crop improvement is difficult in cashew owing to its perennial nature and the conventional approaches of tree improvement take long time to achieve the set objectives. Advances in molecular biology and DNA markers have opened new opportunities in recent years. Although phenotypic markers are important, molecular markers have distinct advantages as they are many and unaffected by the environmental factors, and with these markers, it is possible to select plants possessing economically desirable characters at the seedling stage itself without waiting for the plant to attain reproductive phase. Because of their advantages, DNA markers have been used widely in phylogeny, genetic diversity assessment, gene tagging and mapping studies. This study was undertaken with the following objectives.

Objectives

- To evaluate the already existing mapping population (F_1) for important traits (Phenotyping)
- To identify markers linked to economic traits

Results

To start with, 21 SSR markers available in cashew were used for assessing the parental polymorphism in Ullal-3 and NRC-492, and it was found that only 6 markers could differentiate the parents. Since the number of polymorphic markers was less, SSR markers from pistachio, almond and mango were deployed. Among them, many markers seem to be polymorphic between parents. In this way, a total of 138 primers were screened in parents Ullal-3 and NRC-492 for identification of 39 polymorphic primers (Table 3.5.1). These polymorphic primers were screened in 89 individuals of Ullal-3 × NRC-492 to generate banding patterns or genotyping. Further, phenotyping was done in this population with respect to 11 vegetative and reproductive characters (Table 3.5.2).

However, the data generated with 39 polymorphic markers were not sufficient to carry out the association analysis and more SSR markers need to be generated for screening the parents and then the F_1 population, to generate the marker data. Efforts for developing SSR markers in cashew are under progress in one of the projects and once they are generated, they shall be deployed for generating the marker data.

Table 3.5.1. SSR primers screened in Ullal-3 × NRC-492 population (N= 89)

Species	No. of SSR primers screened	No. of polymorphic SSR primers
Cashew	21	6
Pistachio	28	6
Almond	24	11
Mango	65	16
Total	**138**	**39**

Table 3.5.2. Descriptive statistics of F_1 progenies (N=84)

Character	Minimum	Maximum	Mean	SD	Kurtosis	Skewness
Internodal length (cm)	2.00	13.80	6.01	2.52	0.31	0.77
Tree height (m)	3.10	9.80	5.78	1.23	0.85	0.48
Mean tree spread (m)	3.33	9.70	6.53	1.30	0.18	0.11
Stem girth (cm)	40.00	128.00	72.69	16.28	0.82	0.70
Weight of apple (g)	12.50	76.00	39.98	16.17	-0.90	0.22
Nut weight (g)	2.37	8.49	5.14	1.59	-0.93	0.30
Shell thickness (mm)	1.73	3.77	2.83	0.48	-0.75	-0.06
Shelling (%)	28.22	44.20	35.48	4.08	-0.71	0.33
Kernal weight (g) [along with testa]	0.99	2.78	1.78	0.43	-0.86	0.13
Kernal weight (g) [without testa]	0.88	19.80	1.86	2.03	76.38	8.54
Apple to nut ratio	2.81	18.63	7.86	2.52	3.13	0.89

The preliminary analysis with *chi-square* test indicated the co-segregation of markers such as AL-29 (from almond) with stem girth, nut weight and kernel weight (Table 3.5.3). Similarly, markers like IM-21 (from mango) seem to co-segregate with characters such as stem girth, nut weight, kernel weight, mean tree spread and, IM-28 with stem girth and intermodal length. The strength of this association will be clear upon analysis of mapping population with more SSR markers.

Table 3.5.3. Co- segregation of markers with characters

Markers	Characters
AL-29	Stem girth, nut weight and kernel weight
IM-31	Stem girth, nut weight, kernel weight, tree height and mean tree spread
IM-28	Stem girth and internodal length

3.5.2. Soil and leaf nutrient status of major cashew growing regions and establishment of nutrient diagnostic norms in cashew

Principal Investigator	Dr. Shamsudheen Mangalassery (Since 10 July 2017) Mrs. Prabha Susan Philip (From 18 February 2016 to 10 July 2017) Dr. T.R. Rupa (Till 18 February 2016)
Co-Principal Investigators	Dr. P.L. Saroj (Till 01 October 2016) Dr. M.G. Nayak (From 01 October 2016
Project code	2.1.2
Project duration	November 2013 to October 2018

Introduction

Cashew growing soils are generally deficient in N, P, K, S, Mg, Zn, B and Mo. The yield gap analysis revealed that the optimum production potential of cashew is yet to be tapped. Poor nutrition is likely to be one of the major factors contributing to low nut yield and quality. Optimization of cashew productivity and quality requires an understanding of the nutrient requirements of the tree, the factors that influence nutrient availability and the methods used to diagnose and correct deficiencies. Leaf analysis is a powerful tool in mineral nutrition research with perennial horticultural crops, not only to determine response to various nutrients but also as a diagnostic technique in assessing the deficiency symptoms and making fertilizer recommendations. The critical nutrient norms for agricultural and fruit crops are very well established. However, the information available on cashew is very limited. Absence of suitable soil and plant test norms in relation to optimum nut yield further jeopardizes the timely diagnosis of causes for low productivity in cashew. The project was taken up to collect the information on soil nutrient status in different cashew plantations in the country and to establish nutrient diagnostic norms with the following objectives.

Objectives

- To diagnose the soil and plant nutritional factors limiting the productivity of cashew in major cashew growing regions of India.
- To establish soil nutrient diagnostic norms for major cashew growing regions.
- To establish leaf nutrient diagnostic norms for cashew.

Soil and leaf nutrient status of major cashew growing regions

Regional surveys were carried out in cashew plantations of Puttur, Vengurla, Bhubaneswar, Bapatla, Pilicode and Vridachalam. Soil and leaf samples were collected from 70 orchards in each location. In Puttur, the soil pH ranged from 4.7 to 6.9, electrical conductivity from 0.01 to 0.23 dSm^{-1}, available nitrogen from 63 to 376 kg ha^{-1}, available P from 4.5 to 30.7 kg ha^{-1}, available K from 45 to 373 kg ha^{-1}. In Vengurla, the soil pH ranged from 4.35 to 5.87, electrical conductivity from 0.01 to 0.06 dSm^{-1}, available nitrogen from 150 to 534 kg ha^{-1}, available P from 7.4 to 29.2 kg ha^{-1} and available K from 20.8 to 432.1 kg ha^{-1}. In Bhubaneswar, the soil pH varied from 3.72 to 6.02, electrical conductivity from 0.03 to 0.29 dSm^{-1}, available nitrogen from 100 to 351 kg ha^{-1}, available P from

5.3 to 31.9 kg ha^{-1} and available K from 48.6 to 445.8 kg ha^{-1}. In Bapatla, the soil pH ranged from 5.19 to 6.18, electrical conductivity from 0.02 to 0.79 dSm^{-1}, available nitrogen from 62.6 to 401 kg ha^{-1}, available P from 7.3 to 35.5 kg ha^{-1} and available K from 47.4 to 474.1 kg ha^{-1}. In Pilicode, the soil pH ranged from 4.7 to 5.7, electrical conductivity from 0.02 to 0.13 dSm^{-1}, available nitrogen from 324.6 to 738.6 kg ha^{-1}, available P from 25.0 to 47.4 kg ha^{-1} and available K from 62.0 to 580.6 kg ha^{-1}. In Vridachalam, the soil pH ranged from 4.06 to 7.19, electrical conductivity from 0.02 to 0.51 dSm^{-1}, available nitrogen from 100 to 350 kg ha^{-1}, available P from 5.8 to 66.6 kg ha^{-1} and available K from 50.2 to 300.2 kg ha^{-1}. The percentage of samples under low, medium and high soil test category in different locations is provided in Table 3.5.4. Iron and manganese content were generally sufficient at all sampling locations. Among micronutrients, the deficiency was noticed for zinc and copper. The details on percentage samples deficient/sufficient with respect to zinc and copper are depicted in Fig. 3.5.1 and 3.5.2.

Table 3.5.4. Percentage of samples falling under low, medium and high soil test category for different nutrients at cashew orchards in different locations

Nutrient/Parameter	Location	Low	Medium	High
Organic carbon	Puttur	2.86	14.29	82.86
	Vengurla	20.00	5.71	74.29
	Bhubaneshwar	81.43	18.57	0.00
	Bapatla	91.43	8.57	0.00
	Pilicode	0.00	0.00	100.00
	Vridachalam	74.29	24.29	1.43
Nitrogen	Puttur	94.29	5.71	0.00
	Vengurla	37.14	62.86	0.00
	Bhubaneshwar	94.29	5.71	0.00
	Bapatla	75.71	24.29	0.00
	Pilicode	0.00	75.71	24.29
	Vridachalam	92.86	7.14	0.00
Phosphorus	Puttur	34.29	48.57	17.14
	Vengurla	60.00	5.71	34.29
	Bhubaneshwar	15.71	41.43	42.86
	Bapatla	8.57	58.57	32.86
	Pilicode	0.00	0.00	100.00
	Vridachalam	58.57	30.00	11.43
Potassium	Puttur	80.00	14.29	5.71
	Vengurla	41.43	52.86	5.71
	Bhubaneshwar	57.14	35.71	7.14
	Bapatla	22.86	58.57	18.57
	Pilicode	17.14	71.43	11.43
	Vridachalam	81.43	15.71	2.86

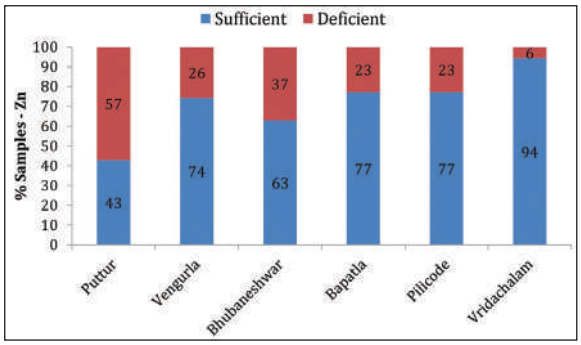


Fig. 3.5.1. Soil status of zinc in different cashew growing areas

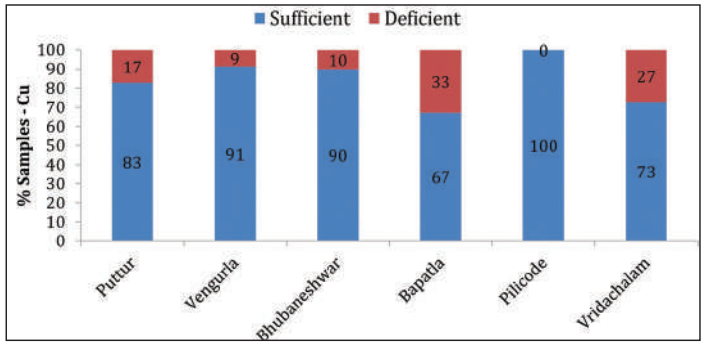


Fig. 3.5.2. Soil status of copper in different cashew growing areas

Leaf samples i.e. index leaves (4th leaf from tip of the shoots) were collected during the regional survey. The collected leaf samples were washed, dried, ground and processed for analysis of various nutrient contents. The leaf nutrient status in different cashew orchards across the country is given in Table 3.5.5.

Table 3.5.5. Range in leaf nutrient status in different cashew growing areas in India

Parameter	Cashew growing regions					
	Puttur	Vengurla	Bhubaneshwar	Bapatla	Pilicode	Vridachalam
N (%)	0.69 to 1.50	0.54 to 1.60	0.41 to 1.45	0.30 to 1.43	1.57 to 2.39	1.16 to 2.19
P (%)	0.10 to 0.15	0.12 to 0.20	0.13 to 0.24	0.15 to 0.21	0.16 to 0.25	0.08 to 0.44
K (%)	0.25 to 1.20	0.05 to 1.08	0.32 to 1.25	0.21 to 0.97	0.19 to 1.05	0.20 to 1.96
Ca (%)	0.12 to 0.29	0.60 to 1.3	0.99 to 2.50	0.99 to 2.20	0.74 to 2.23	0.06 to 1.10
Mg (%)	0.14 to 0.37	0.20 to 1.00	0.15 to 1.05	0.14 to 1.65	0.15 to 1.79	0.07 to 0.66
Fe (ppm)	36.25 to 275.60	39.02 to 249.92	1.98 to 358.60	0.98 to 260.40	16.92 to 242.23	107.90 to 526.20
Mn (ppm)	40.50 to 593.60	61.41 to 246.04	19.06 to 369.40	2.97 to 255.20	18.06 to 179.75	6.09 to 457.40
Zn (ppm)	2.49 to 25.0	5.50 to 76.30	1.98 to 48.50	0.25 to 65.93	2.76 to 32.41	3.79 to 32.92
Cu (ppm)	2.99 to 9.32	2.88 to 44.65	2.42 to 25.70	0.49 to 9.02	0.99 to 15.57	2.35 to 33.02

Nutrient diagnostic norms in cashew

For establishing the nutrient diagnostic norms, the leaf sampling was carried at flushing, flowering and fruit setting stages (October 2017, December 2017 and January 2018) from 100 trees of cashew variety Bhaskara. About 15 leaves were collected from different branches from all four sides. The leaves were immediately transported to the laboratory and washed using tap water, followed by 0.2% detergent solution, 0.1N hydrochloric acid and double distilled water. After washing, the leaves were allowed to dry under room temperature, followed by drying in a hot air oven at 60°C for 48 hours. The dried leaves were then powdered to pass through 0.5 mm sieve and stored in paper bags for analysis. These samples were analysed in the laboratory for N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu, B and Mo using standard methods. Nutrient diagnostic norms have been developed using the Diagnosis and Recommendation Integrated System (DRIS) approach. The deficiency and sufficiency ranges of nutrients in cashew for interpreting leaf tissue analysis are given in Table 3.5.6.

Table 3.5.6. Sufficency ranges of cashew leaf nutrients

Variable	Deficient	Low	Optimum	High	Excessive
N (%)	<1.93	1.93-2.23	2.23-2.82	2.82-3.12	>3.12
P (%)	<0.11	0.11-0.13	0.13-0.18	0.18-0.20	>0.20
K (%)	<0.91	0.91-0.63	0.91-1.47	1.47-1.75	>1.75
Ca (%)	<0.69	0.69-0.92	0.92-1.39	1.39-1.62	>1.62
Mg (%)	<0.34	0.34-0.46	0.46-0.70	0.70-0.82	>0.82
S (%)	<0.56	0.56-0.75	0.75-1.14	1.14-1.33	>1.33
Fe (ppm)	<704.12	704.12-877.64	877.64-1224.67	1224.67-1398.18	>1398.18
Mn (ppm)	<145.79	145.79-306.87	306.87-629.04	629.04-790.13	>790.13
Zn (ppm)	<44.39	44.39-54.15	54.15-73.67	73.67-83.43	>83.43
Cu (ppm)	<50.3	50.30-58.62	58.62-75.26	75.26-83.58	>83.58
B (ppm)	<8.98	8.98-21.46	21.46-46.43	46.43-58.91	>58.91
Mo (ppm)	<2.23	2.23-2.96	2.96-4.44	4.44-5.18	>5.18

3.5.3. Diversity and bio-ecology of insect pollinators and their efficiency in increasing the yield of cashew

Principal Investigator	Dr. K. Vanitha
Co-Principal Investigator	Dr. T.N. Raviprasad
Project code	3.2.1
Project duration	2014-2018

Introduction

Cashew (*Anacardium occidentale* L.), is an important cash crop, grown in Asian countries, East African countries, Brazil and in some packets of Sri Lanka, Australia, etc. Cashew is andromonoecious plant with staminate and hermaphrodite flowers appearing in the same inflorescence. Though its hermaphrodite flowers are self-fertile, they are not self-pollinating because of the arrangements of style and stamen. Besides, the pollen grains are sticky in nature that makes pollinating agents as quite obligatory for pollination. Fruit set in cashew is mainly influenced by the activity of pollinators and it has been confirmed that insects are main agents for pollination and a very less extent of pollination occurs by geitonogamy. In India, very few studies have been conducted on the foraging behaviour of selected pollinators, especially wild bees. Through previous studies, it has been confirmed that insects, mainly bees play a major role in cashew pollination. But, detailed documentation of pollinators including wild bees, insects other than bees involving in pollination, their seasonality, foraging behaviour and other pollinator flora has to be carried out for particular locality to understand the success of pollination ecology. In the same way, the possibility of increasing fruit set of cashew by augmenting pollinators in field has to be attempted. Conservation of pollinators in the field condition and timing of insecticidal spray to ensure their safety are some aspects that need intervention. Hence, the present project was taken up with the following objectives.

Objectives

- To document the diversity of insect pollinators of cashew and their natural enemies.
- To record the bio-ecology of prominent insect pollinators of cashew.
- To document the pollinator flora in cashew ecosystem and their importance.
- To examine the efficiency of pollinators in increasing cashew yield.
- To devise methods to conserve pollinators of cashew.

Materials and methods

The documentation of pollinators was done by conducting random field surveys at fortnight intervals in the cashew plantations of Puttur and Shantigodu region. The flower visitors were collected with fine mesh sweep nets and got identified. The diversity, seasonal incidence, relative abundance of pollinators of cashew were recorded by random surveys. Bee flora was also recorded. The foraging behaviour of pollinators was recorded by recording time spent by individual forager per flower, the number of flowers visited per plant per unit time, movement patterns, number of trips made etc. The importance and the efficiency of pollinators were assessed by controlled exposure of inflorescence to bees. Honey bee colonies were established at Shantigodu and bee activities were observed and the quality of honey was assessed.

Pollination potential of certain pollinators was assessed by single bee visits. The nesting biology, behaviour and natural enemies of predominant wild bees were also documented. Artificial nesting sites comprising drilled wooden blocks and dried sticks of selected plants including cashew were tested for their occupancy of wild bees. The safety of common insecticides against honey bees and wild bees was also tested in laboratory using dry film method besides field observations.

Diversity of pollinators

Cashew flowers are reported to be visited by insects of 40 species belonging to 13 families of three insect orders. Hymenopterans were major floral visitors comprising of bees (belonging to Apidae and Halictidae), ants and wasps followed by dipterans. Species visiting cashew flowers with less frequency without collecting pollen grains were considered as flower visitors but not pollinators. Among the 40 species, only 13 are considered as pollinators of cashew, in which eight species belong to Apidae and five species belong to Halictidae (Fig. 3.5.3). Diversity indices were worked out (Table 3.5.7). Simpson diversity index of 0.11 and Shannon diversity index of 2.3 shows a rich diversity of bees. Many of the dipterans are just visitors. Similarly, visits of sphecids and vespids might be for nectar as well as prey insects. Several ant species move over the cashew inflorescence mainly for extrafloral nectarines (EFN) and the honeydew of sucking pests present on cashew inflorescences. Still, the erratic movement of ants over the flowers may collect pollen and pollinate the flowers.

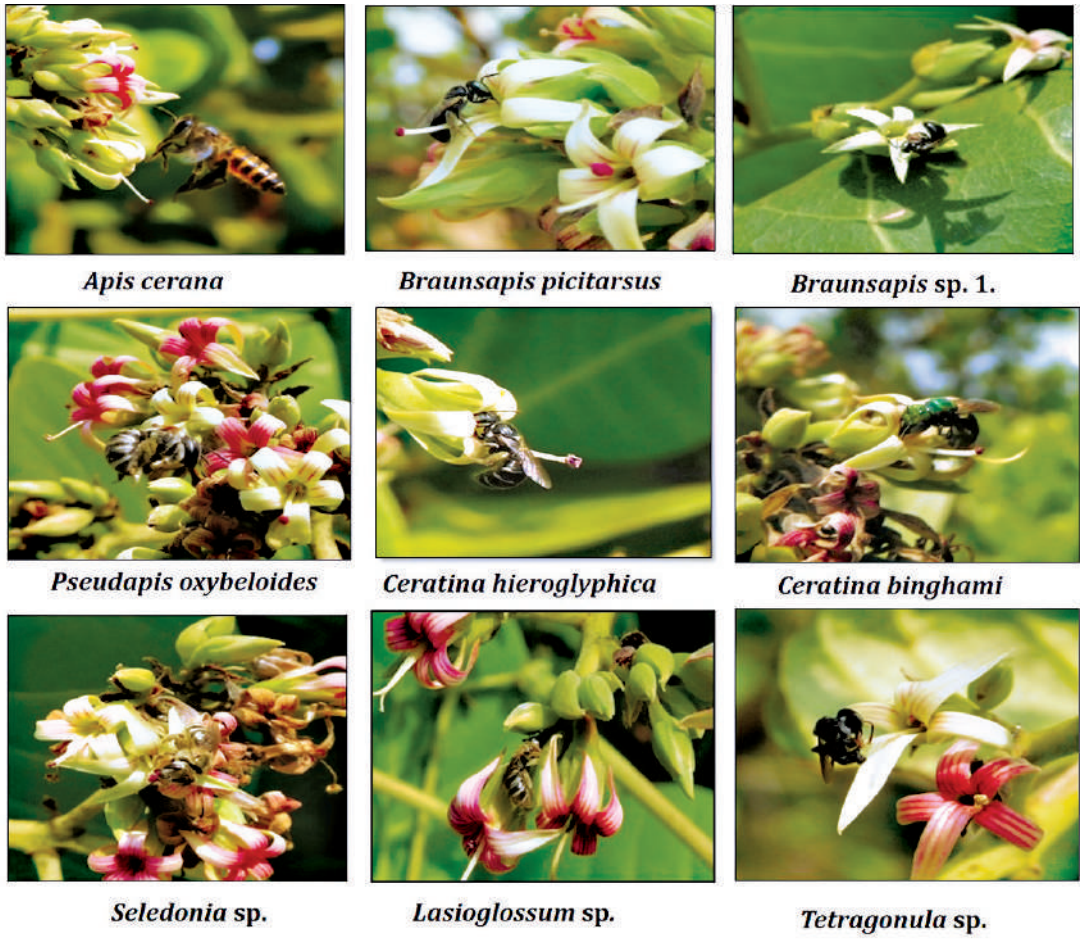


Fig. 3.5.3. Common pollinators of cashew

Table 3.5.7. Diversity indices of Hymenopteran bee pollinators of cashew

Diversity indices	Value
Richness	13.00
Simpson index	0.11
Shannon Index	2.30
Berger parker index	0.21

Relative abundance

Among the two bee families, Apidae was the most abundant with eight species contributing 75.6% of the bee abundance. And within Apidae, the highest species abundance was recorded for *Braunsapis picitarsus* (20%) followed by *Apis cerana-indica* (16.7%). Halictidae bees comprising of five species constituted 24.4% of the total bee abundance, among which *Pseudapsis oxybeloides* was the most abundant species (17.6%).

Foraging behaviour

During morning hours between 8.00 and 9.00 am, only three bee species were noticed foraging on cashew inflorescences, in which *Tetragonula* sp. was the abundant (80%) followed by *A. c. indica*. The stingless bees were actively moving over the panicles mostly for EFN. The peak bee activity was noticed from 11.00 am to 1.00 pm for most of the bees. During 10.00 am to 1.00 pm, *B. picitarsus* was the most abundant species (22–31%) followed by *P. oxybeloides* (18–25%). Later, a drastic decrease in bee abundance was observed during afternoon-evening hours.

Foraging rate in terms of the number of flowers visited/trip was more for *A. c. indica* (6–20) followed by *A. florea* (3–11) and *B. picitarsus* (4–7), while most of the other bees visited 2–5 flowers per trip (Table 3.5.8). Foraging speed varied between bee species. Whenever pollen was collected, the time spent on a flower was the minimum for collection of either pollen or nectar than the collection of both. Time spent by *A. c. indica* for nectar and *P. oxybeloides* for pollen was short (i.e. 1 to 4 s), while it was 3 to 21, 8 to 16 and 5 to 11 s for *A. florea*, *B. picitarsus* and *Tetragonula* sp., respectively. Since pollen was the foraging reward for most of the bee species, fresh male flowers were mostly preferred. Most bees collected pollen followed by nectar in the same male flower or nectar followed by pollen. Nevertheless, it was observed that the same hermaphrodite flower was visited by multiple bee species consequently, thus effecting pollination.

Table 3.5.8. Foraging behaviour of certain bees in cashew plantations

Insect pollinator species	Foraging rate (Nos /trip)		Peak foraging hours	Foraging speed (s)		Pollen load/ insect	
	Mean	Range		Mean	Range	Mean	Range
A. c. indica	11.2	6-20	10.00 am-3.00 pm	3.0	1-4	166.0	89 - 196
A. florea	6.4	3-11	10.00 am-2.00 pm	10.9	3-21	49.6	41 - 66
B. picitarsus	5.3	4-7	11.00 am-1.00 pm	11.5	8-16	804.9	524 - 924
C. hieroglyphica	3.8	3-5	11.00 am-2.00 pm	4.3	2-6	117.1	74-134
Tetragonula sp.	2.5	2-3	08.00 am-2.00 pm	8.5	5-11	135.1	84-156
Lasioglossum sp. 1	2.7	2-3	11.00 am-1.00 pm	3.6	2-5	123.3	79-136
P. oxybeloides	3.9	3-5	11.00 am-1.00 pm	3.1	1-4	813.9	502-998
Seledonia sp.	3.7	3-5	11.00 am-1.00 pm	3.3	2-5	809.6	456- 902

The need of pollinators for fruit set

Controlled exposure of bees during different periods on panicles has a difference in nut set percentage. Nut set was more when flowers were exposed to bees during 11.30 am -1.30 pm followed by 9.30 – 11.30 am. There was no nut set in flowers exposed for insect visit after 4.00 pm. Similarly, no nut set was recorded in caged inflorescences, while maximum nut set was recorded under combined hand and open pollination confirming that increased pollination is required for cashew yield enhancement.

Nesting behaviour of wild bees

Nests of *B. picitarsus* and *C. hieroglyphica* were noticed inside burrows of tiny dried sticks of cashew with clear roundish entrance hole (Fig. 3.5.4). *Tetragonula* bees nested inside holes in lamp posts, tubes and bamboo culms. Interestingly, nests of *P. oxybeloides* were noticed in barren soil exposed to sunlight as well as in the hard lateritic stones. These nests were deep inside beyond 40 cm in the hard lateritic stones. The life cycle of *B. picitarsus* and *C. hieroglyphica* was studied (Table 3.5.9).

Table 3.5.9. Duration of different stages of *C. hieroglyphica* and *B. picitarsus*

Stage of the bee	Duration (Days)	
	C. hieroglyphica	*B. picitarsus*
Egg	3	4-6
Grub	6-8	>30
Pupa	7-8	9-10
Adult (in lab condition)	8-13	4-7

Fig. 3.5.4. Nests of (a) *Ceratina hieroglyphica* (b) *B. picitarsus* and (c) *P. oxybeloides*

Natural enemies of bees

Natural enemies recorded on *Apis cerana* hives include wasps *viz., Vespa* sp., greater wax moth larvae (*Galleria mellonella*) and unidentified beetles. The grubs of *B. picitarsus* were found to be parasitized by Neochalcis group of parasitoids (*Chalcididae*), while, grubs of *C. hieroglyphica* were parasitized to the extent of 2 - 5%. During the rainy season, mummified adults of *C. hieroglyphica* were also noticed to the extent of 3 - 4%.

Bee flora

During flowering periods of cashew, most bee species foraged on cashew, but during the non-flowering period, bees also foraged on surrounding tree species. Weed species visited by bees include *Leucas aspera, Wedelia trilobata, Mimosa pudica, Melas tomamalabathricum, Spermacoce hispida, Blumea* sp., *Antigonon leptopus, Tridax procumbens, Passiflora foetida, Alternanthera* sp., *Gompherena* sp., *Lantana camara, Ixora* sp., *Terminalia* sp. and

Caesalpinia spp. which are common in the study location. *A. leptopus* was found very favourable to several bee species.

Single bee visits

Freshly opened hermaphrodite flowers were confined with a small tissue paper cover after a single visit of bees and covers were removed after two days. Preliminary observations revealed that single successful visits of *B. picitarsus, A. cerana, Pseudapis oxybeloides* and *C. Hieroglyphica* bees could result in 10-35% nut set, which needs to be studied further. But, important factors like pollen load on the bees, the position of bee touching the stigma of flower significantly influence the nut set in this case.

Artificial bee nests

Attempts have been made to design artificial bee nests for wild bees . Wooden blocks made with neat circular holes (1.5 to 5 mm diameter and 7-9 cm length) and thin sticks of bamboo, *Lantana camara, Cenchrus* sp., and cashew were arranged. Bigger holes in wooden blocks were occupied by *Megachilids, Ceratina* sp. and *Tetragonula* sp. *Braunsapis* bees occupied mainly the medium sized holes (60%) and only 5-7% of tiny holes. The tiny sticks, especially of bamboo were also well occupied by *Braunsapis* sp. Hence, such artificial bee nests could help in conserving the wild bees.

Pesticide poisoning

The activity of pollinators including wild bees was very less during the first two days of spraying. After spraying, few dead bees were noticed on the leaves which could be the ones that came in direct contact with the sprayed pesticides. Nut set was low (10.6%) during the 1st week of spraying than the later period (36.3%). The insecticides namely lambda cyhalothrin, carbosulfan and acetamiprid were tested at field doses as well as half the dose by dry film method. Among which lambda cyhalothrin was highly toxic to bees followed by carbosulfan and acetamiprid. The mortality percentage of *A. cerana* and *A. florea* was high compared to *B. picitarsus* and *C.hieroglyphica* for all three insecticides.

Conclusions

Among the 40 species recorded as flower visitors of cashew in the study location, 13 species are considered as pollinators of cashew including wild bees. Nesting sites of different bee species and the common bee flora in the study area were also recorded. Observations revealed that bees are very important in the pollination of cashew, and this study highlights the systematic documentation of various bee species important for cashew, helping the researchers, cashew farmers and beekeepers to plan for proper management and conservation of bee species. Though pollination is a free service provided by bees including several wild bees, they need to be conserved and protected from insecticidal sprays to enhance cashew pollination and productivity. Knowledge on bee flora in and around the cashew plantations, especially during non-flowering periods of cashew, is also important for the conservation of bees.

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

The dissemination of agro-techniques related to nutrient management was slow due to non-involvement of farmers in the technology dissemination programmes. Farmers remained reluctant to adopt the new technologies primarily due to lack of awareness and poor socio-economic conditions. One of the major bottlenecks in realizing the potential yield from cashew is the poor fertility status of soil where cashews are grown and less attention is given to the nutrient management by growers. Technologies developed at research institutes show that 50 to 100% yield increase is possible in cashew by providing timely nutrition. The situation is alarming and will have a deteriorating effect on soil quality as well. This project has been formulated to create a centre for excellence in nutrient management with state of art laboratory facilities and demonstration plot to showcase the usefulness of improved technologies to realize higher yield and income to cashew growers of Karnataka in particular and other regions in general. The demonstration with farmer's participation will benefit the growers to appreciate 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 was made ready for planting. In those 4.5 acres, 3 acres will be used for establishing demonstration plots at normal density planting and 1.5 acres under high density planting. The field was prepared and fenced and made ready for planting with the onset of monsoon. To demonstrate the usefulness of precision agricultural activities installation of drip systems is also planned. Also, a storeroom was constructed.

Field preparation activities for establishing demonstration plots

Front line demonstration in the farmer's 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 meeting 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 these 59 farmers responded well to the trials and carried out activities on advanced plant health management.


Diagnostic field visits in Dakshina Kannada


Diagnostic field visits in Uttara Kannada


Diagnostic field visits in Udupi

Training

Trainings were conducted in the selected districts for the benefit of farmers on advanced cashew production technology. In addition, exposure visits of farmers to the demonstration plots were carried out for lateral spread of scientific knowledge.

Training on advanced cashew production technology at Kundapura, Udupi

Field exposure visit

A field exposure visit was conducted on 5 December 2018 at Udupi district, Karnataka. During this programme, farmers were taken to the cashew demonstration plots being undertaken by ICAR-DCR, Puttur in Udupi district under the RKVY-RAFTAAR project. The farmer's queries on various aspects of cashew production technology were addressed by Dr. Shamsudheen Mangalassery. Farmers interacted with their queries and also shared their experiences about the field visit. A total of 60 farmers participated in the field exposure visit.

Plant health clinic cashew 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 & others a museum was proposed to be established under the project. The work involved right from designing to completion. The design was approved after a series of meetings and consultations. During the financial year 2018-19, the phase I activities of the museum has been completed. This includes the development of models, showcases and interactive kiosks. The phase II will cover wall panelling, providing 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 Mela and Agri Expo – 2018: ICAR-DCR, Puttur participated in Krishi Mela and Agri Expo–2018 conducted at ICAR-Central Plantation Crops Research Institute, Regional Centre, Kidu from 10 to 11 November 2018. The directorate put up an exhibition stall showing the technologies developed by ICAR-DCR, Puttur. The stall was visited by more than 3000 diverse group of beneficiaries such as farmers of Karnataka, Kerala and Tamil Nadu, students, researchers, processors

and the general public. The stall was managed by Dr. Preethi, P., Dr. Eradasappa, E., Mr. Bojappa Gowda and Mr. Vijay Achary.

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

4.3. Farmers visit/field day at ICAR-DCR

Sl. No.	Details	Date	Co-ordinator
1.	Members of Chintana group, Puttur were briefed about cashew crop and its cultivation aspects and were showed the research activities being carried out at ICAR-DCR, Puttur.	10 May 2018	Siddanna Savadi
2.	Delivered lecture on "Scope for Cashew cultivation and new technologies in cashew" to the visiting farmers of Nagamangala taluk, Mandya District.	26 June 2018	Muralidhara, B.M.
	Delivered lecture on "Overview of Cashew" to PG students of Department of Plantation, Spices, Medicinal and Aromatic Crops, & Soil Science and Agricultural Chemistry of College of Horticulture, Bengaluru under UHS, Bagalkot.	30 July 2018	"
	Delivered lecture on "Overview of Cashew" to IV B. Sc. (Hort.) students of College of Horticulture, Mudigere under UAHS, Shivamogga.	1 September 2018	"
3.	Botany students of Vivekananda College, Puttur were given the lecture and demonstration on different Molecular biology and Biotechnology techniques.	4 September 2018	Siddanna Savadi
4.	Field day/exposure visit to DCR experimental fields and sections was arranged to 50 farmers of Farmers Producers Organization, KVK Tiptur, Tumkur Dist of Karnataka.	22 January 2019	Eradasappa, E.

5.	Field day/exposure visit to DCR experimental fields and sections was arranged to 25 farmers from Vengara block, Malappuram under ATMA programme.	15 February 2019	Shamsudheen Managalassery
6.	Field day/exposure visit to DCR experimental fields and sections was arranged to 30 farmers of Haveri district, Karnataka	1 March 2019	Siddanna Savadi
7.	Field day/exposure visit to DCR experimental fields and sections was arranged to 30 farmers from ATMA, Raigad, Maharashtra.	7 March 2019	Shamsudheen Managalassery
8.	Field day/exposure visit to DCR experimental fields and sections was arranged to 45 farmers from ATMA, Wayanad, Kerala.	23 March 2019	Shamsudheen Managalassery

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

- Dr. T.N. Raviprasad participated as a resource person on cashew pest management in the "Cashew Field Day and Cashew Farmers Meet" organized jointly by RKVY and KCDC, Mangaluru on 14 December 2018 and interacted about management strategies of TMB and CSRB with KCDC field staff and managers as well as farmer participants.
- Dr. Shamsudheen Mangalassery conducted monitoring of field trials/ demonstration under RKVY project in Udupi and Uttara Kannada districts on 28 and 29 December 2018 respectively.

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

Development of an exclusive Android application for cashew cultivation

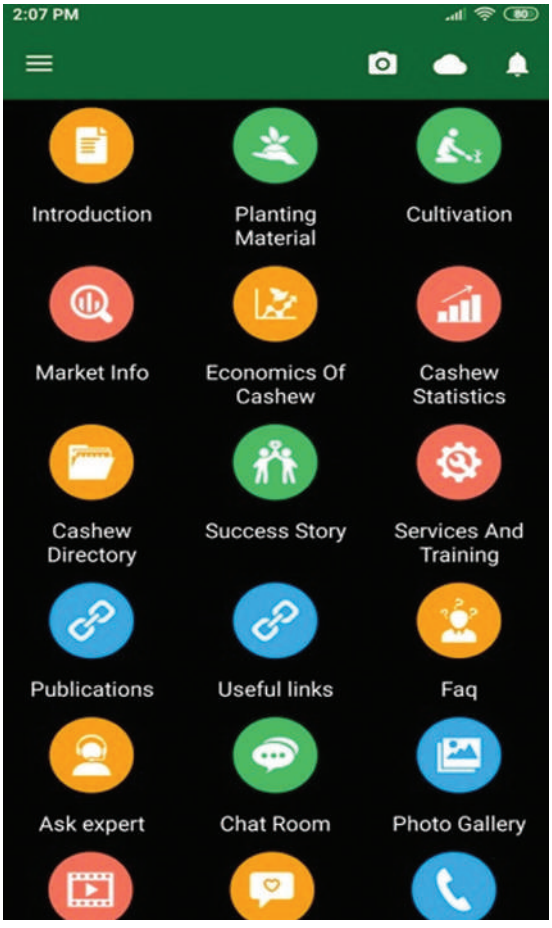
During the year, an Android app named 'Cashew Cultivation' was developed using the latest IT technologies. The app gives comprehensive information on various aspects of cashew cultivation, marketing and stakeholders involved in cashew. The unique features of this app are as follows.

- Farmer/user can upload and store his own cashew images and videos in "My cashew" sub-section of "Cultivation" section. It is also possible to record the expenditure, observations and data of the cashew farm.
- It is possible to order for the requirements of cashew grafts online in "Planting Material" section with the research stations near to farmers in each state.
- Users can give their buy/sell requirements in "Market info" section.
- The app is developed for 10 states of India such as Gujarat, Maharastra, Karnataka, Kerala, Tamil Nadu, Andhra Pradesh, Chattisgarh, Odisha, West Bengal and Meghalaya and the information is made available in 10

languages, i.e., Hindi, English, Gujarati, Marathi, Kannada, Malayalam, Tamil, Telugu, Oria and Bengali.

- User can contact experts through "Ask Expert" section.
- Real-time chatting is possible in "Chat Room" with the users who are using the app at a given point of time.
- E-speak button enables the app to read the text for users in different sections.

The app is being saturated with data sets and cashew cultivation information from different AICRP centres in different languages which will be released soon for public use via google play store.



Main modules in cashew Android app

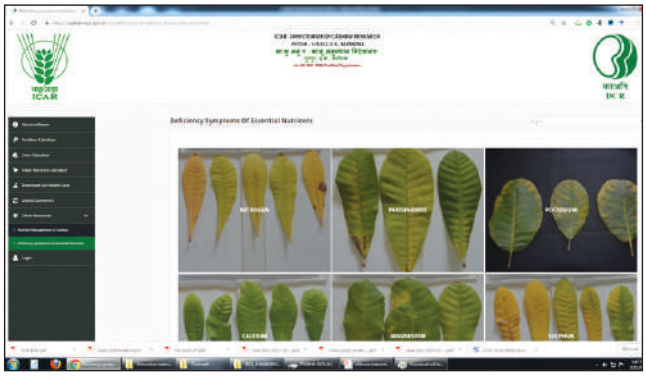
The landing page of cashew Android app

Cultivation modules in cashew Android app

Nutrient management software and mobile app

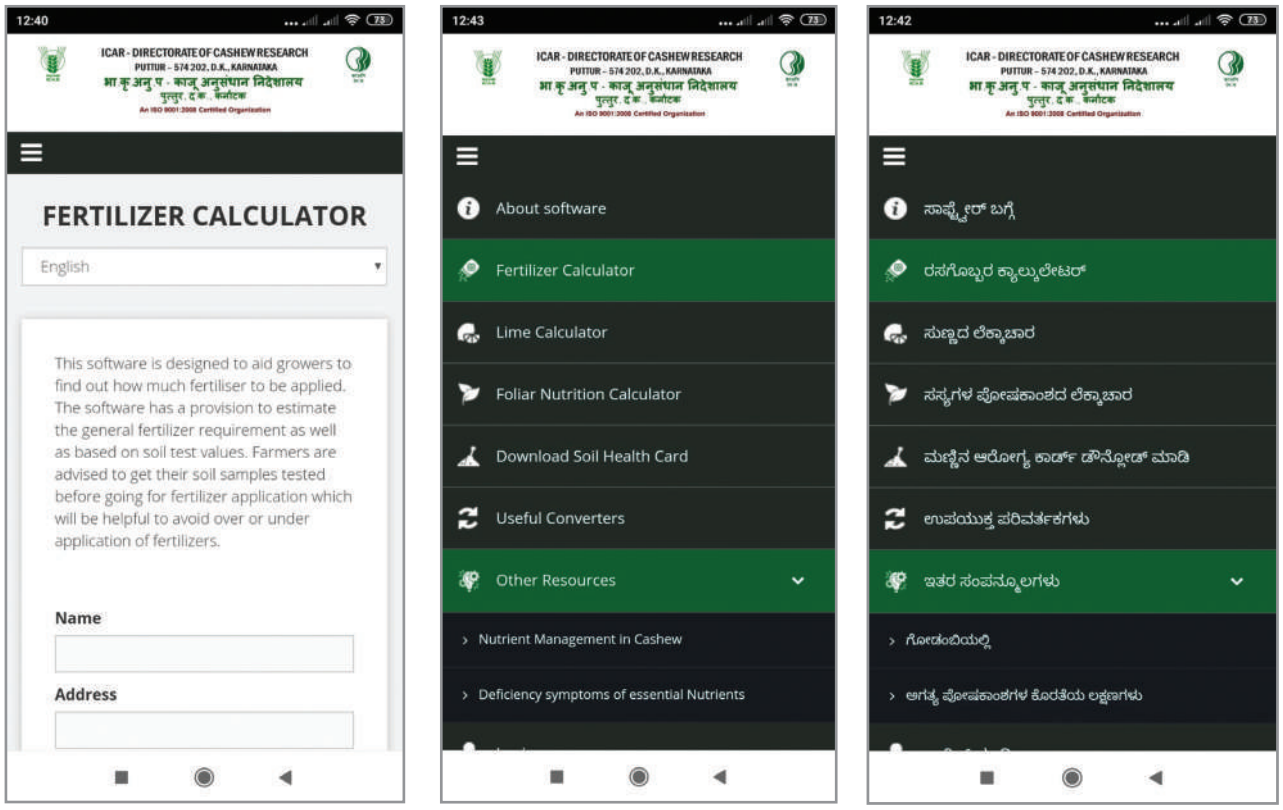
One of the major constraints in realizing the potential yield in cashew was limited attention given by growers on nutrient management. The application of the right quantity of required fertilizer at the right time is important for the judicious management of resources for achieving the maximum benefit and income. In this regard, a software for nutrient management in cashew was prepared under the project funded by RKVY-RAFTAAR. This 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 to download the soil health card issued by ICAR-DCR, Puttur. The link of the software is https://cashew.icar.gov.in/soil

The landing page of the nutrient management software on DCR website



Software showing deficiency symptoms and corrective measures

The mobile app version of the software was also prepared under RKVY-RAFTAAR. This 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



Overview of the mobile app on Cashew Nutrient Manager

Offline software in both English and Kannada was prepared to generate the soil health card, under RKVY-RAFTAAR. It enables to generate error-free soil health card from the analytical results as single and multiple pdf files.

Websites

- Mohana, G.S., and Muthuraju, R. 2018, Developed the webpage of AICRP www.cashew.icar.gov.in/aicrpc
- Mohana, G.S., Muthuraju, R., Adiga J.D., Preethi, P., Muralidhara, B.M. and Siddanna Savadi. 2018, Developed the Cashew phenology webpage www.cashew.icar.gov.in/phenology
- Muthuraju, R. and Mohana, G.S. 2018, Maintained the website of Directorate of Cashew Research https://cashew.icar.gov.in/

4.6. Radio/TV talk/lectures

The details of radio talk, TV talk/interview and lectures by the scientists of ICAR-DCR, Puttur is given below.

M.G. Nayak	Acted as a resource person for the training on cashew cultivation organised by DCCD, Kochi at Mangaluru to the officials of development departments.	28-29 May 2018
M.G. Nayak	Acted as a resource person for training of farmers and staff of KCDC at Moodubidri, Dakshina Kannada, Karnataka.	4 September 2018
Muralidhara, B.M.	Delivered a talk on "Recent developments in Cashew" to the farmers and forest department officials at Moodubidri, Dakshina Kannada, Karnataka. The programme was organised by KCDC.	4 September 2018
M.G. Nayak	Delivered a lecture on "Improved cashew cultivation" to the farmers and officials of KCDC at Kumta, Uttara Kannada.	14 September 2018
	Delivered a lecture on "Cashew" at the seminar organised by Krishik Samaj at Udupi district.	1 December 2018
Mohana, G.S.	Participated as a resource person and gave a talk on "Improved cashew cultivation practices" during Cashew Field Day conducted by Karnataka Cashew Development Corporation, Mangaluru at the ICAR-Directorate of Cashew Research, Puttur.	14 December 2018
M.G. Nayak	TV talk and discussion on "Cashew cultivation practices" on DD1 recorded on 28 January 2019 and telecasted on 2 May 2019.	28 January 2019
Eradasappa, E.	Participated as a resource person and delivered a talk on "Cashew cultivation practices" in the Agri and Horticulture Farmers Mela at Alike, Bantwal Taluk, Dakshina Kannada organized by KAMPU Agriculture and Horticulture Crop Producer Company Limited, Vitla, Bantwal, Dakshina Kannada, Karnataka.	26 February 2019

4.7. Teaching/Training/Guiding of Students

Dr. Siddanna Savadi

- Supervised the research projects and thesis writing of two M.Sc. students of Mangalore University on the topics "Molecular characterization of interspecific hybrids and genetic diversity analysis in cashew (*Anacardium occidentale* L.)" and "Transferability of mango EST-based SSRs and genetic diversity analysis in Cashew (*Anacardium occidentale* L.)".
- Supervised the project and thesis writing of two M.Sc. students of SDM College, Ujire on the topic "Genetic diversity assessment in selected germplasm accessions of cashew (*Anacardium occidentale* L.) based on SSR markers".

5. AICRP / Co-ordination Unit

5.1. Annual Group Meeting (AGM) of AICRP on Cashew - 2018

The Annual Group Meeting (AGM) of Scientists of AICRP on Cashew was organized at the Odisha University of Agriculture and Technology (OUAT), Bhubaneswar from 6 to 8 December 2018. Professor S. Pashupalak, Hon'ble Vice-Chancellor, OUAT, Bhubaneswar and Dr. W.S. Dhillon, ADG (Hort.), ICAR, inaugurated the AGM. More than 75 delegates from Coordinating Centres of cashew, invitees, OUAT staff, and media persons participated in the meeting. The welcome address was delivered by Dr. L.M. Garnayak, Dean of Research, OUAT. The Project Coordinator's report was presented by Dr. M.G. Nayak, Director (Acting), ICAR-DCR, Puttur wherein he highlighted the activities taken up by 14 AICRP Cashew Centres. He mentioned that the centers are maintaining 1726 accessions and have released 43 high yielding cashew varieties for commercial cultivation. Around 3.95 lakh cashew grafts were produced and supplied to farmers during 2017-18. He emphasized the importance of high density planting, canopy management for harvesting solar energy, promotion of intercrops in new plantations and management of CSRB. He informed that AICRP centres are also playing a major role in the transfer of technologies for cashew cultivation and more than 43 trainings were conducted on different aspects of cashew cultivation. The centres have also taken up 13 training and 8 awareness camps in addition to frontline demonstrations in 46 ha area under Tribal Sub Plan Project.

The Presidential address was delivered by Prof. S. Pashupalak wherein he mentioned that cashew is a prominent cash crop and focused on public-private partnership for market intervention. The Chief Guest address was delivered by Dr. W.S. Dhillon, ADG (Horti.), ICAR, and he mentioned that one-third total export earnings from horticultural crops were contributed by the cashew alone which suggests the great economic importance of this crop.

During the meeting a proposal for revised standards for variety release in cashew was presented. On this occasion, H-130, the cashew hybrid of ICAR-DCR was released and recommended for cultivation in farmer's field. On this occasion, three folders in Gujarati language were released by Agricultural Experimental Station (AES, Paria), one folder in Malayalam language by Cashew Research Station (CRS), Madakkathara and three publications by CRS, Bhubaneswar and Status on cashew by ICAR-DCR, Puttur. A website of AICRP-Cashew (https://cashew.icar.gov.in/aicrpc)

was also launched during this occasion and this is designed by Mr. K. Muthuraju and Dr. G.S. Mohana at ICAR-DCR, Puttur. Later, the technical session on 'Crop Improvement' was held in the afternoon. The discussions on 'Crop Management and Crop Protection' were held on 7 December 2018. An 'Interface of farmers, scientists, processors and officials from development departments' was held on 8 December 2018 in which more than 100 farmers, officers from the Horticulture Department of Odisha State and officials of Cashew Development Corporation, Odisha State Agency for Cashew Cultivation besides the Scientists of AICRP-Cashew participated. The session was chaired by Dr. Venkatesh N. Hubballi, Director, DCCD, Kochi. The problems and suggestions of farmers regarding cashew was also discussed at length and the AGM was concluded with the plenary session.

Web page of AICRP on Cashew

6. AWARDS / RECOGNITIONS

6.1. Awards

Dr. J.D. Adiga

- Received the Distinguished Researcher Award-2018 in the International Conference of Scicon series on "Research interventions and advancements in life sciences-2018", held at Pune, Maharashtra by Scire Science, during 1-3 August 2018.

Dr. Shamsudheen Mangalassery

- Received the outstanding best research paper award by Nature Science Foundation, Coimbatore on 30 September 2018.
- Received the Distinguished Scientist Award 2018 of the Agro-Environmental Development Society, Rampur, UP, India during the International conference on emerging issues in agricultural, environmental and applied sciences for sustainable development (EIAEASSD-218).
- Secured the First position in oral presentation in the International conference on emerging issues in agricultural, environmental and applied sciences for sustainable development (EIAEASSD-218) at Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Allahabad, UP, during 27-29 November 2018 for the presentation on "Soil and water management strategies for increasing income from cashew orchards and consideration of natural resources."

Mr. Rajkumar A. Dagadkhair

- Received "SCIRE Nutrition Scientist - 2018", during International Conference of Scion series on "Research interventions and advances in life sciences" held at Pune, Maharashtra by Scire Science, during 1 to 3 August, 2018.

Dr. Babli Mog

- Received Kanwar Virender Singh Memorial All India Best Publication Award in Fruit Science-2018 by SADHNA for research article "Germination and seedling establishment in cashew *(Anacardium occidentale* L): an interaction between seed size, relative growth rate and seedling biomass" authored by Mog, B., Adiga, J.D., Nayak, M.G. and Mohana, G.S. *Journal of Plantation Crops,* 2019, 45(2): 110-120.
- Received second position in oral presentation in the National seminar on abiotic stress management at TNAU, Coimbatore during 25-26 October 2018 for research abstract "Simple screening methodologies for evaluation of cashew accessions for salinity stress tolerance" by Babli Mog, Nayak, M.G. and Mohana, G.S.

Dr. Siddanna Savadi

- Received second prize in the "Smaran shakti" competition held on the occasion of Hindi Sapthaha on 26 September 2018 by Puttur Town Official Language Implementation Committee (TOLIC), ICAR-DCR, Puttur.

Mr. Muralidhara, B.M.

- Received top 25 young scientist awards by the Education Expo TV Research Branding Company Award during 17 June 2018 at Bengaluru.

6.2. Recognitions

Dr. M.G. Nayak

- Member, National steering committee on cashew, Government of India.
- Member, Doubling farmers income, Karnataka state committee (ICAR).
- Member, Committee for verification of GM crops applications, Government of Karnataka.
- Member, Board of Coastal Cashew Technology Development Institute, Kumata, Government of Karnataka.
- Member, Cashew Nursery Certification Committee, DCCD, Kochi.
- Invited as Guest of Honour in Krishi Mela of UAHS, Shivamogga on 4 October 2018.
- Participated in Indian Caju Fest – A Global Event as an invitee 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.
- 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.

Dr. D. Balasubramanian

- Selected as the Member of Executive Committee of Indian Society of Plantation Crops (ISPC) for the period 2018-20.

Dr. J.D. Adiga

- Chaired a session during International Conference of Scicon series on "Research interventions and advancements in life sciences-2018", held at Pune, Maharashtra, during 1-3 August 2018.
- Nominated as the external examiner for conducting final viva voce exam of Ph.D. (Hort.) student at College of Horticulture (UHS, Bagalkot) on 24 August 2018.
- Nominated as the external examiner for conducting qualifying exam of M.Sc. and Ph.D. (Hort.) students in the discipline of Plantation, Spices, Medicinal and Aromatic crops at 3 different PG campuses (Bengaluru, Bagalkot and Arabhavi) of UHS, Bagalkot from 18 to 21 February 2019.

Dr. Mohana, G.S

- Acted as an expert for the selection committee for selection of JRF under the project on 'Development of DUS test guidelines in Cocoa" held on 28 August 2018 at ICAR-CPCRI, Regional Station, Vittal.
- Coordinated the session on "Use of information technology to farmer" during Krishi Yantra Mela organised by Vivekananda College of Engineering and Technology, CAMPCO and others at Puttur, Dakshina Kannada during 23-25 February 2019.

Dr. Shamsudheen Mangalassery

- Recognised as the PG teacher at the University of Agricultural and Horticultural Sciences (UAHS), Shivamogga w.e.f. 8 August 2018.
- Recognised as PG teacher at the University of Horticultural Sciences (UHS), Bagalkot w.e.f. 14 August 2018.
- Served as an external examiner for final thesis viva voce examination of Ms. Aswini, B.N., M.Sc. (Ag.) student in Soil Science & Agricultural Chemistry, College

of Agriculture (KAU), Padannakkad on 12 October 2018.

- Conducted qualifying viva voce examination of three M.Sc. (Ag.) students (Mr. Wayoolang Talang, Mr. Amalendu. M.V. and Ms. Roshni John) at College of Agriculture (KAU), Padannakkad on 2 March 2019.

Dr. Eradasappa, E. and Dr. Siddanna Savadi

- Participated as judge in the Zoology Department event "Polemic (Debate)" held during an Inter-Collegiate Science Fest "Aurora 2019'' at St. Philomena College on 02 February 2019.

Mr. Rajkumar A. Dagadkhair

- Received an appreciation certificate from the organizing committee of International Conference on UNESCO chaired "World Parliament of Science, Religion and Philosophy 2018" (2-5 October 2018) at Maharashtra Institute of Technology Arts Design and Technology (MIT ADT) University, Pune, Maharashtra for outstanding contributions in making the event a grand success.
- Appointed as chairman for question paper setting of semester end examinations of the course "Food laws and Regulation" of M.B.A. (Agri. and Food Business Management - Marketing) held during April - May 2019 by the Chairman, Board of Examinations, Maharashtra Institute of Technology Arts, Design and Technology (MIT ADT) University, Pune, Maharashtra.

Dr. Preethi, P.

- Acted as a panel member for contractual recruitment under Revolving fund project at CPCRI- Regional Station, Vittal on 4 October 2018.

6.3. Resource person/lecture

Mohana, G.S.	Resource person for Inter-collegiate Science Writing and Communication workshop held at St. Philomena College, Puttur, organised by Department of Physics in association with All India Radio, Mangaluru and presented a talk on "Science Writing and Communication".	6 September 2018
Mohana, G.S.	Delivered a lecture on "Plant Genetic Resources in Cashew" during ICAR Sponsored training under CAFT on Conservation and Utilization of Plant Genetic Resources in Plantation and Spice Crops organised for a period of 21 days from 11-31 October 2018 at College of Horticulture, Bengaluru.	24 October 2018
Eradasappa, E.	Delivered a lecture on "Scope of Agricultural Education" and explained the research activities of the Directorate to the 2nd PUC Science Students of Govt. Pre-University College, Puttur, D.K., Karanataka.	26 October 2018
Rajkumar A. Dagadkhair	Delivered a lecture on "Proximate analysis of food" as an invited speaker at two days Board of Student Development, Savitribai Phule Pune University (SPPU), sponsored state level Hands on Workshop on Food analytics and quality control organized by Department of Biotechnology, Sinhgad College of Science, Ambegaon, Pune.	12-13 February 2019

7. PUBLICATIONS

7.1. Research / Review articles

Babli Mog. and Nayak, M.G. 2018. Leaf morphological and physiological traits and their significance in yield improvement of fifteen cashew varieties in west coast region of Karnataka, India. *International Journal of Current Microbiology and Applied Sciences* 7(7):1455-1469.

Babli Mog, Adiga, J.D. and Nayak, M.G. 2018. Role of plant growth hormones in cashew: Key strategy for modifying crop performance. *International Journal of Current Microbiology and Applied Sciences* 7(7):1470-1484.

Mangalassery, S., Kalaivana, D. and Philip, P.S. 2019. Effect of inorganic fertilisers and organic amendments on soil aggregation and biochemical characteristics in a weathered tropical soil. *Soil and Tillage Research* 187: 144-151.

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.* https://doi.org/10.1007/s00271-019-00625-7.

Meena, R.K., Saroj, P.L., Adiga, J.D., Nayak, M.G. and Meena, H.R. 2018. Effect of paclobutrazol on flowering, fruiting and yield of cashew in west coast region of Karnataka. *International Journal of Current Microbiology and Applied Sciences* 7(10): 380-391.

Mohana, G.S. and Nayak, M.G. 2018. Unique decision support system for cashew germplasm management. *Journal of Plantation Crops* 46(2):128-132.

Sajeev, M.V. and Saroj, P.L. 2018. Socio-economic determinants and adoption of pest management practices in cashew farming: A study in Dakshina Kannada, Karnataka. *Journal of Plantation Crops* 46(1):66-73.

Sajeev, M.V., Saroj, P.L. and Meera Manjusha, A.V. 2018. Impact of production technologies on area and productivity of cashew in North Kerala. *Indian Journal of Extension Education* 54(2):100-107.

Vanitha, K. 2018. Egg parasitism in *Humbertiella similis,* a common bark mantid in cashew plantations at Puttur. *Journal of Applied Zoological Researches* 29(1):85-88.

Vanitha, K. and Raviprasad, T.N. 2018. Diversity, species richness and foraging behaviour of pollinators in cashew. *Agricultural Research.* https://doi.org/10.1007/s40003-018-0370-2.

Vanitha, K., Bhat, P.S. and Raviprasad, T.N. 2017. Mantid fauna of cashew plantations, seasonal occurrence and biology of a few species. *Indian Journal of Plant Protection* 45(4):327-333.

Vanitha, K., Raviprasad, T.N. and Shwetha, V. 2018. Life cycle of *Eocanthecona furcellata* Wolff. (Hemiptera: Pentatomidae) a predatory bug in cashew plantations, upon rearing on wax moth larvae. *Journal of Entomology and Zoology Studies* 6(2):3007-3010.

7.2. Abstracts / Chapters in Symposia / Workshops / Seminar

Adiga, J.D. Muralidhara, B.M., Preethi, P. and Savadi, S. 2019. Identification of phenological growth stages of the cashew tree *(Anacardium occidentale* L.) according to the extended BBCH scale. PLACROSYM XXIII (6-8 March 2019), Indian Society for Plantation Crops at Central Coffee Research Institute, Chikkamagaluru, Karnataka, India. p. 61.

Adiga, J.D, Nayak, M.G., Mohana, G.S., Muralidhara, B.M., Savadi, S. and Eradasappa, E. 2018. Evolving cashew hybrids for higher nut yield. 2nd International conference on Research interventions and advancements in Lifescience (SciCon Series - RIAL-2018) (1-3 August 2018), Pune, India. p. 10.

Babli Mog., Nayak, M.G. and Mohana, G.S. 2018. Simple screening methodologies for evaluation of cashew accessions for abiotic stress tolerance: Salt stress as a paradigm. National seminar on abiotic stress management (25-26 October 2018), Department of Crop Physiology, Tamil Nadu Agricultural University at TNAU, Coimbatore, Tamil Nadu, India. p. 46.

Balasubramanian, D. 2019. Prediction model for dehydration characteristics of cashew apple slices. PLACROSYM XXIII (6-8 March 2019), Indian Society for Plantation Crops at Central Coffee Research Institute, Chikkamagaluru, Karnataka, India. p. 141.

Eradasappa, E. and Mohana, G.S. 2019. Investigations on self-compatibility and extent of self and cross-pollination in cashew. PLACROSYM XXIII (6-8 March 2019), Indian Society for Plantation Crops at Central Coffee Research Institute, Chikkamagaluru, Karnataka, India. p. 25.

Lakshmipathi., Adiga, J.D. and Kalaivanan, D. 2018. Influence of plant growth regulators on leaf area, chlorophyll content, carotenoids, stomatal count and yield of cashew. 2nd International conference on Research interventions and advancements in Lifescience (SciCon Series - RIAL-2018) (1-3 August 2018), Pune, India. p. 17.

Mangalassery, S. 2018. Soil and water management strategies for increasing income from cashew orchards and conservation of natural resources. International Conference on emerging issues in agricultural, environmental and applied sciences for sustainable development (EIAEASSD-218) (27-29 November 2018), Agro-Environmental Development Society (AEDS), Majhar Ghat, Rampur, UP at Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Allahabad, UP, India. p. 86.

Mohana, G.S. and Nayak, M.G. 2019. Development of an exclusive android application for cashew cultivation. PLACROSYM XXIII (6-8 March 2019), Indian Society for Plantation Crops at Central Coffee Research Institute, Chikkamagaluru, Karnataka, India. p. 147.

Nayak, M.G. and Muralidhara, B.M. 2019. H-130: A new bold nut cashew hybrid for higher yield and quality. PLACROSYM XXIII (6-8 March 2019), Indian Society for Plantation Crops at Central Coffee Research Institute, Chikkamagaluru, Karnataka, India. p. 26.

Nayak, M.G., Muralidhara, B.M., Janani, P. and Savadi, S. 2019. Performance of cashew *(Anacardium occidentale* L.) varieties under different

planting density for growth and yield traits. PLACROSYM XXIII (6-8 March 2019), Indian Society for Plantation Crops at Central Coffee Research Institute, Chikkamagaluru, Karnataka, India. p. 69.

Rajkumar A. Dagadkhair., Janani, P., Raichurkar, S.J. and Preethi, P. 2019. Tannins reduction in cashew apple juice by techno-economically potent food grade materials. Seminar on process intensification in chemical, food and allied industries (9 March 2019), at University Institute of Chemical Technology (UICT), Kavyatri Bahinabai Chaudhari North Maharastra University, Jalgaon, India. p. 52.

7.3. Books authored/edited

Lakshmipathi., Adiga, J.D. and Kalaivanan, D. 2019. Utilizing growth regulators and micro nutrients in cashew. *Lambert Academic Publishing,* Mauritius, ISBN No. 978-3-330-04672-6. p. 177.

Mohana, G.S. and Nayak, M.G. 2018. Status of cashew research and development in India: A state perspective. *ICAR- Directorate of Cashew Research*, Puttur. p. 157.

7.4. Book Chapters/ Lecture Notes

Bhat, P.S., Raviprasad, T.N., Vanitha, K. and Srikumar, K.K. 2018. Cashew. *In:* Chowdappa, P., Chandrika Mohan and Joseph Rajkumar (Eds.), Pests of Plantation Crops. *Astral International Pvt Ltd.,* New Delhi. pp. 167-198.

Manikantan, M.R., Balasubramanian, D., Shameena Begum, P.P. and Pandiselvam, R. 2019. Value addition in major plantation crops in coastal regions. *In:* Charukar, B.M., Thangam, M., Maruthadurai, R. and Nibedita Nayak (Eds.), Coastal Agriculture for sustainable production vis-à-vis doubling farmers' income. *ICAR-Central Coastal Agricultural Research Institute,* Goa. pp. 32-39.

7.5. Technical Reports / Compendia

Annual Report, 2017-18. All India Co-ordinated Research Project on Cashew. ICAR-Directorate of Cashew Research, Puttur, p. 133 (Eds. Mohana, G.S. and Nayak, M.G.).

Annual Report, 2017-18. ICAR-Directorate of Cashew Research, Puttur, p. 99 (Eds. Mohana, G.S., Vanitha, K. and Siddanna Savadi).

Cashew News, 2018. ICAR-Directorate of Cashew Research, Puttur, Vol. 23(1), p. 12 (Eds. Shamsudheen, M., Vanitha, K., Siddanna Savadi and Mohana, G.S.).

Cashew News, 2018. ICAR-Directorate of Cashew Research, Puttur, Vol. 23(2), p. 12 (Eds. Siddanna Savadi., Shamsudheen, M. and Mohana, G.S.).

7.6. Extension Bulletins / Pamphlets

Balasubramanian, D. and Sandesh, M.S. 2019. Vanijya Uddeshhaglige Labhyavituva Koylthra Thantrajynagalu. ICAR-Directorate of Cashew Research, Puttur, Karnataka, India [Kannada].

Mohana, G.S., Nayak, M.G., Eradasappa, E. 2019. Sudharitha geru thaligalu. ICAR-Directorate of Cashew Research, Puttur, India [Kannada].

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].

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].

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].

Shamsudheen, M., Manikandan. N. and Muralikrishna. K. 2019. Kasumavu-krishireethikal. ICAR-Directorate of Cashew Research, Puttur, Karnataka, India [Malayalam].

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].

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].

7.7. 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. p. 28.

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. p. 28.

7.8. Popular Articles

Adiga, J.D., Muralidhara, B.M., Preethi, P. and Savadi, S. 2018. Identification and codification of phenological growth stages of the cashew tree according to BBCH scale. *Cashew News* 23(2): 2-4.

Babli Mog. and Nayak, M.G. 2019. Utility of canopy management in cashewnut production. *Biomolecule Reports* BR/02/19/09 (ISSN: 2456-8759).

Babli Mog. 2018. Maximization of crop productivity and land utilization through intercropping in Cashew. *Biomolecule Reports* BR/07/18/16 (ISSN:2456-8759).

Babli Mog. 2018. Physiology of flowering in cashew. *Biomolecule Reports* BR/07/18/13 (ISSN: 2456-8759).

Nayak M.G. and Savadi, S. 2018. Global status of cashew production and trade: challenges and strategies for India to regain world leadership. *Agriculture Today's Agriculture Year Book* 2018. pp. 78-81.

Nayak, M. G. and Muralidhara, B.M. 2018. Cashew varieties: recent developments in India. *Cashew Technology Handbook* 2018. A product of Cashewinfo.com. November (special issue). pp. 11-13.

Nayak, M. G. and Muralidhara, B.M. 2018. H-130: uchch upaj aur gunavatta keliye ek naya bada

meve kaajoo sankar. *The Cashew and Cocoa Journal* 7(4): 2-6.

Nayak, M. G. and Muralidhara, B.M. 2018. Ultra density planting - A tool for doubling the cashew production. *The Cashew and Cocoa Journal* 7(4):19-26.

Nayak, M.G. and Muralidhara, B.M. 2018. Athiuccha sadhanropan- Caju uthpadan duguna karne ka tharika. *The Cashew and Cocoa Journal* 7(4):7-13.

Nayak, M.G. and Muralidhara, B.M. 2018. H-130: A new bold nut hybrid for higher yield and quality. *The Cashew and Cocoa Journal* 7(4): 14-18.

Nayak, M.G., Muralidhara, B.M. and Preethi, P. 2018. Quality graft production technology in Cashew. *Cashew Technology Handbook* 2018: A product of Cashewinfo.com. November (special issue). pp. 55-59.

Nayak, M.G., Muralidhara, B.M. and Preethi, P. 2018. Recent technologies for cashew production towards zero hunger. *Indian Farming* 68 (10):52-55.

Vanitha, K. 2018. *Antigonon leptopus*- a favourite plant of bees. *Kerala Karshakan e-journal* 5 (12): 10-13.

Vanitha, K. and Raviprasad, T.N. 2018. Pollinators of cashew, their foraging activity and bee flora. *Cashew News* 23(1): 2-4.

7.9. E-Publications

Preethi, P., Vanitha, K. and Shamsudheen, M. 2018. Ad-hoc recommendations on nutrient deficiency management in cashew (In Tamil), E-publication No. 2/2018, ICAR-Directorate of Cashew Research, Puttur. pp. 1-8.

Shamsudheen, M. 2018. Ad-hoc recommendations on nutrient deficiency management in cashew, E-publication No. 1/2018, ICAR-Directorate of Cashew Research, Puttur. pp. 1-7.

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 (ICAR-IIHR), Bengaluru	Entomology Department for 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 (ICAR-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 post harvest 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 materials
ICAR-Central Plantation Crops Research Institute, (ICAR-CPCRI) Kasargod, Kerala	Evaluation of EPN species in cashew ecosystem Transfer of Technology

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
Malabar Christian College, Calicut, Kerala	Identification of insect parasitoids
M/S Environment Measurement & Control, Kochi, Kerala	Development of moisture meter for cashew on Public-Private-Partnership (PPP) mode
ICAR-Indian Institute of Spices Research (ICAR-IISR), Calicut, Kerala	Analysis of micronutrients in soil & pant samples
Karnataka Cashew Development Corporation (KCDC), Mangaluru	For training of farmers & supply of planting materials
Kerala State Agency for the expansion of Cashew Cultivation (KSACC), Kollam	For large scale distribution of planting materials

9. TRAINING AND CAPACITY BUILDING

Participants	Details	Date
T.N. Raviprasad Shamsudheen Mangalassery Siddanna Savadi D. Balasubramanian	One day Workshop on "Importance of Intellectual Property Rights (IPR) and its Relevance in Agriculture" organized by ITMU Unit of ICAR–DCR, Puttur.	22 October 2018
D. Balasubramanian	Training on "Patent filing, proceedings, patent search, specifications, claim writing, and Filing of trademarks" at Rajiv Gandhi National Institute of Intellectual Property Management (RGNIIPM), Nagpur for 6 days.	29 October 2018 to 03 November 2018
K. Murali Krishna	Capacity building and skill upgradation 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

Status of Budget for training and capacity building (2018-19)

Allocation : Rs. 1.00 lakhs

Utilization : Rs. 0.89 lakhs

10. PARTICIPATION IN SYMPOSIA/ CONFERENCES/ SEMINARS/MEETINGS

Participants	Details	Date
M.G. Nayak Siddanna Savadi Mohana, G.S.	Workshop on "Breeding Strategies in Plantation Crops", ICAR-CPCRI, Regional Station, Vittal	27 April 2018
M.G. Nayak T.N. Raviprasad J.D. Adiga	ICAR- DCR Foundation day and farmers meet at ICAR-Directorate of Cashew Research, Puttur	18 June 201
M.G. Nayak Preethi, P.	Brainstorming workshop on "Development of proforma for ranking of ICAR institutes" at ICAR-National Academy of Agricultural Research Management, Rajendra Nagar, Hyderabad	20 July 2018
J.D. Adiga	2nd International conference on "Research interventions and advancements in Lifescience" Pune, Maharashtra	1-3 August 2018
Rajkumar A. Dagadkhair	International conference on UNESCO chaired "World Parliament of Science, Religion and Philosophy 2018" at Maharashtra Institute of Technology Arts Design and Technology (MIT ADT) University, Pune, Maharashtra	2-5 October 2018
Rajkumar A. Dagadkhair	National conference on "Innovative trends in Agri & Food Business Management" at MIT College of Management, Pune, Maharashtra	11-12 October 2018
Babli Mog	National seminar on "Abiotic stress management" at Tamil Nadu Agricultural University (TNAU), Coimbatore, Tamil Nadu	25-16 October 2018
Shamsudheen Mangalassery	International conference on "Emerging issues in agricultural, environmental and applied sciences for sustainable development (EIAEASSD-2018)" at Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS) Allahabad, UP	27-29 November 2018

T.N. Raviprasad	3rd National workshop on "Data Management by ICAR Research Data Repository for Knowledge Management of the ICAR-Indian Agricultural Statistics Research Institute", New Delhi at NASC Complex, New Delhi	4-5 December 2018
M.G. Nayak Mohana, G.S. Eradasappa, E. Preethi, P.	Annual Group Meeting (AGM) on AICRP on Cashew held at OUAT, Bhubaneswar, Odisha	6-8 December 2018
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 by CEPCI, Kollam at New Delhi	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
Rajkumar A. Dagadkhair	National seminar on "Process intensification in chemical, food and allied industries" University Institute of Chemical Technology (UICT), Kavyatri Bahinabai Chaudhari North Maharastra University, Jalgaon, Maharashtra	9 March 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 [2016-2019]	Mohana, G.S.	D. Balasubramanian Preethi, P. Muralidhara, B.M.
3.	1.1.3. Evaluation of cashew apple germplasm for cashew apple yield and quality traits [2013-2020]	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. Muralidhara, B.M. Eradasappa, E. Siddanna Savadi M.G. Nayak
5.	1.2.2. Development of dwarf and compact cashew hybrids [2013-2027]	Eradasappa, E.	Mohana, G.S. J.D. Adiga
6.	1.2.3. Breeding for improvement of nut size in cluster bearing genotypes [2018–2024]	Eradasappa, E.	Mohana, G.S. M.G. Nayak
7.	1.2.4. Breeding approaches for developing TMB tolerance [2017-2024]	Mohana, G.S.	Eradasappa, E. K. Vanitha
8.	1.2.5. Development of microsatellite markers, linkage analysis and population structure studies in cashew [2017–2020]	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 [2018-2025]	Siddanna Savadi	Eradasappa, E. Mohana, G.S.

10.	***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 [2015-2019]	M.G. Nayak	Mohana, G.S.
Crop Management			
11.	2.1.1. Studies on pruning and phenology in cashew [2018-2020]	J.D. Adiga	Preethi, P. Siddanna Savadi Muralidhara, B.M.
12.	2.1.3. Optimisation of mineral nutrition to cashew under high density planting [2018-2021]	Shamsudheen Mangalassery	M.G. Nayak Preethi, P. Babli Mog
13.	2.1.4. Characterization of physiological responses of cashew to salt and drought stresses [2014-2020]	Babli Mog	-
14.	***Externally Funded Project:*** Farmer participatory soil and plant health management – An attempt for improving livelihood of cashew farmers of coastal Karnataka Funded by: RKVY-FAFTAAR, Government of Karnataka Budget: Rs. 1.89 Crores [2018-2020]	Shamsudheen Mangalassery	M.G. Nayak J.D. Adiga Preethi, P. Muralidhara, B.M.
Crop Protection			
15.	3.1.1. Investigations on semiochemicals for management of TMB and CSRB [2015-2020]	T.N. Raviprasad	K. Vanitha Bakthavatsalam, N. (ICAR-NBAIR) Gajbhiye, N. (ICAR-DMAPR)
16.	3.1.2. Investigations on inflorescence insect pests of cashew and their management [2016-2019]	K. Vanitha	T.N. Raviprasad

17.	3.1.3. Evaluation of newer molecules for their efficacy against tea mosquito bug (TMB) and cashew stem and root borers (CSRB) [2016-2020]	T.N. Raviprasad	K. Vanitha
18.	3.1.4. Standardization of IPM involving EPN and *Metarhizium anisopliae* for management of CSRB [2017-2020]	T.N. Raviprasad	-
Post Harvest Technology			
4.1	**Improving performance of cashewnut processing**		
19.	4.1.1. Developing quality standards for raw cashewnuts [2013-2019]	D. Balasubramanian	K. Vanitha
20.	4.1.2. Design and development of moisture meter for raw cashewnuts [2017-2020]	D. Balasubramanian	Sri. Sreejith (M/S EMCON, Kerala)
21.	4.1.3. Studying comparative performance of cashewnut processing systems in India [2017-19]	D. Balasubramanian	–
4.2	**By-product utilization and product diversification**		
22.	4.2.1. Design and development of mechanized slicer for cashew apple [2018-20]	D. Balasubramanian	Ravindra Naik (ICAR-CIAE)
23.	4.2.3. Development of dehydrated products from cashew apple and sprouts [2019-2021]	Preethi, P.	Shamsudheen Mangalassery
Transfer of Technology			
24.	***Externally Funded Project:*** Development of an exclusive Android application for cashew cultivation Funded by: Directorate of Cashewnut and Cocoa Development (DCCD), Kochi [2017-2019]	Mohana, G.S.	M.G. Nayak

Concluded projects

Sl. No.	Project	PI	Co-PIs
Crop Improvement			
1.	1.8. Genetic analysis of mapping population through molecular markers for important traits in cashew [2012–2018]	Mohana, G.S.	M.G. Nayak Eradasappa, E. Siddanna Savadi J.D. Adiga
Crop Management			
2.	2.1.2. Establishment of nutrient diagnostic norms in cashew [2013-2018]	Shamsudheen Mangalassery	M.G. Nayak
Crop Protection			
3.	3.2.1. Diversity and bio-ecology of insect pollinators and their efficiency in increasing yield of cashew [2014-2018]	K. Vanitha	T.N. Raviprasad

12. CONSULTANCY, PATENTS AND COMMERCIALISATION OF TECHNOLOGY

12.1. Commercialisation of technology

A Memorandum of Understanding (MoU) was signed between ICAR-DCR and M/S Newtech Industries, Karnataka on 12 March 2019 for non-exclusive licensing of technology entitled "Dual mode dryer for raw cashewnuts" developed at this Directorate.

12.2. Collaborative research

Collaborative research was initiated by signing an MoU between ICAR-DCR, Puttur, Karnataka and M/S Environment Measurement and Controls (EMCON), Kochi, Kerala on 18 September 2018, towards developing moisture meter for cashew in Public-Private-Partnership mode.

12.3. Efforts to popularise commercialisable technologies

All commercialisable technologies of this Directorate have been displayed in the web portal of Accelerating Growth of New India's Innovations (AGNIi) an initiative of the Government of India, for commercialization. Response to First Examination Report (FER) of the patent entitled "Rotating drum roasting machine for raw cashewnuts" is submitted to IPO, Chennai. Institute Technology Management Committee (ITMC) Meetings were conducted twice on 17 September 2018 and 12 December 2018 to discuss MoU for collaborative research, assessing technology towards commercialization, response to FER. An attempt has been made to establish Agri-Business Incubator (ABI) at ICAR-DCR with a focused approach on cashew processing.

12.4. Consultancy services

Dr. M.G.Nayak

- Consultancy service and training were provided to Bharatiya Agro Industries Foundation (BAIF) Unit, Vijayanagaram district, Andhra Pradesh on cashew cultivation and nursery management technique from 30 June to 1 July 2018.

Dr. D. Balasubramanian

- Consultancy service provided to M/S HandiHelp Association, Sindhudurg, Maharashtra from 26–28 May 2018, to enhance the performance of cashewnut processing.
- Revised Detailed Project Report (DPR) prepared for M/S Plantation Corporation of Kerala, Kasargod, Kerala (Ref: Engg/ ME/1175 dated 28.05.2018).
- Consultancy provided to M/S Safalam Cashews (Kudumbashree), Kasargod, Kerala for improving qualitative efficiency of cashewnut processing during 26-27 September 2018.

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

13.1. Quinquennial Review Team (QRT)

The Quinquennial Review Team (QRT) was constituted to review 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. 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, Kasargod	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

The QRT made visits to ICAR-DCR and all the centres of AICRP on Cashew and interacted with the scientists. Interaction meeting was also conducted with development departments such as Directorate of Cashewnut and Cocoa Development (DCCD), Kochi, Kerala State Agency for the expansion of Cashew Cultivation (KSACC), ICAR-Agricultural Technology Application Research Institute (ICAR-ATARI), Bengaluru and National Bank for Agriculture & Rural Development (NABARD), Mangaluru. To assess the problems and requirements of processors, the QRT also interacted with different cashew processing industries and office bearers of Karnataka Cashew Manufacturers Association (KCMA), Mangaluru. Based on the consultations the reports were prepared and submitted to ICAR. The major recommendations of QRT include enhancing the production and supply of cashew grafts, the establishment of additional field gene banks, one

in plains regions (Hogalagere) and another in NEH region, developing dwarf and compact cashew hybrids, rootstock breeding programme, studies on salinity tolerance, leaf tissue test based fertiliser scheduling, intensified research on pheromones and kairomone technologies and development of reliable moisture meter.

13.2. Research Advisory Committee (RAC)

The 1st meeting of 8th RAC was held from 1 to 2 June 2018. The meeting was started with the introductory remarks of Chairman of RAC, Dr. D.S. Rathore. Following this, Action Taken Report of previous RAC recommendations was presented by Dr. J.D. Adiga, Principal Scientist & Member Secretary (RAC). This was followed by remarks from members of RAC, Dr. W.S. Dhillon, ADG (Hort-1), Krishi Bhawan, ICAR, New Delhi and Dr. P.C. Lenka, Former Dean, OUAT, Bhubaneswar. Dr. Subhash Chander, Principal Scientist (Agricultural Entomology), ICAR-IARI, New Delhi and Dr. Hebbar, K.B., Principal Scientist (Plant Physiology and Biochemistry), ICAR-CPCRI, Kasargod were the subject matter specialists for the RAC. Thereafter, presentations on the progress of research in Crop Improvement, Crop Management, Crop Protection and Post Harvest Technology were made by the scientists of DCR. For each section, many useful suggestions were offered by RAC members. 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, Kasargod	Member
6.	Dr. S.N. Ojha Principal Scientist, ICAR-CIPHET, Mumbai	Member
7.	Dr. M. Gangadhara Nayak, Director (Acting), ICAR-DCR, Puttur	Member
8.	Dr. W.S. Dhillon, ADG (H-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 31st annual meeting of Institute Research Committee (IRC) of ICAR-DCR, Puttur was held from 27 to 28 June 2018 under the Chairmanship of Dr. M.G. Nayak, Director (Acting). There were five technical sessions chaired by experts of the respective fields. Dr. M.K. Rajesh, Principal Scientist (Biotechnology), ICAR-Central Plantation Crops Research Institute, Kasargod was the resource person for the technical session on 'Crop Improvement'. Dr. G.K. Mukunda, Professor (Horticulture), UAS, Bengaluru was the resource person for 'Crop Management'. For Crop Protection and Post Harvest Technology sessions, Dr. P. Shivarama Bhat, Principal Scientist (Agricultural Entomology), and Dr. R.B. Tiwari, Principal Scientist (Horticulture), Division of Post Harvest Technology, ICAR-Indian Institute of Horticultural Research, 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 discussed. The technical programme of the projects for the year 2018-19 was also finalized.

13.4. Institute Management Committee (IMC)

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, Kasargod, Kerala	Member
9.	The Finance and Accounts Officer, ICAR-CPCRI, Kasargod, Kerala	Member
10.	The Administrative Officer, ICAR-DCR, Puttur, Karnataka	Member Secretary

The 47th IMC meeting of this Directorate was held on 25 October 2018. The proceedings of the 47th IMC was forwarded to council for approval and all the recommendations of the IMC were approved. The 48th meeting of IMC was held on 7 February 2019 wherein IMC members interacted with QRT.

13.5. Institute Joint Staff Council (IJSC)

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 (Official 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)

The IJSC meetings were held on 31 August 2018, 31 October 2018 and 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.

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

14.1. Programmes organized

Foundation Day - 2018

ICAR-Directorate of Cashew Research, Puttur celebrated its 32nd foundation day on 18 June 2018. The function started with the release of "Ultra High Density Planting (UHDP)" technology developed at ICAR-DCR by Shri. Sanjeeva Matandoor, Member of Legislative Assembly, Puttur constituency, Karnataka. It was followed by the lecture on "Ultra High Density Planting in Cashew" by Dr. M.G. Nayak (Acting Director). In his inaugural address, Shri. Sanjeeva Matandur talked about the role of agriculture in Indian society and the recent impacts

of urbanization on agriculture. Guest of Honour, Shri. Prakash Natelkar, Managing Director, Karnataka Cashew Development Corporation, Mangaluru, congratulated the Director and the Institute for the achievements made over the years for improving the economic status of the cashew farmers of the country. Dr. Venkatesh N. Hubballi, Director, Directorate of Cocoa and Cashew Development (DCCD), Kochi, called for the adoption of a village by ICAR-DCR, to promote cashew cultivation. Guest speaker, Fr. Prakash A. Monteiro, Campus Director, St. Philomena College, Puttur, spoke on ethics in the profession. Another guest speaker, Shri. Prasanna Rai, Head, Botany Department, St. Philomena College, Puttur, stressed on maintaining soil health and judicious use of natural resources. More than 120 participants consisting of cashew farmers, representatives of KVK, development departments, media and scientists attended the function.

International Day of Yoga

International Day of Yoga was celebrated at ICAR-DCR on 21 June 2018 to spread awareness about yoga among staff members. On the occasion, Shri. K. Prasanna explained about the importance of yoga, benefits of different *asanas*, how the different

asanas need to be performed and the science behind each of the *asanas*. He demonstrated the sequence of many *asanas* along with the Suryanamaskar. The programme concluded with a pledge that yoga will be performed by the staff regularly for building a strong and healthy India.

Swachhta Hi Seva and Celebration of 150th Birth Anniversary of Mahatma Gandhiji

Swachhata Hi Sewa (Cleanliness is Service), a campaign started as part of Swachch Bharat campaign of the Government of India was carried out at ICAR-DCR, Puttur between 14 September and 2 October 2018. As part of Swachhata Hi Sewa, various activities like cleanliness *shramadan*, and

planting of trees, and awareness programmes like folk song competitions were conducted at ICAR-DCR, Puttur. A grand function for the celebration of 150th birth anniversary of Mahatma Gandhiji and

valedictory function of Swachhata Hi Seva-2018 was organized at ICAR-DCR, Puttur. Prof. Dattatreya Rao, Chief Guest, spoke at length about values, thoughts, dreams and way of living of Mahatma Gandhi. He stressed on values of Mahatma Gandhi such as simplicity, practice and preaches, his

powerful tools of truth and non-violence. Two power point presentations on Swachhta Pakhwada and Gandhian thoughts were presented on the occasion. Towards the end of the function, an elderly guest from Haveri district spoke about the greatness of Mahatma Gandhi and he appreciated grand function organized to pay fitting tributes to Mahatma Gandhi on his 150th birth anniversary. In the end, cultural programmes were held in which staff, students and guest took part enthusiastically and the programme was attended by 40 people.

Vigilance Awareness Week

Vigilance Awareness Week was observed at ICAR-DCR, Puttur between 29 October and 3 November 2018. The Vigilance Awareness Week was started with a pledge administered as per the directives of Central Vigilance Commission (CVC) and ICAR, New Delhi, and was ended after a week. The valedictory function was organised at the Directorate in association with Taluk and District Legal Service Committee, Dakshina Kannada district and the Bar Association, Puttur. In the inaugural address, the chief guest, Shri. Manjunath, Principal Senior Civil Judge and Additional Chief Judicial Magistrate, Puttur narrated the corruption status during pre and post-independence in India. He stressed the need for everyone to join hands to eradicate corruption. The Honorary Guest of the programme Mr. A. Uday Shankara Shetty, Advocate and member, District Legal Services Authority, Mangaluru, spoke about civic duty in the eradication

of corruption. Shri. K. Bhaskar, Kodimbala, President, Bar Association, Puttur expressed his concern over the corruption in the country and its removal. Mr. P. Prashanth Rai was the resource person to speak on “Eradication of Corruption in India - Build India”. The Acting Director of ICAR-DCR, Puttur, Dr. M.G. Nayak, presided over the function and expressed his opinion about corruption free India. The staff of

the Directorate, local school students and teachers, members of parents and teachers association and local representatives participated in the meeting. The legal advisory committee along with the honourable judge answered the queries of the participants on corruption free India.

World Soil Day

World Soil Day was celebrated on 5 December 2018 at Bharatiya Kisan Sangha Hall, Kundapura, Udupi, Karnataka. The programme was attended by 76 participants including farmers from various villages in the Udupi district of Karnataka. Welcoming the gathering Mrs. Vidyasree, ICAR-DCR, Puttur briefed about World Soil Day programme and soil health card scheme. Dr. Shamsudheen Mangalassery (Senior Scientist, Soil Science) briefed about the soil health card programme of Govt. of India and he emphasized on the judicious application of nutrients including micronutrients, based on the soil test report. He also briefed about

the project on Farmer participatory soil and plant health management being undertaken by ICAR-DCR, Puttur with funding support from Rashtriya Krishi Vikas Yojana (RKVY), Govt. of Karnataka. One of the components of the project is to demonstrate the good agricultural practices in the farmer's field in three districts *viz.,* Uttara Kannada, Udupi and Dakshina Kannada. Chief Guest, Mr. Satyanarayana Udupa, District Secretary, Bharatiya Kisan Sangha, emphasized on the importance of cashew as a climate resilient crop for dry areas. Mr. Venkateswara Rao, President, Coconut Producers Federation indicated the need for farmers organization for effective marketing and processing of products. Mr. Sitaram, Taluk Secretary, Bharatiya Kisan Sangha opined that the farmers should take advantage of soil health card scheme and other schemes of state and central governments and to be proactive. Mr. Ramachandra Alsey, Vice President, Bharatiya Kisan Sangha also felicitated during the occasion. The progressive cashew farmer, Mr. Chandra Shekhar Udupa explained about his farming practices and how cashew can be made a profitable enterprise by adopting modern technologies. Later soil health cards were distributed to farmers. The use of soil health cards was also explained to the farmers.

Annual Cashew Day – 2019

The annual cashew day was celebrated on 22 January 2019 at the 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 of ICAR-DCR, H-130 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. She stressed the need for adopting the ultra high density planting system in cashew for higher yields in less space. During the program, the guest of honour, Mr. Shirish, K., Special Officer (Cashew) and Managing director, Kerala State Agency for the 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, Kasargod lauded the

efforts of ICAR-Directorate of Cashew Research in developing modern technologies for improved cashew cultivation. On this occasion, Dr. M.G. Nayak, Director (Acting), ICAR-Directorate of Cashew Research, Puttur announced the formation of Cashew Growers Association of India. In the event, an exhibition on cashew production technologies, different cashew varieties and cashew apple products was organized. Farmers were taken to the experimental fields to show the various cashew research plots. More than 200 cashew farmers participated besides nurserymen, representatives of KVK, development departments and scientists.

Farmer's Fair during the inaugural programme of Pradhan Mantri Kisan Samman Nidhi

The inauguration of Pradhan Mantri Kisan Samman Nidhi (PM-KISAN) scheme by Honourable 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. Under PM-KISAN scheme, Rs. 6,000 will be given per year to small and marginal farmer families having combined land holding/ownership of up to 2 hectares by direct benefit transfer (DBT) mode. 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, D.K., 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, farmers, staff, press and other audience present in the programme. Then the importance of PM-KISAN, its important features and benefits to farmers were explained in Kannada to the audience by Dr. T.N.

Raviprasad, Principal Scientist, ICAR-DCR, Puttur. It was followed by brief speeches of M.P., M.L.A. and the minister present on the occasion who talked about the motive of this unique programme i.e. welfare of farmers. Then at about 11.00 A.M. the Mann Ki Bath programme of PM was webcasted to the assembled audience in which PM spoke on sacrifices of armed forces of India, birth anniversaries of Birsa Munda and Jemshedji Tata, Padmashri awards to the persons rendering social and national services without expecting rewards, especially, the 12 farmer awardees and PM health scheme. 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 and AIIMS hospital at Gorakhpur.

Then interaction session of PM with the beneficiary farmers from different parts of the country through live webcasting organized at different research institutes of ICAR was telecasted. Among these few interactions, PM interacted with one of the farmers of Puttur Shri. Janardhana Bhat, a farmer identified by ICAR-DCR, Puttur. The farmer's opinions about PM-KISAN programme were translated to Hindi for PM by Dr. T.N. Raviprasad, Principal Scientist, 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, Dakshina Kannada. Dr. M.G. Nayak, Director (Acting), Women and other staffs of this Directorate participated in the event. Dr. (Mrs.) 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. (Mrs.) Babli Mog 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.

14.2. Training/Workshop

Workshop on Intellectual Property Rights

One-day Workshop on "Importance of Intellectual Property Rights (IPR) and its relevance in agriculture" was organized by ITMU Unit of ICAR–DCR, Puttur on 22 October 2018 at this Directorate by inviting experts from Karnataka State Council for Science and Technology (KSCST), Bengaluru. Scientists and technical staff of this Directorate and ICAR-CPCRI, Regional Station, Vittal, Karnataka and academicians and scholars of Vivekananda College of Engineering and Technology (VCET), Puttur participated in this workshop.

Interface meetings

Two interface meetings were organized with farmers, processors, scientists and officials of development departments at Bhubaneshwar on 8 December 2018 and at ICAR-DCR, Puttur on 7 February 2019.

15. राजभाषा कार्यान्वयन एवं प्रगति

राजभाषा कार्यान्वयन समिति

1.	डा. एम.जी. नायक	अध्यक्ष
2.	डा. संशुद्धिन एम.	सदस्य
3.	श्री के.एम. जयराम नायक	सदस्य
4.	श्री सीताराम के. (मई 2018 तक)	सदस्य
5.	श्रीमति लीला एम.	सदस्य
6.	श्री रघुराम कुकडे	सदस्य
7.	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 19 सितंबर से 26 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 पखवाडा 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 समापन समारोह के अवसर पर प्रो. विष्णु भट्, निवृत्त हिन्दी प्राध्यापक, संत फिलोमिना कालेज, मुख्य अतिथि थे।

राजभाषा नियम 1976 नियम 11 के अनुपालन हेतु आवश्यक सामग्रियों जैसे प्रपत्र, रबड़ की मोहरें, नाम पट्ट आवश्यकतानुसार द्विभाषा 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 34वीं और 35वीं अर्धवार्षिक बैठक दिनांक 26.07.2018 को और दिनांक 16.12.2018 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 और संयुक्त रूप से आयोजन किया गया।

निदेशालय में निम्नलिखित रिपोर्ट हिंदी में प्रकाशित किया गए:

1. निदेशालय का वार्षिक प्रतिवेदन (वर्ष 2017-18) पूर्ण रूप से हिंदी में।
2. अखिल भारतीय समन्वित काजू अनुसंधान परियोजना की वार्षिक प्रतिवेदन सारांश (वर्ष 2017-18)।
3. 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
Dr. D.S. Rathore	Chairman, Research Advisory Committee, ICAR-DCR	1-2 June 2018
Dr. W.S. Dhillon	ADG (Hort-1), Krishi Bhawan, ICAR, New Delhi	1-2 June 2018
Dr. P.C. Lenka	Former Dean, OUAT, Bhubaneswar	1-2 June 2018
Dr. Subhash Chander	Principal Scientist (Agricultural Entomology), ICAR-IARI, New Delhi	1-2 June 2018
Dr. Hebbar. K.B.	Principal Scientist (Plant Physiology and Biochemistry), ICAR-CPCRI, Kasargod	1-2 June 2018
Shri. Sanjeeva Matandoor	Member of Legislative Assembly, Puttur	18 June 2018 24 February 2019
Shri. Prakash Natelkar	Managing Director, Karnataka Cashew Development Corporation, Mangaluru	18 June 2018
Dr. Venkatesh N. Hubballi	Director, Directorate of Cocoa and Cashew Development, Kochi	18 June 2018
Fr. Prakash A. Monteiro	Campus Director, St. Philomena College, Puttur	18 June 2018
Dr. M.K. Rajesh	Principal Scientist (Biotechnology), ICAR- Central Plantation Crops Research Institute, Kasargod	27 June 2018
Dr. G.K. Mukunda	Professor (Horticulture), UAS, Bengaluru	27 June 2018
Dr. P. Shivarama Bhat	Principal Scientist (Agricultural Entomology), ICAR-Indian Institute of Horticultural Research, Bengaluru	28 June 2018
Dr. R.B. Tiwari	Principal Scientist (Horticulture), Division of Post Harvest Technology, ICAR-Indian Institute of Horticultural Research, Bengaluru	27-28 June 2018
Shri Chinmayananda Swamiji	Chinmaya Mission, Mandya	6 October 2018
Shri. Manjunath	Honourable Senior Civil Judge and Additional Chief Magistrate, Puttur	3 November 2018
Shri. Bhaskar	President Bar association, Puttur	3 November 2018
Shri. A. Udaya Shankar Shetty	District Legal Cell member	3 November 2018
Shri. Prashant Rai	Lawyer, Puttur	3 November 2018
Smt. J. Mercykutty Amma	Minister for Fisheries, Harbour Engineering & Cashew Industries, Govt. of Kerala	22 January 2019

Dr. S.P. Ghosh	Former DDG (Hort.), ICAR, New Delhi	5 February 2019
Dr. S.N. Kandige	Vice President, CAMPCO	20 February 2019
Dr. G. Chandrasekhar	Former, DRDO Scientist, Hyderabad	20 February 2019
Shri. Parshottam Rupala	Union Minister of State for Agriculture and Farmers' Welfare, Govt. of India	24 February 2019
Shri. Amitabh Gautam	Joint Secretary, Department of Agriculture, Co-operation and Farmers' Welfare, Govt. of India	24 February 2019
Shri. Nalin Kumar Kateel	Member of Parliament, Dakshina Kannada	24 February 2019
Shri. M. Krishnappa	Former MLA, Bannur	25 February 2019
Shri. Chandrakant Bellad	Former MLA, Dharwad	4 March 2019
Dr. S. Rajan	Former ADG (Hort.), ICAR, New Delhi	25 March 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. Janani, P.	Scientist (Spices, Plantation, Medicinal and Aromatic Plants)
11.	Dr. Preethi, P.	Scientist (Fruit Science)
12.	#Shri. Muralidhara, B.M.	Scientist (Fruit Science) [On study leave from 20 September 2018 to 19 September 2021]
13.	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	Assistant Chief Technical Officer
4	Shri. Prakash G. Bhat	Assistant 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. K. Seetharama	Technical Officer
10	Shri. M. Bhojappa Gowda	Technical Officer
12	*Shri. Vijay Singh	Sr. Technical Assistant
13	Shri. Ravishankar Prasad	Sr. Technical Assistant
14	*Shri. K. Babu Poojari	Sr. Technical Assistant
15	Shri. Honnappa Naik, P.	Sr. Technician
Administration		
1	*Shri. Jayarama Naik, K.M.	Administrative Officer
2	Smt. M. Rathna Ranjini	Asst. 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
9	Shri. K. Balappa Gowda	Gestetner Operator

*** Transferred or retired**

 # On study leave

Promotions

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

Retirement

- Shri. K. Seetharama, Technical Officer superannuated on 31 May 2018.
- Shri. S. Pernu, Skilled Support Staff superannuated on 31 May 2018.
- Shri. K. Babu Poojari, Senior Technical Assistant superannuated on 31 January 2019.
- Shri. Surendra Kumar Indra, Coffe/Tea maker superannuated on 28 February 2019.
- Shri. Jayarama Naik K.M., Administrative Officer superannuated on 31 March 2019.

Inter-Institutional Transfers

- Dr. Janani, P., Scientist (Spices, Plantation, Medicinal and Aromatic Plants), has been relieved of her duties w.e.f. 30 June 2018 (A.N.), consequent on her transfer to ICAR-Central Potato Research Institute, Shimla, Himachal Pradesh.
- Shri. Vijay Singh, Senior Technical Assistant was relieved of his duties on 10 August 2018 (A.N.) on transfer to ICAR- Indian Institute of Wheat and Barley Research, Karnal.

18. WEATHER DATA (2018)

Month	Temperature (°C)		Humidity (%)		Rainy days	Rainfall (mm)	Mean wind velocity (km/h)	Sunshine hours (h)	Pan evaporation (mm)
	Max.	Min.	FN	AN					
January	33.7	18.8	75	46	0	0.0	2.2	8.4	3.6
February	35.3	21.2	72	34	0	0.0	2.4	8.6	4.3
March	35.2	22.6	73	34	2	27.3	2.7	7.7	4.6
April	35.4	24.9	74	50	3	43.7	2.9	7.8	4.4
May	34.1	24.3	76	60	13	479.1	2.8	5.2	2.7
June	27.7	22.6	88	86	28	1231.4	2.5	2.2	2.9
July	28.3	22.9	91	83	25	1198.5	3.6	3.0	1.9
August	27.7	22.9	91	81	28	883.7	3.4	2.4	2.6
September	32.0	23.5	87	59	5	165.1	2.2	4.3	3.3
October	33.5	24.1	81	55	10	184.0	1.8	7.1	2.8
November	32.8	23.0	78	52	10	57.1	1.6	7.4	3.4
December	33.1	22.1	81	47	1	3.3	1.6	6.9	3.6
Annual average	32.4	22.8	80.6	57.3	-	-	2.5	5.9	3.3
Annual total	-	-	-	-	125	4273.2	-	-	-

Rainfall is 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	
	Germplasm accessions - I	165.00
	Germplasm accessions - II	125.00
	Germplasm accessions - III	128.00
	Germplasm accessions – IV	--
	Germplasm accessions - V	--
4	Database on cashewnut processing in India (2003)	100.00
5	Directory of cashewnut processing industries in India (2003)	100.00
6	Process catalogue on development of economically viable on-farm cashewnut processing	45.00
7	Annotated bibliography on cashew (1995-2007)	205.00
8	Soil and water management in cashew plantations	30.00
9	Biochemical characterization of released varieties of cashew	85.00
10	Pruning and canopy architecturing in cashew	40.00
11	Development of dual-mode dryer for raw cashewnuts	90.00
12	Alternate energy utilization of cashew shell cake for thermal application	90.00
13	Cashew cultivation practices (Pamphlet)	*
14	Status of cashew germplasm collection in India (Booklet)	*
15	Cashew nutritive value (Revised) (Brochure)	*
16	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

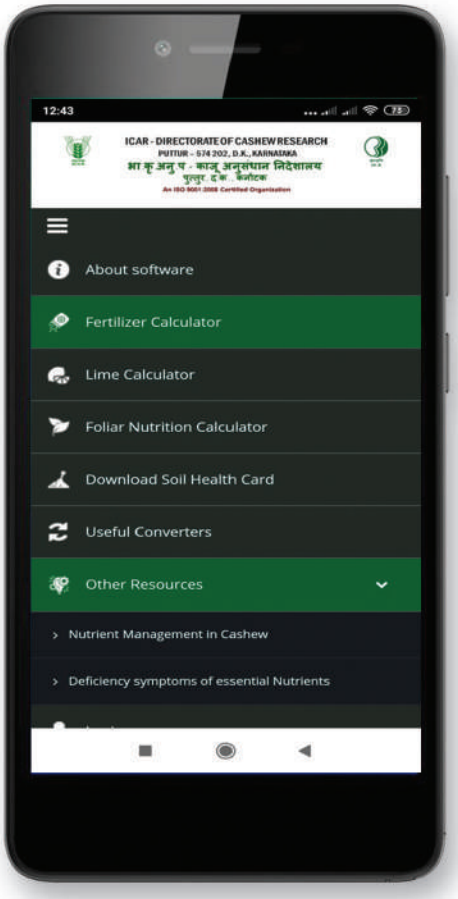
Abbreviation	Expansion
%	Percentage
°Bx	Degrees Brix
°C	Degree Celsius
ADG	Assistant Director General
AGM	Annual Group Meeting
AGNIi	Accelerating Growth of New India's Innovations
AICRP	All India Coordinated Research Project
AICS and CIP	All India Coordinated Spices and Cashew Improvement Project
AIIMS	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
BAIF	Bharatiya Agro Industries Foundation
BBCH	Biologische Bundesantalt Bundessortenamt und Chemische Industrie
Ca	Calcium
CAFT	Centre for Advanced Faculty Training
CCRI	Central Citrus Research Institute
C-DAC	Centre for Development of Advanced Computing
CEPCI	Cashew Export Promotion Council of India
CIAE	Central Institute of Agricultural Engineering
CIPHET	Central Institute of Post Harvest Engineering & Technology
cm	Centimetre
CNSL	Cashew Nut Shell Liquid
CPCRI	Central Plantation Crops Research Institute
CRS	Cashew Research Station
CSRB	Cashew Stem and Root Borer
CSSR	Cashew Simple Sequence Repeats
Cu	Copper
CVC	Central Vigilance Commission
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
DRIS	Diagnosis and Recommendation Integrated System
DUS	Distinctness, Uniformity and Stability
EPN	Entomopathogenic Nematodes
F1	the first Filial generation
Fe	Iron
FER	First Examination Report
FN	Forenoon
g	Gram
GC-MS	Gas Chromatography–Mass Spectrometry
GIA	Grant-in-Aid
h	Hours
ha	hectare
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

Abbreviation	Expansion
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
KSCST	Karnataka State Council for Science and Technology
KVK	Krishi Vigyan Kendra
L	Litre
Max.	Maximum
M/S EMCON	M/S Environment Measurement and Controls
Mg	Mangnesium
MiEST-SSRs	*Mangifera indica* Expressed Sequence tags-Simple Sequence Repeats
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

Abbreviation	Expansion
NRCC	National Research Centre for Cashew
OUAT	Odisha University of Agriculture and Technology
P	Phosphorus
PLACROSYM	Plantation Crops Symposium
PME	Prioritization, 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
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
TMB	Tea Mosquito Bug
TNAU	Tamil Nadu Agricultural University
TOLIC	Town Official Language Implementation Committee
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
VCET	Vivekananda College of Engineering and Technology
VPKAS	Vivekananda Parvatiya Krishi Anusandhan Sansthan
WBE	Whole Body Extracts
WKR	Whole Kernel Recovery
Zn	Zinc

Submission of QRT report to Dr. Trilochan Mohapatra,
Secretary (DARE) & Director General (ICAR)

Visit of QRT to the experimental field at ICAR-DCR, Puttur



भाकृअनुप
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