

वार्षिक प्रतिवेदन ANNUAL REPORT 2020



**Nethra vaman -
Novel dwarf cashew variety**



भारत
ICAR

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



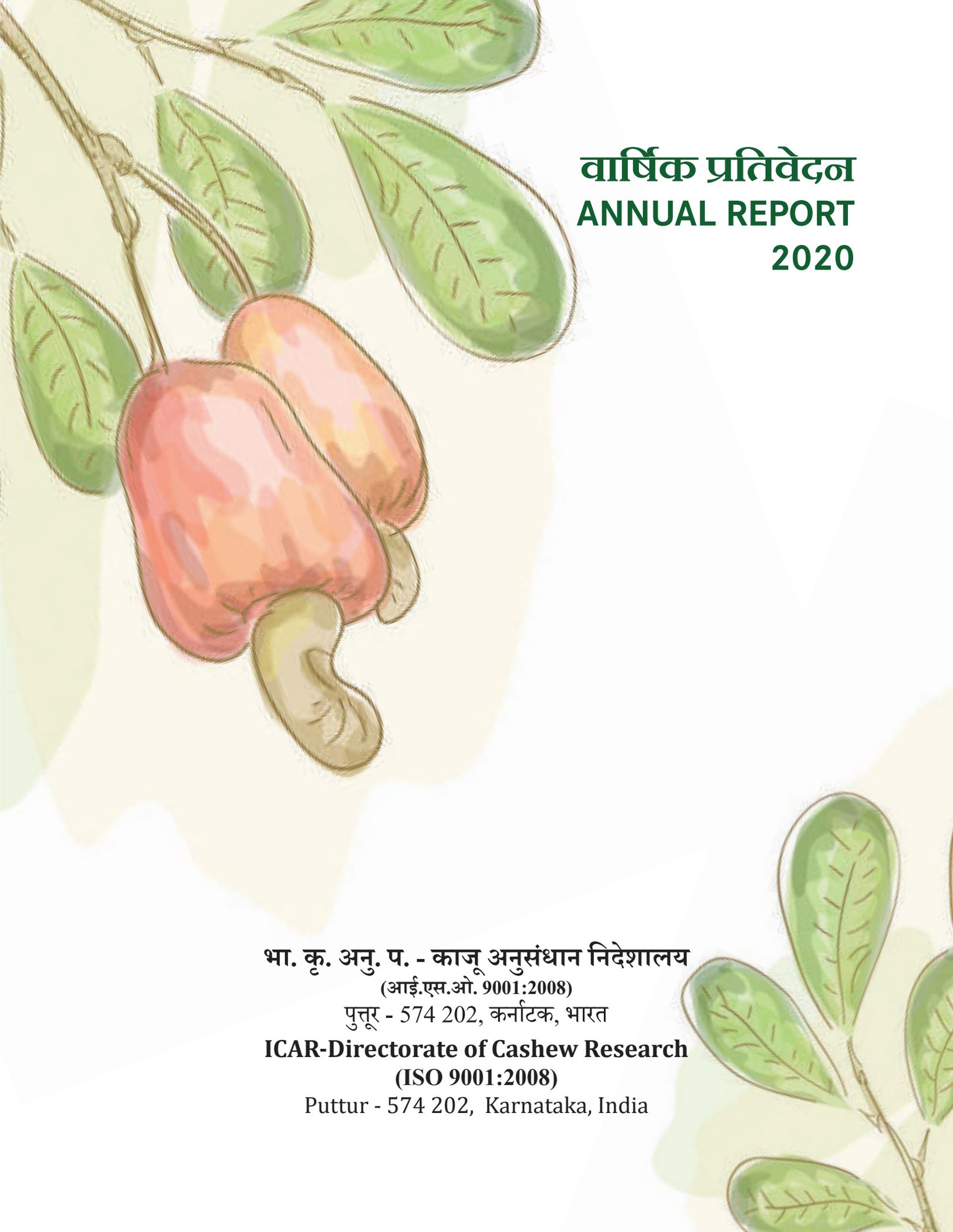
काअनि
DCR



Signing of MoU with M/s. Abhay Engineers, Mangaluru



Signing of MoU with Annai Velankanni Nursery, Vridhachalam, Tamil Nadu

The background of the cover features a stylized illustration of cashew leaves and fruits. The leaves are green with brown veins, and the fruits are shown in various stages of ripeness, from green to red. The illustration is positioned on the left side of the cover, with some leaves extending towards the right.

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Front Cover:

From bottom to top: A plant, stem galling and fruits of Nethra vaman, a novel dwarf cashew variety.

Back Cover:

Images of Cashew Plant Health Clinic Museum, ICAR-DCR, Puttur

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प्रावकथन

मुझे, वर्ष 2020 के लिए भाकृअनुप – काजू अनुसंधान निदेशालय (ICAR - DCR), पुत्तूर का वार्षिक प्रतिवेदन प्रस्तुत करते हुए अत्यंत खुशी हो रही है। इस प्रतिवेदन में रिपोर्टाधीन अवधि के दौरान अन्य संस्थागत गतिविधियों के साथ-साथ अनुसंधान एवं प्रौद्योगिकी हस्तांतरण के अंतर्गत की गई प्रगति को प्रस्तुत किया गया है।

काजू के एक बौने जीनप्ररूप नामतः एनआरसी – 492 को जारी करने हेतु अनुमोदित किया गया। इस वर्ष अनूठे जननद्रव्य ब्लॉक में कुल नौ अनूठी किस्मों को शामिल किया गया है। प्रजनन परीक्षणों में, एक आशाजनक संकर, प्रियंका x एनआरसी 492 की वृक्ष संख्या 3 तथा एक बैकक्रास संतति, वृक्ष संख्या बीडीबी – 626 – 58 में अधिकतम वार्षिक बीज उपज दर्ज की गई। भाकृअनुप – काजू अनुसंधान निदेशालय (ICAR - DCR), पुत्तूर में उत्पन्न काजू की व्यावसायिक किस्म भास्कर के मसौदा जीनोम अनुक्रम का उपयोग करते हुए 75 नवीन एसएसआर मार्करों की डिजाइन की गई और आनुवंशिक विविधता विश्लेषण और हस्तांतरण क्षमता में इनकी उपयोगिता का अध्ययन किया जा रहा है। जुलाई माह में उर्वरकों का प्रयोग करने पर काजू में अगेती पुष्पन देखने को मिला लेकिन इसका उपज पर कोई प्रभाव नहीं पड़ा। काजू में अल्ट्रा सघनता रोपण के लिए नाइट्रोजन – फॉस्फोरस – पोटेशियम की मात्रा का प्रति वृक्ष 80 : 20 : 40 ग्राम के रूप में इष्टतमीकरण किया गया। 200 mM पर लवणता सहिष्णु सूचकांक को भास्कर (70.2 प्रतिशत) में उच्चतम और मडक्कथारा – 2 (39 प्रतिशत) में न्यूनतम दर्ज किया गया। मृदाविज्ञान संभाग की अनुसंधान प्रयोगशाला सुविधाओं का आधुनिक उपकरणों के साथ पुनः सुदृढीकरण किया गया। चार – पाँच दिन पुराने वर्जिन अथवा नव मादा टी मॉस्कटो बग (TMB) के सम्पूर्ण शरीर निष्कर्षण से नर टी मॉस्कटो बग में तीव्र आकर्षण उत्पन्न किया जा सका। काजू तना तथा जड़ वेधक के लिए फिप्रोनिल 5 SC (2.0 मिलि./लितर) और टी मॉस्कटो बग (TMB) के विरुद्ध थियामिथॉक्सम 25 WG (0.2 ग्राम/लितर) और एसिटामीप्रिड 20 SP (0.5 ग्राम/लितर) प्रभावी पाए गए। यहां तक कि उच्च टी मॉस्कटो बग (TMB) दबाव के अंतर्गत भी मई के माह तक वीआरआई-3 में पुष्पन एवं फलन देखा गया। काजू फलों को संक्रमित करने वाली कुल 66 कीट प्रजातियों को दस्तावेजी रूप दिया गया। एक प्रमुख मधुमक्खी प्रजाति बी. मिक्सटा की आणविक पहचान की गई और इसकी आवास संरचना को दस्तावेजी रूप दिया गया। फसलोत्तर प्रौद्योगिकी में, हासिल की गई प्रमुख उपलब्धियों में शामिल थीं : काजू फल के लिए संशोधित मैकेनाइज्ड स्लाइर का विकास; कच्चे काजू बीज के लिए विकसित नमी मीटर का मापांकन; तथा काजू फल तथा काजू अंकुरों से मूल्यवर्धित उत्पादों का विकास। इसके अलावा, भारत में काजू प्रसंस्करण प्रणालियों के तुलनात्मक प्रदर्शन को भी दस्तावेजी रूप दिया गया।

आरकेवीवाई – रफतार के अंतर्गत, कर्नाटक के तीन तटवर्ती जिलों में अग्रिम पंक्ति प्रदर्शन आयोजित किए गए। हितधारकों की जरूरतों को पूरा करने के लिए अनेक अनूठी तथा रोचक विशेषताओं के साथ एक काजू पौधा स्वास्थ्य क्लिनिक म्यूजियम का विकास किया गया। 'कैश्यू इंडिया' ऐप को डाटासेट से समृद्ध बनाया गया। इस निदेशालय में अनुसूचित जाति उप-योजना तथा एसटीसी/टीएसपी जैसी अनेक स्कीमों को प्रभावी तरीके से लागू किया गया। उद्यमियों को सहयोग प्रदान करने के प्रयोजन से भाकृअनुप – काजू अनुसंधान निदेशालय, पुत्तूर में एक कृषि व्यवसाय इनक्यूबेशन (ABI) केन्द्र स्थापित किया गया है। निदेशालय द्वारा एनआईटीटीई, मंगलुरू के अंतर्गत के.एस. हेगड़े मेडिकल अकादमी के साथ एक समझौता ज्ञापन पर हस्ताक्षर किए गए। रिपोर्टाधीन वर्ष में आईटीएमयू द्वारा भाकृअनुप – काजू अनुसंधान निदेशालय, पुत्तूर की सात प्रौद्योगिकियों का व्यावसायीकरण किया गया। विभिन्न कार्यक्रमों जैसे कि संविधान दिवस समारोह, काजू दिवस, भारतीय कृषि अनुसंधान परिषद का स्थापना दिवस, अनुसूचित जाति अनुसूचित जनजाति किसानों की बैठक, सतर्कता जागरूकता सप्ताह, स्वच्छता पखवाड़ा, किसान दिवस तथा तीन प्रशिक्षण कार्यक्रम का आयोजन किया गया। अनुसंधान सलाहकार समिति, संस्थान अनुसंधान परिषद की बैठकों और काजू पर अखिल भारतीय समन्वित अनुसंधान परियोजना की वार्षिक समूह बैठक का आयोजन ऑन-लाइन मोड में किया गया।

मैं, निदेशालय द्वारा की गई प्रगति में अपना मूल्यवान योगदान देने के लिए भाकृअनुप – काजू अनुसंधान निदेशालय के सभी स्टाफ सदस्यों का आभार प्रकट करता हूँ। साथ ही वार्षिक प्रतिवेदन 2020 के संकलन एवं सम्पादन कार्य में सम्पादन समिति के सदस्यों द्वारा किए गए प्रयासों की सराहना करता हूँ।



(अनीता करून)
निदेशक (कार्यकारी)

स्थान : भाकृअनुप – काजू अनुसंधान निदेशालय, पुत्तूर
दिनांक : 30th January, 2021



PREFACE

It is my pleasure to present the Annual report - 2020 of ICAR-Directorate of Cashew Research (ICAR-DCR), Puttur. The report presents the progress made during the period under research and transfer of technology along with other institutional activities.

Under germplasm evaluation, a dwarf cashew genotype, NRC-492 is approved for release. Nine unique types have been included in the unique germplasm block this year. In breeding trials, a promising hybrid, tree No. 3 of Priyanka x NRC 492 and a back cross progeny, tree no. BDB-626-58 recorded highest annual nut yield. Novel SSR markers were designed using draft genome sequence of cashew cv Bhaskara generated at ICAR-DCR and their utility in genetic diversity analysis and transferability are being studied. Fertiliser application during July was found to advance flowering in cashew, but had no influence on yield. For ultra density planting in cashew (2.5 x 2.5 m), NPK dose has been optimized as 80:20:40 g per tree. Highest salinity tolerant index was recorded in Bhaskara 70.2 % and lowest in Madakkathara -2 39 % at 200 mM. The research laboratory facilities of soil science section were further strengthened with modern equipments.

Whole body extracts of virgin female tea mosquito bug (TMB) of 4-5 days old could induce a strong attraction to the male TMB,. Thiamethoxam 25 WG (0.2 g/L) and acetamiprid 20 SP (0.5 g/L) were found effective against TMB, and fipronil 5 SC (2.0 ml/L) against cashew stem and root borer. Even under high TMB pressure, flowering and fruiting were seen in VRI-3 even up to May. A total of 66 insect species infesting cashew flowers have been documented. Molecular identification of an important bee, *Braunsapis mixta* was done and its nest structure has been documented. In post harvest technology, major achievements include development of modified mechanized slicer for cashew apples; calibration of moisture meter developed for raw cashewnuts and development of value-added products from cashew apple and cashew sprouts. Besides, comparative performance of cashewnut processing systems in India has been documented.

Under RKVY-RAFTAAR, front line demonstrations (FLDs) were organized in three coastal districts of Karnataka. A cashew plant health clinic museum has been developed with many unique and interesting features to cater to the needs of stakeholders. The 'Cashew India' app was saturated with more data sets. Schemes like STC/TSP and SCSP were effectively implemented at this Directorate. An agribusiness incubation (ABI) centre has been established at ICAR-DCR for providing support to the entrepreneurs. The Directorate signed a MoU with K.S. Hegde Medical academy under NITTE, Mangaluru, Karnataka. Seven technologies of ICAR-DCR have been commercialized by ITMU during the year. Different programmes like celebration of Constitution day, Cashew day, ICAR-DCR Foundation day and SCSP farmers meet, Vigilance awareness week, Swachta pakhwada, kisan diwas, Hindi week and three trainings were organized. Meetings of Research Advisory Committee, Institute Research Council and Annual Group Meeting of scientists of AICRP on cashew were conducted online.

I am thankful to all DCR staff for their valuable contribution in the progress made by the Directorate and sincerely acknowledge the efforts made by the members of Editorial Committee for the compilation and editing of the Annual Report 2020.

Place: ICAR-DCR, Puttur

Date : 30 January, 2021



(Anitha Karun)

Director (Acting)





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1. कार्यकारी सारांश

भाकृअनुप – काजू अनुसंधान निदेशालय (ICAR - DCR), पुत्तूर, काजू पर अनुसंधान एवं प्रसार संबंधी गतिविधियों के कार्य में संलग्न है। वर्ष 2020 में फसल सुधार, फसल प्रबंधन, फसल सुरक्षा, फसलोत्तर प्रौद्योगिकी तथा प्रौद्योगिकी हस्तांतरण के अंतर्गत चलाई गई गतिविधियों तथा अन्य पहलुओं को यहां संक्षिप्त रूप में प्रस्तुत किया गया है। इस वर्ष सात बाह्य वित्त पोषित परियोजनाओं सहित कुल 43 अनुसंधान परियोजनाएं चलाई गईं जिनमें तीन को पूरा किया गया और बारह नवीन परियोजनाएं थीं।

फसल सुधार

भारत में पहली बार, काजू के एक बौने जीनप्ररूप, एनआरसी – 492 को खेती प्रयोजन के लिए अनुमोदित किया गया। इस वर्ष अनूटे जननद्रव्य ब्लॉक में नौ अनूटी किस्मों को शामिल किया गया। वर्ष 2008 के दौरान रोपी गईं तेरह प्राप्तिओं का लक्षणवर्णन किया गया और टीएमबी प्रतिरोधिता के लिए स्क्रीनिंग करने के साथ साथ काजू डिस्क्रेटर्स के अनुसार वर्गीकरण किया गया। जननद्रव्य डाटाबेस में 76 काजू जननद्रव्य प्राप्तिओं के कुल 842 चित्र शामिल किए गए तथा डाटाबेस साइट को कुल 3523 बार देखा गया।

फल उपज और गुणवत्ता के लिए मूल्यांकित किए गए काजू जीनप्ररूपों के बीच, एनआरसी – 301 में 6.25 का समग्र स्वीकार्यता ग्रेड था। काजू फल में प्रोटीन की मात्रा के लिए कुल 17 जननद्रव्य प्राप्तिओं की छंटाई की गई। बौने तथा सुगठित संकरों के विकास की दिशा में किए गए प्रजनन प्रयासों में एक आशाजनक संकर नामतः प्रियंका x एनआरसी – 492 की वृक्ष संख्या 3 दर्ज की गई जिसमें प्रति वृक्ष 2.39 किलोग्राम की अधिकतम वार्षिक उपज हासिल की गई। बैकक्रास संततियों में, वृक्ष संख्या बीडीबी – 626 – 58 में प्रति वृक्ष 1.07 किलोग्राम की अधिकतम वार्षिक बीज उपज दर्ज की गई और पुनरावृत्ति परीक्षण में क्लोनल मूल्यांकन के लिए छः शीर्ष रैंकिंग वाले सेलेक्शन का कलम-बंधन किया गया। टी मॉस्किटो बग (TMB) सहिष्णुता और उपज के लिए उत्परिवर्तन प्रजनन के तहत विकसित किए गए M_1 पौधों का मूल्यांकन समलक्षणी अथवा फिनोटाइप भिन्नताओं के लिए किया जा रहा है। पुनः टीएमबीटी सहिष्णु (TMBT) किस्मों पर आंकड़ों से पता चला कि ब्लॉक में टीएमबीटी तथा समीपस्थ वृक्षों के बीच टीएमबी संक्रमण स्तर में कोई उल्लेखनीय भिन्नता नहीं थी और मूल्यांकन की गई संततियों में 2 एवं 4 के बीच का नुकसान ग्रेड था।

कलस्टर धारण करने वाले जीनप्ररूपों में बीज आकार में सुधार लाने हेतु किए गए अनुसंधान परीक्षणों के अंतर्गत, पर्यवेक्षण प्रयोजन हेतु 15 क्रास की कुल 408 पौद को खेत में रोपा गया। काजू के महत्वपूर्ण गुणों के

लिए जीन कार्रवाई की प्रकृति को समझने के लिए पीढ़ी माध्य विश्लेषण पर अध्ययन किया जा रहा है। काजू फल में घटी हुई टैनिन मात्रा के लिए प्रजनन पर अनुसंधान परियोजना के तहत मूल्यांकित किए गए 125 F_1 वृक्षों में वृक्ष संख्या 820 में टैनिन की सबसे कम मात्रा दर्ज की गई। जबकि, बल्क परीक्षण में मूल्यांकित किए गए आशाजनक संकरों के बीच दो बार की गई तुड़ाई से प्रति वृक्ष 6.27 किलोग्राम की संचयी बीज उपज के साथ वृक्ष संख्या 480 का प्रदर्शन आशाजनक किस्म के रूप में जारी बना रहा।

मसौदा जीनोम अनुक्रम में लगभग 47,646 एसएसआर की पहचान की गई और काजू के लिए नवीन जीनोम एसएसआर का विकास करने हेतु 75 प्राइमर युग्मों का संश्लेषण किया गया। भास्कर (विशाल टाइप) तथा एनआरसी – 492 (बौना टाइप) के प्ररोह ट्रांसक्रिप्टोम को उत्पन्न किया गया और इस कार्य में इलुमिना अनुक्रमण तथा एसेम्बलड डि नोवो का उपयोग किया गया। एसएसआर विश्लेषण से 55,501 ट्रांसक्रिप्ट्स में कुल 4,882 एसएसआर का पता चला। बीज उपज और काजू छिलके में तेल अंश (CNSL) को नियंत्रित करने वाले क्यूटीएल के आनुवंशिक विच्छेदन को समझने के लिए विकसित की गईं दो मानचित्रण संख्या अथवा पापुलेशन को खेत में रोपा गया और उनका रखरखाव किया गया। डीयूएस परीक्षण के लिए, खेत में एच-130 कलम को रोपा गया और पौधा किस्म एवं कृषक अधिकार संरक्षण प्राधिकरण (PPV & FRA), नई दिल्ली में इसके पंजीकरण के लिए आवेदन प्रस्तुत किया गया।

फसल प्रबंधन

पूरिंग अथवा कटाई-छंटाई पर किए गए परीक्षणों में पता चला कि काजू की भास्कर किस्म में 25 प्रतिशत स्तर की दर पर लेटरल की पूरिंग करने पर प्रति वृक्ष पुष्पगुच्छों के अधिकतम संख्या उत्पादन को बढ़ावा मिला। काजू फीनोलॉजी अथवा घटनाविज्ञान पर उर्वरकों का प्रयोग करने के समय के प्रभाव का अध्ययन किया गया जिसमें पता चला कि जुलाई माह के दौरान उर्वरकों का प्रयोग करने पर किसी भी किस्म में अगेती पुष्पन और फलन हुआ, हालांकि, भास्कर तथा उल्लाल - 3 किस्म में उपज पर इसका कोई प्रभाव दर्ज नहीं किया गया। उपरोक्त परीक्षण में पत्ती नमूनों का विश्लेषण करने पर पता चला कि जुलाई तथा अगस्त माह में उर्वरकों का प्रयोग करने पर उल्लाल - 3 तथा भास्कर के पत्ती नमूनों में क्रमशः नाइट्रोजन का अधिकतम इनटेक और अधिकतम कार्बन मात्रा को बढ़ावा मिलता है।

उच्च सघनता रोपण के अंतर्गत काजू में खनिज पोषण के इष्टतमीकरण पर किए गए परीक्षण में यह पूर्वानुमान लगाया गया कि 0.96 के वांछनीय मान के साथ 2.3 किलोग्राम की औसत वृक्ष उपज हासिल करने के लिए 2.5 x 2.5 मीटर के अन्तराल पर नाइट्रोजन - फॉस्फोरस - पोटेशियम

की मात्रा प्रति वृक्ष 80 : 20 : 40 ग्राम होगी। लवणता के प्रति काजू की छः किस्मों की वृद्धि प्रतिक्रिया से पत्ती ऊतकक्षय तथा क्लोरोसिस जैसी लवण विषाक्तता के प्रभावों का पता चला। NaCl की 200 mM मात्रा पर मडक्कथारा - 2 (68.8 प्रतिशत) तथा भास्कर (34.3 प्रतिशत) में उच्चतर तथा कमतर पत्ती ऊतकक्षय दर्ज किया गया। NaCl की मात्रा में बढ़ोतरी करने पर पौधा ऊंचाई, पत्ती क्षेत्रफल, मेम्ब्रेन स्थिरता सूचकांक, पौधा शुष्क भार, पत्ती में जल मात्रा तथा बायोमास आवंटन में उल्लेखनीय कमी पाई गई। 200 mM पर सबसे अधिक लवणता सहिष्णु सूचकांक को भास्कर (70.2 प्रतिशत) में और सबसे कम सूचकांक को मडक्कथारा - 2 (39 प्रतिशत) में दर्ज किया गया।

पराग अंकुरण पर किए गए स्वः पात्रे अध्ययन के तहत, प्रातः 9.30 बजे से 11.00 बजे के बीच संकलन करने पर काजू के पराग बीजों का अच्छा अंकुरण दर्ज किया गया। जांची गई विभिन्न बढवार मीडिया के बीच, पीईजी मीडिया में बेहतर पराग अंकुरण पाया गया। मृदाविज्ञान संभाग की अनुसंधान प्रयोगशाला सुविधाओं को आरकेवीवाई - रफतार परियोजना के तहत माइक्रोवेव पौधा नमूना पाचन प्रणाली तथा रेफ्रीजरेटिड सेन्ट्रीफ्यूज सहित आधुनिक उपकरणों के साथ पुनः सुदृढ़ बनाया गया।

फसल सुरक्षा

टी मॉस्किटो बग (TMB) के प्रबंधन के लिए सेमियो रसायनों पर किए गए अन्वेषणों के अंतर्गत, यह पाया गया कि चार से पांच दिन पुरानी नव अथवा वर्जिन मादा के सम्पूर्ण शरीर निष्कर्षण (WBE) जिसे डाइक्लोरोमिथेन में तैयार किया गया था और फ्रीजर में इसे भण्डारित करने पर निष्कर्षण को तैयार करने के 45 दिनों बाद भी इसके द्वारा नर टीएमबी में तीव्र आकर्षण उत्पन्न किया जा सका। अवशोषक में टीएमबी फिरोमॉन वाष्पशील यौगिक का संकलन करने के लिए एक नया उपकरण इस्तेमाल किया गया और टीएमबी लिंग फिरोमॉन वाष्पशील के संघटकों की पहचान करने के लिए नमूनों का विश्लेषण किया जा रहा है। थियामिथॉक्सम 25 WG (0.2 ग्राम/लिट्र) तथा एसिटामीप्रिड 20 SP (0.5 ग्राम/लिट्र) द्वारा टीएमबी की उच्चतम मृत्युदर के साथ साथ अंड निक्षेपण विकर्षक उत्पन्न किया जा सका जो कि संस्तुत कीटनाशकों यथा एल - साहलोथ्रिन 5 EC (0.6 मिलि./लिट्र) का प्रयोग करने के समतुल्य था। काजू तना तथा जड़ वेधक (CSRB) के विरुद्ध फिप्रोनिल (2.0 मिलि./लिट्र) में सबसे अधिक नैसेन्ट ग्रब मृत्युदर थी जो कि क्लोरपायरीफोस (10 मिलि./लिट्र) का प्रयोग करने के समतुल्य थी। काजू तना तथा जड़ वेधक (CSRB) से संक्रमित वृक्षों में ग्रब निष्कर्षण उपरांत प्रोफाइलैक्सिस उपचार एवं तदुपरान्त ईपीएन तथा मेटाराइजियम एनीसोप्लाई निलम्बन का प्रयोग करने पर उपचारित काजू वृक्षों में काजू तना तथा जड़ वेधक (CSRB) संक्रमण को कोई नया लक्षण नहीं दिखाई दिया।

उच्च टीएमबी दबाव के तहत, एमडीके-2 में कमतर टीएमबी प्रकोप बना रहा लेकिन उल्लाल-4, वी-4, वी-7 में गंभीर नुकसान हुआ। हालांकि किस्म वीआरआई - 3 में टीएमबी का गंभीर संक्रमण था फिर भी इसमें मई माह तक भी पुष्पन और फलन देखा गया। टीएमबी संक्रमण के उपरान्त कलम के पत्ती नमूनों में फिनोल मात्रा में उल्लेखनीय वृद्धि दर्ज की गई। हमारे कीट ऑर्डर से काजू के पुष्पीय नाशीजीवों के परिणामस्वरूप 67 प्रजातियों का दस्तावेजीकरण किया गया। दिसम्बर 2019 से फरवरी, 2020 तक फूलों में नुकसान पहुंचाने वाली पेरिक्सेरा प्रजाति तथा बॉम्बोटेलिया जोकोसैट्रिक्स का उच्च प्रकोप देखा गया। वर्षा दिनों की संख्या का फल एवं बीज वेधक (0.35), थ्रिप्स (-0.39) तथा माइरिडस (-0.34) के साथ उल्लेखनीय रूप से नकारात्मक सम्बद्धता थी। संतुलित टीएमबी संक्रमण के अंतर्गत पुष्पगुच्छ कैटरपिल्लर्स के कारण उपज में 47.06 प्रतिशत तक की कमी दर्ज की गई।

काजू इकोसिस्टम में घटित होने वाली ब्रॉनसैपिस मधुमक्खियों के प्रजाति कॉम्प्लेक्स में बी. पिसिटार्सिस, बी. मिक्सटा तथा बी. मैलिकी शामिल थीं। बी. मिक्सटा की आणविक पहचान की गई (जीनबैंक प्राप्ति संख्या MW 135190) तथा जीन अनुक्रम को जीनबैंक में तथा जीवन डाटाबेस के बारकोड में अपलोड किया गया है। बी. मिक्सटा तथा इसके प्राकृतिक शत्रुओं की वास संरचना को दर्ज किया गया।

फसलोत्तर प्रौद्योगिकी

कच्चे काजू बीज, बिना छिली काजू गिरी तथा छिली हुई काजू गिरी के लिए श्री-इन-वन नमी मीटर का विकास किया गया है। कृत्रिम रूप से नमी वाली गिरियों के लिए बिना छिली तथा छिली हुई काजू गिरियों हेतु नमी मीटर अच्छा दिखा हालांकि, कच्चे काजू के लिए कार्यक्रम में और अधिक सुधार करने की आवश्यकता है। भारत में काजू प्रसंस्करण प्रणालियों की गुणात्मक प्रभावशीलता को प्रभावित करने वाले कारक हैं : मजदूरों के कौशल का स्तर, मशीन का उत्पादन, अपनाये गए कच्ची सामग्री पैरामीटर तथा प्रसंस्करण पैरामीटर। नैदानिकी जांच से पता चला कि उत्पादन की मात्रा, प्रसंस्करण लागत की प्रतिलोम आनुपतिक है। काजू फल के लिए मैकेनाइज्ड स्लाइसर के प्रदर्शन में सुधार लाने के लिए स्लाइसिंग क्षेत्र में रोटरी डिस्क ब्लेडों का बेवल कोण, डिस्क ब्लेड का व्यास, तथा फी ढलान वक्रता जैसे कारकों में संशोधन किया गया और स्लाइसिंग प्रदर्शन में सुधार पाया गया। आकारहीन स्वरूप में काजू फल स्लाइस (CAS) बनाने के लिए स्लाइस अथवा कतरनों की शुष्कन गतिकी का अध्ययन किया गया।

काजू अंकुरों के भण्डारण जीवनकाल पर खारे घोल के प्रभाव का अध्ययन किया गया। जब काजू अंकुरों को 5 प्रतिशत NaCl के घोल में भण्डारित किया गया तब इनमें वसा मात्रा में उल्लेखनीय कमी के साथ भण्डारण जीवनकाल में 2 दिन (कंट्रोल) से 17 दिनों तक की बढ़ोतरी हुई

लेकिन फाइटिक अम्ल मात्रा में कोई कमी नहीं हुई। काजू अंकुर पाउडर (CSP) के अनुपात में बढ़ोतरी करने पर अनाज एक्स्ट्रैक्ट की पोषणिक एवं खनिज मात्रा में उल्लेखनीय बढ़ोतरी देखने को मिली। काजू अंकुर एक्स्ट्रैक्ट की सफलतापूर्वक तैयारी के लिए काजू अंकुर पाउडर की अनुकूलतम मात्रा 5 से 25 प्रतिशत थी। यह पाया गया कि 8°C तापमान पर भण्डारित 2 प्रतिशत एस्कॉर्बिक अम्ल के साथ उपचारित काजू अंकुर गूदे को दस दिनों तक भण्डारित किया जा सकता है और साथ ही इसके ब्राउनिंग सूचकांक (0.63) में भी कोई परिवर्तन नहीं हुआ।

प्रौद्योगिकी हस्तांतरण

आरकेवीवाई - रफतार द्वारा वित्त पोषित परियोजना के अंतर्गत, 4.5 एकड़ के एक अतिरिक्त प्लॉट क्षेत्रफल को ड्रिप एवं उर्वरीकरण प्रणालियों के साथ उन्नत उत्पादन प्रौद्योगिकी पर ऑन-फार्म प्रदर्शन प्लॉटों के रूप में विकसित किया गया है। वर्ष 2018-20 की अवधि के दौरान कर्नाटक राज्य के तीन तटवर्ती जिलों में किसानों के खेतों में लगाए गए कुल 59 अग्रिम पंक्ति प्रदर्शनों को वैज्ञानिक पोषक तत्व प्रबंधन रीतियों को अपनाने का प्रभाव जानने के लिए जांचा गया। अग्रिम पंक्ति प्रदर्शन प्लॉटों में मृदा पीएच मान, जैविक कार्बन तथा उपलब्ध नाइट्रोजन - फॉस्फोरस - पोटेशियम में सुधार को दर्ज किया गया। पुनः काजू की उन्नत उत्पादन प्रौद्योगिकी पर किसानों को लाभ पहुंचाने के प्रयोजन से चयनित प्लॉटों में अनेक प्रशिक्षण कार्यक्रमों, अवसर दौड़ों तथा प्रक्षेत्र दिवस का आयोजन किया गया। आरकेवीवाई - रफतार के अंतर्गत, आगन्तुकों की जरूरतों को पूरा करने के लिए अनेक अनूठी और रोचक विशेषताओं के साथ एक काजू पौधा स्वास्थ्य क्लिनिक म्यूजियम स्थापित किया गया है। भाकूअनुप - काजू अनुसंधान निदेशालय, पुत्तूर ने दिनांक 5 से 8 फरवरी, 2020 को भाकूअनुप - भारतीय बागवानी अनुसंधान संस्थान, बेंगलुरु में आयोजित राष्ट्रीय बागवानी मेला - 2020 में अपनी भागीदारी दर्ज कराई। भाकूअनुप

- काजू अनुसंधान निदेशालय, पुत्तूर में विभिन्न अनुभागों की विभिन्न गतिविधियों को निदेशालय का दौरा करने वाले किसानों तथा छात्रों को दिखाया गया। वर्ष 2020 के दौरान विभिन्न भाषाओं में विभिन्न अखिल भारतीय समन्वित अनुसंधान परियोजना केन्द्रों के डाटासेट से 'कैश्यू इंडिया' को समृद्ध किया गया। चयनित जिलों में किसानों की आजीविका में सुधार लाने के प्रयोजन से इस निदेशालय में एसटीसी/टीएसपी तथा एससीएसपी जैसी स्कीमों को प्रभावी तरीके से लागू किया गया।

पांच विभिन्न व्यवसाय मॉडल के अंतर्गत उभरते अथवा मौजूदा उद्यमियों के लिए सहयोग प्रदान करने हेतु निदेशालय में एक कृषि व्यवसाय इनक्यूबेशन (ABI) केन्द्र स्थापित किया गया है। भाकूअनुप - काजू अनुसंधान निदेशालय, पुत्तूर द्वारा विशेष अनुसंधान गतिविधियों को चलाने हेतु एनआईटीटीई, मंगलुरु के अंतर्गत के.एस. हेगड़े मेडिकल अकादमी के साथ एक समझौता ज्ञापन पर हस्ताक्षर किए गए। काजू के एक नए संकर नामतः एच-130 का व्यावसायीकरण करने के लिए दिनांक 25 फरवरी, 2020 को प्रौद्योगिकी बैठक आयोजित की गई। निदेशालय ने इस वर्ष आईटीएमयू के माध्यम से तीन प्रौद्योगिकियों का व्यावसायीकरण किया। दिनांक 2 जून, 2020 को एच-130 का पंजीकरण करने के लिए पौधा किस्म एवं कृषक अधिकार संरक्षण प्राधिकरण (PPV & FRA), नई दिल्ली में आवेदन प्रस्तुत किया गया। इस वर्ष अखिल भारतीय समन्वित अनुसंधान परियोजना में कार्यरत वैज्ञानिकों की वार्षिक समूह बैठक, अनुसंधान सलाहकार समिति (RAC) तथा संस्थान अनुसंधान परिषद (IRC) की बैठकों का आयोजन ऑन-लाइन किया गया। निदेशालय में विभिन्न कार्यक्रमों जैसे कि संविधान दिवस समारोह, काजू दिवस, भारतीय कृषि अनुसंधान परिषद का स्थापना दिवस, एससीएसपी किसान बैठक, हिन्दी सप्ताह, सतर्कता जागरूकता सप्ताह, स्वच्छता पखवाड़ा, किसान दिवस तथा तीन प्रशिक्षण कार्यक्रमों का आयोजन किया गया।

1. EXECUTIVE SUMMARY

ICAR- Directorate of Cashew Research, Puttur is involved in research and extension activities on cashew. The research activities carried out during the year 2020 under crop improvement, crop management, crop protection, post harvest technology and the activities under transfer of technology and other aspects are summarized here. This year, a total of 43 research projects including seven externally funded projects were in operation, in which 12 are new projects and three were concluded.

Crop Improvement

For the first time in India, a dwarf cashew genotype, NRC-492 is approved for release. Nine unique types have been included in the unique germplasm block. Thirteen accessions planted during 2008 were characterized and grouped as per cashew descriptors, besides screening for TMB resistance. A total of 842 images of 76 cashew germplasm accessions were included in the germplasm database and the database site was visited 3523 times.

Among the cashew genotypes evaluated for apple yield and quality, NRC-301 had overall acceptability grade of 6.25. Seventeen germplasm accessions were screened for protein content in the cashew apples. The breeding efforts towards development of dwarf and compact hybrids recorded a promising hybrid, tree no. 3 of cross Priyanka x NRC-492 with highest annual nut yield of 2.39 kg/tree. Among the back cross progenies, tree no. BDB-626-58 recorded highest annual nut yield of 1.07 kg/tree and six top ranking selections were grafted for clonal evaluation in the replicated trial. The M_1 plants developed under mutation breeding for tea mosquito bug (TMB) tolerance and yield are being evaluated for phenotypic variations. Further, observations on TMB tolerant (TMBT) types indicated no significant difference in TMB infestation level between TMBT and adjacent

tress in the block and the progenies evaluated had the damage grade between 2 and 4.

Under the research trial to improve nut size in cluster bearing genotypes, a total of 408 seedlings of 15 crosses were field planted for observations. To understand the nature of gene action for important traits of cashew a study on generation mean analysis is underway. Tree no. 820 recorded the lowest tannin content among 125 F_1 trees evaluated under the research project on breeding for reduced tannin content in cashew apples. While, tree no. 480 continued to perform as best promising type with cumulative nut yield of 6.27 kg/tree from two harvests among the promising hybrids evaluated in bulk trail.

About 47,646 SSRs were identified in the draft genome sequence, and 75 primer pairs were synthesized to develop novel genome SSRs for cashew. The shoot transcriptomes of Bhaskara (giant type) and NRC-492 (dwarf type) were generated using the illumina sequencing and assembled *de novo*. SSR analysis revealed a total of 4,882 SSRs in 55,501 transcripts. Two mapping populations developed for understanding genetic dissection of QTLs governing nut yield and cashew nut shell liquid (CNSL) content in cashew were field planted and maintained. For DUS testing, H-130 grafts were planted in field and application for its registration has been submitted to PPV& FRA, New Delhi.

Crop Management

Trials on pruning indicated that pruning of laterals @ 25 % level in cashew cv Bhaskara led to production of highest number of inflorescences per tree. Study on influence of time of fertiliser application on cashew phenology showed that application during July advanced the flowering and fruiting invariable of cultivars, however, no influence on yield was recorded in Bhaskara and

Ullal-3. Analysis of leaf samples in the above experiment indicated that fertiliser application during July and August encourages maximum intake of nitrogen, and highest carbon content in the leaf samples of Ullal-3 and Bhaskara, respectively.

The trial on optimization of mineral nutrition to cashew under high density planting predicted the application dose of NPK at a spacing of 2.5 x 2.5 m to be 80:20:40 g per tree for getting an average tree yield of 2.2 kg with a desirability value of 0.96. The growth response of six cashew cultivars to salinity indicated the effects of salt toxicity such as leaf necrosis and chlorosis. The higher and lower leaf necrosis was recorded in MDK-2 (68.8 %) and Bhaskara (34.3 %) at 200 mM of NaCl. Significant reduction in plant height, leaf area, membrane stability index, plant dry weight, leaf water content and biomass allocation have been recorded with respective increasing doses of NaCl. Highest salinity tolerant index was recorded in Bhaskara (70.2 %) and lowest in MDK-2 (39 %) at 200 mM.

Under *In vitro* studies on pollen germination of cashew, good germination of pollen was recorded when collected between 9.30 am and 11.00 am. Among the different growth media tested, better pollen germination was observed in PEG media. The research laboratory facilities of soil science section were further strengthened with modern equipments including microwave plant sample digestion system and refrigerated centrifuge under RKVY-RAFTAAR project.

Crop Protection

Under the investigations on semiochemicals for management of TMB, it was found that Whole Body Extracts (WBE) of virgin female of 4-5 days old, prepared in dichloromethane could induce a strong attraction to the male TMB even after 45 days of extraction, when WBE was stored under freezer. A new apparatus for collecting TMB pheromone volatile compound in absorbent has

been used and the samples are being analyzed for identifying the components of the TMB sex pheromone volatiles.

Thiamethoxam 25 WG (0.2 g/L) and acetamiprid 20 SP (0.5 g/L) could induce highest mortality of TMB as well as ovipositional repellence and were on par with recommended insecticide *viz.*, L-cyhalothrin 5 EC (0.6 ml/L). Against cashew stem and root borer (CSRB), fipronil (2.0 ml/L) had highest nascent grub mortality and was on par with chlorpyrifos (10 ml/L). Post grub extraction prophylaxis treatment in the CSRB infested trees followed by application of entomopathogenic nematodes (EPN) and *Metarhizium anisopliae* suspension showed no fresh symptoms of CSRB infestation in the treated cashew trees.

Under high TMB pressure, MDK-2 sustained lesser TMB attack, but Ullal-4, Vengurla-4 and Vengurla-7 suffered severe damage. The variety, VRI-3 though got severely infested by TMB, flowering and fruiting were seen even up to May. Significant increase in phenol content was recorded in the leaf samples of grafts after TMB infestation. A total of 67 species have been documented as inflorescence pests of cashew. High incidence of *Perixera* sp. and *Bombotelia jocosatrix* was seen damaging the flowers during December 2019 till February 2020. Number of rainy days had significant negative relationship with apple and nut borers (-0.35), thrips (-0.39) and mirids (-0.34). Reduction in yield up to 47.06 per cent due to inflorescence caterpillars has been recorded under mild infestation of TMB.

Species complex of *Braunsapis* bees occurring in cashew ecosystem include *B. picitarsis*, *B. mixta* and *B. malliki*. Molecular identification of *B. mixta* was done (GenBank Acc. No. MW135190), and the gene sequence has been uploaded to GenBank and the Barcode of Life Database. The nest structure of *B. mixta* and its natural enemies have been studied.

Post Harvest Technology

A three in one moisture meter for raw cashewnuts, unpeeled and peeled cashew kernels has been developed. The moisture meter showed good fit for the unpeeled and peeled cashew kernels for the artificially moistened kernels, however for raw cashewnuts, refinement of the programme is required. Factors influencing qualitative efficiency of cashewnut processing systems in India are degree of skill of the labourers engaged, production of machine, raw material parameters and the processing parameters adopted. Diagnostic investigation indicated that volume of production is inversely proportional to the cost of processing. For improving the performance of mechanized slicer for cashew apple, factors like bevel angle of the rotary disc blades, diameter of the disc blades, fee chute curvature at slicing region were modified and found improved slicing performance. For making cashew apple slices (CAS) into amorphous form, drying kinetics of the slices has been studied.

Storage life of cashew sprouts has increased from 2 days (control) to 17 days when stored in 5 % NaCl solution with significant reduction in fat content but not phytic acid content. Significant increase in nutritive and mineral content of cereal extrudate was observed with increasing proportion of cashew sprout powder (CSP). For successful preparation of cashew sprout extrudates, the optimised quantity of CSP ranged from 5-25 %. It was found that the cashew sprout pulp treated with 2 % ascorbic acid stored at 8 °C can be stored for 10 days without any changes in the browning index (0.63).

Transfer of Technology

Under the project funded by RKVY-RAFTAAR, an additional plot area of 4.5 acre has been developed as on-farm demonstration plots on improved production technology with drip and fertigation systems. Further, fifty-nine front line demonstrations (FLDs) organized in farmers'

fields in three coastal districts of Karnataka during 2018-20 were checked for the influence of adoption of scientific nutrient management practices. Improvement in soil pH, organic carbon and available NPK were recorded in those plots. Further, various trainings, exposure visits and field days were conducted in the selected plots for the benefit of farmers on advanced cashew production technology. Under RKVY-RAFTAAR, a cashew plant health clinic museum has been established with many unique and interesting features to cater to the needs of visitors. ICAR-DCR, Puttur had participated in National Horticulture Fair - 2020 held at IIHR, Bengaluru from 5-8th February, 2020. Farmers and students were given exposure on various activities of different sections of ICAR-DCR. The 'Cashew India' app was saturated with data sets from different AICRP centres for different languages. Schemes like STC/TSP and SCSP were effectively implemented by the Directorate to improve the livelihood of the farmers in selected districts.

An Agribusiness Incubation (ABI) centre has been established for providing support for the entrepreneurs under five different business models. ICAR-DCR signed a MoU with K.S. Hegde Medical Academy under NITTE, Mangaluru, Karnataka to carry out the specific research activities. Technology meet was organized on 25th February, 2020 for commercialization of H-130, a new cashew hybrid. ITMU of the Directorate has commercialized three technologies during the year. The Annual Group Meeting (AGM) of scientists of AICRP, Research Advisory Committee (RAC) and Institute Research Council (IRC) meetings were held online. Different programmes like celebration of Constitution day, Cashew day, ICAR-DCR Foundation day and SCSP farmer's meet, Hindi week, Vigilance awareness week, Swachta pakhwada, Kisan diwas and three trainings were organized.

••••• 2. INTRODUCTION •••••

2.1. History

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

the AICRP on Cashew is operating at 14 Centres distributed in major cashew growing regions of the country. The prefix “ICAR” was added before the Institute name since 2014 according to the instructions of ICAR, New Delhi. The institute is conducting and coordinating research on different aspects of cashew such as germplasm collection and conservation, crop improvement, crop production, crop protection, post harvest technology and transfer of technology.

2.2. Location

The main campus of ICAR-DCR is situated 5 km away from Puttur town at Mottethadka of Kemminje (12.45°N latitude, 75.15°E longitude and 90 m above MSL). The main campus has an area of 69.02 ha having an administrative block, research laboratories and field experimental plots. Besides, the Directorate has an experimental station at Shantigodu, located 13 km away from the main campus which has an area of 80 ha.

2.3. Vision, Mission and Mandates

Vision

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

Mission

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

Mandates

- To undertake strategic, basic and applied research for enhancing productivity, quality, processing efficiency and value addition of cashew.
- To serve as a national repository of genetic resources and scientific information on cashew.

- To coordinate All India Coordinated Research Project on Cashew for addressing location and region-specific problems.
- To promote capacity building through the transfer of technology and consultancy services to stakeholders.

2.4. Organogram

The Director is the administrative head of the Directorate. The Institute Management Committee (IMC), Research Advisory Committee (RAC) and Institute Research Council (IRC) assist the Director in the matters relating to the management and research activities of the directorate respectively (Fig. 2.1). The research and extension on various aspects of cashew are conducted in five sections *viz.*, crop improvement, crop management, crop protection, post harvest technology and transfer of technology. The institute also has different laboratories for sections of horticulture, soil science, plant breeding, plant physiology, biotechnology, plant protection and post harvest technology. The other facilities available at the directorate include Audio Visual Laboratory, Prioritization, Monitoring and Evaluation Cell (PME), Institute Technology Management Unit (ITMU), Agricultural Knowledge Management Unit (AKMU), Vigilance Cell, Women cell, Library, Museum and Agri Business Incubation (ABI). The Directorate also functions as headquarter for the All India Coordinated Research Project on Cashew.

2.5. Library/AKMU/ITMU/ABI

The Directorate has got a well established library in the field of cashew research. The library is serving as an Information Centre on all aspects of cashew research and development in the country. The CD database *viz.* CABHORT, CABPEST, AGRICOLA and AGRIS, SOIL CD, CROP CD, PLANTGENE CD and TROPAG CD and online CAB database are also available. The

library is equipped with automation software and barcoding facility. The library has 1938 books and 2030 back volumes of various journals. The library subscribes 35 national and 2 international journals. The library is a member of Consortium of Electronic Resources on Agriculture (CeRA), New Delhi. Tech-Focuz digital library software is also available for CD Database search.

The Agricultural Knowledge Management Unit (AKMU) was established with the responsibility of developing Information and Communications Technology (ICT) in agricultural research, maintaining the Institute's network, the website and the webserver administration. The AKMU is managing the internet facilities and wi-fi connectivity at the Directorate. The Institute Technology Management Unit (ITMU) was established for intellectual property management and transfer/commercialization of agricultural technologies developed. Besides, an Incubation ABI centre has been established at ICAR-DCR during October 2019 for providing support for emerging or existing entrepreneurs.

2.6. Staff

The Institute has a sanctioned strength of 22 scientific, 19 technical, 14 administrative, 19 skilled support staff, of which 16 scientists, 10 technical staff, 7 administrative staff and 17 skilled support staff are in position and the remaining are vacant as on 31st December, 2020 (Table 2.1).

Table 2.1. Staff position as on 31.12.2020

Category	Sanctioned	Filled	Vacant
Director (RMP)	1	-	1
Scientific	22	16	6
Technical	19	10	9
Administrative	14	7	7
Skilled support staff	19	17	2
Total	75	50	25

2.7. Budget

During the financial year (FY) 2020-21, the total budget allotted to the Directorate was Rs. 715.50 lakhs of which, Rs. 655.03 lakhs were utilised till December, 2020. Under externally funded projects, the total receipts were Rs. 279.00 lakhs, of which Rs. 86.61 lakhs were utilised till December, 2020 and the revenue generation during April-December, 2020 was Rs. 44.10 lakhs. Budget details from April 2020 to December 2020 are presented in Table 2.2, 2.3 and 2.4.

Table 2.2. Budget and expenditure details of DCR for the period (April-December, 2020) (Rs in Lakhs)

Particulars	Allocation	Utilization
GIA capital	0.00	0.00
GIA salary	473.00	469.31
Pension	80.57	68.97
GIA general	116.15	116.11
TSP	18.89	0.05
SCSP	27.19	0.59
NEH	0.00	0.00
Total	715.50	655.03

Table 2.3. Receipts and expenditure under externally funded schemes at DCR for the period (April- December, 2020) (Rs in Lakhs)

Particulars	Allocation	Utilization
RKVY-RAFTAAR, Govt. of Karnataka	268.65	79.43

Table 2.5. Infrastructure and assets

Sl. No.	Details	Amount (Rs.)	Budget head
1	Cashew Plant Health Clinic Museum (Phase -II)	39,40,473.20	RKVY-RAFTAAR (Soil)
2	Island tables /wall tables for Soil Science section	3,98,840.00	
3	Microwave Plant Sample Digestion System (Milestone, Ethos Easy)	19,82,400.00	
4	Refrigerated Centrifuge (REMI CPR 30 PLUS)	3,86,274.00	
5	Culvert, soil and water conservation channel	1,27,444.00	

Particulars	Allocation	Utilization
PPV&FRA, New Delhi	4.30	2.45
DCCD, Cochin	1.02	0.00
ABI	1.50	0.77
ITMU	4.02	3.96
Total	279.00	86.61

Table 2.4. Revenue generation at ICAR-DCR for the period (April- December, 2020) (Rs in Lakhs)

Revenue Target (2020-21)	Revenue generated till December, 2020
118.17	44.10

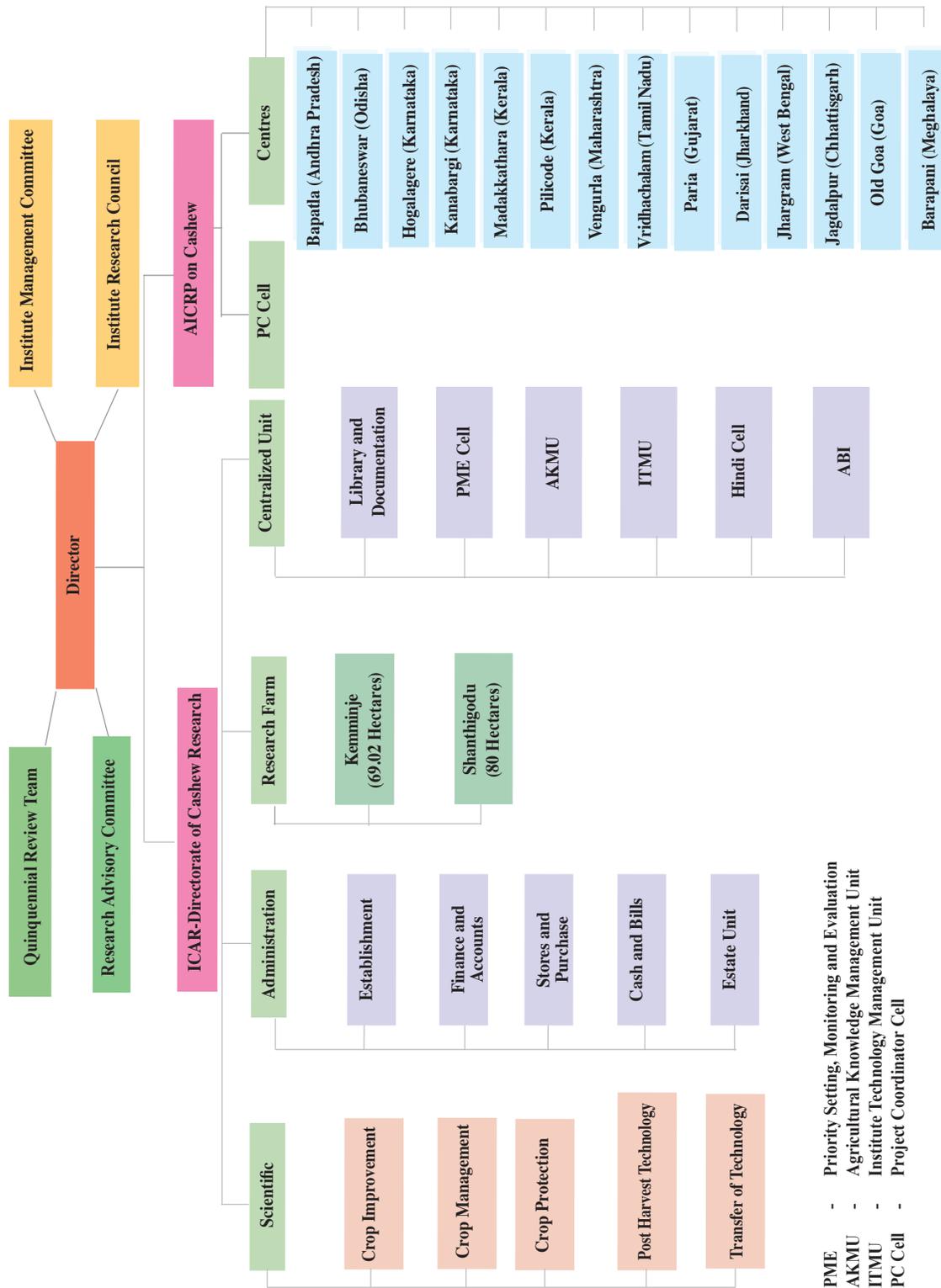
2.8. Production of planting materials

ICAR-DCR has cashew nurseries at both of its campuses: Kemminje and Shantigodu, accredited by Directorate of Cashewnut and Cocoa Development (DCCD), Cochin with four-star rating to cater the need of planting material. Softwood grafts of varieties like Bhaskara, NRCC Selection-2, Ullal-3, Ullal-1, VRI-3, Vengurla-7, Vengurla-4, H-130, Dhana etc. are produced in the nurseries every year to supply to the farmers and other stakeholders. A total of 1,02,047 grafts were supplied to the farmers and developmental agencies from the Directorate during January-December, 2020.

2.9. Infrastructure and assets

The major infrastructures developed during the year 2020 are provided in Table 2.5. During the period, instrumental facilities of the Soil Science section was strengthened with the purchase of modern equipments under the project funded by RKVY-RAFTAAR.

ICAR-Directorate of Cashew Research



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

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



3. RESEARCH ACHIEVEMENTS

3.1. CROP IMPROVEMENT

3.1.1. NRC-492: A novel dwarf cashew variety

Cashew (*Anacardium occidentale* L.) is generally tall and vigorous growing tree with spreading branches and it consumes considerable land area for its cultivation and economic yield. However, pruning attempts in different varieties at the ICAR-DCR, Puttur have resulted in identification of varieties that are responsive to pruning such as VRI-3, H-130 and NRCC Selection -2, and eventually their suitability to high density planting systems. These varieties have been profitably deployed in high and ultra high density planting systems by farmers in different parts of the country. Nevertheless, farmers need to severely prune these varieties every year to economically maintain their orchards which is a labour intensive practice.



Fig. 3.1.1. A tree of NRC-492

The drudgery of pruning in high density planting systems can be reduced to a greater extent by introducing genetically dwarf varieties. However, the country was hitherto lacking dwarf cashew genotypes and for the first time, the Directorate has come up with the identification of a dwarf cashew accession NRC-492 (Nethra vaman) (Fig. 3.1.1 and 3.1.2). This was evaluated for ten years and recently it is approved for release for cultivation in the Annual Group Meeting of scientists of

AICRP on cashew held during 18-19th December, 2020. The dwarf genotype was selected from the seedling progenies. Upon characterisation and evaluation, its slow growth and dwarf character were confirmed. The accession was subsequently conserved in the National Cashew Field Gene Bank at the Directorate. The salient features are given in the Table 3.1.1.

Table 3.1.1. Features of NRC-492 as per Cashew Descriptor

Character	Particulars
Tree height (10 th year)	2.5 m (dwarf)
Tree spread (10 th year)	6.0 m (Intermediate)
Internodal length	0.9 cm (Short)
Duration of flowering	Precocious flowering, long duration (>90 days)
Nut weight	5.5-6.0 g (Intermediate)
Apple weight	50 g (Medium)
Cashew apple skin and colour	Glossy, red colour, crispy and less fibrous
Special character	Stem galling
Yield	1.0-1.5 kg (4 th year of planting)
Cumulative yield (6 harvests)	9.1 kg



Fig. 3.1.2. Stem galling, fruits and nuts of NRC-492

The accession suits well for ultra density planting system (3m x 3m spacing). When compared to varieties which are suitable for ultra density planting, this variety can be maintained with minimum pruning and trimming as orchard management practices. The genotype is also observed performing fairly well under partial shaded conditions and thus it may be suitable for under planting in widely spaced coconut plantations where there is more than 50-60 per cent sunshine penetration. The genotype is moderately susceptible to major pest of cashew *i.e.*, Tea Mosquito Bug (TMB) like any other cashew variety but it is easier to take plant protection sprays as plants are dwarf in nature. The variety is also amenable for homestead and terrace gardens, and for bonsai cultivation.



It is hoped that this variety brings in a new interest in cashew cultivation to increase the production of cashew.

3.1.2. Management of genetic resources in cashew

Germplasm conservation

A new block of unique germplasm types has been established with planting of four unique types including purple mutant and two wild relatives of *Semecarpus prainii* (Fig. 3.1.3). Nine more unique types *viz.*, NRC-492, Taliparamba-1, Kodippady-2, NRC-116, MGN-1, MGN-2, exotic hybrid, interspecific hybrid and *Anacardium microcarpum* have been planted in this block.



Fig 3.1.3. *S. prainii* tree located in Long Island; Fruits and nuts of *S. prainii*

Germplasm evaluation

Accessions planted (13 nos) during 2008 were characterized for reproductive characters and grouped as per cashew descriptors during the season (Table 3.1.2). Field screening for tea mosquito bug (TMB) damage in the accessions (NRC-514 to NRC-528) was carried out from 2015-16 to 2019-20. Compared to the last five years, TMB incidence was more during 2020. All the accessions had infestation of TMB and the mean maximum damage grade was recorded on

NRC-515 (3.24) followed by NRC-521 (2.82) in the scale of 0-4, while, minimum damage grade was noticed on NRC-524 (1.15). Depending on the field population, the TMB damage grade during the last five years was found to vary widely in the accessions over the years. Overall mean TMB damage grade of last five years was high on NRC-528 (0.99), followed by NRC-521 (0.95) and least damage was recorded on NRC-526 (Table 3.1.3).

Table 3.1.2: Details of accessions characterized during the fruiting season in the year 2019

Data field	Descriptor	Descriptor state	No. of Accessions
7	Tree habit	3 Upright and compact	11
		5 Upright and open	
		7 Spreading	
9	Leaf shape	1 Oblong	13
		2 Obovate (Club-shaped)	
		3 Oval	
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	
28	Season of flowering	3 Early (Nov-Dec)	13
		5 Mid (Dec-Jan)	
		7 Late (Jan-Feb)	
31	Mature cashew apple colour	1 Yellow	1
		2 Red	7
		3 Yellow red	3
		4 Red purple	2
32	Shape of cashew apple	1 Cylindrical	7
		2 Conical-obovate	2
		3 Round	4
		4 Pyriform	
50	Attachment of nut to cashew apple	3 Loose	6
		5 Intermediate	
		7 Tight	7
35	Nut weight	3 Low (<5 g)	1
		5 Intermediate (5-7 g)	9
		7 High (>7 g)	3
43	Weight of cashew apple	3 Low (<27 g)	5
		5 Medium (27-52 g)	
		7 High (>52 g)	
62	Apple to nut ratio	3 Low (<6)	8
		5 Medium (6-12)	
		7 High (>12)	
63	Shelling percentage	3 Low (<18 %)	6
		5 Intermediate (18-28 %)	
		7 High (>28%)	

Data field	Descriptor	Descriptor state	No. of Accessions
64	Kernel weight	3 Low (<2 g)	9
		5 Intermediate (2-2.5 g)	3
		7 High (>2.5 g)	1
65	Attachment of peel to kernel	3 Loose	12
		5 Intermediate	
		7 Tight	1

Table 3.1.3. TMB grades for the germplasm under field screening

Germplasm	TMB grade (2019-20)	Overall Grade (2015-16 to 2019-20)
NRC-514	1.66	0.74
NRC-515	3.24	0.92
NRC-516	1.84	0.69
NRC-517	2.55	0.76
NRC-518	-	0.56
NRC-519	1.20	0.54
NRC-520	1.87	0.70
NRC-521	2.82	0.95
NRC-522	2.40	0.77
NRC-523	1.60	0.61
NRC-524	1.15	0.78
NRC-525	1.18	0.65
NRC-526	-	0.40
NRC-527	-	0.70
NRC-528	2.44	0.99

(- Trees dead during course of time)

Germplasm survey and collection

During February 2020, germplasm survey was conducted in Karnataka Cashew Development Corporation (KCDC) plantations in Dakshina Kannada, Udupi and Uttara Kannada districts to locate TMB tolerant

types due to severe outbreak during the year, but tolerant types were not found. One apparently dwarf type was located in Darle Gudda in Kundapur division and it is under observation. The planting material for H-130, a hybrid from ICAR-DCR, Puttur and two hybrids from Bapatla station viz., BPP-9 and BPP-10 were prepared for inclusion in National Cashew Field Gene Bank (NCFGB) during the planting season. Applications were submitted to obtain IC numbers for BPP-9, BPP-10, NRC-492 and NRC-546 (H-130).

Germplasm database enrichment

A total of 842 images comprising of tree, bark, leaf, flower, inflorescence, fruit and nut belonging to 76 cashew germplasm accessions were uploaded onto the cashew germplasm database during the year. The database site was visited 3523 times.

Maintenance of Core collection

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

3.1.3. Screening of cashew germplasm for apple and nut characters

The germplasm accessions were screened for protein content. Among the 17 accessions, NRC-79 had highest protein (23.45 %), while, NRC-467 had the lowest protein content (13.45 %) (Table 3.1.4).

Table.3.1.4 Protein content in the apples of cashew accessions

Acc. No.	Protein (%)	Acc. No.	Protein (%)
NRC-14	18.20	NRC-203	17.15
NRC-41	21.21	NRC-206	14.23
NRC-66	15.24	NRC-215	17.54
NRC-79	23.45	NRC-218	19.85
NRC-90	17.23	NRC-340	19.54
NRC-102	18.17	NRC-344	20.31
NRC-103	16.34	NRC-384	19.18
NRC-192	17.25	NRC-467	13.45
NRC-201	17.45		

3.1.4. Evaluation of cashew apple genotypes for apple yield and quality

Cashew apple morphology and yield

Among the accessions evaluated during 2020, NRC-176 recorded maximum height (5.67 m), girth (66.14 cm) and canopy spread (6.47 m) (Table 3.1.5). NRC-301 had the longest (10.17 cm) and heaviest apples (181.58 g) and NRC-270 had the broadest apples (7.09 cm) (Table 3.1.6).

Table 3.1.5. Plant morphological parameters of cashew apple accessions

Acc. No.	Growth parameters		
	Height (m)	Girth (cm)	Canopy spread (m)
NRC-301	5.34	62.14 ^{ab}	5.74
NRC-189	4.83	59.08 ^{abc}	5.21
NRC-176	5.67	66.14 ^a	6.47
NRC-270	4.86	52.64 ^{abc}	5.29
NRC-112	4.57	57.42 ^{abc}	5.88
NRC-389	4.69	53.83 ^{abc}	5.06
NRC-175	3.99	49.08 ^{bcd}	5.45
NRC-183	4.22	50.67 ^{bcd}	4.99
NRC-75	3.64	45.47 ^{cd}	4.91
NRC-140	4.29	50.50 ^{bcd}	5.08
NRC-120	3.65	52.25 ^{abc}	4.95
NRC-493	4.13	55.39 ^{abc}	6.07
NRC-111	4.49	62.78 ^{ab}	6.18
NRC-144	5.36	57.25 ^{abc}	5.55
Vengurla-8	4.03	35.67 ^d	4.39
CV(%)	17.01	17.45	14.68
CD (0.05)	NS	1.54	NS

Table 3.1.6. Cashew apple morphology, yield and nut yield

Acc. No.	Apple characters			Yield		Nut wt (g)
	Weight (g)	Length (cm)	Breadth (cm)	Apple yield (kg/ tree)	Nut yield (kg/ tree)	
NRC-75	86.54	7.18	4.55	4.78	0.39	7.01
NRC-111	128.42	9.06	5.26	22.60	2.48	13.91
NRC-112	139.44	8.40	5.44	21.56	2.19	13.90
NRC-120	122.69	7.15	5.54	17.50	1.51	10.57
NRC-140	119.91	8.68	4.76	17.43	1.41	9.62
NRC-144	118.74	8.11	5.19	10.11	0.79	9.23
NRC-175	90.49	5.94	5.58	36.47	3.02	7.60
NRC-176	64.20	5.61	4.46	15.43	1.30	7.33
NRC-183	119.68	8.22	5.20	1.95	0.24	14.45
NRC-189	105.32	7.36	5.52	13.59	1.65	12.76
NRC-270	113.63	6.84	7.24	10.95	1.05	10.92
NRC-301	181.58	10.17	6.24	13.07	0.87	12.10

Acc. No.	Apple characters			Yield		Nut wt (g)
	Weight (g)	Length (cm)	Breadth (cm)	Apple yield (kg/ tree)	Nut yield (kg/ tree)	
NRC-389	77.92	6.27	5.98	6.64	0.75	8.78
NRC-493	68.29	9.00	4.60	5.57	1.02	12.53
Vengurla-8	66.13	7.74	4.32	3.96	0.57	9.49
CV%	17.54	16.04	15.99	13.95	14.45	16.95
CD (0.05)	3.84	2.53	1.74	3.65	3.77	3.71

Organoleptic evaluation of fresh cashew apple

All the 14 accessions were subjected to organoleptic evaluation in respect of colour, fragrance, flavour, texture, taste and overall acceptability (Table 3.1.7). The results indicated

that NRC-301 is more acceptable with overall acceptability grade of 6.25. However, its acceptability is little lesser than the check variety Vengurla-8 (6.75).

Table 3.1.7. Details of organoleptic evaluation

Acc. No.	Colour & Fragrance	Flavour	Texture	Taste	Over all acceptability
NRC-75	4.50	4.50	4.00	4.50	4.00
NRC-111	7.20	4.80	5.80	5.00	5.60
NRC-112	5.20	4.60	4.60	4.20	4.40
NRC-120	3.00	2.40	2.40	2.20	2.00
NRC-140	4.00	3.50	4.50	3.50	3.50
NRC-144	5.00	4.00	5.00	4.00	3.50
NRC-175	5.00	5.20	5.20	5.60	5.60
NRC-176	5.75	5.00	5.50	4.75	5.25
NRC-183	6.00	6.00	6.40	6.00	5.80
NRC-189	3.00	4.00	4.00	4.00	4.00
NRC-270	5.75	5.50	5.75	5.50	5.50
NRC-301	7.75	5.75	5.50	5.00	6.25
NRC-389	5.00	5.50	6.00	5.50	5.50
NRC-493	6.00	5.25	6.00	4.75	5.25
Vengurla-8	6.25	6.50	6.50	6.25	6.75

3.1.5. Development of dwarf and compact cashew hybrids

Direct and reciprocal crosses

Observations on nut yield and growth traits such as stem girth (cm), tree height (m), tree spread (m) and yield per tree (kg) were recorded in 12 selected trees. The data recorded for nut yield and growth characters is presented in Table 3.1.8. There was severe outbreak of TMB

incidence during this year and yield levels were very low. Tree no.3 of cross Priyanka x NRC-492 recorded highest annual nut yield of 2.39 kg and gave second highest cumulative nut yield of 12.81 kg over 5 harvests. Tree no.149 of NRC-492 x Madakkathara 2 (Fig.3.1.4) recorded

2nd highest annual nut yield of 1.80 kg and the highest cumulative nut yield of 12.90 kg over 5 harvests. The cumulative nut yield of local check Bhaskara was 11.11 kg over five harvests.

The top ten ranking selections were grafted for clonal evaluation in the replicated trial. All these promising selections will be further evaluated for their growth and yield.



Fig. 3.1.4. Nuts and apples of tree no.149 and semi tall tree no.8

Backcrosses

Observations on nut yield and growth traits such as stem girth, tree height, tree spread and yield per tree were recorded in 16 selected trees. The data recorded for nut yield and growth characters is presented in Table 3.1.8. There was severe outbreak of TMB incidence during the year and yield levels were very low. Tree No.BDB-626-58 recorded highest annual nut yield of 1.66 kg and gave cumulative nut yield of

8.47 kg over 4 harvests. It is semi-tall with height of 4.5 m and 4.75 m average tree spread. Tree no. BDB-626-97(Fig.3.1.5) recorded annual nut yield of 0.48 kg and the highest cumulative nut yield of 8.64 kg over 4 harvests. The cumulative nut yield of local check Bhaskara was 7.42 kg/tree over 4 harvests (Table 3.1.9). The top six ranking selections were grafted for clonal evaluation in the replicated trial.



Fig. 3.1.5. Cluster of nuts of high yielding backcross progeny BDB-626-58.

Table 3.1.8. Promising selections with their growth parameters and nut yield (Jan –Dec 2020)

Sl.No.	Cross	T.No.	Girth (cm)	Height (m)	Spread (m)		Nut wt (g)	Nut Yield (kg/tree)	Cumulative nut yield (5 yrs) (kg/tree)
					E-W	N-W			
Selections in 2018									
1	Vengurla-4 x NRC-492	28	77.0	7.3	6.5	7.0	5.50	0.88	10.48
2		65	63.0	5.6	6.3	6.8	7.50	0.50	11.16
4	Vengurla-4 x Taliparamba-1	122	77.0	5.5	6.5	8.0	6.00	0.21	11.08
5	Priyanka x NRC-492	3	80.0	7.5	6.1	8.5	6.50	2.40	12.81
6	Madakkathara-2 x NRC-492	102	78.5	6.8	7.5	7.0	6.20	0.28	8.29
7	NRC-492 X Madakkathara-2	149	75.0	6.8	8.0	7.5	6.60	1.80	12.90
Selections in 2019									
1	Dhana x NRC-492 (Semi tall)	29	57	4.5	5.3	6.5	8.30	1.34	6.30
2	NRC-492 X Dhana	49	64.0	6.0	6.0	6.1	8.04	0.46	7.03
4		53	70.5	5.7	7.0	6.5	5.90	0.54	8.26
5	Madakkathara-2 x NRC-492	13	90.	6.5	6.5	8.5	6.00	0.37	8.63
6		117	93.0	7.0	8.0	7.5	5.00	1.10	9.34
7		99	81.0	7.0	6.5	8.5	5.00	0.21	6.40

*The cumulative nut yield of local check Bhaskara is 11.11 kg over 5 harvests.

Table 3.1.9. Promising progenies identified in back cross population

Plant No.	Height (m)	Spread (m)		Girth (cm)	Nut yield (kg/tree)	Cumulative nut yield (kg/tree) (3 harvests)
		EW	NS			
BDB-372-4	4.75	4.0	3.00	41.00	0.81	3.56
BDB-372-23	5.50	4.00	7.10	68.00	0.87	6.09
BDB-372-36	5.0	3.50	3.10	51.50	0.38	3.60
BDB-372-37	7.50	5.00	6.20	60.00	0.55	6.53
BDB-372-46	6.50	3.00	4.00	52.50	0.34	4.25
BDB-372-60	5.30	4.50	3.00	39.00	0.39	8.35
BDB-372-61	7.00	6.90	7.50	62.00	0.67	6.84
BDB-372-84	5.00	7.10	6.50	75.50	0.75	8.14
BDB-372-90	7.00	6.00	7.10	53.00	0.34	5.08
BDB-626-49	5.50	5.00	6.00	65.50	0.58	6.01
BDB-626-58	4.50	5.50	4.00	46.00	1.67	8.47
BDB-626-97	4.50	5.50	6.00	48.00	0.48	8.64
BDB-626-113	4.00	4.00	5.00	48.50	0.99	6.75

Plant No.	Height (m)	Spread (m)		Girth (cm)	Nut yield (kg/tree)	Cumulative nut yield (kg/tree) (3 harvests)
		EW	NS			
BDB-626-114	4.50	5.00	6.10	45.50	0.25	2.92
BDB-626-122	5.00	5.50	5.00	50.50	0.21	6.16
UDU-577-85	5.00	5.50	6.00	54.50	0.75	4.73

*The cumulative nut yield of local check Bhaskara was 7.42 kg/tree over 3 harvests.

3.1.6. Mutation breeding and interspecific hybridization in cashew for TMB tolerance with high yield

Mutation Breeding

A total of 114 seedlings and grafts (from gamma ray treated seeds and scion sticks) of two popular varieties *i.e.* Bhaskara and Ullal-3 planted during 2018 were maintained. In few seedlings, phenotypic variations such as puckering of leaves, dwarfness and excessive branching were

recorded. The M₁ progenies will be screened for TMB tolerance in the subsequent seasons.

Interspecific hybridization

Earlier, two Ullal-1 x *A. microcarpum* progenies were identified to be relatively tolerant and designated as TMBT. These progenies were assessed for TMB damage during the year and scoring was done on these trees (Table 3.1.10). From the results, it was evident that no significant difference was observed between TMBT and adjacent trees.

Table 3.1.10. TMB damage grade in TMBT and adjacent trees

Mean TMB grade (0-4) *			
TMBT1	TMBT2	Adjacent tree 1	Adjacent tree 2
1.0	0.68	0.72	0.72

*(Mean of 26 shoots/tree) (Scoring standard: Resistant = 0.0-1.0, Moderately resistant = 1.1-2.0, Moderately susceptible = 2.1-3.0, Susceptible = 3.1-4.0)



Fig. 3.1.6. Free choice and no choice test

Further, one of these relatively TMB tolerant progenies was crossed as male parent, with two popular varieties Ullal-3 and Vengurla- 4 to develop pre-breeding lines for TMB tolerance. The lab screening of 15 pre-breeding lines (under free choice) for TMB infestation indicated that 6 had damage symptoms (Fig. 3.1.6). Other

progenies need to be tested further. Under no choice test (single plant confined with TMB nymphs @ 2 nos for 48 hours), all the 21 tested plants had infestation of TMB with damage grade between 2 and 4. The progenies (65) planted in the field will be tested in the next phase.

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

For improving the nut size in the cluster bearing genotypes with small and medium nut size, 247 seedlings of nine crosses between cluster bearing types x bold nut types and 161 seedlings of six crosses made between medium x bold nut and bold x bold nut types were planted during October 2018 along with check varieties viz., Bhaskara and NRCC Selection-2 with spacing of 4m x 4m. During the post rainy season of 2020, shape pruning in all these plants was carried out and plants are being maintained in the field with proper care and gap filling of few was done with check varieties. Flowering in two precocious types was recorded.

3.1.8. Generation mean analysis in cashew to understand the nature of gene action for important traits

Generation mean analysis employing six generations viz., P₁, P₂, F₁, F₂, B₁ and B₂ was initiated in the year 2019 to estimate the nature of gene action for important traits in cashew. During this year, 161 F₂ nuts through selfing of F₁ (Bhaskara x NRC-492) and 163 B₂ nuts through backcrossing of F₁ with another parent (NRC-492) were produced. As there was poor germination in both of these generations in the greenhouse, at present 50 F₂ plants and 33 B₂ seedlings are maintained with proper care (Fig. 3.1.7). In order to plant all the six generations in the field, grafting of four generations viz., P₁, P₂, F₁ and B₁ was carried out during November 2020 using the scions from plants which were planted in the year 2014. The successful grafts are maintained in the nursery at Shantigodu and their status is given the Table 3.1.11. In order to increase the population size of F₂ and B₂, selfing and backcrossing was initiated during December 2020.



Fig. 3.1.7. Seedlings of F₂

Table 3.1.11. Status of grafts / seedlings available in six generations

Sl. No.	Generation	Parentage	No. of grafts
1	P ₁	Bhaskara	18
2	P ₂	NRC-492	16
3	F ₁	Bhaskara x NRC-492	17
4	B ₁	F ₁ x Bhaskara	135
	Generation	Parentage	No of Seedlings
5	F ₂	Selfing of F ₁	50
6	B ₂	F ₁ x NRC-492	33

3.1.9. Breeding for reduced tannin content in cashew apples of popular cultivars

The project was started in the year 2019. During 2020, tannin content in cashew apples from 125 F₁ trees of crosses between *A. microcarpum* and cultivars of *A. occidentale* viz., Ullal-1, Ullal-3, Bhaskara, Vengurla-4 was analyzed. Tree nos. 820, 834, 829, 822, 830 of the cross Bhaskara x *A. microcarpum* were the top five for the lowest tannin content with 0.35, 0.43, 0.44, 0.46, 0.54 mg/g fresh weight corresponding to 0.04, 0.04, 0.04, 0.05, 0.05 %. Tannin contents of Ullal-1, Ullal-3, Bhaskara, and Vengurla-4 were 3.83, 0.85, 1.09, and 2.34 mg/g fresh wt respectively with 0.38, 0.09, 0.11 and 0.23 % respectively (Table 3.1.12). Among these, the lower tannin content hybrids will be used for backcross hybridization with popular cultivars for reducing the tannin content.

Table 3.1.12. Mean tannin content of F₁ population and cultivars

Tree no.	Tannin (mg/g fresh weight)	Tannin (%)	Tree no.	Tannin (mg/g fresh weight)	Tannin (%)	Tree no.	Tannin (mg/g fresh weight)	Tannin (%)
488	1.55	0.16	747	1.36	0.14	827	2.58	0.26
665	3.44	0.34	748	1.84	0.18	828	0.60	0.06
666	4.53	0.45	749	2.38	0.24	829	0.44	0.04
667	2.84	0.28	751	1.91	0.19	830	0.54	0.05
669	4.71	0.47	752	2.03	0.20	831	1.62	0.16
670	4.94	0.49	753	4.51	0.45	832	1.89	0.19
671	4.52	0.45	755	3.51	0.35	833	0.97	0.10
672	2.97	0.30	756	1.32	0.13	834	0.43	0.04
673	3.96	0.40	757	1.15	0.11	835	0.84	0.08
674	4.62	0.46	758	2.35	0.24	836	1.35	0.13
677	3.97	0.40	761	1.23	0.12	837	1.87	0.19
680	3.99	0.40	762	2.38	0.24	838	0.73	0.07
681	4.57	0.46	763	1.97	0.20	840	0.91	0.09
682	4.07	0.41	764	1.22	0.12	841	1.62	0.16
683	3.72	0.37	765	1.12	0.11	842	2.42	0.24
688	3.87	0.39	769	2.57	0.26	843	1.16	0.12
691	4.05	0.41	771	1.31	0.13	845	1.31	0.13
697	3.00	0.30	773	0.95	0.10	846	1.13	0.11
698	2.88	0.29	774	3.21	0.32	847	0.87	0.09
703	3.24	0.32	775	2.62	0.26	848	0.73	0.07
706	2.85	0.28	777	1.06	0.11	851	1.04	0.10
707	3.77	0.38	781	0.58	0.06	854	1.09	0.11
708	3.39	0.34	782	3.70	0.37	855	1.19	0.12
720	4.37	0.44	787	2.31	0.23	857	1.26	0.13
722	3.66	0.37	792	3.77	0.38	778	1.15	0.11
723	4.33	0.43	794	3.56	0.36	779	1.15	0.11
726	4.91	0.49	796	1.00	0.10	780	2.00	0.20
727	3.61	0.36	801	4.19	0.42	783	3.26	0.33
731	1.71	0.17	802	1.58	0.16	785	1.67	0.17
732	0.97	0.10	805	1.15	0.12	788	1.07	0.11
733	1.60	0.16	806	3.04	0.30	789	2.01	0.20
734	1.56	0.16	807	0.58	0.06	790	1.49	0.15
735	3.73	0.37	808	0.80	0.08	791	1.42	0.14
736	1.01	0.10	809	1.69	0.17	793	2.33	0.23

Tree no.	Tannin (mg/g fresh weight)	Tannin (%)	Tree no.	Tannin (mg/g fresh weight)	Tannin (%)	Tree no.	Tannin (mg/g fresh weight)	Tannin (%)
737	3.53	0.35	811	2.21	0.22	799	1.80	0.18
738	3.51	0.35	812	1.54	0.15	800	1.37	0.14
739	0.84	0.08	813	2.08	0.21	803	1.56	0.16
740	1.22	0.12	814	0.94	0.09	866	2.79	0.28
742	1.02	0.10	815	1.94	0.19	Bhaskara	1.09	0.11
743	2.10	0.21	816	1.29	0.13	Ullal-1	3.83	0.38
744	1.60	0.16	819	0.99	0.10	Ullal-3	0.85	0.09
745	1.61	0.16	822	0.46	0.05	Vengurla-4	2.35	0.23
746	1.54	0.15	823	1.73	0.17			

3.1.10. Genetic improvement of cashew for yield and quality traits

3.1.10.1. Evaluation of promising varieties and bold nut hybrids in bulk trial

The seedling selection, tree no. 480 continued to perform as best promising type recording the highest cumulative nut yield of 6.27 kg per tree from two harvests (Table 3.1.13).

Table 3.1.13. Yield of promising varieties and bold nut hybrids

Genotype	Yield (kg/tree)	Cumulative yield of 2 harvests (kg/tree)
Tree no. 480	2.04	6.27
H-32/4	0.22	0.91
NRC-493	0.12	0.68
H-1616	0.07	0.49
Bhaskara	0.93	3.78
CD @ 5%		0.43
CV (%)		14.38

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

Designing of primers for SSRs identified from the draft genome sequence

Primers were designed for 47,646 SSRs identified in the draft genome sequence generated at ICAR-DCR, Puttur in the previous year. A total of 75 primer pairs were synthesized to develop novel genomic SSRs for cashew.

Shoot transcriptomes analysis

The shoot transcriptomes of giant cultivar Bhaskara and Dwarf accession NRC-492 were generated using the illumina sequencing and assembled *de novo* (Fig. 3.1.8). A total of 138 million high quality adapter free reads were utilized in assembly and annotations. Assembly of high quality reads resulted in 55501 transcripts. The average length of assembled transcripts was 855 bp. About 55 % of transcripts were functionally annotated against Viridiplantae database. Simple sequence repeat (SSR) analysis revealed a total of 4882 SSRs in 55501 transcripts.

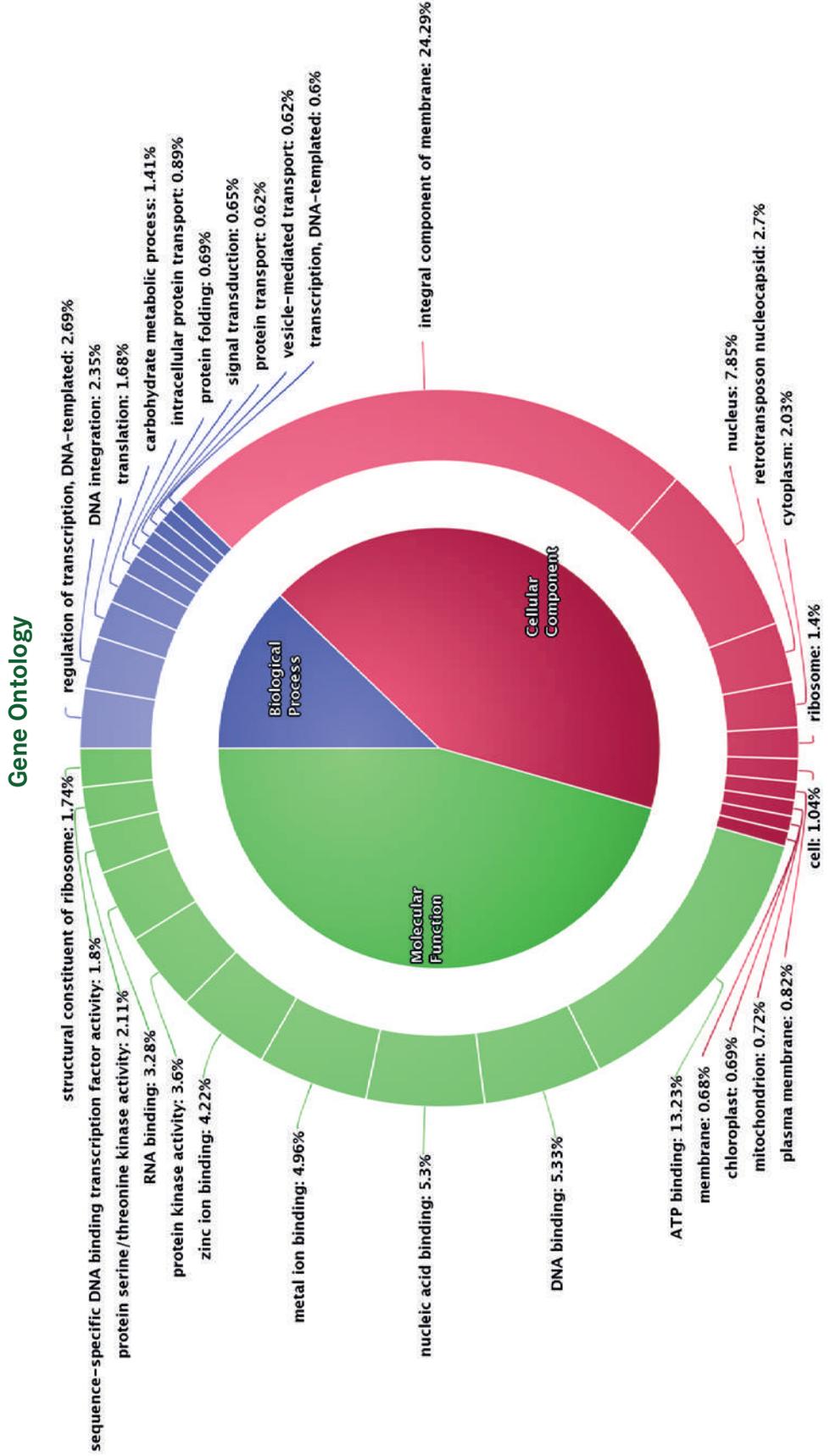


Fig. 3.1.8. Gene ontology of cashew shoots transcriptome

Field planting of seedlings from the crosses

Seedlings of cross NRC-492×Vengurla-7, Vengurla-7×NRC-492, NRC-492×H-130, NRC492×Bhaskara and NRC 492×Thaliparamba crosses produced in the previous year were raised in the nursery and planted in the field during 2020 at a spacing of 3×3 m and 4×4 m.

3.1.12. Genetic dissection of QTLs governing nut yield and Cashew Nut Shell Liquid (CNSL) content in cashew

Field planting of mapping populations

The two mapping populations (Bhaskara×NRC-188 and Vengurla-7×NRC-116) developed in the previous year were planted in the field at a spacing of 5×5 m and 3×3 m (Fig. 3.1.9).



Fig. 3.1.9. View of mapping populations planted in the field

In vivo grafting of F₁ seedlings of field planted seedlings and nursery raised seedlings

Shoots of the newly planted F₁ seedlings were grafted on to the tree to record their growth pattern on the shoots of trees and these could also act as

the duplicate clones. In the previous year, 42 F₁ seedling scions were grafted on the side shoots of main stem. Out of which, 23 survived and three of the survived produced inflorescences in a year time (Fig. 3.1.10). The panicle producing shoots belonged to the crosses Bhaskara×NRC-188 and Vengurla-7×NRC-116. There were also changes in the leaf morphology i.e., a change of seedling type to the mature type leaves.



Fig. 3.1.10. In vivo grafted seedlings of mapping populations produced flowers in a year on mature trees (inside -Fruits)

Externally Funded Projects:

3.1.13 Development of morphological descriptors and DUS test guidelines for cashew

Thirty reference varieties for the purpose of DUS testing established at a spacing of 6 x 6 m with four plants per variety were maintained during 2020. The application for registration of the hybrid, H-130 was submitted to the PPV&FRA, New Delhi and the plants of H-130 were planted adjacent to the reference variety block for DUS testing.

3.2. CROP MANAGEMENT

3.2.1. Studies on pruning and phenology in cashew

The pruning treatments were imposed on Bhaskara trees in the months of June, August and September. The pruning response of Bhaskara was better when pruning was done in September. Pruning of laterals @ 25 % level led to production of highest number of panicles per tree leading to highest yield closely followed by pruning of laterals at @ 50 % level (Table 3.2.1).

Table 3.2.1. Effect of pruning on number of flowering panicles and yield in variety Bhaskara

Treatment	Flowering panicles/tree	Yield (kg/tree)
June @ 25 % leader	0	0
June @ 50 % leader	0	0
June @ 25 % lateral	41.00	1.72
June @ 50 % lateral	31.50	1.31
August @ 25 % leader	17.00	0.69
August @ 50 % leader	35.00	1.43
August @ 25 % lateral	25.00	1.03
August @ 50 % lateral	47.00	1.89
September @ 25 % leader	36.50	1.47
September @ 50 % leader	25.50	1.06
September @ 25 % lateral	64.50	2.66
September @ 50 % lateral	64.00	2.50
Control	35.50	1.47
CD@ 5 %	4.53	0.09
CV(%)	6.39	3.20

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

The influence of time of recommended dose of fertiliser (RDF) application on the cashew phenology was recorded in cashew cultivars viz., Ullal-3 and Bhaskara (Table 3.2.2). The RDF was applied in the months of July, August and September and the phenological growth stages were recorded at fortnight intervals from October, 2019 onwards. The study showed that the buds were at 010 stage (dormant stage) till first fortnight of October, 2019 invariable to cultivar and time of fertiliser application. When the time of fertiliser application is considered, July application advanced the flowering and fruiting invariable to cultivars.

Further, nitrogen content was estimated in leaf and soil samples collected from both the cashew varieties to study the influence of time of RDF application in altering the phenology of cashew trees. In Bhaskara, the average nitrogen content in leaves has increased from 0.78 to 1.03 percent in August application, indicating August application encourages maximum intake of nitrogen in Bhaskara (Table 3.2.3). Whereas in Ullal-3, the maximum nitrogen intake was recorded in July application (Table 3.3.4). However, the time of application of fertilisers did not have any influence on yield of both the cultivars (Table 3.2.5).

Table 3.2.2. Different phenological stages influenced by time of fertiliser application in variety Bhaskara

Time of fertiliser application	Phenological observation at fortnight interval (in code)											
	Bhaskara											
	October		November		December		January		Feb		March	
	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd
Control	010	019	313	317	511	516	613	713	719	815	-	-
July	010	019	313	513	613	711	713	815	Senescence	Senescence	-	-
August	010	019	313	511	511	516	613	715	813	819	-	-
September	010	019	313	317	511	517	517	613	713	719	815	819

Table 3.2.3. Different phenological stages influenced by time of fertiliser application in variety Ullal-3

Time of fertiliser application	Phenological observation at fortnight interval (in code)											
	Bhaskara											
	October		November		December		January		Feb		March	
	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd
Control	010	017	313	513	513	611	613	711	813	819	-	-
July	010	017	313	117	516	517	611	711	819	-	-	-
August	010	017	313	516	516	611	613	713	815	819	-	-
September	010	017	313	516	613	711	713	719	813	819	-	-

Table 3.2.4. Nitrogen uptake pattern of leaves as influenced by time of fertiliser application

Time of fertiliser application	Time of leaf sample collection	Average nitrogen content in leaf samples (%)	
		Bhaskara	Ullal-3
July	Control (July before fertiliser application)	0.773±0.33	0.471±0.22
	August	0.846±0.02	0.713±0.55
	September	0.970±0.21	0.819±0.14
August	Control (August before fertiliser application)	0.777±0.36	0.519±0.03
	September	1.034±0.05	0.695±0.09
September	Control (September before fertiliser application)	0.798±0.48	0.538±0.24
	October	0.886±0.18	0.689±0.21

Values are mean ± standard deviation of three replicates.

Table 3.2.5. Yield of cashew as influenced by time of fertiliser application

Time of fertiliser application	Average yield (kg/tree)			
	Bhaskara	Rank of treatments	Ullal-3	Rank of treatments
July	1.21±0.001	3	0.79±0.001	5
August	1.23±0.049	2	0.90±0.002	3
September	1.14±0.001	4	0.88±0.209	4
October	1.31±0.001	1	1.08±0.066	2
Control	1.08±0.01	5	1.11±0.12	1
CD (p-0.05)	0.17 (NS)		0.12 (NS)	
CV(%)	8.74		15.52	

Values are mean ± standard deviation of three replicates.

Estimation of carbon in leaf samples

Carbon content was also estimated for the leaf samples collected from both the cashew varieties. In Bhaskara, the maximum carbon content was recorded in August when fertilisers

were applied during July (Table 3.2.6). But, the maximum carbon content was recorded in September when fertilisers were applied during August in Ullal-3.

Table 3.2.6. Leaf carbon content as influenced by time of fertiliser application

Time of fertiliser application	Time of leaf sample collection	Average carbon content in leaf samples (%)	
		Bhaskara	Ullal-3
July	Control (July before fertiliser application)	45.29±2.11	43.40±1.20
	August	52.90±0.76	31.57±0.23
	September	30.19±0.13	32.61±0.91
August	Control (August before fertiliser application)	41.64±1.45	43.27±1.74
	September	32.56±0.58	49.28±1.77
September	Control (September before fertiliser application)	41.11±1.29	47.62±0.47

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

To standardise the fertiliser recommendation under high density or ultra density planting (UDP) in cashew, the existing ultra density plots of variety H-130 at 2.5 x 2.5 m spacing were selected. As per the response surface function approach of statistical analysis, 20 treatments comprising different combinations of N, P₂O₅ and K₂O were imposed. The analysis of leaf samples at flushing during 2018-19 showed percent nitrogen content from 0.66 to 2.15, phosphorus from 0.17 to 0.44, potassium from 0.11 to 0.75, calcium from 0.38 to 1.74 and magnesium from 0.11 to 0.48. The micronutrients content in leaf samples varied from 15.06 to 446 ppm for iron, 110 to 498 ppm for manganese, 37.8 to 62.3 ppm for zinc, 22.7 to 56.3 ppm for copper and 5.6 to 12.7 ppm for boron. The raw cashewnut yield ranged from 0.63 to 2.18 kg/tree. It was 1.6 to 2.3 kg/tree during the year 2019-20. The predicted NPK dose for UDP at a spacing of 2.5 x 2.5 m was found to be

80:20:40 g/tree/year for the yield of 2.2 kg/tree with a desirability value of 0.96.

3.2.3. Characterization of physiological responses of cashew (*Anacardium occidentale* L.) to salinity and drought stresses

The growth responses of six cashew cultivars [Bhaskara, VTH-174, VTH-30/4, Ullal-3, Vengurla-4 (V-4) and Madakkathara-2 (MDK-2)] to salinity were investigated at seedling stage. Changes in morphological parameters, growth, pigment content and biomass partitioning parameters were assessed during salinity stress.

Leaf toxicity symptoms

The toxic effects observed on the leaves were mainly chlorosis and necrosis (Fig. 3.2.1). At 50 mM, no leaf necrosis was observed. At 100 mM, the rate of leaf necrosis was 5 %. At 150 and 200 mM, the rate surpassed 39.5 % and 50.2 %. The higher and lower leaf necrosis (%) was recorded in MDK-2 (68.8 %) and Bhaskara (34.3 %) at 200 mM (Fig. 3.2.2).

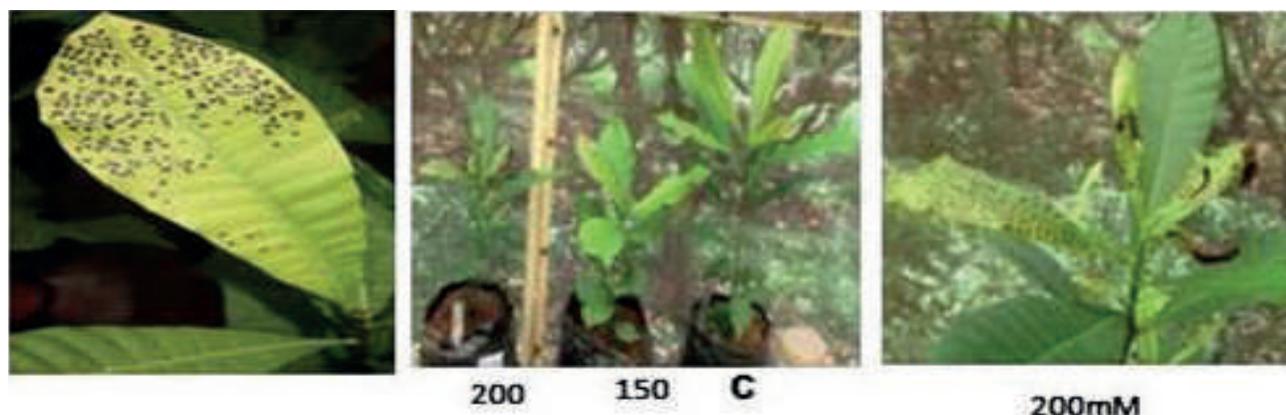


Fig. 3.2.1. Salinity induced leaf toxicity symptoms at 150 and 200 mM NaCl treatments

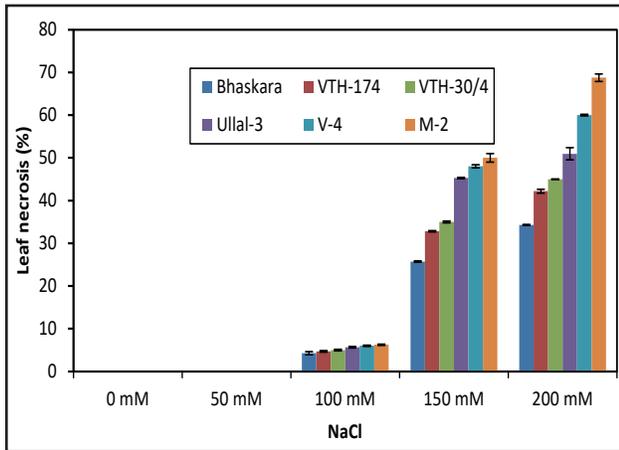


Fig. 3.2.2. Leaf necrosis at different concentrations of NaCl

Effect on morphological parameters

Plant height reduced by 3.8, 22.1, 41 and 62.7 per cent after exposure to 50, 100, 150 and 200 mM, respectively over control. Reduction in plant height was maximum and minimum in MDK-2 (93.3 %) and Bhaskara (49.2 %), respectively at 200 mM. Similarly, total leaf area was reduced by 19.9, 38, 60.8 and 86.9 per cent at 50, 100, 150 and 200 mM over control. Reduction in leaf area was maximum and minimum in MDK-2 (87.7 %) and Bhaskara (38.1 %), respectively at 200 mM. Bhaskara was able to maintain higher cell membrane stability (48.9 %), while the same was lower in MDK-2 (18.9 %) among accessions at 200 mM (Table 3.2.7).

Table 3.2.7. Influence of different levels of salinity stress on morphological parameters of cashew cultivars

Variety	NaCl	PHT	SL	RL	LA	MSI
Bhaskara	0	60.0 ^a ±1.4	27.9±0.99 ^a	16.2±0.27 ^a	111.8±0.88 ^a	73.5 ^a ±0.3
	50	58.6 ^a ±0.1	24.6±0.65 ^b	16±0.50 ^a	101.5±0.72 ^b	70.7 ^a ±1.8
	100	53.2 ^b ±0.1	23.1±0.12 ^{bc}	15.6±0.56 ^a	97.8±0.43 ^c	56.1 ^b ±1.4
	150	45.5 ^c ±0.1	21.9±1.01 ^{bc}	15.1±0.17 ^a	89.5±0.69 ^d	51.3 ^c ±1.2
	200	40.2 ^d ±0.4	20.7±1.24 ^c	14.7±0.68 ^a	80.9±1.01 ^e	48.9 ^c ±1.9
VTH-174	0	53.4 ^a ±0.4	22±0.23 ^a	15.3±0.45 ^a	109.4±0.52 ^a	60.3 ^a ±1.5
	50	50.4 ^b ±0.2	19.3±0.76 ^b	15±0.58 ^a	97.6±1.10 ^b	45.8 ^b ±1.2
	100	47.6 ^c ±0.1	18±0.54 ^{bc}	14.7±1.08 ^a	85.4±0.84 ^c	42.9 ^b ±1.9
	150	42.1 ^d ±0.3	17±0.23 ^{cd}	14±0.34 ^a	78.6±0.31 ^d	37.3 ^c ±0.8
	200	38.6 ^e ±0.1	15.6±1.10 ^d	13.7±0.56 ^a	70.3±0.85 ^e	33.9 ^c ±1.4
VTH-30/4	0	53.6 ^a ±0.7	21.2±0.63 ^a	15±0.23 ^a	106.23±0.59 ^a	58.8 ^a ±1.3
	50	50.6 ^b ±0.2	18.5±0.39 ^b	14.7±0.21 ^{ab}	93.5±0.31 ^b	43.2 ^b ±1.1
	100	46.8 ^c ±0.1	17.2±0.37 ^{bc}	14.2±0.77 ^{ab}	82.1±0.50 ^c	41.7 ^b ±1.1
	150	41.2 ^d ±0.2	16.2±0.20 ^c	13.8±0.23 ^{ab}	74.8±0.86 ^d	35.5 ^c ±1.1
	200	36.5 ^e ±0.1	14.7±0.61 ^d	13.4±0.41 ^b	66.5±0.92 ^e	30.5 ^d ±0.9
Ullal-3	0	60.5 ^a ±1.7	22.1±0.20 ^a	14.6±0.51 ^a	137.9±1.46 ^a	55.4 ^a ±0.7
	50	58.7 ^a ±0.4	19±0.21 ^b	14±0.56 ^a	110.3±0.95 ^b	38.7 ^b ±2.1
	100	50.1 ^b ±0.2	17.6±1.05 ^{bc}	13.6±0.75 ^a	90.7±1.24 ^c	36.3 ^b ±0.8
	150	40.3 ^c ±0.5	16.5±0.75 ^c	13.1±0.89 ^a	73.9±0.63 ^d	28.7 ^c ±1.2
	200	34.2 ^d ±0.2	14.3±0.51 ^d	12.6±0.75 ^a	61.8±0.88 ^e	23.1 ^d ±0.8
V-4	0	59.0 ^a ±0.3	22.3±0.34 ^a	13.1±0.62 ^a	110.8±1.01 ^a	42.4 ^a ±0.7

Variety	NaCl	PHT	SL	RL	LA	MSI
	50	56.8 ^b ±0.2	18.9±0.46 ^b	12.4±0.30 ^{ab}	84.8±0.91 ^b	33.6 ^b ±1.5
	100	43.1 ^c ±0.1	17±1.35 ^{bc}	12.1±0.18 ^{ab}	70.9±1.74 ^c	30.8 ^b ±1.4
	150	38.5 ^d ±0.3	16±0.79 ^{cd}	11.6±0.69 ^{ab}	54.7±0.76 ^d	24.6 ^c ±1.1
	200	32.2 ^e ±0.3	13.8±1.05 ^d	11±0.45 ^b	44.7±1.11 ^e	20.3 ^d ±0.9
MDK-2	0	58.0 ^a ±0.1	20.1±0.44 ^a	12.5±0.91 ^a	96.9±0.75 ^a	40.5 ^a ±2.9
	50	56.2 ^b ±0.2	17±0.46 ^b	11.8±0.89 ^{ab}	73.4±0.30 ^b	32.3 ^b ±0.3
	100	41.3 ^c ±0.3	15.1±0.7 ^{bc}	11.1±0.30 ^{ab}	60.7±1.14 ^c	28.6 ^b ±1.2
	150	35.6 ^d ±0.1	14.1±0.71 ^{cd}	10.6±0.20 ^{ab}	46.9±1.02 ^d	21.7 ^c ±1.2
	200	30.0 ^e ±0.2	12.2±0.72 ^d	10.2±0.37 ^b	35.8±0.53 ^e	18.9 ^c ±2.2
NaCl		2336.022**	92.728**	9.976**	3134.911**	323.324**
Varieties (V)		149.623**	71.644**	39.722**	1071.283**	351.224**
V x NaCl		39.082**	0.221 NS	0.064 NS	67.865**	3.409**

Values are expressed as mean±S.E. (n=4). Means followed by a different letter within a column for each cashew variety are significantly different at $P<0.05$ according to the Duncan's Multiple Range Test (DMRT). PHT denotes plant height (cm), SL-shoot length (cm), RL- root length (cm), LA-leaf area (cm²), MSI- membrane stability index (%).

* and **, Significant at 1% and 5%, respectively; NS, not significant.

Effect on growth parameters

Significant changes in leaf dry weight, root dry weight, shoot dry weight and shoot to root ratio were observed at 150 and 200 mM. At 200 mM, 88.9 per cent reduction in leaf dry weight was observed with least reduction in Bhaskara (43.4 %) and maximum reduction in MDK-2 (53.5 %) over control. Root dry weight was reduced by 20.9 per cent with Bhaskara (16.6 %) and MDK-2 (20.5 %) recording lower and higher reduction at 200mM. Shoot dry weight was reduced by 45 per cent at 200 mM, where, MDK-2 recorded higher reduction (40.2 %) and Bhaskara recorded lower reduction (28.9 %). Total plant biomass reduced by 7.4, 15.5, 35.7 and 78 per cent at 50, 100, 150 and 200 mM over control. At 200 mM, MDK-2 exhibited higher reduction (70 %) while Bhaskara exhibited lower reduction (42 %).

Relative water content (RWC) and membrane leakage (ML)

Significant reduction in leaf water content was observed at 150 mM (30.1 %) and 200 mM

(39.4 %) over control. Reduction in RWC was maximum and minimum in MDK-2 (61.4 %) and Bhaskara (26.1 %) at 200 mM (Fig. 3.2. 3).

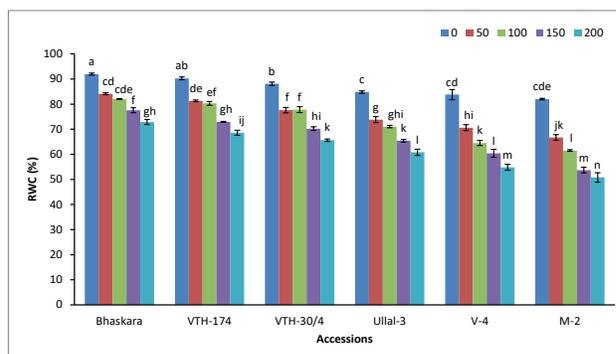


Fig. 3.2.3. Salinity stress induced reduction in leaf relative water content after 30 days of treatments

Loss of cell membrane in leaves was highest at 150 mM (63.2 %) and 200 mM (67.6 %) among treatments over control. At 200 mM, the percent membrane loss was 48.7 % in Bhaskara, while the same was 79.6 % in MDK-2 among accessions (Fig. 3.2.4).

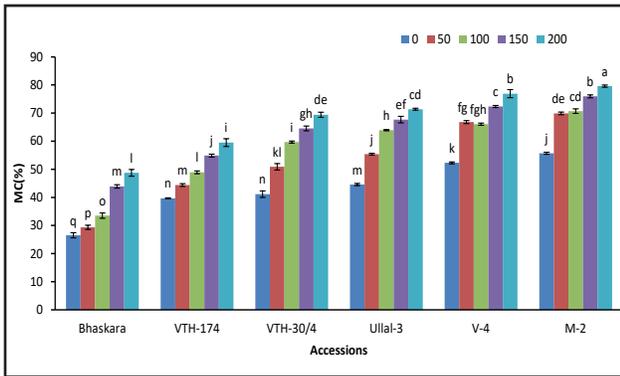


Fig. 3.2.4. Extent of membrane leakage in leaves of cashew cultivars after Salinity stress

Photosynthetic pigment contents

Significant reduction in Chl a (by 27.6 % and 35.4 %), Chl b (32.9 % and 50.9 %) and total Chl (16.6 % and 40.4 %) were observed at 150 and 200 mM. The pigment contents were higher in Bhaskara and lower in MDK-2.

Biomass partitioning parameters

The levels of 150 and 200 mM reduced percent biomass allocation to leaf by 19.7 and 24.3 over control. Percent biomass allocation to root increased by 11.2 and 22.5 at 150 and 200 mM over control (Fig. 3.2.5).



Fig. 3.2.5. Influence of salinity stress on biomass partitioning parameters of cashew cultivars

Salt stress also led to decrease in relative growth rate (RGR). However, maximum reduction was observed at 150 mM (66.6 %) and 200 mM (75 %) over control. Leaf area ratio (LAR) was not significantly affected by salinity

where the reduction was only 5 % at 200 mM over control. Specific leaf area (SLA) was also not significantly affected by salinity treatments where the reduction was 1.4 % at 200 mM (Table 3.2.8).

Table 3.2.8. Influence of different levels of salinity stress on relative growth rate, leaf area ratio and specific leaf area of cashew cultivars

Variety	NaCl	RGR	LAR	SLA
Bhaskara	0	0.15 ^a ±0.00	16.425 ^a ±0.33	167.05 ^a ±2.96
	50	0.13 ^b ±0.00	16.15 ^a ±0.50	178.58 ^{cd} ±5.18
	100	0.12 ^c ±0.00	16.34 ^a ±0.32	188.38 ^{bc} ±4.03
	150	0.11 ^d ±0.00	15.98 ^a ±0.37	199.2 ^{ab} ±4.02
	200	0.08 ^e ±0.00	16.9 ^a ±0.41	213.4 ^{ab} ±7.23
VTH-174	0	0.15 ^a ±0.00	16.6 ^a ±0.34	176.55 ^b ±2.04
	50	0.13 ^b ±0.00	16.28 ^{ab} ±0.11	184.35 ^b ±3.90
	100	0.12 ^c ±0.00	14.75 ^c ±0.32	182.3 ^b ±6.77
	150	0.1 ^d ±0.00	15.2 ^{bc} ±0.55	187.78 ^b ±6.18
	200	0.07 ^e ±0.00	16.75 ^a ±0.40	207.18 ^a ±5.84
VTH-30/4	0	0.14 ^a ±0.00	16.6 ^b ±0.21	204.5 ^a ±4.15
	50	0.16 ^b ±0.00	15.88 ^b ±0.28	218.0 ^a ±6.58
	100	0.12 ^c ±0.00	14.68 ^{bc} ±0.30	211.23 ^a ±7.31
	150	0.09 ^d ±0.00	15.63 ^c ±0.43	223.25 ^a ±15.70
	200	0.05 ^e ±0.00	18.05 ^a ±0.55	242.6 ^a ±19.85
Ullal-3	0	0.14 ^a ±0.00	22.28 ^a ±0.49	287.58 ^a ±5.66
	50	0.13 ^b ±0.00	18.73 ^b ±0.19	283.63 ^a ±8.16
	100	0.10 ^c ±0.00	17.48 ^{bc} ±0.50	259.88 ^{ab} ±9.45
	150	0.08 ^d ±0.00	16.88 ^c ±0.65	247.68 ^b ±11.17
	200	0.03 ^e ±0.00	20.7 ^a ±0.78	248.45 ^b ±10.05
V-4	0	0.11 ^a ±0.00	20.93 ^a ±0.25	300.13 ^a ±9.57
	50	0.1 ^b ±0.00	16.98 ^b ±0.24	284.38 ^a ±13.55
	100	0.09 ^c ±0.00	15.08 ^b ±0.53	276.65 ^a ±18.51
	150	0.06 ^d ±0.00	15.0 ^b ±1.14	261.63 ^a ±9.28
	200	0.03 ^e ±0.00	16.03 ^b ±0.76	264.8 ^a ±32.33
MDK-2	0	0.11 ^a ±0.00	19.08 ^a ±0.77	305.4 ^a ±17.71
	50	0.10 ^b ±0.00	14.98 ^b ±0.22	309.5 ^a ±18.64
	100	0.08 ^c ±0.00	14.13 ^b ±0.19	291.3 ^a ±17.68
	150	0.05 ^d ±0.00	14.28 ^b ±0.60	262.05 ^a ±13.80

Variety	NaCl	RGR	LAR	SLA
	200	0.03 ^e ±0.00	18.03 ^a ±0.94	244.6 ^a ±24.56
NaCl		9220.96**	45.79**	0.88NS
Varieties (V)		2320.46**	29.11**	57.84**
VxNaCl		61.21**	5.09**	2.34**

Values are expressed as mean±S.E. (n=4). Means followed by a different letter within a column for each cashew variety are significantly different at $P<0.05$ (DMRT). * and ** Significant at 1% and 5%, respectively; NS, not significant. RGR - relative growth rate, LAR-leaf area ratio and SLA- specific leaf area

Salinity tolerance index (STI)

Salinity tolerance index was affected by salt stress. STI values were 93.3, 83.8, 71.2 and 53.7 per cent at 50, 100, 150 and 200 mM. Among the accessions, Bhaskara recorded higher STI values (70.2 %) and the same was minimum in MDK-2 (39 %) at 200 mM (Fig. 3.2.6).

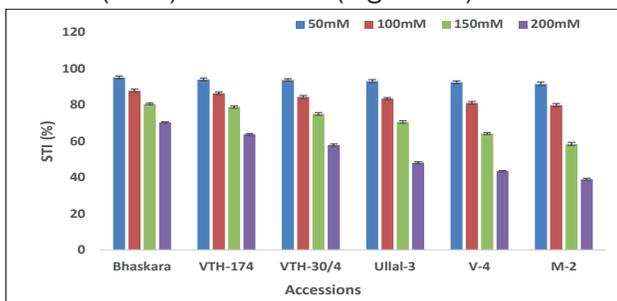


Fig. 3.2.6. Salinity tolerance index values of cashew cultivars after imposition of different levels of salinity

3.2.4. *In vitro* pollen germination and pollen tube growth of cashew varieties in response to high temperature stress

Cashew cultivation is under the threat of climate change due to shift in rainfall pattern and sudden rise in temperature leading to poor pollination, irregular flowering and poor fruit set. In this

context, an experiment has been planned to study the influence of temperature on pollen germination and pollen tube growth in order to screen cashew cultivars for high temperature tolerance. Initially, timing of pollen collection for maximum pollen germination has been standardized. Good pollen germination was observed when collected between 9.30 AM and 11.00 AM. Additionally, different growth medium viz., Sucrose (5, 10 and 30 %) and Ployethylene Glycol (PEG) with boric acid, calcium nitrite and magnesium sulphate were tested for maximum pollen germination. Better pollen germination was observed with PEG media.

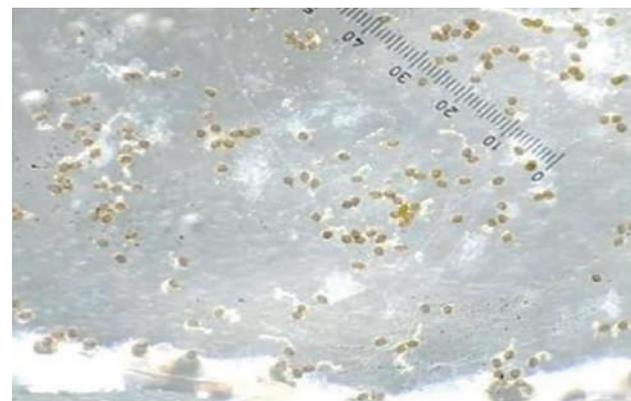


Fig. 3.2.7. Microscopic image of pollen grains and pollen growth

3.3 CROP PROTECTION

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

The laboratory reared virgin TMB females aged 4-5 days were placed in net cages and hung randomly in cashew plots. On confirming the “calling activity” (secretion of pheromone volatiles) as evidenced by attraction of TMB males to such caged virgin TMB females, these were brought to the laboratory immediately and stunned in a freezer. Subsequently the whole body extracts (WBE) of these virgin TMB females were prepared by macerating in Di-chloromethane @ 5-10 ml/female. When stored under freezer, the WBE could induce a strong attraction to the TMB males in the field conditions even after 45 days after extraction (DAe) (Fig. 3.3.1). This observation indicates that the components of sex pheromone remain stable and active, which is a positive aspect in future research.



Fig. 3.3.1. TMB males attracted to WBE @ 45 DAe (in 15 mins)

A new apparatus set-up has been designed and installed for collection of sex pheromone volatiles of virgin TMB (Fig. 3.3.2). The initiation of sex pheromone release was confirmed by

placing the test virgin TMB females in a modified cylindrical sticky trap and only on attraction of TMB males; such females were utilized for pheromone volatile collection. The volatile adsorbent formulations viz., either Poropak or Tenax were activated at 120 °C and cooled.



Fig. 3.3.2. Laboratory set up for TMB pheromone volatile collection

This adsorbent (@ 0.5 g/batch) was placed in a watch glass in the collection bottle and clean air was passed through a series of filter bottles having RO water and activated charcoal, and subsequently over the active virgin TMB females at approximately 0.8 - 1.0 L/h using a vacuum pump. The set up was operated for a period of 6.0 h and the adsorbent was collected into a mini flask and kept airtight for further analysis. These samples are being analysed using GC-EAD at ICAR-National Bureau of Agricultural Insect Resources, Bengaluru to know the components of the TMB sex pheromone volatiles.

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

3.3.2.1. Evaluation against TMB

The shoots were treated with the test insecticides under field conditions and brought to

laboratory for evaluation. Thiamethoxam (0.2 g/L) and acetamiprid (0.5 g/L) could induce highest mortality of TMB nymphs and adults, as well as oviposition repellence and were on par with the recommended insecticide *viz.*, L-cyhalothrin (0.6 ml/L). It was observed that none of the insecticides could induce significant mortality after 21 DAT (Fig. 3.3.3). The lowest TMB feeding damage score of <1.0 was recorded in L-cyhalothrin, thiamethoxam and acetamiprid treatments while the other treatments had TMB feeding damage score of >3.0 after 48 h of release (Fig. 3.3.4).

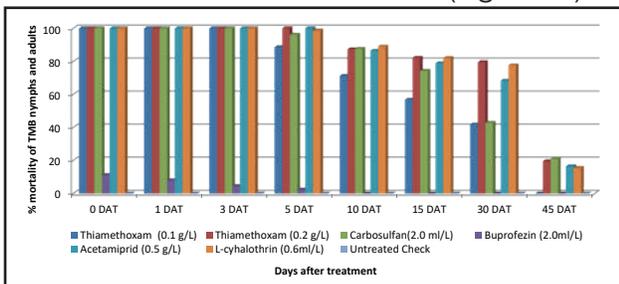


Fig. 3.3.3. Mean mortality (%) of TMB - Field spray evaluation trials

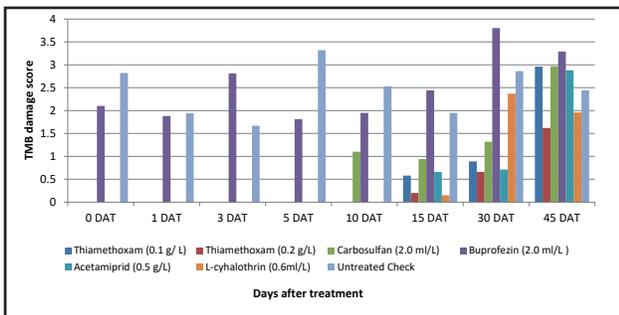


Fig. 3.3.4. Mean feeding damage score by TMB – Field spray evaluation trials

The cost of spraying per tree worked out to be lowest for L-cyhalothrin (Rs. 0.78) followed by thiamethoxam (Rs. 1.00) and acetamiprid (Rs. 2.50) which were effective against TMB in that order and were on par. The number of ants and pollinators visiting the treated and untreated trees was found to be on par with each other after 10 days of spray, indicating that the test insecticides did not have much detrimental effect on the activity of the non-target organisms.

3.3.2.2. Evaluation against CSRB incidence

The treatment with Fipronil (2.0 ml/L) had highest nascent larval mortality of CSRB (> 80.0 %) which was on par with the mortality recorded for chlorpyrifhos (10.0 ml/L) (Fig. 3.3.5). The results of trials on oviposition deterrence could not yield consistent results as the adult female beetles nibbled the cotton tape of treated oviposition twigs which resulted in considerable mortality. The cost of treatment per tree was lesser for fipronil (Rs. 5.60) than that of chlorpyrifhos (Rs. 7.00).

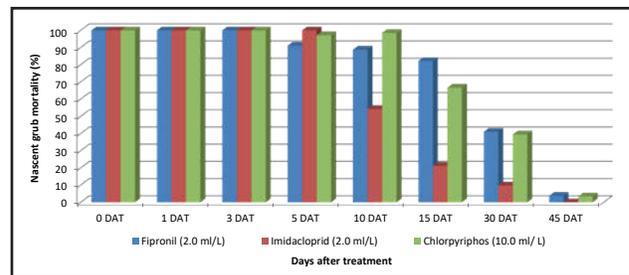


Fig. 3.3.5. Nascent grub mortality of CSRB grubs - Field trials

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

The cashew trees infested by CSRB in the initial stages were identified for treatment and the insect stages were carefully removed from such trees. Those trees were swabbed and drenched with the treatment suspensions and observed at 15 days intervals for any external symptoms of residual or fresh infestation *viz.*, fresh frass or oozing of the gum or resin. None of the treated cashew trees showed any fresh symptoms of infestation however, only a few trees showed residual infestation after treatment; one tree each in (a.) drenching with the suspension of *Steinernema carpocapsae* IJs; (b.) drenching with suspension of chlorpyrifhos (0.2 %) and in (c.) untreated check. The CSRB grubs were subsequently removed by chiseling of the

infested bark, and there was no tree mortality during the current season. However, due to the lower number of trees per treatment, no conclusive inference could be obtained.

3.3.4. Cashew - tea mosquito bug interactions and the defensive responses

The aim of the study is to identify the traits of TMB tolerance in specific cashew varieties to understand their interaction. The damage by TMB and other flower pests was more this year from November 2019 to March 2020 and the growth pattern after TMB damage and mechanical damage could not be recorded continuously, as the buds were continuously damaged by TMB. In the plots under high TMB pressure, MDK-2 sustained lesser TMB attack, as its flushing and flowering was delayed. But, Ullal-3, Ullal-4, Vengurla-4, Vengurla-7 suffered

severe damage and thus flowering and fruit set was very less. VRI-3 though got severely infested by TMB till February, flowering and fruiting were continuous till May. In Bhaskara, though there was TMB damage, less extent of flowering occurred.

Potted cashew grafts were exposed to TMB @ 2 nymphs/shoot and changes in chlorophyll, total phenols and tannins were estimated after 24 and 48 hours of feeding. No significant changes in chlorophyll content and tannins in the leaf samples, but significant increase in phenol content ($P < 0.001$) was evident upon TMB damage. Increase in phenol content was more at 48 h after infestation (42-70 % increase over control) compared to 24 h after infestation in all the five cashew varieties tested (Table 3.3.1).

Table. 3.3.1. Changes in phenol content as influenced by TMB feeding

Variety	Phenol (mg/100g)	Variety	Phenol (mg/100g)
Vengurla-7 c	3.23	Dhana b	6.47
Vengurla-7 a	4.05	Bhaskara c	1.25
Vengurla-7 b	5.39	Bhaskara a	1.47
MDK-2 c	3.58	Bhaskara b	2.08
MDK-2 a	4.00	Ullal-4 c	5.28
MDK-2 b	6.27	Ullal-4 a	5.70
Dhana c	4.58	Ullal-4 b	7.12
Dhana a	6.08		
CV	1.65 %	LSD @ 1 %	0.22

Variety followed by 'C' indicates control, 'a'- 24 hours after infestation, 'b'- 48 h after infestation.

Honey dew method was attempted to estimate the feeding preference indirectly on the matured or semi-matured shoots, where appearance of necrotic spots due to TMB feeding is not conspicuous as

they appear in tender shoots (Fig. 3.3.6). Appearance of spots on filter paper (treated with bromocresol green) was noticed, but it was not uniform among the replicates, thus requiring modifications in the method.



Fig. 3.3.6. Honey dew method

3.3.5. Investigations on inflorescence pests of cashew and their management

Several insect species attack cashew flowers during different phenological stages of the inflorescences. The pest species infesting cashew flowers were documented at plantations of ICAR-DCR, farmers' plantations at Puttur and Sulia taluks of Dakshina Kannada and at AICRP centres on cashew during 2020. During January-March 2020, incidence of tea mosquito bug was very severe (>80 % incidence). Documentation of pests on cashew flowers at Puttur included 66 species from four insect orders (Fig. 3.3.7 and Table 3.3.2) and a mite. Among all pest groups, Lepidopterans were dominant comprising 33 species followed by Hemipterans with 22 species. A complex of pest species was recorded on the same inflorescences including webbers, loopers, TMB, mirids, thrips, beetles etc. Damage by *Perixera* sp., *Bombotelia jocosatrix*, *Gyrtona* sp., *Gatesclarkeana* sp., *Ascotis selenaria*, *Tinolius* sp., *Aetholix flavibasalis* on the inflorescences was noticed this year. In general, early flowering cashew types had more pest infestation compared to mid and late flowering types. High incidence of *Perixera* sp. (Fig. 3.3.8) and *B. jocosatrix*

was also observed on cashew flowers during December 2019 – February 2020 and December 2020. The natural enemies occurring on *Perixera* sp. were collected and submitted for identification. The other common pests recorded at AICRP centres include hairy caterpillar, semi looper, apple and nut borer (ANB) and thrips at Jagdalpur, leaf and blossom webber, ANB, aphids and mealy bugs at Vridhachalam, flower thrips, ANB and hairy caterpillars at Madakkathara.

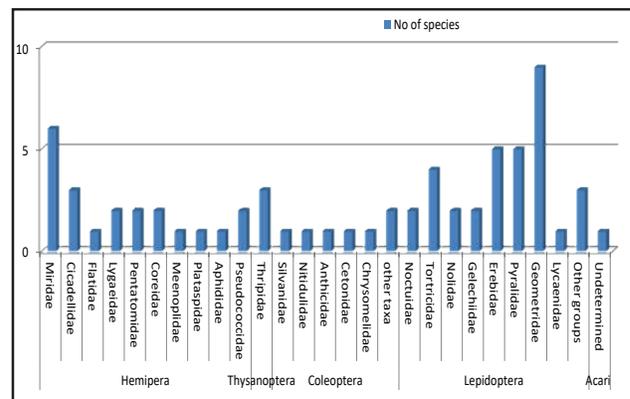


Fig. 3.3.7. Species abundance of inflorescence pests of cashew

Infestation by lepidopterans especially *H. haligramma* and *Anarsia* sp. started soon after the emergence of inflorescences reaching a peak during the last week of December or first fortnight of January. Population of most of the lepidopteran species decreased drastically during March. Natural enemies recorded on different inflorescence pests are given in table 3.3.3. Weather parameters and the incidence of pests as well as natural enemies were correlated based on four years data. Though rainfall had no significant relationship with any of the pest population, number of rainy days had significant negative relationship with ANB (-0.35), beetles (-0.35), thrips (-0.39) and mirids (-0.34). The correlation between pest population and natural enemies was significantly positive (0.7).

Table 3.3.2. Pest species documented on cashew inflorescences

Sl. No	Scientific name	Family	Sl. No	Scientific name	Family
1	<i>Helopeltis antonii</i> Sign.	Miridae	34	<i>Bombotelia jocosatrix</i> Guen.	Noctuidae
2	<i>H. bradyi</i> Waterhouse		35	<i>Gyrtona</i> sp.	
3	<i>H. theivora</i> Waterhouse		36	Undetermined sp.1	
4	<i>Pachypeltis maesarum</i>		Tortricidae	37	<i>Dudua aprobola</i> M.
5	<i>Eurystylus</i> sp.			38	<i>Gatesclarkeana</i> sp.
6	<i>Campylomma livida</i> Reuter			39	<i>Archips</i> sp.
7	<i>Lygus</i> sp.			40	Undetermined sp. 1
8	<i>Neodartus</i> sp.	Cicadellidae	41	Undetermined sp. 2	Nolidae
9	<i>Kolla ceylonica</i> Young		42	<i>Nanaguna</i> sp.	
10	<i>Bothrogona sclerotica</i> Young		43	Unidentified sp. 1	
11	Undetermined sp.	Flatidae	44	<i>Hypotima haligramma</i> M.	Gelechiidae
12	<i>Dieuches indicus</i> Eyles	Lygaeidae	45	<i>Anarsia</i> sp.	Crambidae
13	<i>Graptostethus servus</i> F.		46	<i>Aetholix flavibasalis</i> Guenee	
14	<i>Nezara viridula</i> (Linnaeus)	Pentatomidae	47	<i>Lamida moncusalis</i> Walker	Pyralidae
15	<i>Halys</i> sp.		48	<i>Thylacoptila paurosema</i> M.	
16	<i>Riptortus</i> sp.	Coreidae	49	<i>Orthaga</i> sp.	
17	<i>Cletus</i> sp.		50	Undetermined sp.1	
18	Undetermined sp.	Meenoplidae	51	<i>Hyposidra talaca</i> Walker	Geometridae
19	<i>Coptosoma</i> sp.	Plataspidae	52	<i>Hyposidra</i> sp.	
20	<i>Toxoptera odinae</i> (Van der Goot)	Aphididae	53	<i>Oenospila flavifusata</i> Walker	
21	<i>Ferrisia virgata</i> Cockerell	Pseudococcidae	54	<i>Thalassodes quadraria</i> Guenee	
22	<i>Planococcus</i> sp.		55	<i>Pingasa ruginaria</i> Guenee	
23	Undetermined sp.	Fulgoridae	56	<i>Perixera</i> sp.	
24	<i>Thrips hawaiiensis</i> (Morgan)	Thripidae	57	<i>Ascotis selenaria</i> (Denis & Schiffermuller)	
25	<i>Thrips florum</i> Schmutz		58	Undetermined sp. 1	
26	<i>Scirtothrips dorsalis</i> Hood		59	Undetermined sp. 2	
27	<i>Oryzaephilus surinamensis</i> (L.)	Silvanidae	60	Undetermined sp. 3	
28	Undetermined sp.	Nitidulidae	61	<i>Rapala manea</i> Hewitson	Lycaenidae
29	<i>Pagria costatipennis</i> Jacoby	Chrysomelidae	62	<i>Eublemma versicolor</i> Walker	Erebidae
30	<i>Oxycetonia</i> sp.	Cetoniidae	63	<i>Somena (Euproctis) scintillans</i> Walker	
31	Undetermined sp.		64	<i>Euproctis fraterna</i> Moore	
32	Undetermined sp.	Anthicidae	65	<i>Tinolius</i> sp.	
33	Other undetermined group	-	66	Undetermined sp. 2	
			67	Mites- <i>Oribatella</i> sp. (Cryptostigmata)	

Observations showed that under mild infestation of TMB (G1), presence of inflorescence pests especially caterpillars could cause

reduction in nut set up to 47.06 % in unsprayed trees compared to trees sprayed with lambda cyhalothrin 5 EC which is a recommended

insecticide for cashew pest management. Fruit set observed in the unsprayed inflorescences could be from the random rachii escaped the attack of

flower pests. The plants having severe infestation of inflorescence pests @ 2-4 larvae/inflorescence had very low nut set (0-1 nut/inflorescence).

Table 3.3.3. Natural enemies of inflorescence pests of cashew and extent of parasitism

Sl. No.	Pest	Parasitoid		Period	Parasitism (%)
	Pest	Species	Family/Order		
1	<i>T. paurosema</i>	<i>Phanerotoma</i> sp.	Braconidae	Feb-Mar	2-5
2	<i>T. paurosema</i>	Undetermined sp.	Diptera	Feb-Apr	1-2
3	<i>T. paurosema</i>	<i>Thrathala flavorbitalis</i>	Ichneumonidae	Jan-May	15-30
4	<i>Ferrisia virgata</i>	<i>Aenasius advena</i>	Encyrtidae	Jan-Mar	5-10
5	Undetermined Geometrid	<i>Parapanteles</i> sp.	Braconidae	Sep-Nov	2-5
6	<i>Hyposidra</i> sp.	<i>Euplectrus</i> sp.	Eulophidae	Sep-Nov	1-2
7	<i>A. flavibasalis</i>	<i>Apanteles</i> sp.	Braconidae	Jan-mar	2-4
8	<i>Archips</i> sp.	<i>Apanteles</i> sp.	Braconidae	Jan-Mar	20-25
9	Undetermined webbers	Undetermined sp.	Ichneumonidae	Jan-Mar	1-3
10	<i>H. haligramma</i>	<i>Apanteles</i> sp.	Braconidae	Nov-Mar	5-15
11	<i>E. scintillans</i>	<i>Apanteles</i> sp.	Braconidae	Jan-Mar	10-20



Fig. 3.3.9. Cashew flowers damaged by *Perixera* sp.

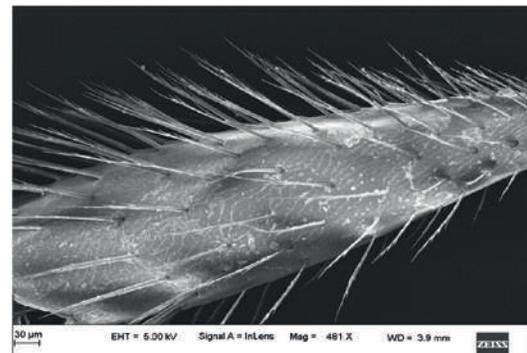
3.3.6. Pollination efficiency of important bees in cashew

Species complex of *Braunsapis* bees

Documentation of *Braunsapis* species occurring on the cashew flowers in Puttur region during 2020 resulted three species namely *B. picitarsis*, *B. mixta* and *B. malliki*. Among the three *Braunsapis* species, *B. mixta* was more abundant (70.5 %) followed by *B. picitarsis* (29.3 %) and *B. malliki* (0.2 %). Besides, a tiny *Ceratina* sp. (undertermined sp.) was also found nesting in dried cashew sticks.



Scopa in female *B. mixta*



Reduced scopa in male *B. mixta*

Fig. 3.3.10. Scanning Electron Microscopic images of hind leg of *B. mixta*

DNA sequence of *B. mixta*

The bee specimen was subjected for molecular identification at ICAR-NBAIR, Bengaluru. DNA extraction was done using a hind leg of adult using Qiagen DNeasy® kit, following the manufacturer’s protocols. The species was bidirectional sequenced and checked for homology, insertions and deletions, stop codons, and frame shifts by using NCBI BLAST and ORF finder. The sequence was uploaded to GenBank and the Barcode of Life Database. Molecular identification of the specimen revealed that the bee species was *B. mixta*. The sequences showed 100 % similarity to *B. mixta* (GenBank Acc. No. KY072614) through BLAST sequence analysis and the sequences were submitted to NCBI and accession numbers were retrieved (GenBank Acc. No. MW135190).

Nest structure of *B. mixta*

Nests of *B. mixta* consisted of a simple tunnel without any partitions. Nest walls were smooth, without particular lining. Length of nest burrow widely varied between 1.2 and 17.4 cm (Table 3.3.4). All the stages of *B. mixta* were in contact with each other inside the nests. The immature stages were fed progressively by adult bees. When the cell length and number of individuals per nest was correlated, a non significant relationship was found ($r = 0.17$). Number of adults in the active nest during collection varied from 1-11, but majority had single adult. A significant positive correlation was obtained between number of adults and brood (0.61) as well as with eggs (0.58, $P < 0.001$). Mean per capita brood and eggs as a function of the number of females per nest indicated positive relationship (Fig. 3.3.11). Longevity of female and male bees was up to 75 and 35 days respectively, under laboratory conditions.

Table 3.3.4. Nest structure of *B. mixta*

Observations	Mean \pm SD	Range
Entrance diameter (mm)	1.59 \pm 0.39	1.1 - 2.5
Cashew stick thickness (mm)	9.40 \pm 4.08	4.0- 20.5
Nest thickness (mm) (inner space)	3.45 \pm 0.78	2.0-5.2
Active nest space (Nest length) (cm)	7.74 \pm 4.09	1.2-17.4
No. of individuals/ active nest	6.82 \pm 6.99	1-39
No. of adults/ nest during collection	1.95 \pm 1.55	1-11

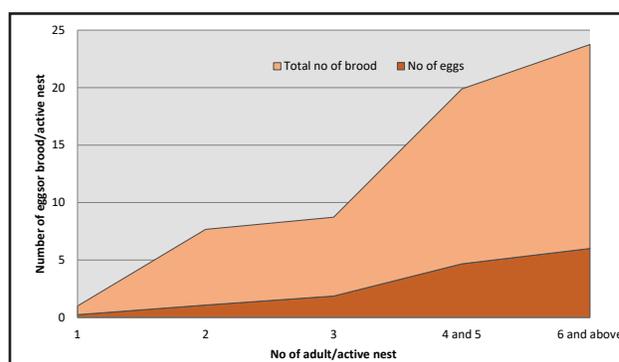


Fig. 3.3.11. Mean per capita brood and mean per capita eggs as a function of the number of females per nest

Performance of artificial bee nests

The artificial bee nests comprising drilled wooden blocks and dried cut sticks of bamboo, lantana, Johnson’s grass and cashew showed good occupation by the bees of *B. mixta* followed by *B. picitarsis*. A new set of trap nests with standard hole size (3.0 mm) was also made during 2020 and the bee occupancy is being recorded. The newly installed nests started occupying by the bees within one week of installation. These nests will be utilized for confined pollination studies.

Natural enemies of *B. mixta*

Several spiders and wasps especially Sphecids were noticed in the artificial bee nests. But the wasps did not predate on the bees in the vicinity of nests. Adults of a parasitic bee species viz., *Braunsapis kaliago* were seen along with *B. mixta*. *Neochalcis breviceps* (Masi) (Chalcidoidea: Chalcididae) has been recorded as parasitoid of *B. mixta*. Adults of a Torymid parasitoid, *Diomorus* nr. *indicus* were seen at the nest entrance trying to oviposit on guarding female. Nevertheless, no pathogenic infection or moribund dead bees were found in any of the active nests.

Observations on *Apis cerana indica* colonies in cashew plantations

Apis cerana indica bee colonies are being maintained at Shantigodu campus of ICAR-DCR, Puttur. In order to record the bee visit pattern, the bee colonies were shifted to cashew plantations during January (3rd week) at around 40 % flowering of trees and the bee visit patterns were recorded. Though number of bees visited cashew flowers was more compared prior to installation of bee hives, the difference in bee visits was not significant before and after keeping bee hives which might be due to inappropriate shifting time of colonies. In subsequent flowering season, colonies have been shifted during initial flowering itself, and observations on bee visits and nut set are in progress.

3.4. POST HARVEST TECHNOLOGY

3.4.1. Design and development of moisture meter for raw cashewnuts

A 3-in-1 moisture meter for raw cashewnuts, unpeeled and peeled cashew kernels has been developed with provision for testing moisture for nuts and kernels separately, and changes were incorporated in the developed moisture meter by the collaborating partner (Fig. 3.4.1).



Fig. 3.4.1. Moisture meter for raw cashewnuts, unpeeled and peeled cashew kernels

Testing of developed moisture meter for raw cashewnuts, unpeeled and peeled cashew kernels was carried out with stored nuts. Raw cashewnuts were sorted into small, medium, large and mixed nuts based on its minor axis dimension and used for evaluating the performance of moisture meter. Raw cashew nuts were soaked in water for 48 h to raise its moisture content to test the moisture meter. Percent moisture content of small, medium, large and mixed nuts was determined as 6.8, 9.4, 10.2 and 9.3 on dry basis (d.b.), respectively. After soaking, corresponding moisture was raised to 29.7, 30.9, 32.9 and 29.2 per cent d.b. Test results of moisture meter for these nuts *i.e.* artificially moistened nuts, showed a coefficient of correlation of ≤ 0.72 . The due reasons for the low 'r' value are the moisture gradient in the layers of the raw cashewnuts and the present calibration range of moisture meter (5 to 14% d.b.). However, the moisture meter

showed good fit for the unpeeled and peeled cashew kernels for the artificially moistened kernels ($R^2 < 0.92$). Thus for raw cashewnuts, refinement of the programme for higher accuracy is required. Resultant data of testing of moisture meter for artificially moistened raw cashewnuts and processed cashew kernels indicated further scope for improvement.

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

Data analysis of cashewnut processing units in three different regions classified under manual, semi mechanized and automated categories reveals that processing cost per unit weight computed to be the lowest for fully mechanized units due to bulk production and higher operational capacity of installed machinery in the line of processing. It is reaffirmed that the cost of processing decreased with degree of mechanization and quantum of processing but worked out to be higher than cost of processing projected by the processing units located in Vietnam. Diagnostic investigation indicated that volume of production is inversely proportional to the cost of processing. W320 grade cashew kernels serve as benchmark to predict the price of other grades. Factors influencing qualitative efficiency of cashewnut processing are identified as the degree of skill of the labourers engaged, production efficiency of machine, raw material parameters and processing parameters adopted.

3.4.3. Design and development of mechanized slicer for cashew apple

Major components of the modified mechanized slicer are rotary slicer, apple conveyor cum regulator and feed hopper with inclined singulation unit. Various factors influencing slicing of the cashew apples *viz.*, bevel angle of the rotary disc blade, number of disc blades, diameter of the disc blades and feed chute curvature at slicing region were suitably

changed for improving the performance. Slicing of fruits could be achieved without breakage continuously. A belt conveyor with vertical guide at regular interval has been fabricated and bridged with slicer for continuous production. Feed hopper having capacity of ~20 kg and inclined elevator were incorporated in the mechanized slicer (Fig. 3.4.2) for effective convey of cashew apples towards slicing end. Vibratory mechanism is provided at the boot location of feed hopper to transfer the apples to inclined modular conveyor to achieve singulation and facilitate transportation of apples in a required orientation to ensure shape after slicing.

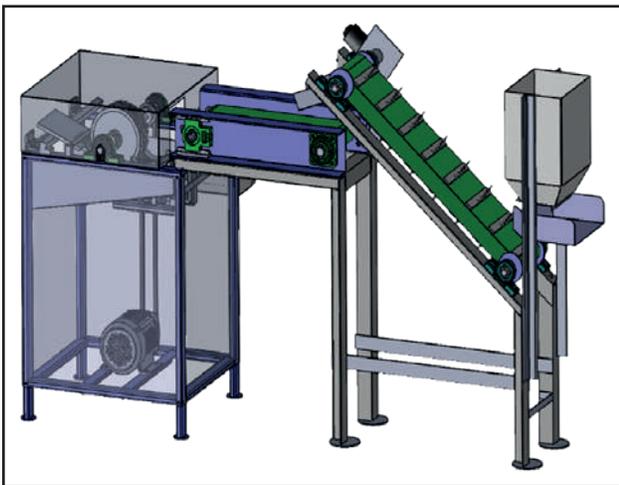


Fig. 3.4.2. Isometric view of modified mechanized slicer for cashew apples

In view of converting the slices into amorphous form to use it as an ingredient in extruded food products, cashew apple slices (CAS) were exposed to hot air environment to reduce its moisture content and make it amenable for grinding. CAS of 2-2.5 mm thick were exposed to air temperature maintained at 40 °C, 50 °C and 60 °C in forced convective dryer for selected varieties *viz.*, Bhaskara, Dhana, Ullal-3 to assess its rate of drying and changes in the surface colour characteristics in amorphous form. Fig. 3.4.3. depicts drying kinetics of CAS which is primarily influenced by air temperature.

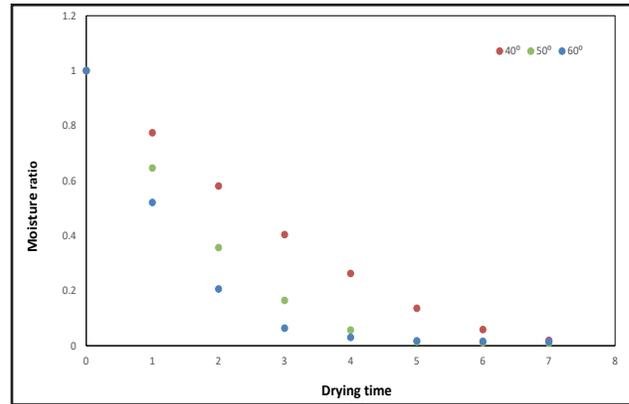


Fig 3.4.3. Drying behaviour of cashew apples slices exposed to different air temperature

Drying rate found to be faster at higher temperature owing to accelerated moisture migration within the cashew apple slice. Drying of CAS followed falling rate period of drying irrespective of air temperature indicating removal of free moisture in the beginning followed by bound moisture by diffusion. Apparently, varietal influence on moisture diffusion in cashew apples was found to be low due to negligible changes in the composition of the fruits.

Cashew apples were treated with lye solution to ease peeling off the outer skin containing more tannin content. To compare the rate of drying between peeled and unpeeled CAS, selected varieties *viz.*, Bhaskara, Ullal-3 and Dhana were exposed to hot air environment maintained at 50 °C in a convective dryer. It is evident that the differential rate of drying observed for cashew apples slices irrespective of varieties and with or without skin (Fig. 3.4.4). However, it ensured that the rate of drying of cashew apple slices found to be faster for lye peeled rather than unpeeled slices. Presence of exterior waxy skin could provide resistance for moisture diffusion. Besides, it was observed that the surface colour of the powder derived from CAS found to differ in its chroma and saturation which plays an important role in food product preparations.

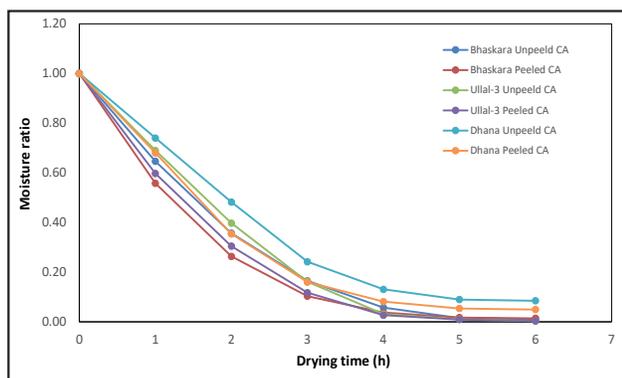


Fig. 3.4.4. Varietal changes on drying behaviour of unpeeled and peeled cashew apple slices

3.4.4. Development of dehydrated products from cashew apple and sprouts

Effect of brine solution on storage life of cashew sprouts

Cashew sprouts were stored in brine solution prepared using sodium chloride (NaCl), lactic acid (LA) and water (control) to study their effect on storage life. Cashew sprouts stored in 5 % NaCl solution increased the storage life of cashew sprout (17 days) compared to control (2 days) (Fig. 3.4.5) with significant reduction in fat content, but without further significant reduction in phytic acid content (Fig. 3.4.6. and 3.4.7).

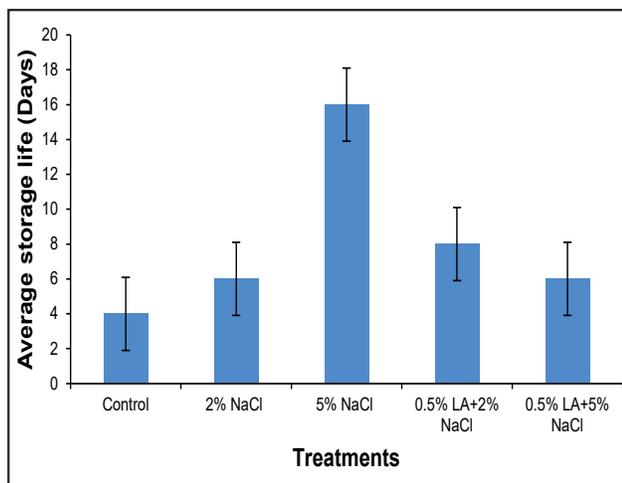


Fig. 3.4.5. Effect of brine solution on storage life of cashew sprout

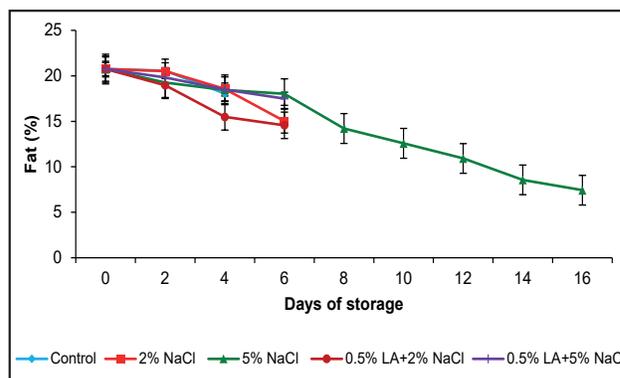


Fig. 3.4.6. Effect of brine solution on fat content of stored cashew sprout

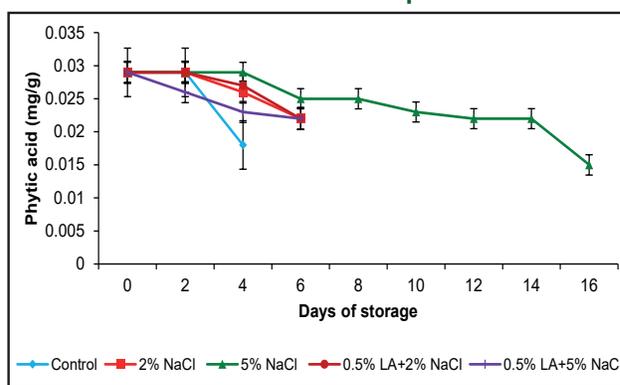


Fig. 3.4.7. Effect of brine solution on phytic acid content of stored cashew sprout

Cashew sprout extrudates

Corn flour and rice flour are the major ingredients in the extruded product preparation which are poor in minerals, proteins and fibre. Hence, to enrich the product with biominerals, protein and fibre, the mineral-rich Cashew Sprout Powder (CSP) was added as one of the ingredients along with commercially available corn flour and rice flour. The cashew sprouts were collected and dried under 35-40 °C for 24-32 h in a cabinet dryer, powdered using a mixer and used for the experiment. The optimised quantity of CSP ranged from 5-25 % for its successful preparation along with commercially available corn and rice flour (Fig. 3.4.8). Significant increase in nutritive and mineral content was observed with the increasing proportion of CSP.



75 % RF + 25 % CF



5 % CSP+70 % RF + 25 % CF



10 % CSP+65 % RF + 25 % CF



15 % CSP+60 % RF + 25 % CF



20 % CSP+55 % RF + 25 % CF



25 % CSP+50 % RF + 25 % CF

Fig. 3.4.8. CSP extrudates prepared using different proportions of cashew sprout powder (CSP), rice flour (RF) and corn flour (CF)

Browning index studies for cashew sprout pulp storage

Cashew sprout is rich in phenols (27.71 mg gallic acid equivalents/g) compared to cashewnuts (2.05 mg gallic acid equivalents/g) and hence, it is highly susceptible to browning especially after pulping. This browning behaviour of fresh sprout pulp obstructs the storage life and cause inconvenience during the product development. The cashew sprout pulp was treated with chemicals such as 2 % ascorbic acid (AA), 0.5 % calcium carbonate (CC), and combination of both, and stored under ambient conditions (28 ± 2 °C) and low temperatures (4 °C and 8 °C). Results showed that, the cashew sprout pulp treated with 2 % AA and stored at 8 °C can be stored for 10

days without any changes in the browning index (0.63) whereas the pulp without treatments had maximum browning index during the 2nd day of storage (1.66) (Fig. 3.4.9 and 3.4.10).

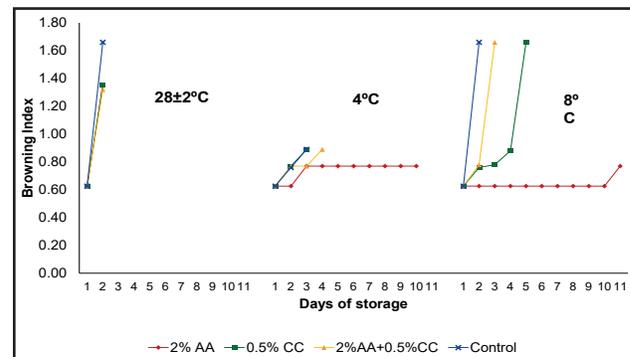


Fig. 3.4.9 Browning index of treated and untreated CS pulp stored under different temperature



Control CS pulp on 1st day of storage



Control at 28±2 °C on 2nd day of storage



2% AA treated CS pulp at 8 °C on 11th day of storage

Fig. 3.4.10. Control and 2 % ascorbic acid treated cashew sprout pulp stored at ambient and low temperature

3.5. CONCLUDED PROJECTS

Concluded project I

3.5.1. Project: Investigations on semio-chemicals for management of TMB and CSRB

Project Leader : T.N. Raviprasad

Project Associate : K. Vanitha,
N. Bakthavatsalam (ICAR-NBAIR) and N. Gajbhiye,
(ICAR-DMAPR)

Project Duration : 10/2014 to 10/2020

3.5.1.1. Introduction

In view of the substantial losses of raw cashew nut yield caused by the two major insect pests of cashew viz., tea mosquito bug (TMB) and cashew stem and root borers (CSRB), it is imperative to manage them for obtaining viable yields. To reduce the dependence on synthetic insecticides for plant protection, alternate eco-friendly approaches involving semio-chemicals such as attractants and pheromones are to be investigated. The project envisages the identification of semio-chemical 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. Further, the analysis of plant based materials like fresh frass and oozed gum from the CSRB infested trees and synthetically formulating the component profile can help in attracting the fecund females of CSRB for oviposition and trapping, and can also be an indicator of the occurrence of the emerged CSRB beetles in a given locality during a particular season.

3.5.1.2. Objectives

i. To identify and confirm response inducing volatile fractions in extracts/volatiles collected from insect body of TMB and from plant sources for CSRB.

- ii. Characterisation of the electro antennogram (EAG) response inducing fraction by GCMS analysis.
- iii. Biosynthesis of the characterised compounds and development of the bait formulation/s.
- iv. Laboratory and field evaluation of different bait formulations.

3.5.1.3. Results

a. Tea Mosquito Bug

Determining the calling age of TMB females under field conditions

The adults of TMB emerging from laboratory cultures were collected daily in the morning and evening, sexed and kept separately in different rearing cages. The age of the virgin females was recorded and the different age groups (0-7 Days After Emergence [DAE]) of the TMB adult females were used as bait using DELTA® sticky traps to confirm the “Calling Age” of the females. The sticky traps having a horizontal sticky liner were utilized for the field observations on TMB pheromone studies (Fig. 3.5.1.1. & 3.5.1.2). The live bait (a virgin female TMB) was placed in cotton mesh cage and hung on the upper angle of the cage; along with a tender cashew shoot placed in a glass vial having water to provide the food source.

The virgin females of TMB did not elicit response from the males of TMB in field condition during the initial 2-3 DAE. Hence, the TMB virgin females were evaluated for confirming their “calling age” in days. The observations revealed that the virgin TMB females aged 4 and 5 DAE elicited the maximum response (with cumulative catches of 338 and 250 males/trap respectively) as indicated by the total number of male TMB

catches/trap (Fig. 3.5.1.3). No trap catches of TMB males was observed, when either the

lesser aged or > 6 days aged females were used as live baits (Table 3.5.1.1).

Table 3.5.1.1. Trap catches of TMB males towards different age groups of virgin TMB females (2017-18)

Age of TMB virgin female (DAE)	Period of the day	Cumulative number of TMB males trapped					
		Oct.17	Nov.17	Dec.17	Jan.18	Feb.18	Mar.18
1 DAE	AM / PM	0	0	0	0	0	0
2 DAE	AM / PM	0	0	0	0	0	0
3 DAE	AM / PM	0	0	0	0	0	0
4 DAE	AM	36	81	338	196	112	37
	PM	27	50	167	133	151	67
5 DAE	AM	34	162	148	17	147	69
	PM	41	153	250	16	236	66
6 DAE	AM	0	0	0	0	0	0
	PM	0	0	0	0	0	0

During 2018-19, the maximum number of TMB males trapped by a single female was 51 / trap when a 4-days old virgin female TMB was

used as bait and it was 43/trap when a 5 days old virgin female TMB was used as live bait (Table 3.5.1.2).

Table 3.5.1.2. Mean TMB male catches using live virgin TMB females as bait (2018-19)

Age of TMB virgin female (DAE)		Cumulative number of TMB males/trap						
		Sep. 18	Oct. 18	Nov. 18	Dec. 18	Jan. 19	Feb. 19	Mar. 19
4 DAE	AM	-	22	51	31	19	8	-
	PM	-	31	49	-	26	-	-
5 DAE	AM	-	29	33	43	20	11	-
	PM	-	27	19	22	-	-	-
	AM		109	152	96	65	19	
6 DAE	PM	-	-	-	-	-	-	-



Fig. 3.5.1.1 Delta sticky traps baited with live TMB females installed in cashew canopy



Fig. 3.5.1.2. Males of TMB attracted to the virgin TMB female baited trap



Fig. 3.5.1.3. TMB catches on 4th (L) and 5th (R) days after emergence

Determining the diurnal rhythm of pheromone activity by TMB females under field conditions

A field trial was carried out to confirm the activity of pheromone release by TMB females during different durations of the day. It was found that maximum catches occurred between 10.30 am and 12.30 pm and between 3.30 pm and 4.30 pm. This can provide an indication about the duration for extraction of sex pheromone from the virgin females for further analysis as well as the most suitable time of the day for installing the sex-pheromone baited traps to avoid rapid vaporization of the pheromone from the septa. Further detailed observations indicated that the diurnal rhythm of attraction was observed during 8.30 am to 11.00 am and during 3.30 pm to 5.00 pm. The number of males attracted during the mornings (12-35 males/trap) surpassed the number of males attracted in the evenings (13-17 males/trap) (Fig. 3.5.1.4). Males of TMB trapped within 1 h of trap placement is shown in Fig. 3.5.1.5.

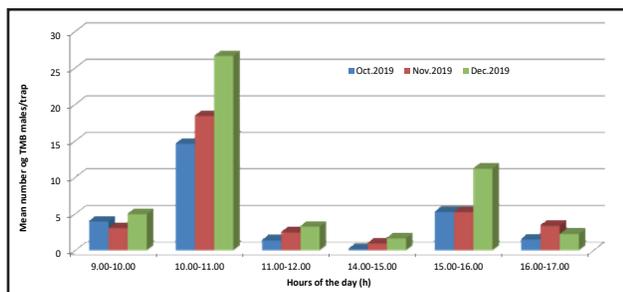


Fig.3.5.1.4. Trap catches of TMB males during different times of the day



Fig. 3.5.1.5. Males of TMB trapped within 1hr of trap placement

Assessing and confirming the pheromone activity of Whole Body Extracts (WBE) of TMB females under field conditions

After the confirmation of *in vivo* sex pheromone activity through field evaluations in virgin TMB females, trials were conducted to confirm the response eliciting activity of the sex pheromone compounds *in vitro*. The virgin TMB females aged 4-5 days, reared in the laboratory were first placed as bait in the net cages of DELTA traps in cashew orchards from 9.00 am - 10.00 am to activate their “calling instinct”; and after confirming the attraction of the TMB males to such TMB females placed as bait, these TMB females were immediately brought to the laboratory. They were stunned by placing in a freezer for 10 - 15 mins and macerated with dichloromethane or n-hexane or methanol to obtain the active components into these solvents as WBE.

Amongst all the solvents used for preparing the extracts of virgin TMB, the attraction of TMB males was maximum to the WBE prepared in dichloromethane. Hence, it was used in further extractions.



Fig. 3.5.1.6. Trap catches of TMB males in WBE baited DELTA trap

The WBE was stored in a freezer and subsequently evaluated for their retention of male attraction capacity as in Fig. 3.5.1.6. [at 5, 10, 15, 30, 45 and 60 Day After Extraction (DAe)] in comparison to the live TMB females used as baits (Table. 3.5.1.3). The maximum

cumulative number of TMB male catches/trap with WBE as bait versus TMB virgin females as live-bait was 67:2 on 10 DAe, 8:85 on 15 DAe, 100:94 on 30 DAe, 65:79 on 30 DAe and 62:72 on 60 DAe. This confirms that WBE in DCM could elicit similar response compared to live virgin TMB females under field conditions upto 60 DAe (Fig. 3.5.1.7). The males of TMB showed response within 5.0 minutes after installation of traps. Maximum number of TMB males trapped in the WBE baited cylindrical traps was 44/trap within 1.0 h of installation.



Fig.3.5.1.7. TMB male catches using WBE as bait (@ 60 DAe) [L] and with virgin female as bait [R]

Table 3.5.1.3. Comparative catches of TMB males in Whole Body Extract (WBE) and live female baited traps

Location	Bait source / No. of TMB males attracted									
	10 DAe	TMB female	15 DAe	TMB female	30 DAe	TMB female	45 DAe	TMB female	60 DAe	TMB female
NCGB-1	11	13	14	14	19	16	12	14	9	11
Scion Bank-1	14	12	12	15	21	18	10	13	6	7
NCGB-2	9	8	17	11	14	13	6	6	8	8
Ento.plot	9	11	13	11	10	12	11	16	12	14
Micronutr. plot	7	5	8	10	13	14	6	6	10	12
NCGB-3	8	12	9	13	13	11	9	11	11	15
Scion Bank-2	9	11	14	11	10	10	11	13	6	5
Total	67	72	87	85	100	94	65	79	62	72

Trap design modification for enhancing the accuracy of TMB male catches

During the field observations, it was observed that the males of TMB though initially attracted to the virgin TMB females (used as live bait); landed on the non-sticky outer surface of the trap and after frantic searching for the female, in many cases escaped away without getting trapped. Such escape of males was 30.77 - 46.29 per cent. To have an accurate evaluation of various baits and other parameters, it is essential to obtain

the exact numbers of the TMB males attracted to the traps. Hence, the trap design which was initially in the form of triangular with adhesive only at the base was modified to form a perforated cylinder with the total outer surface being the sticky layer and a virgin TMB female being placed in the centre of the cylinder (Fig. 3.5.1.8). This ensured more than 95.0 percent entrapment of the attracted TMB males; while a few were not essentially trapped due to landing on the edges of the sticky liner or on the wire frame (Table 3.5.1.4).

Table 3.5.1.4. Trap catches of male TMB in Delta and modified cylinder traps

Delta trap			Modified Cylinder trap		
Total no. of males alighted	Total no. of males trapped	% trap catch	Total no. of males alighted	Total no. of males trapped	% trap catch
39	27	69.23	33	32	96.96
28	15	53.71	40	39	97.50
44	29	65.90	38	38	100.00
38	21	55.26	42	40	95.23
29	19	65.51	37	35	94.59



Fig. 3.5.1.8. Trap catches of male TMB in modified cylinder trap

Apparatus set up for pure collection of TMB sex pheromone volatiles

It was indicated that live virgin females of TMB as well as WBE of 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 with insect body compounds, especially lipids in the extracts, thereby making it challenging to

segregate the active sex pheromone compounds. Hence, an alternate method of volatile collection *i.e.* use of solid 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 DAE were placed in a net cage and secured in the field and the ‘calling TMB females’ were later transferred into 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 calling virgin TMB 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, Anand 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. The possible group of organic compounds in the samples was identified as carenes, diethyl-esters, phthalic acid derivatives, naphtha derivatives, pinenes, acetophenones etc.

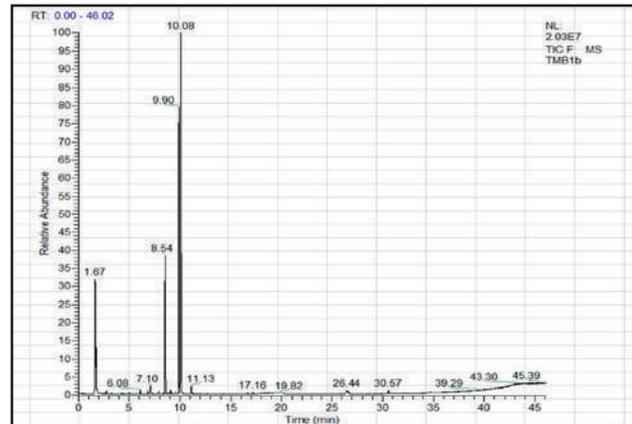
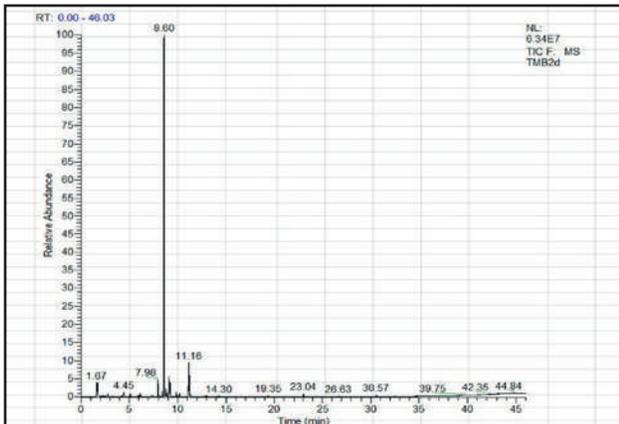


Fig.3.5.1.9. GC-MS elution graphs of adsorbed female sex pheromone volatiles of TMB

Cashew Stem and Root Borers

Evaluation of fresh frass extract- synthetic bait trials for CSRB

As the attraction of CSRB females and males to the fresh frass in infested trees was confirmed earlier in studies, the fresh frass was collected and extracted in n-hexane. The frass material volatiles were concentrated by cold suction in n-hexane and di-chloromethane, which were later characterised using head-space analyser and GC-MS. The components identified from fresh frass collected from CSRB infested cashew trees were phenols, ketones, polyphenols, naphtha-derivatives, geraniol, butyrates and aldehydes. These

were formulated using synthetic formulations in various random ratios to confirm their attraction to the adult CSRB beetles. 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 using sticky vane traps and bucket traps in various cashew plots having CSRB infested trees in both campuses (Kemminje and Shantigodu) of ICAR-DCR (Fig. 3.5.1.10).

Attraction of CSRB to these components was not recorded in field conditions and stereoisomers of these compounds are presently being evaluated under field situations.



a. Hanging bucket trap fixed onto CSRB infested tree



b. Cross-vane sticky trap with synthesized components (bait) in field



c. Close up of cross-vane sticky trap with bait

Fig. 3.5.1.10. Different traps tested for kairomonal activity for CSRB

Subsequently, the fresh frass collected from infested cashew trees was directly assessed for its efficacy as bait using sticky traps. However, no trap catches of CSRB beetles were obtained possibly due to lower adhesiveness of these traps (as adult beetles are quite strong to be caught on sticky traps), or due to non-attraction by synthetic frass formulations or due to escape of attracted CSRB beetles. Hence, a physical-trapping mechanism has to be devised to confirm the attractiveness of various baits under field conditions.

Conclusion

The sex pheromone system in TMB is active only in case of virgin females and not in males. The active “calling age” of the virgin TMB females for sex pheromone release is 4-5 days after emergence of the adults. The peak period of “calling” by the virgin TMB females was noticed to be 9.00 - 11.00 am and 3.30 - 5.00 pm under field conditions. The most effective solvent for extraction of sex pheromone of TMB females was di-chloromethane. The WBE of TMB virgin females could elicit equal response to that of a virgin TMB female and could retain its efficacy when stored in freezer. The modified cylindrical trap could effectively trap up to 97 percent of the TMB males attracted to the bait. The extracts of frass could elicit response under EAG, however the synthesized components of these extracts did not show any attraction of the beetles. Various traps baited with the synthetic components of frass extracts / volatiles did not elicit any trap catches.

Concluded project II

3.5.2. Project Title: Evaluation of alternative insecticides/products for management of tea mosquito bug (TMB) and cashew stem and root borers (CSRB)

Project Leader : T.N. Raviprasad
 Project Associate : K. Vanitha
 Project Number : 3.1.3
 Project Duration : 10/2016 to 10/2020

Introduction

Pest management of tea mosquito bug (TMB), *Helopletis antonii* and cashew stem and root borers (CSRB), *Plocaederus* spp. is being presently achieved by adopting pesticidal intervention. However, the recommended pesticides such as carbaryl, monocrotophos, chlorpyrifos etc., are being phased out for their usage in horticulture. Hence, alternate insecticides need to be evaluated for their efficacy against both the major pests of cashew. Both the pests have a typical nature of damage viz., TMB inflicts damage by sucking the plant sap while the CSRB is an internal feeder (borer insect) which necessitates the adoption of insecticides which are indisputably systemic and also have slight contact action along with an acceptable duration of residual toxicity. Further, unlike the 2nd generation of insecticides, the 3rd generation of insecticides derived / synthesised from neo-nicotinoids and IGHs have negligible or no effect on warm blooded animals and non-target organisms. The chances of developing resistance to these group of insecticides is also very meagre and hence such insecticides were identified as candidates for evaluation against the two major pests of cashew.

Objectives

- Identification of the most effective insecticide for inducing highest mortality of the damaging immature/ adult stages of TMB and CSRB.
- Recording the intensity of feeding repellency at different durations after application.
- Documenting the possibility of oviposition deterrence as well as,
- Evaluating the maximum duration till the residual toxicity is retained under field conditions.

Results

Laboratory and field evaluation of test insecticides versus TMB

The test insecticides, namely, thiamethoxam (0.1 g/L and 0.2 g/L), acetamiprid (0.5 g/L), carbosulfan (2.0 ml/L), buprofezin (2.0 ml/L) with L-cyhalothrin (0.6 ml/L) as check were evaluated for TMB by recording the various parameters *viz.*, a) mortality induction and b) feeding deterrence.

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-off of test chemical. 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 trials for determining residual toxicity of the test insecticides beyond 5 DAT was done by spraying the test insecticides onto tagged flushing branches and evaluating those treated tender cashew shoots at regular intervals. The treatments were imposed on the labelled cashew trees, by using a pneumatic hand sprayer and the shoots were collected at 10 DAT, 15 DAT and 30 DAT for evaluating the feeding deterrence induced by different treatments. Five TMB (nymphs or adults) were released and allowed for feeding for 6 h and later these were removed. The feeding damage induced was scored after 24 h as per the standard damage score scale of 0-4.

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). Buprofezin being a synthetic growth regulator did not induce mortality of TMB nymphs or adults even on 1 DAT. High mortality of TMB (88.6 - 100.0 %) was obtained

in thiamethoxam (0.2 g/L), acetamiprid (0.5 g/L), carbosulfan (2.0 ml/L), and recommended insecticide L-cyhalothrin (0.6 ml/L) upto 5 DAT. The mortality rates decreased significantly later on and were 56.8, 82.2, 74.3, 78.9 and 82.1 per cent on 15 DAT for thiamethoxam (0.1 g/L and 0.2 g/L), acetamiprid (0.5 g/L), carbosulfan (2.0 ml/L), buprofezin (2.0 ml/L) with L-cyhalothrin (0.6 ml/L), respectively (Fig. 3.5.2.1).

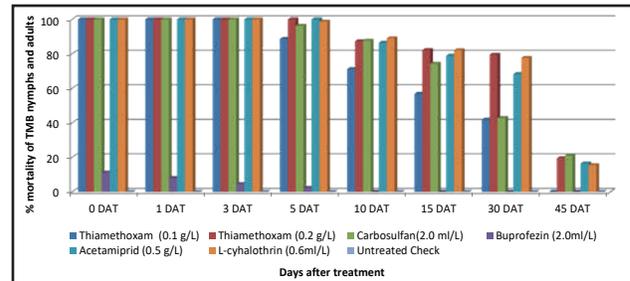


Fig. 3.5.2.1. Mortality percentage of TMB due to test insecticides

It was noticed that only thiamethoxam (0.2 g/L) and L-cyhalothrin (0.6 ml /L) could result in a damage score below 0.5 on 15 DAT. None of the test insecticides could lead to damage scores lower than 1.50 at 45 DAT under laboratory evaluation indicating that residual toxicity could last only for less than 30 days after spray (Fig. 3.5.2.2.).

The cost of insecticide spray per tree worked out to be lowest for L-cyhalothrin (Rs.0.78) followed by thiamethoxam (Rs. 1.00) and by acetamiprid (Rs.2.50) which were effective against TMB in that order and were on par.

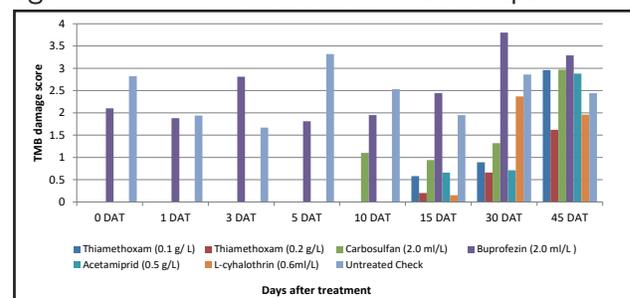


Fig. 3.5.2.2. Damage score of TMB in insecticide treated shoots

Laboratory and field evaluation of insecticides against CSRB

For determining the effectiveness of test insecticides against CSRB, the nascent grub mortality (both under laboratory and field trials) and oviposition deterrence (under laboratory trials) have been recorded for fipronil (2.0 ml/L), imidacloprid (2.0 ml/L) with chlorpyrifos (10 ml/L) as check. For laboratory evaluation of test insecticides, stout twigs of cashew were collected and sprayed with test insecticides till they were well drenched and shade dried. Later



Fig. 3.5.2.3. Evaluation of grub mortality at laboratory

The trials on oviposition deterrence did not yield consistent results as the fecund female CSRB beetles had nibbling behaviour on the oviposition tape and this led to random mortality of the female beetles released onto the oviposition twigs. Similarly, field evaluation of these test insecticides was also done by placing the eggs by slight scooping of the outer bark of any treated cashew branch. The eggs of CSRB (obtained from laboratory reared cultures) were protected with a cotton tape and were further covered by cellophane strip, to avoid predation. The hatching and mortality of CSRB grubs was recorded on 7th day of egg placement. The different zones of the same treated cashew branch were utilized for residual toxicity for 3,

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 onto the cashew twigs (Fig. 3.5.2.3 and 3.5.2.4). 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. 3.5.2.4. Evaluation of grub mortality at field

5, 10, 15, 30 and 45 DAT (days after treatment). The mortality percentage of nascent grubs of CSRB, indicated that fipronil (2.0 ml/L) (84.2 %) was on par with the recommended insecticide chlorpyrifos (86.7 %); up to 15 DAT but induced lesser mortality of nascent CSRB larvae. Significant mortality of CSRB nascent grubs up to a maximum period of 10 DAT was recorded for fipronil (2.0ml/L - 88.8 %), imidacloprid (2.0 ml/L - 54.3 %) with chlorpyrifos (10 ml/L - 98.5 %) beyond which the effectiveness of imidacloprid dropped drastically (< 24.0 %) and all the test insecticides led to least mortality of 10.0 per cent at 45 DAT. Further, the cost of treatment per tree for fipronil was lesser (Rs. 5.60) than that of chlorpyrifos (Rs. 7.00).

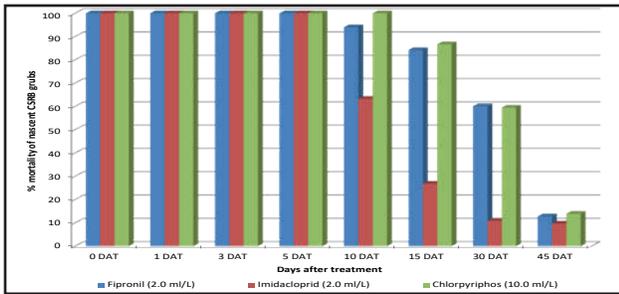


Fig. 3.5.2.5. Mortality of nascent CSRB grubs upon insecticide treatment

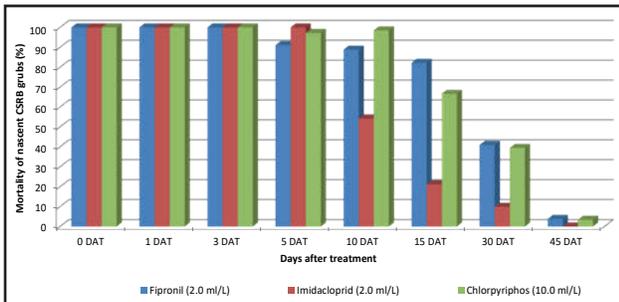


Fig. 3.5.2.6. Mortality of nascent CSRB grubs upon insecticide treatment

Conclusions

Thiamethoxam (0.2 g/L), acetamiprid (0.5 g/L) and carbosulfan (2.0 ml/L) were on par with L-cyhalothrin (0.6 ml/L) in inducing mortality of TMB upto 10 DAT. While the mortality levels induced by thiamethoxam (0.2 g/L) (79.5 %) were on par with L-cyhalothrin (0.6 ml/L) (77.6 %) on 30 DAT. The damage score by TMB was the lowest for thiamethoxam (0.2 g/L) (0.66) amongst the test insecticides and was on par with L-cyhalothrin (0.6 ml/L) (0.37) on 30 DAT. Hence, the alternate newer insecticides viz., thiamethoxam (0.2g/L) and acetamiprid (0.5 g/L) can be recommended for management of TMB.

The sequential nascent grub mortality of CSRB was in chlorpyrifos (10 ml/L - 98.5 %), fipronil (2.0ml/L - 88.8 %) and imidacloprid (2.0 ml/L - 54.3 %) at 10 DAT while the per cent values for nascent grub mortality were 41.0, 39.9 and 19.9 on 30 DAT, respectively. In order to manage the CSRB in initial stages; the recommendation

of fipronil (2.0 ml/L) as an alternative to the presently recommended insecticide chlorpyrifos (0.2 %) would be beneficial.

Concluded project III

3.5.3. Project Title: Standardization of pest management practices involving EPN and *Metarhiziumanisopliae* for management of cashew stem and root borers (CSRB)

Project Leader : T.N. Raviprasad
 Project Associate : Rajkumar (ICAR-CPCRI)
 Project Number : 3.1.4
 Project Duration : 09/2017 to 10/2020

Introduction

Presently, pest management of cashew stem and root borers (CSRB), *Plocaederus* spp. is being achieved by adopting pesticidal intervention; viz., swabbing and drenching with Chlorpyrifos against CSRB. However, during the field surveys for natural enemies of CSRB it was noticed that a local strain of *Metarhizium anisopliae* was found to be infecting the grubs of CSRB under field situation. Further, during the earlier trials, it was found that the infective juveniles (IJs) suspension of entomopathogenic nematode (EPN) species viz., *Steinernema* and *Heterorhabditis* could induce significant mortality of CSRB grubs and could stay alive in soils for more than 150 days and retain their virulence. Use of any effective bio-control agent will alleviate the possibility of contamination and due to their host specificity, the natural enemies do not cause any ecological imbalance. Further, the IJs of EPN as well as *Metarhizium anisopliae* can survive in soil or saprophytically and multiply so that the ensuing pest population will also be terminated as and when incidence occurs. Hence, in this context it was opined that these natural enemies need to be evaluated for their efficacy so that suitable IPM schedule can be recommended to manage this important pest of cashew.

Objectives

- i) To record the effectiveness of selected test EPN species (coleopteran infecting strains) for mortality induction, field survival and virulence.
- ii) To record the field efficacy of the test candidate species and effect on non-target organisms, if any.
- iii) To work out the IPM schedule of utilizing these species for management of CSRB and recommend for adoption

Results

Survey for indigenous natural enemies: Entomopathogenic fungi (EPF) – *Metarhizium anisopliae*

Surveys were done to identify natural enemies of the major pests of cashew viz., CSRB and TMB in cashew plots of ICAR-DCR and KCDC plantations. During the field surveys, natural mortality of CSRB grubs and pre-pupae was noticed during late August till November (Fig. 3.5.3.1). Particularly, cashew trees in severe stages of infestation which had older aged CSRB grubs were recorded to have infection by *M. anisopliae* (Fig. 3.5.3.2). The infestation percentage ranged between 6.0 and 34.0 per cent during different months of survey. No other fungal pathogen was encountered.

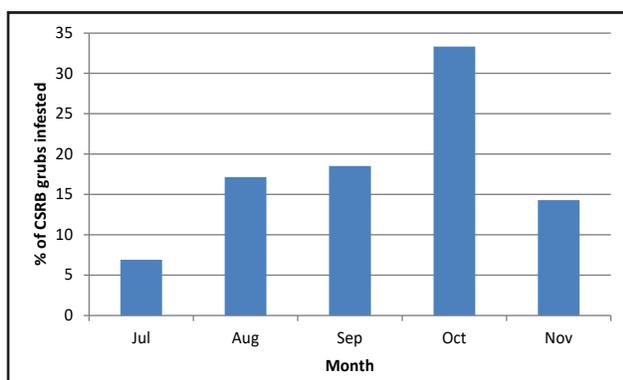


Fig.3.5.3.1. Seasonal occurrence of *M. anisopliae* in CSRB infested trees



Fig. 3.5.3.2. Natural infection of pre-pupa of CSRB by *M. anisopliae*

Evaluation of indigenous *M. anisopliae* spawn for its efficacy against CSRB

The locally encountered strain of *M. anisopliae* was evaluated under laboratory conditions for its virulence in causing mortality of CSRB grubs. Aqueous spore suspension of the isolated local strain of *M. anisopliae* was applied topically at 10^4 spores / μ l (1 ml /grub) and through feed to CSRB grubs aged between 15 to 30 days (1 ml/5x5 cm² of cashew bark). All the treated CSRB grubs got infected, became moribund within 5 days after treatment and showed 100 per cent mortality within 15 days after treatment in topical application and within 21 days in case of application of spores through bark as feed (Table 3.5.3.1). However, under field conditions the application of spawn suspension onto infested tree trunks would be a feasible approach.

The infested CSRB cadavers were incubated and the aqueous spore suspension (10^4 spores/ μ l) could induce 100 % mortality of CSRB grubs on topical application and through feed for more than 60 days after sporulation and subsequently induced lower mortality of 60 % during 120 days; after sporulation.

Table 3.5.3.1. Mortality of CSRB grubs induced by *M. anisopliae* through different application modes

Days after Treatment (DAT)	% Mortality of the treated CSRB grubs	
	Topical application of <i>M. anisopliae</i> suspension @ 10 ⁴ spores/μl	<i>M. anisopliae</i> suspension provided through feed @ 10 ⁴ spores/μl
3	0.00 ^a	0.00 ^a
5	57.14 ^b	42.85 ^b
7	60.00 ^{bc}	53.33 ^c
10	76.92 ^{bc}	53.84 ^c
15	100.00 ^d	71.42 ^d
21	100.00 ^d	100.00 ^e

Survey for indigenous natural enemies: Entomopathogenic nematodes (EPN) – *Heterorhabditis* and *Steinernema*

Extensive soil sampling from rhizosphere of cashew trees was undertaken in KCDC plantations of Kunthur, Koila, Alangar, Sowthadka and Thurkalike and analysed for presence of entomopathogenic nematodes (EPN) at ICAR-CPCRI, Kasargod. The entomopathogenic nematodes occurred in 25 out of 81 soil samples were analysed. The natural populations of Rhabditid group of nematodes were generally encountered in higher numbers, however, Steinernematid and Heterorhabditid groups were not encountered.

Three coleopteran infecting EPN strains of genus *Heterorhabditis* and *Steinernema* viz., *Heterorhabditis indica*, *Steinernema carpocapsae* and *S. abbasi* were multiplied on larvae of greater wax moth (*Galleria mellonella*). The emerging infective juveniles (IJs) were applied topically onto the test insect larvae; *Plocaederus* spp. at 0.5 ml suspension/5 larvae containing approximately 10³ IJs/ml, 10⁴ IJs/ml and 10⁵ IJs/ml. All these treatment concentrations were infective to the CSRB grubs under laboratory conditions and led to emergence of virulent IJs. In continuation

of the simulated pot experiments conducted in an earlier research project on soil survival and virulence of the coleopteran infecting EPN, field evaluations of all three EPN species for the above parameters was attempted in KCDC plantations of Alangar, Ramakunja and Sowthadka. The EPN suspensions having various concentrations of IJs i.e. 1, 4, 6 and 10 LE/100ml (LE = larval equivalent) were drenched in to the soil and gently raked upto 15–30 cm depth.

Soil samples were collected at monthly intervals, brought to the laboratory and slightly moistened to activate the available IJs and the grubs of CSRB aged 45–90 days were allowed to crawl in these samples for 6 h. It was observed that all the three species of EPN applied into the soil displayed virulence and could induce more than 90 % mortality up to 180 days. The mortality of CSRB grubs in soil samples treated with 1 LE/100ml and 4 LE/100ml of EPN suspension was less and further reduced after 30 days of treatment (Table 3.5.3.2 and Table 3.5.3.3). Another important observation was the higher survival of IJs obtained from such soils having more of organic matter and from shaded conditions in comparison to those samples of exposed soils.

Table 3.5.3.2. Mortality of CSRB grubs in the treated soil samples obtained from cashew ecosystem: a) *Heterorhabditis indica*

Location	Concentration of EPN IJs evaluated			
	1 LE/100ml	4 LE/100ml	6 LE/100ml	10 LE/100ml
Ramakunja-ES	25.00	33.06	46.39	73.89
Ramakunja-SS	40.56	49.16	72.50	89.44
Alangar-ES	19.16	17.22	26.94	50.00
Alangar-SS	31.11	20.55	38.05	58.61
Sowthadka-ES	11.67	21.94	27.78	58.89
Sowthadka-SS	23.61	42.67	37.78	70.55
CD @ 5 %	6.321	5.874	5.882	6.017

ES = Exposed Soil; SS = Shaded soils and LE = larval equivalent

Table 3.5.2.3. Mortality of CSRB grubs in the treated soil samples obtained from cashew ecosystem: b) *Steinernema carpocapsae*

Location	Concentration of EPN IJs evaluated			
	1 LE/100ml	4 LE/100ml	6 LE/100ml	10 LE/100ml
Ramakunja-ES	8.61	12.5	28.33	66.94
Ramakunja-SS	11.67	18.89	30.83	73.05
Alangar-ES	15.55	17.22	15.17	76.67
Alangar-SS	16.39	18.88	31.66	78.05
Sowthadka-ES	11.67	21.66	46.66	79.44
Sowthadka-SS	21.11	26.66	55.56	92.5
CD @ 5 %	5.523	6.327	5.241	5.287

ES = Exposed Soil; SS = Shaded soils and LE = larval equivalent

Field evaluation of EPN and *M. 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 LE/infested tree and @ 10 LE/healthy tree in comparison with treated

check i.e., chlorpyrifos 0.2 %. The survival and virulence of IJs of these EPN has been confirmed up to 180 days in shaded ecosystem and they could induce mortality in the CSRB grubs. None of the treated healthy cashew trees showed any signs of reinfestation by the pest and these treatments could not check the residual infestation of CSRB, which needed recurrent extraction of pest stages based on exudation of frass.

As the trials were restricted to the lesser number of CSRB infested trees only in the DCR plots, the statistical validity could not be established. However, the trend indicated that

application of EPN and *M. anisopliae* in the rhizosphere could prevent fresh incidence by CSRB. The residual inoculum of CSRB needs to be tackled by administering higher dosage of these bio-control agents and in a suitable manner to gain contact with the CSRB grubs feeding below the bark surface.

Conclusion

Natural occurrence of a strain of *M. anisopliae* infecting CSRB grubs was recorded. *M. anisopliae* could induce 100 per cent mortality of CSRB grubs through topical application and through oral ingestion (through feed) in 15 and 21 days respectively.

The cashew ecosystem surveyed in Dakshina Kannada district did not have any indigenous populations of EPN species of *Steinernema* or *Heterorhabditis*. Survival of IJs suspension of the EPN species viz., *H. indica*, *S. carpocapsae* and *S. abbasi* was observed for 180 days with retained virulence to CSRB in the soils having organic matter and in shaded locations.

Application of *M. anisopliae* spawn @ 250 g/tree and 500 g/tree and identified strains of EPN i.e., *Steinernema* and *Heterorhabditis* @10 LE/infested tree could prevent reinfestation of treated trees by CSRB; which needs to be further confirmed in large plot evaluations.

••••• 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

A project funded by Rashtriya Krishi Vikas Yojana - Remunerative Approaches for Agriculture and Allied Sector Rejuvenation (RKVY-RAFTAAR), Govt. of Karnataka was initiated to create a state-of-the-art laboratory facilities and demonstration plots to showcase the usefulness of improved technologies to realize higher yield and income to the cashew growers of Karnataka in particular and other regions in general. The demonstration with farmers' participation is expected to allow the growers to realize the impact of technologies in the field.

On-farm demonstration

For establishing demonstration plot on improved production technology for the visiting farmers, an additional plot area of 4.5 acres developed this year. Of these 4.5 acres, 3 acres was planted under normal density planting and 1.5 acres was under high density planting. The entire area was fenced and provided with gates.

To demonstrate the usefulness of precision agricultural activities drip and fertigation systems were installed (Fig. 4.1).

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

Farmer participatory front line demonstrations were organised across 59 farmers fields located in three coastal districts of Karnataka, namely Uttara Kannada, Dakshina Kannada and Udupi during 2018-19 and 2019-20 under rainfed conditions (Fig. 4.2). The details of varieties of cashew and age of the plantation of the selected fields are provided in Table 4.1. The farmers were instructed to follow the recommended soil fertiliser application based on soil test data for a patch of 1 acre consisting of 80 trees. In the rest of the area, they were advised to continue farming as followed by them earlier and record the data on raw cashewnut yield on both the fields. They were given financial support for all the inputs as well other agronomic management required for cashew such as weeding, training and pruning, plant protection and soil and water conservation activities.



Fig. 4.1. Field view of demonstration plot

Table 4.1. Details of cashew variety grown, age of the plantation and baseline raw cashewnut yield

Variety of cashew	Age of the plantation	No. of farmers	Baseline yield of raw cashewnut (2017-18)	
			Range (kg/ac)	Mean±SD
Bhaskara	5	2	88.0-120.0	104.0±22.6
	6	5	80.8-176.0	120.2±36.4
	7	2	64.0-248.0	156.0±130.1
	8	5	96.0-352.0	214.4±95.7
Ullal-1	5	4	52.0-184.0	90.0±62.9
	6	3	80.0-104.0	88.5±13.4
	8	4	64.0-200.0	111.0±61.1
Ullal-2	8	2	96.0-176.0	136.0±56.6
Ullal-3	5	4	52.0-200.0	98.0±69.0
	6	4	80.0-200.0	124.0±53.3
	8	2	168.0-240.0	204.0±50.9
Vengurla-4	5	3	68.0-120.0	89.3±27.2
Vengurla-7	5	6	56.0-160.0	90.0±38.2
	6	4	64.0-160.0	108.0±40.0
	8	4	120.0-176.0	150.0±23.9
	10	2	264.0-360.0	312.0±67.9
VRI-3	5	3	68.0-160.0	105.3±48.4



Fig. 4.2. Field visits to front line demonstration plots

The adoption of scientific nutrient management practices as per the soil test and leaf nutrient status was beneficial to improve the nutrient uptake by the plants as observed from the increased leaf nutrient status of all essential nutrients and to increase the benefit-cost ratio.

Cashew Plant Health Clinic Museum

Due to the perennial nature of cashew and its seasonality of production, providing field exposure on all aspects is difficult during a particular visit of farmers to the research organizations. This necessitated the need for

a modern Plant Health Clinic Museum (PHCM) on cashew with the help of modern information and communication technologies. This facility can provide one-stop point for dissemination of cashew related technologies to farmers, students, researchers and other stakeholders. Hence, a state-of-the-art cashew museum was established with the support of RKVY-RAFTAAR, Govt. of Karnataka at the ICAR- DCR, Puttur.

The museum cum plant health clinic has been developed with many unique and interesting features (Fig. 4.3). The kiosk in the museum provides relevant information about cashew cultivation and processing. The plant health aspects can be learnt with the images and videos in the kiosk through different custom-made software for pest attack, disease incidence and nutrient deficiency symptoms along with options for their management. The digital display frames provide information on all aspects of cashew cultivation, management, processing and value

addition through videos. Digital translates/ bromides are illuminated films or transparencies lit from behind or above, which provide information on various facets of development and care required for cashew orchards. Press button information board helps to learn about different attributes of popular varieties of cashew.

Further, the storytelling boards present information in an appealing audiovisual format. Scrolling translates help to increase the linguistic capacity of the museum where information in all possible languages is provided. The sample enclosures showcase the specimens, samples and models of different items related to cashew. Another interesting aspect in the museum is the mural painting that depicts the elements of historical and current events of cashew.

The museum can serve as a visual treat to the visitors, a knowledge bank of cashew crop and cater to the diagnostic needs of visitors.



Fig. 4.3. Cashew plant health clinic museum at ICAR-DCR, Puttur

Training and exposure visits

Various trainings were conducted in the selected districts for the benefit of farmers on advanced cashew production technology. Three exposure visits of farmers were carried out to

the demonstration plots for lateral spread of scientific knowledge (Fig. 4.4.). Soil health cards were distributed to 60 farmers participating in the demonstration.



Fig. 4.4. Exposure visits

Field days on soil and plant health management in cashew

Field days conducted during 2020 are given in table 4.2 and Fig. 4.5.

Table 4.2. Field days conducted

Sl.No.	Location and number of farmers attended	Date	Co-ordinator/ Associates
1	Ankola, Uttara Kannada district - 46 farmers	6 th January, 2020	Dr. Shamsudheen, M. Mr. B.M. Muralidhara
2	Mundgod, Uttara Kannada district - 41 farmers	7 th January, 2020	Dr. Shamsudheen, M. Mr. B.M. Muralidhara
3	Kundapura, Udupi district - 35 farmers	31 st January, 2020	Dr. Shamsudheen, M. Dr. J.D. Adiga
4	Alankar, Dakshina Kannada district - 54 farmers	07 th February, 2020	Dr. Shamsudheen, M. Dr. M.G. Nayak



Fig. 4.5. Glimpses of field days conducted

4.2. Exhibition

ICAR-DCR, Puttur participated in National Horticulture Fair - 2020 held at ICAR-IIHR, Hesarghatta, Bengaluru from 5 - 8th February, 2020 and put up an exhibition stall. On an average, 15,000 farmers and visitors visited the

stalls in the fair every day. During this fair, many farmers showed interest in cashew cultivation and value-added cashew products. The stall was managed by Mr. Prakash G. Bhat and Mr. M. Bhojappa Gowda.

4.3. Diagnostic field visit/farmers or students visits/demonstration by scientists at ICAR-DCR

Sl. No.	Details	Date	Co-ordinator
1.	Led the team of committee comprising of Officials of UAHS, Shimoga and KCDC, Mangaluru to survey and assess the extent of damage by TMB, reasons for yield loss and to suggest management measures in KCDC plantations of Dakshina Kannada, Udupi and Uttara Kannada districts as per the suggestions of MD, KCDC, Mangaluru and Director, DCCD, Cochin.	1 st week of January	Dr. M.G. Nayak
2.	Students of third year B.Sc., (Hort.) UAHS, Mudigere (68 Nos).	22 nd January, 2020	Mr. Prakash G. Bhat
3.	Students of M.Sc., (Botany) from Alva's College, Mudbidri (41 Nos).	12 th January, 2020	
4.	Student trainees from Rangasamudra Horticulture Training Institute, Mysore (20 Nos)	13 th February, 2020	
5.	Farmers under SADH, Sakaleshpura (40 Nos).	19 th Febraury, 2020	
6.	Farmers on study tour from Utter Kannada District (20 Nos).	28 th February, 2020	

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

The 'Cashew India' app was saturated with data sets from different AICRP centers for different languages during the year. A total of 11,606 grafts have been booked via the app as on 31st December, 2020 by farmers. The Google Play store rating of the app is 4.3 and the app is downloaded by 1991 different users.

4.5. Websites /apps

Dr. Mohana, G.S. (AKMU In-charge) and Mr. Muthuraju R. (Senior Technical Officer, AKMU) maintained and updated

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

- The cashew germplasm database <https://cashew.icar.gov.in/dcr>

4.6. Technical advices provided

Dr. D. Balasubramanian, Principal Scientist (AS & PE) provided several technical advices during 2020 including detailed project report preparation for financial assistance to revive cashewnut processing system, processing of cashewnuts and cashew apples, quality assessment, safety in operation of processing units, training on cashew and incubation facility, starting up cashew processing units etc for the beneficiaries from Tamil Nadu, Hyderabad, Karnataka, Maharashtra, Goa, Telengana and Kerala.

4.7. Radio talk

Dr. M.G. Nayak had participated in a 'Phone in Programme' of All India Radio, Mangaluru on 15th April, 2020 and delivered a talk on 'Handling of cashew activities during COVID-19 scenario', which was telecasted on 19th April, 2020.

5. Implementation of STC/TSP and SCSP

Scheduled Tribe Component/Triabab Sub Plan (STC/TSP)

STC/TSP project was implemented by the Directorate for the benefit of scheduled tribe community from different parts of Dakshina Kannada to improve their livelihood by supporting agricultural and self employment activities and also encouraged the use of sustainable energy sources like solar light. Establishment of six cashew orchards was supported under the TSP

scheme during this year. Five cashew cultivars viz., Bhaskara, Vengurla-4, Vengurla-7, Ullal-3 and MDK-2 were grown over an area of 4.7 hectares. The machineries such as sewing machine, weed cutting machine, and daily used items like solar lights requested by the TSP applicants were procured and distributed to the beneficiaries, besides supporting the poultry rearing.



View of STC/TSP cashew orchards

Scheduled Caste Sub Plan (SCSP)

During January-June 2020, ICAR-DCR, Puttur has taken up many activities for the welfare of members of scheduled caste community. Under this programme, selected farmers from Dakshina Kannada, Kodagu and Chitradurga districts were provided with cashew grafts and financial support to meet the initial cost of cultivation. Poultry units and apiculture units were also supplied to the interested and selected farmers for improving their livelihood, and the required trainings and exposure visits were provided. Besides, agricultural machineries and other household items including weed cutter, chain saw, sprayers, aluminium tree climbing ladders, areca plate making machine, sewing machines, water storage tanks and solar lights for houses were distributed to the needy beneficiaries. Exposure tours to 54 interested SCSP farmers in two batches were conducted in collaboration with KVK, Mangaluru during 26-29th February, 2020 and 10-13th March, 2020. The team

visited KVK, Gonikoppal, Kodagu; KVK, Suttur; Nanjanagudu, Mysuru; University of Agricultural Sciences, Bengaluru; Fisheries Research Institute Centre, Hebbal and Hesarghatta; Indian Institute of Horticulture Research, Bengaluru and Biotechnology Park, Hassan.



Distribution of sewing machines to SCSP beneficiaries



Exposure tour under SCSP

To promote cashew cultivation, 6400 cashew grafts were supplied to 41 farmers belonging to Scheduled Caste including 24 from Gadag, 11 from Kodagu and six from Dakshina Kannada districts. All of them were provided with 100 % financial aid during December 2020 for establishment of cashew plantation by direct benefit transfer (DBT) mode. Besides, livelihood support through supply of cow heifers, cow mats, desi lambs and agricultural implements were extended for the SCSP applicant farmer beneficiaries from Kodagu, Dakshina Kannada, Gadag, and Chitradurga districts.

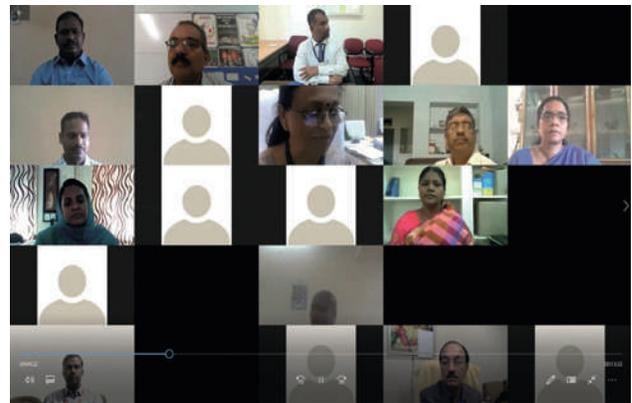
6. AICRP / Co-ordination Unit

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

The Annual Group Meeting (AGM) of Scientists of AICRP on Cashew was organized on a virtual platform during 18-19th December, 2020. Dr. Anitha Karun, Director (Acting) presented the project coordinator's report and welcomed all the delegates. The Inaugural address was delivered by Dr. B.K. Pandey, ADG (Hort-II.), ICAR, New Delhi, wherein, he expressed his concern about increasing the production and productivity of cashew in the country for doubling the income of the farmers. The scientists from different AICRP centers presented their research findings in different technical sessions. The technical session on 'Crop Improvement' was chaired by Dr. Niral V., Principal Scientist, ICAR-CPCRI and co-chaired by Dr. M.S. Aneesa Rani, Professor, Dept. of Fruit Science, Tamil Nadu Agricultural University, Coimbatore followed by 'Crop Management' session which was chaired by Dr. V.S. Korikanthimath, Former Director, ICAR-Central Coastal Agricultural Research Institute, Goa and co-chaired by Dr. J.D. Adiga, Principal Scientist, ICAR-DCR. The Crop Protection Session was held on 19th December, 2020 which was chaired by Dr. Kesavan Subaharan, Principal Scientist (Entomology), NBAIR and co-chaired by Dr. Joseph Rajkumar, A., Principal Scientist, ICAR-CPCRI which was followed by an interactive session chaired by Dr. Venkatesh N. Hubballi, Director, DCCD, Cochin wherein farmers, scientists, processors and officials from other

development departments had participated. During the session the problems and suggestions of farmers regarding cashew was also discussed at length.

The session on variety release proposal was chaired by Dr. A.K. Singh, Deputy Director General (Horticulture), ICAR, New Delhi. He reiterated the importance of cashew research and called for improving the productivity. Further he suggested the formation of FPOs in cashew. During the session, Dr. M.G. Nayak, Principal Scientist (Horticulture) presented the variety release proposal for the dwarf cashew variety, NRC-492 and after thorough discussion, it was approved for release. The AGM was concluded with vote of thanks by Dr. Mohana, G.S. Principal Scientist and Scientist-in-charge, PC Cell, ICAR-DCR, Puttur.



AICRP - AGM in progress (virtual mode)

7. Agribusiness Incubation

A new Agribusiness Incubation (ABI) Centre under National Agricultural Innovation Fund (NAIF), ICAR, New Delhi has been established at ICAR-DCR, Puttur for providing support for emerging or existing entrepreneurs. After installation and commissioning, the basic guidelines for incubating new / existing entrepreneurs was prepared with 5 different business models viz., i) Custom hiring; ii) Innovative technology development; iii) Detailed project report for new entrepreneur; iv) Value addition and v) Consultancy for specific problems.

Three incubatees have registered with ABI and utilized State-of-the-Art processing facility on the basis of 'Custom hiring'. During this phase, mentorship was provided on technical, management and market aspects to the incubatees. Besides, an online training program was organized for 'Tribal Women' operating cashewnut processing unit in Jagadapur, Chhattisgarh from 9-15 July, 2020. An amount of Rs. 54,350/- has been generated through ABI services during 2020.



An incubatee receiving certificate

8. AWARDS/RECOGNITIONS/RESOURCE PERSONS/LECTURE

8.1. Awards

Dr. M.G. Nayak

- Received 'Fellowship of International Society for Noni Science, Chennai, India for the year 2020' in recognition of contributions made in the field of Agricultural Sciences/Noni/Biological Sciences.

Dr. J.D. Adiga

- Received 'Fellowship of International Society for Noni Science, Chennai, India for the year 2020' in recognition of contributions made in the field of Agricultural Sciences/Noni/Biological Sciences.

Dr. K. Vanitha

- 'Best poster presentation award (I prize)' for the paper 'Bee visits play a vital role in pollination of cashew' by K. Vanitha and T.N. Raviprasad' during the XVII AZRA International Conference on 'Frontier research in applied zoology and insect pest management strategies: a way forward for food and nutritional security' held on 12-14th February, 2020 at University of Agricultural Sciences, Raichur, Karnataka.
- 'Kanwar Virender Singh Memorial All India Best publication award 2019' for the publication 'K. Vanitha, P.S. Bhat, T.N. Raviprasad and K.K. Srikumar (2016). Biology and behaviour of *Ephestiasula pictipes* (Wood-Mason) (Hymenopodidae: Mantodea) under captive breeding, International Journal of Pest Management, 62, 4: 308-318' by Society for Advancement of Human and Nature (SADHNA), Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India.
- First best oral presentation award for the paper 'Insect pests of cashew apples,

seasonality, damage and natural enemies' presented in International Web-Conference on Food Security through Sustainable Agriculture (FSSA), VAKSANA-2020 21-22nd September, 2020 by Shri Vaishnav Institute of Agriculture, Indore (M.P.), India.

- 'Young Scientist Award-2020' in the field of Agriculture and Allied Sciences by Dr. B. Vasantharaj David Foundation, Chennai during National Conference on "Recent Scientific Advances in Agricultural and Environmental Sciences" on 22nd November, 2020 in Chennai, Tamil Nadu.

Dr. Veena, G.L.

- 'Best Young Scientist Award-2020' by EET CRS, Research wing for excellence in professional education and Industry by Education Expo TV research branding company Mumbai, India.
- 'Young Scientist Award-2020' from Astha Foundation, Meerut, UP, India during International Web Conference on 'Global Research Initiatives for Sustainable Agriculture and Allied Sciences' organized by the GRISAAS-2020 during 28-30th December, 2020.

Mr. Muralidhara, B.M.

- 'Young Scientist award' from Astha Foundation, Meerut, UP, India during International web Conference on 'Global Research Initiatives for Sustainable Agriculture and Allied Sciences' organized by the GRISAAS-2020 during 28-30th December, 2020.
- 'Best Oral Presentation Award' for the paper entitled 'Morphological characterization of south Indian avocado (*Persia americana* Mill.) presented in International Web Conference (GRISAAS-2020) held during 28-30th December, 2020.

8.2. Recognitions

Dr. M.G. Nayak

- Nominated as a member of National Advisory Board of International Symposium on Coastal Agriculture (ISCA 2020): Transforming Coastal Zone for Sustainable Food and Income Security being organised in Kolkata during 16-19th March, 2021.
- Nominated as a member of Organic Certification Committee of Agricultural and Processed Food Products Export Development Authority (APEDA).

Dr. T.N. Raviprasad

- Recognized as Member of Doctoral Committee for Applied Zoology by Mangalore University, Mangaluru vide Notification no. MU/EXB/Phg.D./CR51/2019-20/E13 dated 03.03.2020.

Dr. D. Balasubramanian

- Acted as member of the 'Expert Panel' in an international webinar entitled "Impact of COVID-19 on cashew industry in India and solutions to boost the sector post pandemic" organized by 'World Business Club' (WBC) under the banner "Together We Stand Against COVID-19" on 28.07.2020.

Dr. J.D. Adiga

- Nominated as external examiner for conducting qualifying exam of M.Sc., and Ph.D. (Hort.) students in the discipline of Fruit Science at three different PG campuses (Bengaluru, Bagalkot and Arabhavi) of UHS, Bagalkot.

Mr. Rajkumar, A.D.

- Appointed as a subject expert to design course curriculum of B.Sc., Honors (Food Science), specialization at M.Tech. (Food Technology), Post Graduate Diploma (Food Technology) in the discipline of Food Science

and Technology on 12th February, 2020 by Board of Studies and Principal (MIT- CFT) Dean, Faculty of Technology MIT ADT University, Pune.

- Appointed as a paper setter for end semester examinations (July - August 2020) of Fourth Semester M.B.A. (Agri and Food Business Management - Marketing) for the course Food Laws & Regulation by Chairman, Board of Examinations, MIT Art, Design and Technology University, Pune, on recommendations of Head of the Department.
- Appointed as a Chairman cum paper setter for end semester examinations (January 2021) of Third Semester M.B.A. (Agri and Food Business Management) for the course, Food Processing Management by Chairman, Board of Examinations, MIT Art, Design and Technology University, Pune, on recommendations of Head of the Department.

Dr. P. Preethi

- Acted as external examiner for conducting qualifying exam of M.Sc. (Hort.) student in the discipline of Fruit science at College of Agriculture, Padannakkad, Kerala Agricultural University.

Dr. Shamsudheen Mangalassery

- Acted as external examiner for conducting qualifying exam of M.Sc., (Ag.) student in the discipline of Soil Science & Agricultural Chemistry at College of Agriculture, Padannakkad, Kerala Agricultural University.

Dr. Raghurama Kukkude

- Awarded Ph.D. Degree from Mangalore University, Mangalagangothri on 27-02-2020. The research topic was "Marketing of Information Products and Services in ICAR Institute Libraries of South India" submitted to the Dept. of Library and Information Science, Mangalore University.

8.3. Resource person/lecture

Mohana, G.S.	Presentation on “Trends in cashew breeding – Problems and Prospects” in Botany department, Alvas college, Mudbidri.	24 th February, 2020
Rajkumar, A.D.	Delivered a talk on “Nutrition and Health” during ten days village adoption program (VAP) organized by MIT College of Food Technology, MIT-ADT University Pune held at village Wadebolhai, Pune.	3 rd - 12 th March, 2020
K. Vanitha	Acted as resource person in the farmers’ training programme on “Recent cultivation practices and homestead valorization of cashew apple in hill zone of Karnataka” sponsored by MIDH and DCCD, Cochin in Neechadi, Sagar taluk of Karnataka and presented on pests of cashew and their management.	6-7 th March, 2020
Mohana, G.S.	Presentation on “Advances in Cashew breeding” in the Webinar organised by the Department of Botany, St. Aloysius College, Mangaluru through Google Meet.	16 th June 2020
Rajkumar, A.D.	Delivered a talk on “Present status, Opportunities and Future Challenges of Indian Fruit Production and Processing” during one day National Webinar on “Future Opportunities in Food Processing Sector after Covid 19 held at Sau KSK College of Food Technology, Beed, Maharashtra.	6 - 12 th August, 2020
Rajkumar, A.D.	Delivered a guest lecture on “Challenges in fruit juice probiotication” during one month national online training, for students of B.Tech. Agricultural engineering from various State Agricultural Universities, organized by Krishi Career Academy, Pune Maharashtra.	17 th September, 2020
Mohana, G.S.	Delivered a talk on “Cashew cultivation” at Saraswathi Vidyalaya, Kadaba, Dakshina Kannada in Udyoga Nypunya Tarabeti Shibira.	28 th September, 2020
Rajkumar, A.D.	Delivered guest lecture on “Recent Trends in Food Technology” on the occasion of World Food Day organized by Society of Food Engineers (SOFE) at Department of Food Process Engineering, Vaugh Institute of Agricultural Engineering & Technology (VIAET) Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj, Uttarpradesh.	16 th October, 2020
Preethi, P.	Acted as a resource person and presented topic on “Role of Fruits and Vegetables in meeting the nutritional security in India” in 1 day webinar on ‘Let food be the medicine in the era of life style diseases’ organized by Dept. of Post Harvest Technology, College of Horticulture, UHS, Bagalkote.	16 th October, 2020
J.D. Adiga	Delivered an invited talk on “Breeding cashew for novel traits” during international e-conference on ‘Advances and future outlook in Biotechnology and Crop improvement for sustainable productivity’ organized by UHS, Bagalkot.	24-27, November, 2020
Mohana, G.S.	Delivered a talk on “Cashew cultivation” in Udyoga Nypunya Tarabeti Shibira at Bharathi Higher Primary School, Aalankaru, Dakshina Kannada	3 rd December, 2020
J.D. Adiga	Acted as a resource person in the Training programme to farmers on “Improved production practices of cashew” held at College of Horticulture, Mudigere.	4 th December, 2020

●●●●● 9. PUBLICATIONS ●●●●●

9.1. Research / Review article

- Eradasappa, E., Adiga, J. D. and Mohana, G.S. 2020. Hybrid vigour and variability for key growth characters and yield in cashew (*Anacardium occidentale* L.). *Journal of Plantation Crops*, 48 (2): 71-81.
- Janani, P. and Adiga, J.D. 2020. Studies on effect of rootstocks on root distribution pattern of cashew. *International Journal of Chemical Studies*, 8 (3): 1991-1994.
- Janani, P., Adiga, J.D. and Kalaivanan, D., 2020. Effect of certain rootstocks on vegetative, reproductive growth and yield of cashew cultivars. *Current Journal of Applied Science and Technology*, 39 (16): 1-11.
- Mangalassery, S., Preethi, P., Muralidhara, B.M. and Nayak, M.G. 2020. Improving the productivity through site specific nutrient management in cashew through a mobile app in coastal India. *Current Journal of Applied Science and Technology*, 39 (48): 73-88. [<http://krishi.icar.gov.in/jspui/handle/123456789/45367>].
- Nayak, M.G., Muralidhara, B.M., Janani, P., and Savadi, S. 2020. Performance of cashew (*Anacardium occidentale*) varieties under different planting density for growth and yield traits. *Indian Journal of Agricultural Sciences*, 90 (8): 1453-9.
- Patil, S.V., Nagaraja, G., Rajkumar, G. R., Lingaraju, N.N. and Adiga, J.D. 2020. Nitrogen management strategies to improve growth and yield of cashew. *International Journal of Chemical Studies*. 8 (5): 611-614.
- Preethi, P., Mangalassery, S., Shradha, K., Pandiselvam, R., Manikantan, M.R., Reddy, S.V.R., Ramyashree Devi, S. and Nayak, M. G. 2020. Cashew apple pomace powder enriched the proximate, mineral, functional and structural properties of cereal based extrudates. *LWT- Food Science and Technology*, 110539. doi:<https://doi.org/10.1016/j.lwt.2020.110539>. 10 November 2020. [<http://krishi.icar.gov.in/jspui/handle/123456789/43320>]
- Ramteke, V., Yaspal Singh Nirala, M.G. Nayak and G.S. Mohana. 2020. Evaluation of apple and nut characters of cashew germplasm from Bastar region, Chhattisgarh, India. *Journal of Plantation Crops*, 48 (2): 142-145.
- Savadi, S., Muralidhara, B.M., and Preethi, P. 2020. Advances in genomics of cashew tree: molecular tools and strategies for accelerated breeding. *Tree Genetics & Genomes*, 16 (5): 1-15.
- Savadi, S., Sowmya, K., Megha, V.S., Muralidhara B.M. and Mohana G.S. 2020. Genetic diversity and identification of interspecific hybrids of *Anacardium* species using microsatellites. *Brazilian Journal of Botany*, [<https://doi.org/10.1007/s40415-020-00678-5>].
- Vanitha K. and D. Balasubramanian. 2020. Vulnerable stages of cashewnuts for pest infestation and the pest influence on kernel quality. *Journal of Entomology and Zoology Studies*. 8 (5): 1807-1812. [<http://krishi.icar.gov.in/jspui/handle/123456789/43493>].

9.2. Abstracts/Chapters in Symposia/ Workshops/Seminars

Raviprasad T.N., Vasanthi. P and Bakthavatsalam, N. 2020. Evaluation of semio-chemicals extracted from host bark on *Plocaederus ferrugineus* L. (Coleoptera: Cerambycidae). Paper presented in *XVII AZRA International Conference on "Frontier Research in Applied Zoology and Insect Pest Management Strategies: A way Forward for Food and Nutritional Security"* during 12-14th February, 2020 at UAS, Raichur.

Vanitha K. and Raviprasad, T.N. 2020. Bee visits play a key role in pollination of cashew. *In: XVII AZRA International Conference on "Frontier Research in Applied Zoology and Insect Pest Management Strategies: A way Forward for Food and Nutritional Security"* during 12-14th February, 2020 at UAS, Raichur. [<http://krishi.icar.gov.in/jspui/handle/123456789/36192>].

Vanitha, K. 2020. Foraging behaviour of a wild bee species, *Pseudapis oxybeloides* Smith in cashew. *In: XVII AZRA International Conference on "Frontier Research in Applied Zoology and Insect Pest Management Strategies: A way Forward for Food and Nutritional Security"* during 12-14th February, 2020 at UAS, Raichur. [<http://krishi.icar.gov.in/jspui/handle/123456789/36195>].

Savadi S., Sowmya K., Megha V.S., Muralidhara B.M. and Mohana G.S. (2020). Cross species amplification of Mango EST-SSRs, and assessment of genetic diversity and inter-specific hybrid purity in cashew (*Anacardium occidentale* L.). *In:*

International e-Conference on Genetics and Plant Breeding Research in Post COVID-19 Era, Department of Genetics & Plant Breeding, Ch. Charan Singh University Campus, Meerut - 250 004 (UP), India during 13-14th June, 2020.

Vanitha, K. 2020. Record of foliage pests of cashew as pests of flowers and report of other flower pests. *In: International Web Conference on Ensuring food safety, security and sustainability through crop protection is being organized by Bihar Agricultural University from 5-6th August, 2020.*

Vanitha K. and T.N. Raviprasad. 2020. Insect pests of cashew apples, seasonality, damage and natural enemies. *In: International Web-Conference on Food Security through Sustainable Agriculture (FSSA), VAKSANA-2020* organized by Shri Vaishnav Institute of Agriculture, Indore (M.P.), India during 21-22nd September, 2020.

Eradasappa, E. Mohana, G.S., Adiga, J.D. and Siddanna Savadi. 2020. Identification of putative molecular markers associated with nut weight and kernel weight and four growth traits in cashew. *In: International e-Conference on 'Advances and Future Outlook in Biotechnology and Crop Improvement for Sustainable Productivity'* organized by the Department of Biotechnology and Crop Improvement, College of Horticulture, Bengaluru during 24-27th November, 2020.

Savadi, S., Sandesh, M.S., Muralidhara, B.M., Eradasappa, E., Shamsudheen, M., Adiga, J.D., Mohana, G.S. and Karun, A. (2020). *De-novo* assembly, annotation and phylogenetic analysis of cashew genome. *In: International e-Conference on Advances and Future Outlook in*

Biotechnology and Crop Improvement for Sustainable Productivity. University of Horticultural Sciences, Bagalkot (UHSB), College of Horticulture, Bengaluru, India. 24-27th November, 2020.

9.3. Book Chapters/ Lecture Notes

Yadav A., S. Kumar, P.S. Gujjar, D. Nayak, Bandana and P. Preethi. 2020. Innovative Techniques for Horticulture Developments: Released Fruit Varieties and Hybrids in India. (Ed: Peter, K.V.). Brillion Publishing. pp: 251-287. [<http://krishi.icar.gov.in/jspui/handle/123456789/43321>].

Rajesh U Modi, K. Manjunatha, Prem Veer Gautam, T. Nageshkumar, R. Sanodiya, V. Chaudhary, G.R.K. Murthy, I. Srinivas and Ch. Srinivasa Rao. 2020. Climate-Smart Technology Based Farm Mechanization for Enhanced Input Use Efficiency. In: Ch. Srinivasarao et al., (Eds). In: Climate Change and Indian Agriculture: Challenges and Adaptation Strategies. Published by ICAR-National Academy of Agricultural Research Management, Hyderabad, Telangana, India. Pp: 325-358.

9.4. Technical Reports / Compendia

Annual Report-DCR, 2019. ICAR-Directorate of Cashew Research, Puttur, Karnataka, India p. 102 (Eds. Savadi, S., Mangalassery, S. and Mohana, G.S). [<http://krishi.icar.gov.in/jspui/handle/123456789/42301>]

Annual Report-DCR (Hindi). 2019. ICAR-Directorate of Cashew Research, Puttur, Karnataka, India p. 100 (Eds. Savadi, S., Mangalassery, S. and Mohana, G.S). [<http://krishi.icar.gov.in/jspui/handle/123456789/43496>].

Annual report, 2019. All India Coordinated Research Project on cashew, Directorate of Cashew Research, Puttur, P. 156. [Eds. Mohana, G.S. and Nayak, M.G.]

Cashew News, 2020. ICAR-Directorate of Cashew Research, Puttur, Vol. 25 (1), p. 12 (Eds. Vanitha, K. and Mohana, G.S.).

Cashew News, 2020. ICAR-Directorate of Cashew Research, Puttur, Vol. 25 (2), p. 12 (Eds. Vanitha, K. and Mohana, G.S.).

9.5. Technical bulletins

Mangalassery, S., Nayak, M.G., Preethi, P. and Muralidhara, B.M. 2020. Soil and water conservation and irrigation management in cashew, Technical Bulletin No. 31, ICAR-Directorate of Cashew Research, Puttur, Karnataka, India, p. 34. [<http://krishi.icar.gov.in/jspui/handle/123456789/34861>].

Nayak, M.G., Muralidhara, B.M., Mangalassery, S. and Preethi, P. 2020. Gerubelayalli poshakamshakala nirvahane. Technical Bulletin No. 32, ICAR-Directorate of Cashew Research, Puttur, Karnataka, India, p. 30. [<http://krishi.icar.gov.in/jspui/handle/123456789/36897>].

Nayak, M.G., Preethi, P., Muralidhara, B.M. and Mangalassery, S. 2020. Ultra density planting in cashew. Technical Bulletin No. 33, ICAR-Directorate of Cashew Research, Puttur, Karnataka, India, p. 31. [<http://krishi.icar.gov.in/jspui/handle/123456789/43022>].

षंसुधीन मंगलशेरी, सिद्दन्न सवदी. 2020. काजू में पोषकतत्व एवं जल प्रबंधन. तकनीकी पत्रिका सं. 34. भा. कृ. अनु. प. - काजू अनुसंधान निदेशालय, पुत्तूर, कर्नाटक, भारत, पृ.54. [<http://krishi.icar.gov.in/jspui/handle/123456789/43024>].

9.6. Extension Bulletins / Pamphlets

Mangalassery, S., Nayak, M.G., Preethi, P. and Muralidhara, B.M. 2020. Soil and water conservation, and irrigation management in cashew. ICAR-Directorate of Cashew Research, Puttur, Karnataka, India, [Extension leaflet-English]. 13 March 2020. [<http://krishi.icar.gov.in/jspui/handle/123456789/36200>].

Mangalassery, S., Nayak, M.G., Preethi, P. and Muralidhara, B.M. 2020. Mobile App on “DCR – Cashew Nutrient Manager”. ICAR-Directorate of Cashew Research, Puttur, Karnataka, India, [Extension leaflet-English]. 10 July 2020. [<http://krishi.icar.gov.in/jspui/handle/123456789/38625>].

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9.7. Popular Articles

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9.8. E-Publications

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Vanitha, K. 2020. Cashew leaf miner: biology, damage and management measures. *Agriculture and food e-newsletter*. 2 (5): 353-355. [<http://krishi.icar.gov.in/jspui/handle/123456789/40614>].

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9.9. Customised instruction materials

Balasubramanian, D. 2020. Guidelines for availing incubation facilities of the Agri Business incubation (ABI) centre for ICAR-Directorate of Cashew research. Puttur - 574 202. [<https://cashew.icar.gov.in/abi-guidelines/>]

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February 2020). ICAR-Directorate of Cashew Research, Puttur, Karnataka, India, pp. 8. [<http://krishi.icar.gov.in/jspui/handle/123456789/34862>].

Sandesh, M.S., Savadi, S., Muralidhara, B.M., Mangalassery, S. and Preethi, P. 2020. Gerukrishiyalli poshakansha nirvahane mobile yapana balakeya mahithi [Customised instruction material on the use of mobile App “Cashew Nutrient Manager”] (01 February 2020). ICAR-Directorate of Cashew Research, Puttur, Karnataka, India, pp. 8. [<http://krishi.icar.gov.in/jspui/handle/123456789/43021>].

9.10. Training Manual

Eradasappa, E., Mog, B., Savadi, S. and Mangalassery, S (Eds). 2020. Training manual on cashew production and post harvest technologies. ICAR-Directorate of Cashew Research, Puttur, Karnataka, India. 132 p. [<http://krishi.icar.gov.in/jspui/handle/123456789/34854>].

10. 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.
	Identification of parasitoids of bees.
	DNA barcoding of bee species.
University of Agricultural Sciences (UAS), GKVK, Bengaluru.	Identification of insects associated with cashew, parasitoids and predators.
ICAR-Indian Agricultural Research Institute (IARI), New Delhi.	
Directorate of Cashewnut and Cocoa Development (DCCD), Cochin.	Training programmes for farmers and frontline demonstrations.
AICRP-Cashew Centres located in SAUs / ICAR institutes.	Multilocational testing, exchange of research findings/ germplasm/planting material.
ICAR-Central Plantation Crops Research Institute, Kasaragod, Kerala.	Evaluation of EPN species in cashew ecosystem. Production of Cashew based extrudates. Physiological studies in cashew.
M/s Environment, Measurement and Control, Cochin, Kerala.	Development of moisture meter for cashew in Public-Private-Partnership (PPP) mode.
Kerala State Agency for the expansion of Cashew Cultivation (KSACC), Kollam, Kerala.	For large scale distribution of planting material and area expansion in cashew.
All India Cashew Growers Association, Puttur.	Facilitated its formation and provided technical advice to the association.
ICAR-Central Institute of Agricultural Engineering (Regional centre), Coimbatore, Tamil Nadu.	Development of postharvest technology and farm machinery.
K.S. Hegde Medical Academy under NITTE, Mangaluru.	Studies on the health benefits of different cashew based value added products.
Alvas College, Mudbidri.	Research and training collaboration.
KVK, Mangaluru.	Exposure tours under SCSP activities.

11. HUMAN RESOURCE DEVELOPMENT AND CAPACITY BUILDING

Participants	Details	Date
Muralikrishna, K.,	Training on 'Repair and maintenance' organized by CIAE-Bhopal.	13-18 th January, 2020
Shamsudheen Mangalassery, Muthuraju, R.	e-office online training programme (Employee Master Data and introduction to e-office) using Microsoft Team organized by IASRI, New Delhi.	30 th April-1 st May, 2020
Eradasappa, E.	Online workshop on 'Training management information system (TMIS) for HRD Nodal Officers of ICAR'	18 th May 2020
Muthuraju, R.	e-office online training programme (e-file module) specially for Master trainers of the institutes. using Microsoft Team organized by IASRI, New Delhi.	25 th June, 2020
Manjunatha, K.	Completed Professional Attachment Training (PAT) on 'Studies on operational parameters of drone sprayer' in partial fulfilment of the requirement for the ARS (ICAR) in the Department of Farm Machinery & Power Engineering, College of Agricultural Engineering, University of Agricultural Sciences, Raichur, Karnataka.	1 st July, 2020 - 30 th September, 2020
Siddanna Savadi	Management Development Program on Implementation of Access and Benefit Sharing Regulations in Agriculture Research: Awareness cum sensitization work shop organized by ICAR-NAARM, Hyderabad.	07-10 th July, 2020
Siddanna Savadi	Online EDP for Master Trainers on Access and Benefit Sharing (ABS) Regulations in India and Nagoya Protocol (Conducted as part of the UNDP-GEF Global ABS Project) organized by ICAR-NAARM, Hyderabad.	15-17 th July, 2020
Shamsudheen Mangalassery	Online training workshop for 'Vigilance officers of ICAR Institutes' organised by ICAR-National Academy of Agricultural Research Management, Rajendranagar, Hyderabad, Telengana.	05-07 th August, 2020
Eradasappa, E. K. Vanitha, and Preethi, P.	Online training on 'Analysis of Experimental Data using R Training' organized by NAARM, Hyderabad.	5-11 th August, 2020
Balasubramanian, D.	Online 'Orientation workshop and training program for ABI Units' conducted by ICAR-NAARM, Hyderabad.	17-19 th August, 2020
Manjunatha, K.	Online course on 'Remote Sensing and Digital Image Analysis' conducted by Indian Institute of Remote Sensing (IISR), ISRO, Dehradun.	17 th August, 2020 - 11 th September, 2020
Balasubramanian, D. & Siddanna Savadi	Virtual Workshop-cum-Training on 'Intellectual Property Rights in Agricultural Research & Education in India' conducted by National Agricultural Higher Education Project (NAHEP) in association with Intellectual Property and Technology Management (IP&TM), ICAR, New Delhi.	12-28 th September, 2020

Participants	Details	Date
Scientists & technical staff of DCR	Online workshop cum training on 'Digital Field Data Book' organized by ICAR-CPCRI, Kasaragod and ICAR-IIMR, Hyderabad on 18.09.2020 (1 day).	18 th September, 2020
Shamsudheen Mangalassery	MDP on Priority setting, Monitoring and Evaluation of Agricultural Research Projects (online mode) organised by ICAR-National Academy of Agricultural Research Management, Rajendranagar, Hyderabad, Telengana.	12-17 th October, 2020
Abdulla, P.	Online training programme for Administrative and Finance Officers of ICAR conducted by ICAR-NAARM, Hyderabad.	23-27 th November, 2020
Muthuraju, R.	Generic online training in Cyber Security for Central Government Ministries/Departments organized by Ministry of Electronics and Information Technology (MeitY), Government of India.	16 th December, 2020
Balasubramanian, D.	Paid up training on 'Preparation of Detailed Project Report (DPR)' for agricultural and Food processing Industries organized by M/s. R4 Food consultants, India.	15-16 th December, 2020

12. PARTICIPATION IN SYMPOSIA/CONFERENCES/ SEMINARS/WEBINARS/MEETINGS

Participants	Details	Date
Mohana, G.S.	Made a presentation on “Trends in cashew breeding – Problems and Prospects” in Botany Department, Alvas college, Mudbidri.	24 th February, 2020
Balasubramanian, D.	Webinar on “How to set up Food Processing Industry” presented by Dr. Suvrat Kumar Singh, Professor, Department of Food Process Engineering, Sam Higginbotham University of Agriculture, conducted by ALABYAM (NIFTEM Technical Society) in association with AFST (I), NIFTEM Chapter.	23 rd March, 2020
	Webinar on “Essentials of Agripreneurship” presented by Dr Ranjit Kumar, Head, Agribusiness Management, ICAR-NAARM, Hyderabad.	27 th March, 2020
	Webinar on “Automation and Robotics for Industrial Operation (Motion Reimagined)” conducted by M/s Mr. Rajneesh Arora, Sales and Product Development, Adverb Technologies, India jointly with Mr. Subba Bangera, Chairman, Active BIZ Solutions, India.	29 th March, 2020
Preethi, P.	Webinar on “Role of dietary species in human health and wellness” organized by Association for Food Science and Technology (India) - AFSTI	12 th May, 2020
Siddanna Savadi	Webinar in the series of next generation genomics and integrated breeding for crop improvement (VII-NGGIBCI) on “Genomics for food, health and nutrition.” Organized by Center of Excellence in Genomics & Systems Biology (CEGSB), ICRISAT, Patancheru, Hyderabad	14 th May, 2020
Mohana, G.S.	Webinar organized by the Department of Botany, St. Aloysius College, Mangaluru and made presentation on “Advances in Cashew breeding”.	16 th June, 2020
Siddanna Savadi	International e-conference on “Genetics and Plant Breeding Research in Post COVID-19 Era,” Department of Genetics & Plant Breeding, Ch. Charan Singh University Campus, Meerut – 250 004 (UP), India.	13-14 th June, 2020
Manjunatha, K.	Webinar on “Challenges & Advancements in the field of Spectroradiometry” organized by Sinsil International Private Limited.	07 th July, 2020
	Webinar on “Hyperspectral imaging: Introduction & challenges in Field, Airborne application” organized by Sinsil International Private Limited and Resonon Hyperspectral imaging solutions, Bozeman, MT, USA.	15 th July, 2020
Balasubramanian, D.	Webinar on “Introduction of GC, GCMS, GCMSMS and its applications” organized by Mr. Uttam Karmakar, M/s. Thermo Fisher, India.	10 th July, 2020

Participants	Details	Date
Balasubramanian, D.	International webinar on “Impact of COVID 19 on cashew industry in India and solutions to boost the sector post pandemic” organized by ‘World Business Club’ (WBC) under the banner “Together We Stand Against COVID-19”.	28 th July, 2020
K. Vanitha	National webinar on “Future Prospects of Apiculture in India” at University of Agricultural Sciences, Bangalore organised by All India Coordinated Research Projection Honey Bees & Pollinators and Department of Apiculture, UAS, GKVK, Bengaluru, Karnataka	28 th July, 2020
K. Vanitha	Virtual Conference - Drones Application Technology in “Spraying for Crop Protection” between 1030 – 1400 Hrs. Federation of Indian Chambers of Commerce and Industry.	29 th July, 2020
Balasubramanian, D.	Webinar on “Global market encounter - Focus on Processing - Post Corona” conducted by African Cashew Alliance, Accra, Ghana.	29 July, 2020
Preethi, P.	Webinar on “Post COVID-19 Entrepreneurial Opportunities in Supply Chain of fresh Fruits and Vegetables” organized by BESST-HORT, ICAR-IIHR, Bengaluru	21 st August, 2020
Balasubramanian, D.	Online “Business Meet” conducted by ICAR-Central Plantation Crop Research Institute, Kasaragod, Kerala and presented the activities of Agri Business Incubation (ABI) and technological information of ICAR-DCR.	22 nd August, 2020
K. Vanitha	National webinar on “Plant Health Management for Sustainable Agriculture” organized by National Institute of Plant Health Management, Hyderabad.	04 th September, 2020
Muralidhara, B.M.	National webinar on “Exploration of Underutilized Fruit Crops for Health and Nutritional Security for Future Generation” organized by University of Horticultural Sciences.	10 th September, 2020
	National webinar on “Avocado (Butter fruit): An Emerging Fruit Crop” organized by HEEU, RHREC, Bengaluru.	14 th September 2020
Preethi, P.	Webinar on ‘A session on accessing Taylor and Francis journals’, organized by Taylor and Francis group.	15 th September, 2020
G.S. Mohana	Webinar organized by “Enterprise Diversification In Coconut sector –Kannada” CPCRI and gave a talk on e-market websites	18 th September, 2020
	Webinar on “ICT applications in Agriculture” organized by College of Horticulture, Mysore and participated as a resource person.	22 nd September, 2020
Preethi, P.	Webinar on “How to publish open access and succeed with your publication”, organized by Taylor and Francis group.	5 th October, 2020
G.S. Mohana	Webinar and training on “DUS data management/automation/Image analysis” organised by PPV-FRA, New Delhi.	6- 7 th October, 2020



Participants	Details	Date
Eradasappa, E.	International e-conference on “Multidisciplinary approaches for plant disease management for achieving sustainability in agriculture” organised by Department of Plant Pathology, College of Horticulture, Bengaluru (UHS, Bagalkot).	6-9 th October, 2020
Preethi, P.	Webinar on “Let food be the medicine in the era of life style diseases” organized by Dept. of Post-harvest technology, College of Horticulture, UHS, Bagalkote.	16 th October, 2020
	Online mini symposium on “Food structure and functionality – Structuring foods for sustainable world” being organized by Elsevier.	20 th October, 2020
Eradasappa, E.	International Webinar on “Genomic selection in crop plants” organized by the PlantGenomia.	24 th October, 2020
Manjunatha, K.	Webinar on “Krishi Gyan Sindhu” organized by South Asia, EBSCO and Europe and Asia, CABl.	24 th November, 2020
Eradasappa, E., Muralidhara, B.M., Thondaiman, V., and Veena, G.L.	International e-conference on “Advances and Future Outlook in Biotechnology and Crop Improvement for Sustainable Productivity” organized by the Department of Biotechnology and Crop Improvement, College of Horticulture, Bengaluru.	24-27 th November, 2020
K. Vanitha	Virtual workshop on “Gender Sensitization” to Celebrate Seventh Anniversary of Notification of Act - The Sexual Harassment of Women at Workplace (Prevention, Prohibition and Redressal) Act, 2013 organized by ICAR.	15 th December, 2020
Rajkumar, A.D.	National workshop on “Web-based Plagiarism Detection Software” - URKUND organized in association with Institution’s Innovation Council-MITADT University, Pune under the aegis of ShodhShuddhi initiative of MHRD, Govt. of India and supported by INFLIBNET & eGalactic.	15 th December, 2020
K. Vanitha & P. Preethi	Sixth National conference on “Agricultural scientific Tamil” organized by Agricultural scientific Tamil society, New Delhi at International Institute of Tamil Studies (MS Swaminathan Research Foundation Campus), Taramani, Chennai.	21 st -22 nd December, 2020
Muralidhara, B.M.	International web conference on “Global Research Initiatives for Sustainable Agriculture and Allied Sciences” organized by the GRISAAS-2020.	28-30 th December, 2020
Scientists of ICAR-DCR.	AGM of AICRP on cashew conducted on virtual mode	18-19 th December, 2020

13. 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. ^a
2.	1.1.2. Screening of cashew germplasm for apple and nut characters [03/2016-03/2024]	Mohana, G.S.	D. Balasubramanian Preethi, P. ^b Veena, G.L. (since 12.10.2020) Muralidhara, B.M. ^a
3.	1.1.3. Evaluation of big cashew apple genotypes for apple yield and quality [10/2013-06/2021]	Preethi, P. ^c (till 10.8.2020) Eradasappa, E. (since 10.8.2020)	Eradasappa, E. (till 10.8.2020) K. Vanitha Veena, G.L.
1.2. Genetic improvement of cashew			
4.	1.2.1 Genetic improvement of cashew for yield and quality traits [1986 -Long Term]	J.D. Adiga	Mohana, G.S. M.G. Nayak Eradasappa, E. Siddanna Savadi Veena, G.L. Muralidhara, B.M. ^a
5.	Seedling selection in cashew-2 (as new experiment under 1.2.1) “Evaluation of half-sibs of HYVs” [10/2020-09/2030]	Eradasappa, E.	Mohana, G.S.
6.	1.2.2 Development of dwarf and compact cashew hybrids [06/2012-05/2027]	Eradasappa, E.	Mohana, G.S. J.D. Adiga
7.	1.2.3 Breeding for improvement of nut size in cluster bearing genotypes [06/2018 – 05/2024]	Eradasappa, E.	Mohana, G.S. M.G. Nayak
8.	1.2.4 Breeding approaches for developing TMB tolerance [09/2017-08/2030]	Mohana, G.S.	Eradasappa, E. K. Vanitha
9.	1.2.5 <i>De novo</i> genome assembly, linkage analysis and population structure studies in cashew (<i>Anacardium occidentale</i> L.) [09/2017 – 08/2020]	Siddanna Savadi	Mohana, G.S. J.D. Adiga

Sl. No.	Project	PI	Co-PIs
10.	1.2.6 Genetic dissection of QTLs governing nut yield and cashew nut shell liquid (CNSL) content in cashew [06/2018-05/2025]	Siddanna Savadi	Eradasappa, E., Mohana, G.S.
11.	1.2.7 Generation mean analysis in cashew to understand the nature of gene action for important traits [05/2019 - 04/2025]	Eradasappa, E.	Mohana, G.S.
12.	1.2.8 Breeding for reduced tannin content in cashew apples of hybrids of popular cultivars [05/2019 - 04/2025]	Eradasappa, E.	Mohana, G.S. J.D. Adiga Preethi, P. ^b (till 10.8.2020) Veena, G.L.
13.	1.2.9. Development and evaluation of polyclonal hybrids from core collection in cashew [10/2020-09/2030]	Mohana, G.S.	Eradasappa, E.
14.	1.2.10. Polyploidy breeding in cashew [10/2020-09/2030]	Mohana, G.S.	Eradasappa, E.
15.	<i>Externally Funded Project:</i> Development of morphological descriptors and DUS test guidelines for cashew Funded by: Protection of Plant Varieties and Farmers' Rights Authority (PPV&FRA), New Delhi Budget: Rs. 10 Lakhs [04/2015-03/2021]	M.G. Nayak	Mohana, G.S.
16.	Establishment of a Centre of Excellence for Biotechnology Needed for Genomics Assisted Breeding in Cashew Funded by: RKVY-RAFTAAR, Government of Karnataka Budget: Rs. 75 lakhs [04/2020 to 03/2021]	Siddanna Savadi	Mohana, G.S.
Crop Management			
17.	2.1.1 Studies on pruning and phenology in cashew [09/2017-08/2021]	J.D. Adiga	Preethi, P. ^b (till 30.12.2020) Siddanna Savadi Thondaiman, V. (since 12.10.2020) *Muralidhara, B.M. ^a
18.	2.1.3 Optimisation of mineral nutrition to cashew under high density planting [06/2018 - 05/2021]	Shamsudheen Mangalassery	M.G. Nayak Preethi, P. ^b (till 28.6.2020) Babli Mog

Sl. No.	Project	PI	Co-PIs
19.	2.1.4 Characterization of physiological responses of cashew (<i>A. occidentale</i> L.) accessions to salt and drought stresses [10/2015-09/2020]	Babli Mog	Thondaiman, V. (since 12.10.2020) Veena, G.L. (since 12.10.2020)
20.	2.1.6 <i>In-vitro</i> pollen germination and pollen tube growth of cashew varieties in response to high temperature stress [05/2019-04/2021]	Babli Mog	Shamsudheen Mangalassery Eradasappa, E. K.B. Hebbar Veena, G.L.
21.	2.1.7. Development of nutrient management schedules for cashew based on leaf nutrient status [10/2020-09/2023]	Shamsudheen Mangalassery	Thondaiman, V.
22.	2.1.8. Carbon cycling, sequestration and nutrient dynamics in cashew orchards	Shamsudheen Mangalassery	Babli Mog & Manjunatha, K.
23.	2.1.9. Development of cashew (<i>Anacardium occidentale</i> L.) based cropping system under rainfed condition of Karnataka [10/2020-09/2023]	Thondaiman, V.	J.D. Adiga Shamsudheen Mangalassery K. Vanitha Babli Mog
24.	2.1.10. Effect of growth regulator in combination with flower and fruit-set enhancing chemicals on cashew (<i>Anacardium occidentale</i> L.). [10/2020-09/2022]	Thondaiman, V.	J.D. Adiga K. Vanitha Veena, G.L. Babli Mog
Crop Protection			
3.1. Management of Insect Pests of Cashew			
25.	3.1.2 Investigations on inflorescence insect pests of cashew and their management [10/2016-09/2021]	K. Vanitha	T.N. Raviprasad
26.	3.1.5 Cashew tea mosquito bug interactions and the defensive responses [05/2019-04/2023]	K. Vanitha	T.N. Raviprasad Preethi, P. ^b Thondaiman, V. (Since 12.10.2020) Shamsudheen Mangalassery (Since 12.10.2020)
27.	3.1.6. Characterization and synthesis of female sex pheromone of tea mosquito bug (<i>Helopeltis antonii</i>) and its bioassay [10/2020-09/2025]	T.N. Raviprasad	K. Vanitha Bakthavatsalam, N. (ICAR-NBAIR)

Sl. No.	Project	PI	Co-PIs
3.2 Arthropod Bio-diversity and Pollinator Activity in Cashew			
28.	3.2.3 Influence of <i>Apis cerana indica</i> and <i>Braunsapis</i> spp. on pollination and fruit set of cashew [05/2019-04/2023]	K. Vanitha	Veena, G.L (Since 12.10.2020)
Post Harvest Technology			
4.1 Improving performance of cashewnut processing			
29.	4.1.2 Design and development of moisture meter for raw cashewnuts [07/2018-06/2020]	D. Balasubramanian	Sreejith (M/s EMCON, Kerala)
30.	4.1.3 Studying comparative performance of cashewnut processing systems in India [10/2017-09/2021]	D. Balasubramanian	-
31.	4.1.4. Optimizing processing parameters in cashew for enhancing whole kernel recovery [10/2020-09/2021]	D. Balasubramanian	
32.	4.1.5. Design, development and performance evaluation of cashew fruit and nut separator [10/2020-09/2024]	Manjunatha, K.	D. Balasubramanian Ravindra Naik (ICAR-CIAE, Coimbatore)
33.	4.1.6. Design and development of gadgets for cashew fruit harvesting and collection. [10/2020-09/2024]	Manjunatha, K.	D. Balasubramanian Ravindra Naik (ICAR-CIAE, Coimbatore)
4.2 By-product utilization and product diversification			
34.	4.2.1 Design and development of mechanized slicer for cashew apple [10/2014-06/2022]	D. Balasubramanian	Ravindra Naik (ICAR-CIAE, Coimbatore)
35.	4.2.3 Development of dehydrated products from cashew apple and sprouts [06/2018-05/2021]	Preethi, P. (till 10.8.2020) Shamsudheen Mangalassery (Since 10.8.2020)	Shamsudheen Mangalassery (till 10.8.2020)
Transfer of Technology			
36.	<i>Externally Funded Project:</i> Development of an exclusive android application for cashew cultivation Funding: Directorate of Cashewnut and Cocoa Development (DCCD), Cochin Budget: Rs. 5.0 Lakhs [09/2017-09/2021]	Mohana, G.S.	M.G. Nayak

Sl. No.	Project	PI	Co-PIs
37.	<i>Externally Funded Project:</i> Farmer participatory soil and plant health management – An attempt for improving the livelihood of cashew farmers of coastal Karnataka Funded by: RKVY-RAFTAAR, Government of Karnataka. Budget: Rs. 1.89 Crores [04/2018-03/2021]	Shamsudheen Mangalassery	M.G. Nayak J.D. Adiga Preethi, P. ^b (till 30.12.2020) Muralidhara, B.M. ^a
38.	Utilization of cashew apple for new products and entrepreneurship development of rural women and youth in Karnataka for mitigating the effect of COVID-19. Funded by: RKVY-RAFTAAR, Government of Karnataka Budget: Rs. 57.0 lakhs [04/2020-03/2021]	Preethi, P. ^b (till 10.08.2020) Shamsudheen Mangalassery (since 10.08.2020)	M.G. Nayak Manjunatha, K. (since 21.11.2020) Veena, G.L. (since 21.11.2020)
39.	Improving area, production and productivity of cashew in Shivamogga and Chitradurga districts in Karnataka Funded by: RKVY-RAFTAAR, Government of Karnataka Budget: Rs. 36 lakhs [04/2020-03/2021]	Mohana, G.S.	M.G. Nayak Eradasappa, E.
40.	Development of an AI-based app for identification of pests and diseases in cashew Funded by: RKVY-RAFTAAR, Government of Karnataka Budget: Rs. 16 lakhs [04/2020-03/2021]	Mohana, G.S.	K. Vanitha Shamsudheen Mangalassery

^aOn study leave, ^b- transferred to IIHR, Bengaluru.

Concluded projects

Three projects were concluded during October 2020.

1.	3.1.1 Investigations on semiochemicals for management of TMB and CSRB [10/2014-10/2020]	T.N. Raviprasad	K. Vanitha Bakthavatsalam, N. (ICAR-NBAIR) Gajbhiye, N. (ICAR-DMAPR)
2.	3.1.3 Evaluation of alternative insecticides/ products for the management of tea mosquito bug (TMB) and cashew stem and root borers (CSRB) [10/2016-10/2020]	T.N. Raviprasad	K. Vanitha
3.	3.1.4 Standardization of IPM involving EPN and <i>Metarhizium anisopliae</i> for management of CSRB [09/2017-10/2021]	T.N. Raviprasad	Rajkumar, (ICAR-CPCRI)

14. PATENTS, COMMERCIALISATION OF TECHNOLOGY, CONSULTANCY, ADVISORY VISITS AND TALKS DELIVERED

14.1. Technology meet: Showcasing of cashew hybrid, H-130 to the nursery owners

ICAR-Directorate of Cashew Research, Puttur organized a technology meet on 25th February, 2020 for commercialization of cashew hybrid: H-130. Nursery owners from Tamil Nadu, Maharashtra, Karnataka states and officials of Karnataka Cashew Development Corporation (KCDC), Mangaluru attended technology meet. Varietal characters and field performance of H-130, its advantages over other varieties and details about licensing of this technology to the nursery owners were discussed.



Technology meet in progress

14.2. Commercialization of ICAR-DCR technologies by ITMU

ICAR-DCR commercialized three technologies in the year 2020.

- M/s. Tamim Foods, Goa signed Memorandum of Understanding (MoU) for non-exclusive licensing of 'Cashlime'- a ready to serve beverage technology on 28th February, 2020.
- Annai Velankanni Nursery, Vridhachalam, Tamil Nadu signed MoU for non-exclusive licensing of 'H-130: Cashew hybrid' technology on 15th July, 2020.

- Rotating drum roasting machine technology was licensed to M/s. Abhay Engineers, Mangaluru on Non-exclusive licensing basis on 13th October, 2020.



Signing of MoU with M/s. Tamim Foods, Goa



Signing of MoU with M/s. Abhay Engineers, Mangaluru

14.3. Patent/Plant Variety registration

ITMU, ICAR-DCR and PME Cell facilitated the following patent and plant variety registration processes.

- ICAR-DCR filed application for registration of 'H-130: cashew hybrid' with PPV&FRA, New Delhi under PPV&FR Act 2001 on 2nd June 2020.
- A hearing of patent filed by ICAR-DCR on 'Rotating drum roasting machine for raw cashewnut' is being called on 27th January, 2021 by The Indian Patent Office, Chennai.

14.4. Advisory visits / Consultancies/ Talks delivered

Scientist	Details	Date
Shamsudheen Mangalassery	On-site evaluation of innovative cashewnut propagation technique at Kannur, Kerala on the request of National Innovation Foundation (NIF), India, Dept. of Science and Technology, Govt. of India.	20 th February, 2020
M.G. Nayak	Delivered a talk in cashew varieties and improved cashew cultivation practices on virtual platform to the Maha Caju Growers Association.	18 th August, 2020
M.G. Nayak	Participated in 188 th Board meeting of KCDC LTD, Mangaluru on virtual platform.	12 th August, 2020
M.G. Nayak	Participated in 189 th Board meeting of KCDC LTD, Mangaluru on virtual platform.	20 th November, 2020
M.G. Nayak	Participated in 42 nd Annual General Meeting of the share holders of KCDC Ltd, Mangaluru in virtual platform.	
M.G. Nayak	Delivered a talk on 'Establishment and management of cashew orchards' on virtual platform to Agricultural Information. com (publisher of Agriculture and Industry Survey Magazine).	24 th December, 2020

14.5. Activities taken up during COVID-19 crisis

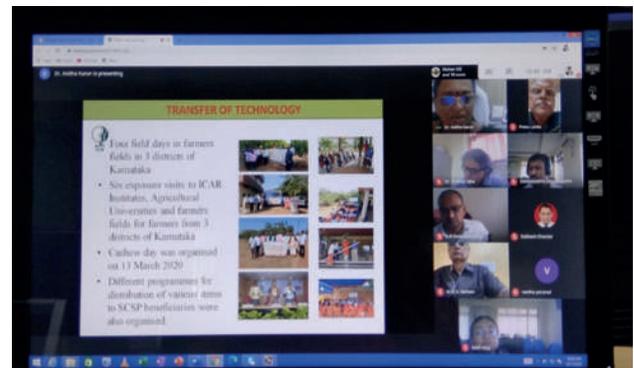
- COVID-19 advisories were provided in the website of the institute and social media for May, June and July, 2020.
- The Directorate has taken up distribution of food kits for the few needy local people and tender coconuts to the traffic police personals on duty.

15. RAC /IRC/ IMC/ IJSC MEETINGS

15.1. Research Advisory Committee (RAC)

The third meeting of 8th RAC was held on 11th September, 2020 on virtual platform with the welcome address by Dr. Anitha Karun, Director (Acting), ICAR-DCR, Puttur. She presented the research highlights of ICAR-DCR for the year 2019-20 including administrative aspects. Dr. D.S. Rathore, Chairman, RAC in his introductory remarks emphasized about improving the profitability of stakeholders through input use efficiency. Members of RAC suggested on the need to develop good agricultural practices for cashew, adoption of technologies in use for mango viz., rock planting, soil management models, conservation horticulture for cashew, IPM modules for cashew pest management, influence of climate change, developing specialized strategy for cashew extension etc. Dr. S.N. Ojha remarked that All India Cashew Extension Network can be established by DCR and cashew map for extension

can be prepared. Dr. B.K. Pandey, ADG (Hort.) mentioned that KVKs should be utilized for village development. Thereafter, action taken report on the previous RAC was presented by Dr. J. Dinakara Adiga, Member Secretary (RAC). Subsequently, presentations on progress of research were made by the scientists of DCR including new project proposals. Based on the presentations and discussions, the RAC made recommendations and suggestions.



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-Central Institute of Fisheries Education (CIFE), Mumbai	Member
7.	Dr. M. Gangadhara Nayak, Director (Acting), ICAR-DCR, Puttur [Dr. Anitha Karun, Director (Acting), ICAR-DCR, Puttur since 17.08.2020]	Member
8.	Dr. W.S. Dhillon, ADG (HS-I), ICAR, KAB-II, Pusa, New Delhi. [Dr. B.K. Pandey, ADG (HS-II), ICAR, New Delhi]	Member
9.	Dr. J.D. Adiga, Principal Scientist (Horticulture), ICAR-Directorate of Cashew Research, Puttur	Member Secretary

15.2. Institute Research Council (IRC)

The 33rd annual meeting of IRC of ICAR-DCR, Puttur was held during 12-13th October, 2020 under the Chairmanship of Dr. Anitha Karun, Director (Acting). There were five technical sessions chaired by experts of the field: Dr. M. Sankaran, Principal Scientist (Fruit Science), Division of Fruit Crops, ICAR-IIHR, Bengaluru for Crop Improvement, Dr. H.P. Maheshwarappa, Project Co-ordinator (Palms), ICAR-CPCRI, Kasaragod for Crop Management, Dr. A.N. Shylesha, Principal Scientist (Entomology), Division of Germplasm Conservation and Utilization, ICAR-NBAIR, Bengaluru for crop protection, Dr. V. Palanimuthu, Professor, Research Engineer and University Head (Ag. Engg.), AICRP (PHET), UAS, GKVK, Bengaluru for post harvest technology and Dr. Anithakumari, P., Principal Scientist (Ag. Extension), ICAR-CPCRI (RS), Kayamkulam



and Dr. Chandran, K.P., Principal Scientist (Ag. Statistics), Division of Social Sciences, ICAR - CPCRI, Kasaragod for transfer of technology sessions. In each session, results of various ongoing projects were presented along with new project proposals by the scientists of DCR and the technical programme for 2020-21 was finalized.

15.3. ITMC meetings

In the current year, 15th and 16th Institute Technology Management Committee (ITMC) meetings were held on 29th January, 2020 and 21st September, 2020, respectively, under the Chairmanship of Director (Acting), ICAR-DCR. A total of seven technologies viz. Cashew apple RTS juice, Cashew apple jam, Cashew apple jelly, Cashew apple cider, Cashew apple crisp, Cashewnut sprout products and Cashew hybrid, H-130 were recognized for commercialization.



15.4. Institute Management Committee (IMC)

The composition of present IMC is as follows:

Name and Address	Status
Director (Acting), ICAR-DCR, Puttur - 574 202, Karnataka.	Chairperson
The Joint Director of Horticulture, Directorate of Horticulture, Govt. of Karnataka, Lalbagh, Bangalore 560 004	Member
The Special Officer (Cashew), Aravind Chambers, Mundakkal West, Near DCC Office, Kollam - 691 001, Kerala	Member
Dr. S. U. Patil, Associate Director of Research, ZARS, Brihmavara (UAHS Simogga), Udupi District-576213, Karnataka.	Member

Name and Address	Status
Sri Kadamajalu Subhash Rai, Kedambady, Village & Post Thigaladi, Puttur Taluk, DK District, Karnataka	Member
Sri Udaya Kumar M, S/o Vasudeva Acharya, 'Kaveri Prasad' House, Peraje, Mandekolu Post & Village, D.K. District Sullia Taluk 574239, Karnataka	Member
Dr. Ishwara Bhat, Principal Scientist, ICAR-Indian Institute of Spices Research, Marikunnu, P.O., Kozhikode- 673012 Kerala	Member
Dr. M.K. Rajesh, Principal Scientist, ICAR-Central Plantation Crops Research Institute, Kasaragodu - 671124, Kerala	Member
Dr. D.V. Sudhakar Rao, Principal Scientist, ICAR- Indian Institute of Horticultural Research, Hesaraghatta lake post, Bangalore- 560089, Karnataka	Member
Dr. M. N. Sheela, Head, Crop improvement ICAR- Central Tuber Crops Research Institute, Sreekariyam P.O, Thiruvananthapuram- 695017, Kerala	Member
Dr. B. K. Pandey, Asstt. Director General (Hort-II), Indian Council of Agricultural Research, Krishi Anusandhan Bhavan -II, Pusa Campus, New Delhi - 110012	Member
Senior Finance & Accounts Officer, ICAR- Central Plantation Crops Research Institute, Kasaragod - 671124, Kerala State	Member
The Administrative Officer, ICAR- DCR, Puttur-574202	Member Secretary

15.5. Institute Joint Staff Council (IJSC)

The newly constituted IJSC includes

Name	Status
Director	Chairperson, IJSC
Dr. Mohana G.S., Principal Scientist	Member (Official side)
Dr. K. Vanitha, Scientist	Member (Official side)
Sri. Muralikrishna K, Chief Technical Officer	Member (Official side)
Administrative Officer	Member (Official side)
Asst. Finance & Accounts Officer	Secretary (Official side)
Asst. Administrative Officer	Member (Staff side)
Smt. Reshma K, PA	Member (Staff side)
Ms. Winnie Lobo, Asst.	Member (CJSC)
Sri Bojappa Gowda. Technical Officer	Member (Staff side)
Sri. Honnappa Naik P, Sr. Technician	Member (Staff side)
Sri. Vijaya Achary, Skilled Support Staff	Member (Staff side)
Sri T. Padmanabha, Skilled Support Staff	Member (Staff side)

••••• 16. PROGRAMMES, WORKSHOPS, SEMINARS, TRAINING, ••••• FARMERS DAYS AND OTHER EVENTS ORGANISED

16.1. Programmes organized

Celebration of Constitution Day – Activities

As per the directives of ICAR, New Delhi, ICAR -DCR, Puttur has taken up different activities to honour the 70th year of the adoption of Constitution of India from 26th November, 2019 to 26th November, 2020. Initially, the brochures, standees and banners of Constitution Day were uploaded in ICAR-DCR website along with the reports. During the period of report, reading of preamble, singing competition on patriotic songs, essay writing competition, quiz competition, signing of banner pledge board, a meeting with the youth club, Shantigodu, talk on 'Indian constitution and Fundamental Duties', talk on 'Land Legislations and Reforms' were arranged. On 13th March 2020, a meeting

was convened with farmers, for which Dr. R. Selvamani, IAS, Chief Executive Officer (CEO), Dakshina Kannada Zilla Panchayat was the chief guest. The CEO explained the fundamental duties of Indian citizens and emphasized on Article 3 of the Constitution. A total of 177 participants including farmers, President and members of All India Cashew Growers Association (AICGA), staff of DCR and general public were present during the programme. According to the directives of the Council, the staff of ICAR-DCR have joined with the Hon'ble President of India for reading of 'Preamble of Indian Constitution' in the main conference hall at 11.00 am of 26th November, 2020 through DD News. The winners of different competitions were awarded subsequently.



**Dr. R. Selvamani, CEO, DK Zilla Panchayat
addressing the gathering**



Signing the banner pledge board

Cashew Day

The 'Cashew day' was celebrated on 13th March, 2020 at ICAR-DCR, Puttur with the theme of "Empowerment of Scheduled Caste Community through SCSP programmes". Mrs. Sindhu Rupesh, IAS, Deputy Commissioner, Dakshina Kannada District was the chief guest of the programme. Dr. Yathish Ullal, Assistant Commissioner, Puttur Division and Sri. T. Ramesh Babu, Tahsildar,

Puttur were also present on the occasion. The Deputy Commissioner distributed agricultural implements to the selected farmers of Scheduled Castes. She said that DK district is known for cashew and farmers can earn good income by following modern practices. She expressed her appreciation for the benefits given to Scheduled Caste community under the Government Scheme.

Many farmers and the office bearers of All India Cashew Growers Association (AICGA), DCR staff, family members and public participated in the programme. Four publications related to cashew crop management, intercropping and fruit processing were released during the occasion. A total of 110 farmers participated besides nursery men, representatives of KVK, development departments, NGOs and scientists.

ICAR-DCR Foundation day and SCSP farmers' meet



ICAR-DCR, Puttur celebrated its 35th Foundation day on 18th June, 2020 along with SCSP (Schedule Caste Sub Plan) farmers meet. The function was inaugurated by the Chief Guest Sri. Chaniya Kalthadka, President, Sullia taluk panchayat. Agricultural implements were distributed to the selected farmers from Puttur, Belthangady, Sullia and Kadaba taluks. The Guest of Honour, Sri. Radhakrishna Borker, President, Puttur Taluk Panchayat spoke on the occasion and requested the farmers to make proper use of the facilities given by the government to make a self-reliant living. Sri. Saja Radhakrishna Alva, President, Committee for Social Justice, Puttur Panchayat and Sri. Boodyiar Radhakrishna Rai, former president of APMC, Puttur were also present during the occasion. Three extension folders and the Annual Report-2019 of the Directorate were released on the occasion.

Precautionary measures for COVID-19 were strictly followed during the programme according to the guidelines.

Vigilance Awareness Week

ICAR-DCR, Puttur celebrated the Vigilance Awareness Week from 27th October, 2020 to 2nd November, 2020. On 27th October, 2020, integrity pledge was taken by the staff. Posters on the theme "Satark Bharat, Samriddh Bharat" (Vigilant India, Prosperous India) were displayed and a special webpage on vigilance related activities was created to sensitise the people. The valedictory function was held at the main conference hall of the Directorate on 02nd November, 2020, observing the COVID protocol. Dr. Shamsudheen Mangalassery, Senior Scientist & Vigilance Officer, ICAR-DCR, Puttur welcomed the gathering. The programme was inaugurated by Shri. Manjunatha, Hon'ble Principal Senior Civil Judge & ACJM and Chairman, Taluk Legal Services Committee, Puttur. He stressed the need to be vigilant to make India prosperous. Sri. Manohar, K.V, President, Bar Association, Puttur emphasised that DCR should be a role model organisation in terms of transparency. The resource person, Adv. Mahesh Kaje, Puttur, delivered a special talk on the theme in which, he mentioned that one has to inculcate self-satisfaction, self-determination and self-consciousness. The programme was presided over by Dr. Anitha Karun, Director (Acting) of the Directorate. She highlighted that various



initiatives by the Govt. of India especially digital means are helping to bring more transparency in official dealings. During the occasion, Shri. Suresh Rai, Vice President and Shri. Manjunatha, N.S, Secretary, Bar Association, Puttur were also present. Shri. T.E. Janardhanan, Administrative Officer, ICAR-DCR, Puttur proposed vote of thanks. The programme was organised jointly by ICAR-DCR, Puttur, Legal Cell, Puttur and Bar Association, Puttur. The programme was attended by 44 members.

Swachhta Pakhwada

ICAR-DCR, Puttur has observed “Swachhta Pakhwada” from 16th-31st December, 2020 by conducting various day-wise activities as per the guidelines of the Council following COVID-19 protocol. The Swachh Bharat Committee of ICAR-DCR has planned the day-wise activities and action plan leaders were assigned. On 16th December, 2020, Swachhta pledge was administered to all the staff of ICAR-DCR by Dr. J.D. Adiga (Nodal Officer, Swachh Bharat, ICAR-DCR, Puttur). The different activities taken up include training on e-office implementation, sanitization and cleaning (of institute premises, women cell, residential area, play ground, children’s park and residential park), quiz, debate competition, organization of Kisan Diwas, talk on ‘Recycling of waste water and water harvesting structures of agriculture/ horticulture’ and address by VIP



on ‘Waste Management’. Prizes and certificates were distributed to the winners of different competitions on the valedictory day.

Kisan Diwas

On 23rd December, 2020, “Kisan Diwas” was organized at ICAR-DCR following COVID guidelines. The event started with ICAR song as well as Kisan song of the State of Karnataka. This was followed by welcome address from Dr. Eradasappa, Scientist (Plant Breeding). The programme was chaired by Dr. T.N. Raviprasad, Principal Scientist (Ag. Entomology) and Dr. J. D. Adiga, Principal Scientist (Hort.) & Nodal Officer (Swachha Bharat). Mr. Manikandan, Sr. Technical Officer of ICAR-DCR delivered a speech on ‘Eco-friendly operation of pesticide application in the field and precautions to be taken before the spray’. Dr. T.N. Raviprasad emphasized on farmers role in the economy of the country. Dr. J.D. Adiga stated about the importance of



reducing plastic in farming and in day-to-day life and emphasized on farm machineries. Farm implements like pruning knife, secateurs, cow mat and grafts of cashew and coconut saplings were distributed to the farmers. Mr. Raghuram Kukkude, STO delivered vote of thanks. A total of 30 farmers from Dakshina Kannada district participated in the event.

16.2. Training/Workshop

Training Programme on “Cashew production and Post Harvest Technologies

The ICAR-DCR, Puttur organised a training programme on “Cashew production and Post Harvest Technologies” during 10-14th February, 2020 for the farmers and officials from the state of Meghalaya, sponsored by the Meghalaya Basin Management Agency. Dr. M.G. Nayak, Director (Acting) inaugurated the programme and spoke about the immense scope of cashew cultivation in Meghalaya with respect to the climate and land availability. He stressed on finding suitable varieties of cashew for the Meghalaya region and utilization of cashew apples for the preparation of value added products and beverages. Mr. Saurabh Bose, Senior Manager, Megha-LAMP Project, Meghalaya explained the activities of Meghalaya Livelihoods Access to Market Project funded by International Fund for Agricultural Development and Govt. of Meghalaya, being implemented by the Meghalaya Basin



Management Agency (MBMA). Mr. Zacharius Marak, District Programme Manager, MBMA highlighted the lack of scientific ways of managing cashew plantations in Meghalaya. The training programme consisted of lectures, demonstrations, field and laboratory visits, visit to progressive farmers and processing industries. The programme was attended by 20 farmers and officials from Meghalaya.

Training on Cashew apple processing

The ICAR-DCR, Puttur organized a training programme on “Recent cashew cultivation practices and homestead valorization of cashew apple in the hill zone of Karnataka” from 6 to 7th March, 2020 at Neechadi village, Sagar Taluk, Shivamogga. The training programme was organized with funding support from Directorate of Cashewnut and Cocoa Development (DCCD), Cochin.

Mr. Chandrasekhar, President, Cashew Growers Association, Tumari, Shivamogga inaugurated the programme and spoke about the importance of cashew in livelihood security of people in the hill zone of Karnataka. Dr. M.G. Nayak, Director (Acting) highlighted the importance of ultra density planting and the need to use specific pruning responsive varieties to increase the yield and productivity of cashew in the country. He stressed the need for proper utilization of cashew apples for improving the farm income and for employment generation. The



training programme consisted of lectures, field visits and hands on training on value addition and post harvest handling of cashew apple. A total of 125 farmers from the Sagar taluk of Shivamogga district in Karnataka participated in the training.

In-house training on usage of Krishi portal

An in-house training on 'Usage of Krishi portal' was held at Audio-Visual Lab, ICAR-DCR, Puttur on 25th January, 2020 for the DCR scientists and technical staff. Sequential steps involved in uploading the publications in krishi portal website were demonstrated.

Online training on cashew nut processing

An online program was organized to provide consultancy cum training for Tribal

Women operating cashewnut processing unit in Jagadapur, under Chhattisgarh Forest Minor Produce Federation Cooperative Unit (CFMPFCU) from 9-15th July, 2020 which was inaugurated by DDG (Hort.), ICAR, New Delhi.



17. राजभाषा कार्यान्वयन एवं प्रगति

राजभाषा कार्यान्वयन समिति

1. डा. एम.जी. नायक (अगस्त 2020 तक) डा. अनिता करुण (अगस्त 2020 से)	अध्यक्ष
2. डा. षंसुधीन एम	सदस्य
3. डा. इ. ईरदासप्पा	सदस्य
4. श्री. पी. अब्दुल्ला	सदस्य
5. श्रीमती. एम. रत्न रंजिनि	सदस्य
6. श्रीमती. लीला एम.	सदस्य
7. श्री. रघुराम कुकडे (22.6.2020 तक) श्रीमती. रेष्मा के (23.6.2020 से)	सदस्य
8. श्री. उमाशंकर सदस्य (22.6.2020 तक) श्री. विजय आचारी (23.6.2020 से)	सदस्य
9. श्री. प्रकाश जी. भट्ट	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 को 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 जागरूकता पैदा कराने हेतु राजभाषा विभाग की ओर से जारी किए गए वार्षिक कार्यक्रम के अनुसार हर साल इस निदेशालय में सितंबर में हिंदी सप्ताह समारोह आयोजन किया जाता है। इस अवसर पर कर्मचारियों के लिए विभिन्न प्रतियोगिताओं जैसे हिंदी निबंध लेखन, प्रारूप, टिप्पण एवं मसौदा लेखन प्रतियोगिता, क्विज प्रतियोगिता आदी आयोजित की जाती है।

इस वर्ष कोविड19- महामारी के कारण राजभाषा हिंदी के गतिविधियों पर भी असर पड़ा। सामान्य रूप से जिन बैठक और कार्यक्रम आयोजन की जानी थी उसे रोकना पड़ा और हिंदी सप्ताह को भी बहुत सरल रूप में आयोजन किया गया। हिंदी सप्ताह के मौके पर स्कूल विद्यार्थियों को आनलाईन हिंदी प्रतियोगिता आयोजन किया गया था। दिनांक 29.12.2020 को हिंदी सप्ताह का समापन समारंभ को गूगल मीट द्वारा आयोजन किया गया। डा. अनिता करुण, प्रभार निदेशक, डी.सी.आर. पुत्तूर, समारंभ के मुख्य अतिथी थे। विद्यार्थियों के लिए घोषित पुरस्कारों को उनके विद्यालय में मुख्य अध्यापकों को हस्तांतरित किया गया, ताकी उन्हें सही समय पर उसे विद्यार्थियों को दे सके।

राजभाषा नियम 1976 नियम 11 के अनुपालन हेतु आवश्यक सामग्रियों जैसे प्रपत्र, रबड़ की मोहरें, नाम पट्ट आवश्यकतानुसार द्विभाषी में तैयार कर समय समय पर मार्गनिर्देश दिया जाता है। सम्मेलनों का बैनर एवं निमंत्रण पत्र द्विभाषा में ही प्रदर्शित किया जाता है। हिंदी पत्रों की आवृत्ति 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 जनेवरी में 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 कार्यालयों में राजभाषा हिन्दी का कार्यान्वयन सुनिश्चित करने की दृष्टि से पुत्तूर और विट्टूल में स्थित केंद्रीय सरकार के कार्यालय, उपक्रम, बैंक सहित 15 सदस्य कार्यालय सम्मिलित नगर राजभाषा कार्यान्वयन समिति (नराकास) का घटन किया गया है। पुत्तूर नराकास की 37वीं अर्धवार्षिक बैठक दिनांक 29.1.2020 को निदेशक महोदय की अध्यक्षता में आयोजित की गई। बैठक में सदस्य कार्यालयों से राजभाषा कार्यान्वयन से संबंधित अर्धवार्षिक प्रगति रिपोर्ट की समीक्षा की गई। काजू अनुसंधान



निदेशालय की ओर से आयोजित हिंदी कार्यशाला और प्रशिक्षण में नराकास के सदस्य कार्यालयों को भी आमंत्रित किया गया और संयुक्त रूप से आयोजन किया गया।

निदेशालय में निम्न लिखित रिपोर्ट हिंदी में प्रकाशित किया गया:

1. निदेशालय का वार्षिक प्रतिवेदन (वर्ष 2020) पूर्ण रूप से हिंदी में।
2. अखिल भारतीय समन्वित काजू अनुसंधान परियोजना की वार्षिक प्रतिवेदन सारांश (वर्ष 2020)
3. अर्ध वार्षिक, पत्रिका 'काजू समाचार' में हिंदी समिती की गतिविधियों के बारे में प्रतिवेदन।
4. दैनंदिन प्रयोग में आने वाले प्रपत्रों का हिंदी रूपान्तरण।

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



••••• 18. DISTINGUISHED VISITORS •••••

Name	Address	Date of visit
Dr. M. Dattathreya Rao	Former Head, Department of Sociology, St. Philomena College, Puttur, Karnataka.	31 st January, 2020
Sri. Rajesh	Headmaster, Priyadharshini English Medium School, Bettampady, Puttur, Karnataka.	04 th March, 2020
Dr. R. Selvamani, IAS	Chief Executive Officer, Dakshina Kannada Zilla Panchayat, Puttur, Karnataka.	13 th March, 2020
Mrs. Sindhu B. Rupesh, IAS	Deputy Commissioner and District Magistrate, Dakshina Kannada, Puttur, Karnataka.	
Dr. Yathish Ullal	Assistant Commissioner, Puttur Division, Puttur, Karnataka.	
Sri. T. Ramesh Babu	Tahsildar, Puttur, Puttur, Karnataka.	
Sri B. Ramanath Rai	Former Minister of Environment and Forests of the State of Karnataka, Puttur, Karnataka.	06 th June, 2020
Sri. Chaniya Kalthadka	President, SulliaTaluk Panchayat, Puttur, Karnataka.	17 th June, 2020
Sri. Radhakrishna Borker	President, Puttur Taluk Panchayat, Puttur, Karnataka.	
Sri. Saja Radhakrishna Alva	President, Committee for Social Justice, Puttur Taluk Panchayat, Puttur, Karnataka.	
Sri. Boodiyar Radhakrishna Rai	Former president of APMC, Puttur, Karnataka.	
Sri. Prakash S. Netalkar, IFS	Managing Director, Karnataka Cashew Development Corporation Ltd, Mangaluru, Puttur, Karnataka.	29 th June, 2020
Mr. Manjunatha	Hon'ble Principal Sr. Civil Judge & ACJM, Chairman, Taluk Legal Services Committee, Puttur, DK, Puttur, Karnataka.	02 nd November, 2020
Sri. Manohar, K.V.	President, Bar Association, Puttur, Karnataka.	
Sri. Mahesh Kaje	Advocate, Puttur, Karnataka.	
Shri. Suresh Rai,	Vice President, Bar Association, Puttur, Karnataka.	
Shri. Manjunatha, N.S.	Secretary, Bar Association, Puttur, Karnataka.	
Dr. Rajesh Bejjangala	Director (Kannada Division), Kannur University, Kerala.	30 th December, 2020

19. PERSONNEL

Research Management Position		
1.	Dr. M.G. Nayak	Director (Acting) till 17 th August, 2020 (FN)
2.	Dr. Anitha Karun	Director (Acting) since 17 th August, 2020 (AN)
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.	Principal 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 th March, 2018 to 20 th March, 2021]
9.	Dr. Babli Mog	Scientist (Plant Physiology)
10.	Dr. Preethi, P.	Scientist (Fruit Science) [transferred to IIHR on 30 th December, 2020]
11.	Shri. Muralidhara, B.M.	Scientist (Fruit Science) [On study leave from 20 th September, 2018 to 19 th September, 2021]
12.	Dr. Siddanna Savadi	Scientist (Agricultural Biotechnology)
13.	Dr. Manjunatha, K.	Scientist (Farm Machinery and Power) [Since 4 th April, 2020]
14.	Dr. V. Thondaiman	Scientist (Spices, Plantation, Medicinal and Aromatic Plants) (Since 17 th August, 2020)
15.	Dr. G.L. Veena	Scientist (Fruit Science) [Since 4 th September, 2020]
Technical		
1.	Shri. K. Muralikrishna	Chief Technical Officer
2.	Shri. P. Abdulla	Chief Technical Officer
3.	Shri. R. Arulmony	Chief Technical Officer (retired on 30 th May, 2020)
4.	Shri. Prakash G. Bhat	Chief Technical Officer
5.	Shri. N. Manikandan	Sr. Technical Officer
6.	Shri. Raghurama Kukude	Sr. Technical Officer
7.	Shri. K.V. Ramesh Babu	Sr. Technical Officer
8.	Shri. R. Muthuraju	Sr. Technical Officer
9.	Shri. M. Bhojappa Gowda	Technical Officer
10.	Shri. Ravishankar Prasad	Sr. Technical Assistant
11.	Shri. Honnappa Naik, P.	Sr. Technician

Administration

1.	Shri. T.E. Janardhanan	Administrative Officer (on additional charge)
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

Skilled Support staff

1.	Sri. K.Shiva (retired on 30 th June, 2020)	10.	Sri. K. Narayana
2.	Sri. N. Narayana Naik	11.	Sri. B. Narayana Poojari
3.	Sri. Vijay Achary	12.	Sri. B. Kushalappa
4.	Sri. Veerappa	13.	Sri. B. Babu Gowda
5.	Sri. K. Annu	14.	Sri. T. Padmanabha
6.	Sri. Krishnappa Naik	15.	Sri. S. Monappa
7.	Sri. V. Sundara	16.	Sri. B. Seetharama
8.	Sri. C.H. Hariya Naik	17.	Sri. K. Gopalakrishna
9.	Sri. K. Umanath Shetty	18.	Smt. S. Kasturi

Promotion

- Dr. G.S. Mohana, Senior Scientist (Genetics and Cytogenetics) has been promoted to Principal Scientist (Genetics and Cytogenetics) w.e.f. 24th April, 2018.

Retirement

- Mr. R. Arulmony, Chief Technical Officer (Librarian) superannuated on 30th May, 2020.
- Mr. K. Shiva, Skilled Support Staff superannuated on 30th June, 2020.

Joining

- Dr. Manjunatha K, Scientist (Farm Machinery and Power) joined this Directorate on 4th April, 2020.
- Dr. V. Thondaiman, Scientist (Spices, Plantation, Medicinal and Aromatic Plants) joined this Directorate on 17th August, 2020 upon transfer from ICAR- Directorate of Medicinal and Aromatic Plants Research (DMAPR), Anand, Gujarat.
- Dr. Veena, G.L., Scientist (Fruit Science) joined this Directorate on 4th September, 2020, upon transfer from ICAR- Central Institute for Subtropical Horticulture, Lucknow, Uttarpradesh.

Transfer

- Dr. P. Preethi, Scientist (Fruit Science) has been relieved of her duties from ICAR-DCR, Puttur w.e.f. 30th December, 2020 upon her transfer to Indian Institute of Horticultural Research, Bengaluru.

••••• 20. WEATHER DATA (2020) •••••

Month	Temperature (°C)		Humidity (%)		Rainy days (Nos)	Rainfall (mm)	Mean wind velocity (km/h)	Sunshine (h)	Pan evaporation (mm)
	Max.	Min.	FN	AN					
January	34.15	20.65	77.10	46.61	0.00	0.00	1.98	294.60	3.45
February	34.10	21.28	79.93	39.59	1.00	3.20	2.29	256.00	4.19
March	34.65	22.84	77.16	45.10	1.00	1.20	2.58	236.90	4.80
April	33.95	23.70	77.90	48.90	4.00	49.50	2.73	230.50	5.58
May	32.95	23.77	84.06	59.23	7.00	215.90	2.34	193.20	3.98
June	31.12	21.50	90.50	81.60	25.00	523.70	2.05	54.70	2.61
July	29.60	22.13	91.26	80.61	28.00	804.30	1.80	53.30	2.75
August	27.37	22.01	89.39	77.97	23.00	746.90	2.22	45.00	2.34
September	25.03	22.77	80.14	77.21	27.00	614.00	1.94	69.00	2.26
October	25.65	22.16	75.65	70.61	14.00	318.40	1.66	125.40	2.49
November	26.93	21.40	69.27	54.23	6.00	87.30	1.69	222.50	3.01
December	25.19	20.45	77.84	48.39	1.00	19.80	1.84	259.80	2.69
Annual average	30.06	22.06	80.85	60.84	-	-	2.09	170.08	3.35
Annual Total	-	-	-	-	137.00	3384.20	-	-	-

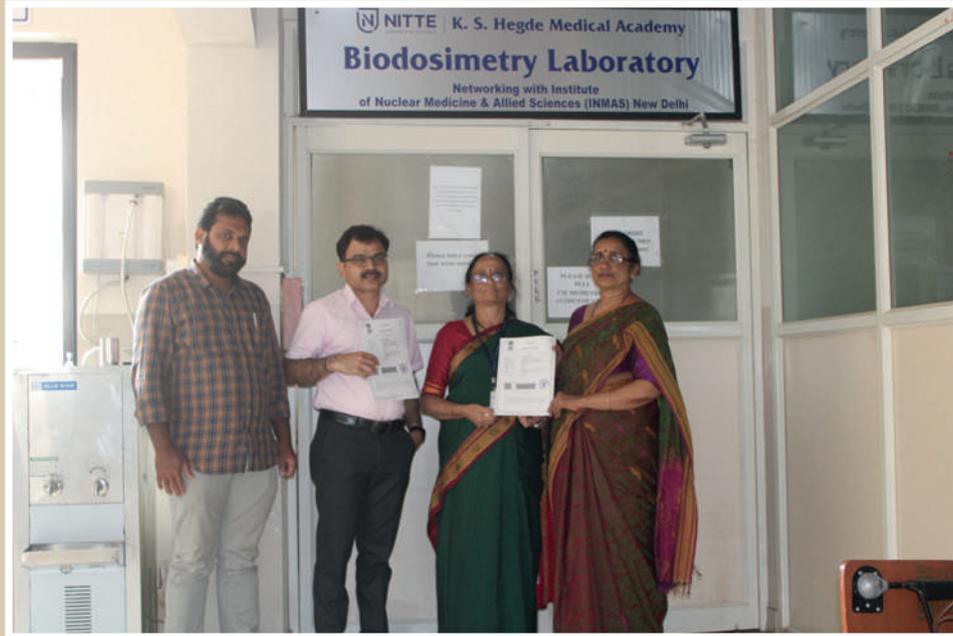
Rainfall, rainy days and sunshine hours are monthly total; other parameters are monthly mean values.

••••• 21. PUBLICATIONS FOR SALE •••••

Publication	Price (Rs)
Cashew production technology (Revised)	60.00
Softwood grafting and nursery management in cashew (Revised)	45.00
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	—
Process catalogue on development of economically viable on-farm cashewnut processing	45.00
Annotated bibliography on cashew (1995-2007)	205.00
Soil and water management in cashew plantations	30.00
Biochemical characterization of released varieties of cashew	85.00
Pruning and canopy architecturing in cashew	40.00
Development of dual-mode dryer for raw cashewnuts	90.00
Alternate energy utilization of cashew shell cake for thermal application	90.00

Price indicated above does not include postage.

Address your enquiries to the Director, ICAR-Directorate of Cashew Research, Puttur - 574202, Dakshina Kannada, Karnataka.



Signing of MoU with K.S. Hegde Medical Academy under NITTE, Mangaluru



Signing of MoU with M/s. Tamim Foods, Goa



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