ICAR-DIRECTORATE OF CASHEW RESEARCH

Darbe (P.O), Puttur - 574 202,
Dakshina Kannada, Karnataka



वार्षिक प्रतिवेदन

ANNUAL REPORT 2025







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भा.कृ.अनु.प. - काजू अनुसंधान निदेशालय

(An ISO 9001:2008)



Inauguration of CoE Profiling & Bioactive components Lab by
Dr. Himanshu Pathak, Former Secretary (DARE), Director General (ICAR) New Delhi.



Visit of Honorable Dr. Himanshu Pathak, Former Secretary (DARE),
Director General (ICAR),New Delhi to ICAR-DCR, Karnataka.



Visit of Honorable Dr. Sanjay Kumar Singh, Deputy Director General (Horticultural Sciences),
ICAR, New Delhi to ICAR-DCR, Karnataka.

वार्षिक प्रतिवेदन

Annual Report 2025

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(आई.एस.ओ. 9001:2008)

पुत्तूर – 574 202, कर्नाटक, भारत

ICAR-DIRECTORATE OF CASHEW RESEARCH

(ISO 9001:2008)

Puttur - 574 202, Karnataka, India

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प्रस्तावना



मुझे आईसीएआर–काजू अनुसंधान निदेशालय, पुत्तूर की यह वार्षिक रिपोर्ट प्रस्तुत करते हुए प्रसन्नता हो रही है, जिसमें 2025 की अनुसंधान उपलब्धियों और संस्थागत उपलब्धियों का दस्तावेजीकरण किया गया है। यह रिपोर्ट नई किस्मों, नवोन्मेषी प्रौद्योगिकियों और जिन किसान समुदायों की हम सेवा करते हैं, उनके साथ मजबूत संबंधों के माध्यम से भारत के काजू क्षेत्र की सेवा में कृषि विज्ञान के उच्चतम मानकों को बनाए रखने के लिए हमारी टीम के सामूहिक संकल्प का प्रमाण है।

यहां प्रलेखित कार्य फसल सुधार, फसल प्रबंधन, फसल संरक्षण, कटाई के बाद की प्रौद्योगिकी और प्रौद्योगिकी हस्तांतरण जैसे विभिन्न विभागों की सामूहिक प्रतिबद्धता और उपलब्धियों को दर्शाता है, जिनका उद्देश्य जीन बैंक से लेकर किसान के खेत तक और प्रयोगशाला से लेकर वाणिज्यिक बाजार तक, काजू की खेती के संपूर्ण क्षेत्र में ज्ञान को आगे बढ़ाना है।

यह वर्ष विशेष रूप से महत्वपूर्ण रहा है क्योंकि एक नई किस्म, नेत्रा समृद्धि, की पहचान की गई है और राज्य किस्म रिलीज समिति (State Variety Release Committee) द्वारा इसे उच्च उपज देने वाली, गुच्छेदार किस्म के रूप में मान्यता दी गई है, जिसमें शेल्लिंग (shelling) का प्रतिशत भी अधिक है, और यह काजू की फसल सुधार क्षेत्र में एक महत्वपूर्ण योगदान है। नई दिल्ली स्थित पीपीवीएफआरए द्वारा तीन काजू किस्मों को डस् (ईरद) प्रमाणपत्र प्रदान करना, किस्म विकास और बौद्धिक संपदा प्रबंधन क्षेत्र में निदेशालय की प्रतिष्ठा को और मजबूत करता है। फसल संरक्षण के क्षेत्र में, प्रतिरोध जीन अभिव्यक्ति (resistance gene expression) और थ्रिप्स जैव विविधता में मूलभूत खोजों ने टिकाऊ कीट प्रबंधन के लिए नए रास्ते खोल दिए हैं।

फसल प्रबंधन के अलावा, कटाई के बाद और मूल्यवर्धन पर किए गए हमारे शोध से व्यावसायिक रूप से लाइसेंस योग्य नवाचार प्राप्त हुए हैं – जिनमें मध्यम ग्लाइसेमिक काजू–सेब स्वीटनर, वैक्यूम–फ्राइड उत्पाद और खाद्य प्रौद्योगिकियों की एक विस्तृत श्रृंखला शामिल है, जिन्हें अब गैर–अनन्य लाइसेंसिंग के तहत उद्योग भागीदारों को हस्तांतरित किया जा रहा है। आईसीएआर स्थापना दिवस पर छह प्रौद्योगिकियों को मान्यता और प्रमाणन प्राप्त हुआ, जो हमारे कार्य के व्यावहारिक प्रभाव को रेखांकित करता है।

किसानों के प्रति हमारी प्रतिबद्धता दृढ़ बनी रही, जिसके तहत कर्नाटक और आंध्र प्रदेश में 118 एकड़ से अधिक क्षेत्र में 86 यूएवी–आधारित फील्ड प्रदर्शन आयोजित किए गए और 513 किसानों को सीधे तौर पर शामिल किया गया। सहभागी पहुंच की यह भावना हमारे इस विश्वास को दर्शाती है कि अनुसंधान का पूर्ण अर्थ तभी प्राप्त होता है जब वह उन लोगों तक पहुंचता है जो भूमि पर खेती करते हैं।

यह प्रतिवेदन हमारे प्रबंधन, वैज्ञानिक, संस्थागत तथा सामाजिक योगदान का एक पारदर्शी विवरण प्रस्तुत करता है तथा सहयोगियों, नीति–निर्माताओं, उद्योग भागीदारों और व्यापक शोध समुदाय को भारतीय काजू के लिए अधिक उत्पादक और सतत भविष्य के निर्माण में हमारे साथ जुड़ने के लिए आमंत्रित करता है।

(जे दिनकर अडिग)
निदेशक

स्थान: भा.कृ.अनु.प. – काजू अनुसंधान निदेशालय पुत्तूर
दिनांक: 31.12.2025

PREFACE

I am pleased to present this Annual Report of the ICAR-Directorate of Cashew Research, Puttur, Karnataka which documents the research accomplishments and institutional milestones of 2025. This report stands as a testament to our team's collective resolve to uphold the highest standards of agricultural science in service of India's cashew sector through the development of new varieties, innovative technologies, and strengthened bonds with the farming communities we serve.

The work documented herein reflects the collective commitment and achievements of different sections *viz.*, Crop Improvement, Crop Management, Crop Protection, Post-Harvest Technology and Transfer of Technology to advancing knowledge across the full spectrum of cashew cultivation, from the gene bank to the farmer's field, and from the laboratory bench to the commercial marketplace.

This year has been particularly significant because a new variety, Nethra Samruddhi, has been identified and approved by the State Variety Release Committee as a high-yielding, cluster-bearing variety with a high shelling percentage, and it stands as a landmark contribution to cashew crop improvement. The award of DUS certificates for three cashew varieties by Protection of Plant Varieties and Farmers' Rights Authority (PPVFRA), New Delhi, further affirms the Directorate's standing in varietal development and intellectual property stewardship. On the frontiers of crop protection, foundational discoveries in resistance gene expression and thrips biodiversity have opened new pathways for sustainable pest management.



Beyond crop management, our post-harvest and value-addition research has yielded commercially licensable innovations including a medium glycaemic cashew apple sweetener, vacuum-fried products, and a range of food technologies now being transferred to industry partners under non-exclusive licensing. Six technologies were recognised and certified at the ICAR Foundation Day, underscoring the translational impact of our work.

Our commitment to farmers remained steadfast, with 86 nos. of UAV-based field demonstrations covering over 118 acres and directly reaching 513 nos. of farmers across Karnataka and Andhra Pradesh. This spirit of participatory outreach reflects our belief that research achieves its fullest meaning only when it reaches those who till the farm land.

This report is offered as a transparent account of our stewardship, scientific, institutional, and social and as an invitation to collaborators, policymakers, industry partners, and the wider research community to engage with us in shaping a more productive and sustainable future for Indian cashew.

Place: ICAR-DCR, Puttur
Date: 31.12.2025

J Dinakara Adiga,
Director

CONTENTS

1	Executive Summary	01
2	Introduction	05
3	Research Achievements	
	3.1 Crop Improvement	09
	3.2 Crop Management	45
	3.3 Crop Protection	52
	3.4 Post – Harvest Technology	68
	3.5 Transfer of Technology	76
	3.6 Concluded Projects	86
4	Extension and Outreach	116
5	Agri-Business Incubation Center	119
6	Consultancies, Patents and Commercialization of Technology	121
7	Linkages and Collaborations	124
8	Human Resource Development	125
9	Awards and Recognitions	129
10	Publications	136
11	Ongoing and Concluded Research Projects	141
12	RAC / IRC / IMC /IJSC Meetings	155
13	Rajbhasha	159
14	Programmes/Events Organised	161
15	Distinguished Visitors	168
16	Personnel	169
17	Weather Data 2025	172

1. कार्यकारी सारांश

भा.कृ.अनु.प.–काजू अनुसंधान निदेशालय पुत्तूर काजू पर अनुसंधान और विस्तार गतिविधियों में कार्यरत है। वर्ष 2025 के दौरान फसल सुधार, फसल प्रबंधन, फसल सुरक्षा, कटाई–पश्चात प्रौद्योगिकी, प्रौद्योगिकी हस्तांतरण और अन्य संबंधित गतिविधियों के अंतर्गत किए गए अनुसंधान कार्यों की मुख्य उपलब्धियों और प्रगति का सारांश नीचे दिया गया है। इस वर्ष के दौरान, कुल 41 संस्थान परियोजनाएँ और 10 बाहरी वित्तपोषित परियोजनाएँ कार्यान्वित की गईं।

नेत्रा समृद्धी (पेड़ संख्या 480) की पहचान की गई और इसे संस्थान स्तर पर मोचन किया गया; इसे राज्य किस्म मूल्यांकन समिति द्वारा भी अनुमोदित किया गया। इसे VTH30/4 से सीडलिंग चयन (हाफ–सिब) के माध्यम से विकसित किया गया है। यह लगातार उच्च उपज देने वाली, गुच्छों में फलने वाली और उच्च शेलिंग प्रतिशत वाली एक आशाजनक किस्म हैं। वर्तमान में, काजू जीन बैंक में 603 एक्सेसन्स (संग्रह) संरक्षित हैं। इस वर्ष के दौरान, मूल्यांकन और लक्षण वर्णन के लिए 18 काजू जर्मप्लाज्म और सेमेकार्पस एनाकार्डियम (*Semecarpus anacardium*) के सात (7) एक्सेसन्स एकत्र किए गए हैं। इस वर्ष के दौरान, वेंगुर्ला–9, नेत्रा गंगा, नेत्रा वामन, नेत्रा उभया, नेत्रा जंबो–1, और पूर्णिमा किस्मों के पंजीकरण के लिए DUS प्रमाणपत्र पीपीवीएफआरए (PPVFRA), नई दिल्ली से प्राप्त किए गए। कम समय में बड़ी संख्या में नमूनों के कुशल विश्लेषण के लिए उपयोगी, त्वरित सीएनएसएल (CNSL) और कर्नेल तेल निष्कर्षण प्रोटोकॉल विकसित किए गए। काजू में संभावित प्रतिरोध (R) जीनों की माइनिंग और एक्सप्रेशन प्रोफाइलिंग ने टीएमबी (TMB) संक्रमण के दौरान काजू में संभावित R जीनों के अस्थायी एक्सप्रेशन प्रोफाइल के बारे में मूलभूत अंतर्दृष्टि प्रदान की।

भास्कर, प्रियंका और वीटीएच–174 (VTH-174) ने सूखे के प्रति कई गुणों वाली बेहतर सहनशीलता दिखाई; जबकि वीटीएच–30/4 और मडक्कथारा–2 सबसे अधिक संवेदनशील थे। नारियल के बुरादे से बनी खाद (coir pith compost) को गुणवत्तापूर्ण ग्राफ्ट उत्पादन के लिए एक वैकल्पिक माध्यम के रूप में पहचाना गया। किसानों के खेतों में काजू की चार किस्मों में कार्बन संचयन (carbon sequestration) की मात्रा का आकलन किया गया। कुल मिलाकर, संस्थान की 41 परियोजनाएँ और बाहरी स्रोतों से वित्तपोषित 10 परियोजनाएँ पूरी की गईं।

वर्जिन TMB मादाओं से निकले वाष्पशील पदार्थों के ईएजी और जीसी–एमएस (EAG और GC-MS) विश्लेषण में, यह देखा गया कि कुल 12 यौगिकों का पता चला, जिनमें क्लोरो–बेंजीन, एथिल–बेंजीन, एथिल अल्कोहल (जैसे ऑक्टेनॉल–डेकेनॉल), और एथिल एसीटोफेनोन शामिल थे; इन सभी की स्थिति फेरोमोन प्रीकर्सर या फेरोमोन जैसी है। एकत्रित थ्रिप्स नमूनों की पहचान से पता चला कि काजू में थ्रिप्स की 23 प्रजातियाँ पाई जाती हैं, जो टेरेब्रांटिया और ट्यूबुलिफेरा (Terebrantia और Tubulifera) उप–गणों के अंतर्गत तीन कुलों थ्रिपिडे, फ्लेओथ्रिपिडे और एओलोथ्रिपिडे (Thripidae, Phlaeothripidae और Aeolothripidae) - से संबंधित हैं। काजू की पत्तियों पर पाई जाने वाली तीन प्रजातियाँ – *Retithrips syriacus, Selenothrips rubrocinctus* और Mecynothrips simplex -पत्तियों से ही एकत्रित की गईं, जबकि शेष 20 प्रजातियाँ काजू के फूलों से प्राप्त हुईं। टीएम्बी–संक्रमित टहनियों और मंजरियों से जुड़े सबसे प्रमुख रोगजनकों की पहचान पेस्टालोटिपोसिस spp (Pestalotiposis spp.) के रूप में की गई, जिसके बाद कोलेटोट्राइकम स्पी., लैसियोडिप्लोडिया स्पी., फ्यूसेरियम स्पी. और कर्वुलरि स्पी. (*Colletotrichum* spp., *Lasiodiplodia* spp., *Fusarium* spp. और *Curvularia* spp). का स्थान रहा। पौध–गलन (seedling rot) रोगजनक के बहु–जीन विश्लेषण के माध्यम से – जिसमें आंतरिक अनुलेखित स्पेसर (internal transcribed spacer) (ITS), translation elongation factor अनुवाद दीर्घीकरण कारक

(Tef 1), RPB2, ßtubulin, nuclear Larger Sub Unit (एदर) और nuclear Smaller Sub Unit (ददर), रोगजनक की प्रजाति–स्तर तक की पहचान बेल्ट्रानिया रोम्बिका (*Beltrania rhombic*) के रूप में सुनिश्चित की गई।

फ्लेवोनोइड मेटाबोलाइट्स के लक्षण–निर्धारण में, ऊतक–विशिष्ट (tissue-specific) भिन्नता स्पष्ट रूप से देखी गई; जहाँ स्यूडो–फलों (pseudo fruits) में फ्लेवोनोल्स अधिक मात्रा में पाए गए, वहीं पत्तियों में फ्लेवन–3–ओल्स की प्रधानता रही। काजू सेब के टुकड़ों की वैक्यूम फ्राइंग की तैयारी में, मशीन और सामग्री के मापदंडों के सहक्रियात्मक प्रभाव की जाँच की गई। काजू सेब से एक तरल स्वीटनर (मीठा करने वाला पदार्थ) विकसित किया गया, जिसका ग्लाइसेमिक इंडेक्स मध्यम है और जिसमें उच्च एंटीऑक्सीडेंट गतिविधि, विटामिन तथा खनिज मौजूद हैं। इस उत्पाद की शेल्फ लाइफ (भंडारण अवधि) कमरे के तापमान पर एक वर्ष से अधिक है।

निदेशालय की विभिन्न तकनीकों का व्यावसायीकरण और लाइसेंसिंग – जैसे कि काजू की किस्में (नेत्रा जंबो–1, नेत्रा जंबो–2 और नेत्रा उभया), 3–इन–1 काजू नट सेपरेटर, पल्प एक्सट्रैक्टर और रेशेदार सामग्री अलग करने वाली मशीन, किसान ट्रैकिंग प्रणाली संस्करण–1, काजू स्प्राउट कुकीज़, काजूप्राश (CashewPrash) और डाइट काजू सेब मफिन, काजू सेब साइडर, काजू सेब पोमेस पाउडर कुकीज़, काजू सेब फ्रूट बार, काजू सेब जैम, जेली और कैशलाइम (Cashlime) - विभिन्न फर्मों को गैर–विशिष्ट लाइसेंसिंग' (non-exclusive licensing) के तहत प्रदान की गई है।

इस अवधि के दौरान, कर्नाटक और आंध्र प्रदेश में ड्रिप सिंचाई के साथ सामान्य घनत्व वाली रोपाई के तहत किस्मों के ऊएफ्ई के लिए कुल 8 हेक्टेयर क्षेत्र को कवर किया गया, और कर्नाटक में ड्रिप सिंचाई के साथ उच्च घनत्व वाली रोपाई के लिए 1 हेक्टेयर क्षेत्र को कवर किया गया। वास्तविक कृषि परिस्थितियों में एग्रोकेमिकल्स, सूक्ष्म पोषक तत्वों और जैविक कीटनाशकों के छिड़काव के लिए मानवरहित हवाई वाहनों (UAVs) के उपयोग को प्रदर्शित करने के लिए कुल 86 क्षेत्रीय प्रदर्शन आयोजित किए गए। इन प्रदर्शनों ने सामूहिक रूप से 118.5 एकड़ क्षेत्र को कवर किया और इसमें सीधे तौर पर 513 किसान शामिल हुए।

संस्थान को मार्च 2025 में बेंगलुरु में आयोजित राष्ट्रीय बागवानी मेले में 'सर्वश्रेष्ठ स्टॉल पुरस्कार' भी मिला। यह पुरस्कार संस्थान को प्रौद्योगिकी प्रदर्शन, प्रभावी प्रस्तुति और किसानों तक अपनी पहुँच बनाने में दिखाई गई उत्कृष्टता के सम्मान में दिया गया।

यह वर्ष विशेष रूप से महत्वपूर्ण रहा, जिसकी एक मुख्य घटना 29 सितंबर 2025 को नई दिल्ली में 'भारतीय काजू क्षेत्र को पुनर्जीवित करना: प्रतिस्पर्धात्मकता का निर्माण और समृद्धि में वृद्धि' विषय पर आयोजित राष्ट्रीय कार्यशाला थी। इस कार्यशाला का आयोजन आसीएआर–काजू अनुसंधान निदेशालय, पुत्तूर द्वारा 'इंडियन एकेडमी ऑफ हॉर्टिकल्चरल साइंसेज' (IAHS), नई दिल्ली और 'राष्ट्रीय बागवानी बोर्ड' (NHB), गुरुग्राम के सहयोग से 'हाइब्रिड मोड' में किया गया था। यह कार्यशाला एक जीवंत मंच साबित हुई, जहाँ वैज्ञानिक, नीति–निर्माता, डीसीसीडी और अपेडा (APEDA) जैसे अन्य विकास विभागों के अधिकारी, प्रसंस्करणकर्ता और किसान एक साथ आए। इस मंच पर उन्होंने कच्चे काजू (RCN) के मामले में आत्मनिर्भरता प्राप्त करने और इस क्षेत्र को पुनर्जीवित करने से जुड़े प्रमुख मुद्दों, चुनौतियों और रणनीतियों पर गहन विचार–विमर्श किया।

यह बताना ज़रूरी है कि इस साल के दौरान, छह टेक्नोलॉजीज़ – जैसे काजू में पत्ती पोषक तत्व निदान के मानक, 3–इन–1 काजू सेपरेटर, पल्प निकालने और रेशेदार सामग्री को अलग करने वाली मशीन, काजू सेब फ्रूट बार, काजू प्राश, पैडल से चलने वाला पोर्टेबल शियर–टाइप काजू सेब और नट सेपरेटर, और ट्विस्टिंग मैकेनिज्म वाला पोर्टेबल सेमी–ऑटोमैटिक काजू सेब और नट सेपरेटर को आसीएआर के स्थापना दिवस, 2025 के मौके पर आसीएआर द्वारा प्रमाणित किया गया। इस दौरान पाँच पेटेंट और ग्यारह कॉपीराइट के लिए आवेदन किए गए, जिनमें से छह कॉपीराइट को मंज़ूरी मिल गई।

1. EXECUTIVE SUMMARY

ICAR-Directorate of Cashew Research, Puttur, Karnataka is involved in research and extension activities on cashew. The salient achievements and progress of research activities carried out during the year 2025 under Crop Improvement, Crop Management, Crop Protection, Post-Harvest Technology and Transfer of Technology and other related activities are as summarized. During the year, a total of 41 nos. of institute projects and 10 nos. of externally funded projects were executed.

Nethra Samruddhi (Tree No. 480) was identified and released at the institute level, and it was also approved by the State Varietal Release Committee. It is developed through seedling selection (half-sib) from VTH30/4. It was found to be promising, with consistently high-yielding, cluster-bearing habit and high shelling percentage. Currently, 603 accessions are maintained in the cashew gene bank. During the year, 18 cashew germplasm and seven accessions of *Semecarpus anacardium* have been collected for evaluation and characterization. The DUS certificates for registration of Vengurla-9, Nethra Ganga, Nethra Vaaman, Nethra Ubhaya, Nethra Jumbo-1, Poornima varieties were obtained from PPVFRA, New Delhi during the year. The mining and expression profiling of candidate resistance (R) genes in cashew provided foundational insights into the temporal expression profiles of candidate R genes in cashew during TMB infestation

Bhaskara, Priyanka, and VTH-174 showed superior multi-trait drought tolerance and VTH-30/4 and Madakkathara-2 were most susceptible. Coir pith compost media as alternative media for quality graft production was identified. Carbon sequestration was quantified in four varieties of cashew in a farmer's field.

While analysing eluted volatiles of virgin TMB females using EAG and GC-MS it was noticed that a total of 12 compounds, comprising of chloro-benzenes, ethyl-benzenes, ethyl alcohols like octonol- decanol, and ethyl acetophenones, were traced, which have pheromonal precursor / pheromone activity. Identification of the collected thrips specimens, revealed the occurrence of 23 species of thrips in cashew belonging to the suborders Terebrantia and Tubulifera under three families, *viz.,* Thripidae, Phlaeothripidae and Aeolothripidae. Three species viz., *Retithrips syriacus*, *Selenothrips rubrocinctus* and *Mecynothrips simplex* on the cashew leaves were collected from leaves, while the remaining 20 were from the cashew flowers. The most predominant pathogens associated with TMB infested shoots and panicles were identified as *Pestalotiposis* spp. followed by *Colletotrichum* spp., *Lasiodiplodia* spp., *Fusarium* spp. and *Curvularia* spp. The multi-gene analysis of seedling rot pathogen with internal transcribed spacer (ITS), translation elongation factor (Tef 1), RPB2, β-tubulin, nuclear Larger Sub Unit (LSU) and nuclear Smaller Sub Unit (SSU) to confirm up to species level identification of pathogen as *Beltrania rhombica*

In flavonoid metabolites characterization, a clear tissue-specific variation was observed, with flavonols being more abundant in pseudo fruits, while flavan-3-ols dominated in leaves. Synergic effect of machine and material parameters towards preparation of vacuum frying of cashew apple slices was investigated. A liquid sweetener from cashew apples was developed which has a moderate glycemic index, high antioxidant activity, vitamins and minerals. The shelf life of the product is more than a year at room temperature.

Commercialization and licensing of different technologies of Directorate *viz.*, cashew varieties (Nethra Jumbo-1, Nethra Jumbo-2 and Nethra Ubhaya), 3-in-1 Cashew Nut Separator, Pulp Extractor and fibrous Material Separating Machine, Farmers Tracking System version-1, cashew sprout cookies, CashewPrash and diet cashew apple muffins, Cashew apple cider, Cashew apple pomace powder cookies, Cashew apple fruit bar, Cashew apple jam, Jelly, and Cashlime under nonexclusive licensing to different firms.

During the period, a total of 8.0 ha of area covered for FLTD of varieties under normal density planting with drip irrigation in Karnataka and Andhra Pradesh and an area of 1.0 ha for high density planting with drip irrigation in Karnataka. A total of 86 field demonstrations were organized to showcase the application of Unmanned Aerial Vehicles (UAVs) for spraying agrochemicals, micronutrients, and organic pesticides under real farm conditions. These demonstrations collectively covered 118.5 acres and directly involved 513 farmers. The institute also received the Best Stall Award at the National Horticulture Fair organized in March 2025 at Bengaluru, in recognition of its excellence in technology demonstration, effective showcasing, and impactful farmer outreach.

The year was particularly eventful, marked by the organisation of the National Workshop on "Revitalising the Indian Cashew Sector for Building Competitiveness and Enhancing Prosperity" on 29 September 2025 at New Delhi in hybrid mode by ICAR–Directorate of Cashew Research, Puttur, in collaboration with the Indian Academy of Horticultural Sciences (IAHS), New Delhi and the National Horticulture Board (NHB), Gurugram. The workshop served as a vibrant platform, bringing together scientists, policy makers, officials from other developmental departments such as DCCD, APEDA, processors and farmers to deliberate on the key issues, challenges, and strategies to achieve self-sufficiency in RCN and revive the sector.

It is noteworthy to mention that during the year, six technologies *viz.*, leaf nutrient diagnostic norms in cashew, 3-in-1cashew nut separator, pulp extractor and fibrous material separating machine, cashew apple fruit bar, cashew prash, portable pedal operated shear type cashew apple and nut separator and portable semi-automatic cashew apple and nut separator with twisting mechanism were certified by ICAR during ICAR Foundation Day, 2025. Five patents and eleven copyrights were filed during the period, out of which six copyrights were granted.

2. INTRODUCTION

2.1. History

Cashew (*Anacardium occidentale* L.) is an introduced crop to India by the Portuguese in the 16th Century which is a Native of Eastern Brazil. Cashew is a crop with high economic value and is earning considerable foreign exchange for the country. During 1950's the research on cashew initiated. *Ad hoc* schemes for cashew reserach were sanctioned by the Indian Council of Agricultural Research (ICAR), which were located at Kottarakkara (Kerala), Ullal (Karnataka), Bapatla (Andhra Pradesh) 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 Vth and VIth 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 VIIth Plan period, AICS & CIP was bifurcated into two separate projects, one on cashew and another on spices. The headquarters of independent AICRP on Cashew was shifted to the newly established NRCC, Puttur in 1986. NRCC was upgraded and renamed as Directorate of Cashew Research (DCR) by ICAR on 23 March 2009 under XI Plan. At present, the AICRP on Cashew is operating at 14 centers which were distributed in major cahsew growing areas of the country. As per the instruction of ICAR-New Delhi, the prefix ICAR was added before the institute name since 2014.

2.2. Location

The main campus of ICAR-DCR is situated 5 kms away from Puttur town at Mottethadka village of Kemminje (12.45°N latitude, 75.15°E longitude and 90 m above MSL). The main campus has an area of 69.02 ha consisting of an administrative block, research laboratories and field experiment plots. Besides, the Directorate has an Experimental Station at Shantigodu, located 13 km away from the main campus which has an area of 80 ha. The institute is conducting and coordinating research on different aspects of cashew such as germplasm collection and conservation, crop improvement, crop production, crop protection, post-harvest technology and transfer of technology.

2.3. Vision, Mission and Mandate

Vision

- Accomplishing self sufficiency in raw cashewnut production and to achieve 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.

Mandate

- To undertake strategic, basic and applied research for enhancing productivity, quality, processing efficiency and value addition of cashew.
- To serve as a national repository of genetic resources and scientific information on cashew.
- To coordinate All India Coordinated Research Project on Cashew for addressing location and region-specific problems.
- To promote capacity building through the transfer of technology and consultancy services to stakeholders.

2.4. Organogram

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

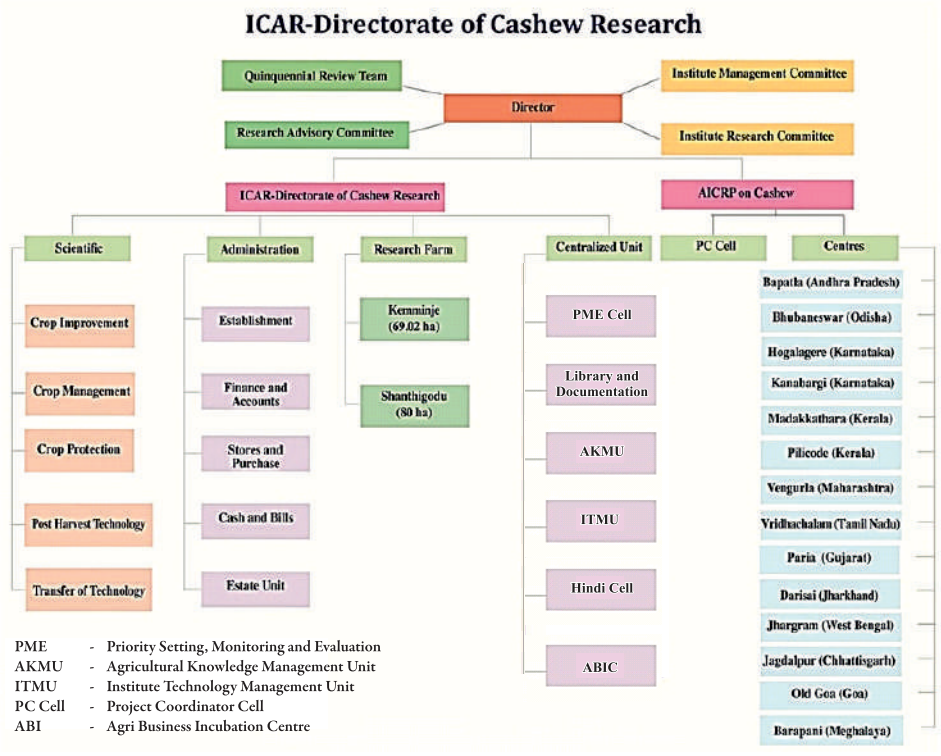


Fig. 2.1 : Organogram of ICAR-Directorate of Cashew Research

2.5. Library/AKMU/ITMU/ABI

The Directorate has got a well-established library in the field of cashew research. DCR Library & Information Centre (DLIC) has kept its mission to acquire, organize, preserve and disseminate information resources on horticulture, plantation crops especially on cashew research and development. DLIC a rich collection of information resources in the form of books, journals, technical bulletins, annual reports, brochures/ pamphlets, etc., on all aspects of cashew production, plant breeding, agricultural entomology, plant pathology, soil science and allied fields of horticulture. During the period, library procured 23 textbooks and subscribed 10 Indian journals at the cost of Rs. 1,00000/-. All these books were classified as per the DDC (Dewey Decimal Classification) scheme and Catalogued as per the AACR-II (Anglo American Classified Rules) and displayed in the library. Library has a total collection of 2014 textbook/reference books, around 400 back issues of journals, 2255 bound volumes of journals, 684 annual reports, 569 newsletters/ conference proceedings received from various ICAR Institutes, State Agricultural Universities (SAU's) and other national / international organizations on gratis/exchange programme. KOHA-An Integrated Library Management System (ILMS) software is being implemented in the library to enhance the utility of library resources and services. DLIC is accessing the journals and other information resources from various publishers through One Nation One Subscription (ONOS) platform. It also maintained the CD-ROM databases on horticulture, pesticide, plant genetics, soil science, crop sciences, etc. Document Delivery Service, Internet browse service, Current Awareness Service (CAS), newspaper clipping service, reprography service, sale of institute publication are some of the services provided from the library.

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 for commercialization of agricultural technologies. At this Directorate, ITMU takes care of commercialization of technologies developed by ICAR-DCR, Puttur.

Agri Business Incubation Centre (ABI) operated in this institute funded by the National Agricultural Innovation Fund (NAIF) under the Division of Intellectual Property and Technology Management, Indian Council of Agricultural Research, New Delhi has the 'State-of-the-Art' processing facility for promotion of entrepreneurship and business environment in the cashew eco system.

2.6. Staff

The Institute has a sanctioned strength of 22 scientific, 19 technical, 16 administrative and 19 skilled support staff, of which 16 scientists, 6 technical staff, 6 administrative staff and 9 skilled support staff are in position and the remaining are vacant as on 31st December 2025. (Table 2.1).

Table 2.1: Staff strength at ICAR-DCR, Puttur (as on 31.12.2025)

Category	Sanctioned	Filled	Vacant
Director (RMP)	1	1	-
Scientist	22	16	6
Technical	19	6	13
Administrative	16	6	10
SSS	19	9	10
Total	**77**	**38**	**39**

2.7. Budget

During the financial year (FY) 2025-26, the total budget allotted till December 2025 to the Directorate was Rs. 522.99 Lakhs of which Rs. 481.75 Lakhs were utilized (Table 2.2). Under externally funded projects, the total receipts were Rs. 346.64. Lakhs, of which Rs. 199.92 Lakhs was utilized (Table 2.3). The revenue generation during FY 2025-26 was Rs. 182 Lakhs till December 2025 (Table 2.4).

Table 2.2 : Budget and Expenditure Details of ICAR-DCR from April 2025- Dec 2025 (Rs. in Lakhs)

Particulars	Allocation	Utilization
ONEH General	412.50	394.72
ONEH Capital	18.78	10.03
TSP General	15.00	10.00
TSP Capital	4.15	3.74
SCSP General	65.00	55.70
SCSP Capital	7.56	7.56
Total	**522.99**	**481.75**

Table 2.3 : Receipts and expenditure under externally funded schemes at DCR for April 2025 - Dec 2025 (Rs. in Lakhs)

Particulars	Allocation	Release and Utilization
PM-RKVY GoK	323	172
PPV&FRA, New Delhi	5.04	0.84
DCCD, Cochin	0.5	0.5
DCCD (Training)	5.92	0.00
ABI	6.03	4.98
ITMU	6.15	5.51
Total	**346.64**	**199.92**

Table 2.4 : Revenue generation at ICAR-DCR from April- 2025 to December- 2025 (Rs in Lakhs)

Revenue target (2025)	Revenue Generated (2025)
182	182

2.8. Infrastructure and assets

A chemical ecology laboratory has been established with the funding by PM RKVY-RAFTAAR, Govt. of Karnataka with the facilities like GC-EAD (gas chromatography coupled electro antennography detector), air entrainment units, y tubes for bioassays, heat block, microscope etc. The consumables and other minor equipments are being purchased for taking up the trials on insect olfactory responses.

A Drone Technology Laboratory was established with the funding of PM RKVY-RAFTAAR, Govt. of Karnataka. The laboratory is equipped with state-of-the-art, cutting-edge technologies, viz., drones, sensors, and software.

A center of excellence for Profiling and Bioactive Components was established with the funding from PM RKVY-RAFTAAR, Govt. of Karnataka was established with state-of-the-art facilities like High Pressure liquid chromatography, Spectrophotometer, Gas chromatography mass spectrometry and other necessary equipments.

2.9 Production of planting materials

ICAR-DCR has cashew nurseries at both of its campuses: Kemminje and Shantigodu, accredited by Directorate of Cashewnut and Cocoa Development (DCCD), Kochi with four-star rating to cater the need of planting material. Softwood grafts of varieties like Bhaskara, NRC Selection-2, Ullal-1, Ullal-3, Ullal-4, VRI-3, Madakkathara-2, Priyanka, Vengurla-7, Vengurla-4, Nethra Ganga, Nethra Jumbo-1, Nethra Ubhaya, Dhana etc. are produced in the two nurseries between June and August, every year for supplying to the farmers. During the year 2025, a total of 308676 cashew grafts were produced from Shantigodu (201050) and Kemminje (107626).

3. RESEARCH ACHIEVEMENTS

3.1 CROP IMPROVEMENT

Priority Area: Genetic Improvement of Cashew for productivity, quality and resistance to biotic and abiotic stresses through conventional and biotechnological approaches

3.1.1: Collection, Conservation, Characterization and Evaluation of Cashew Genetic Resources

Status of Cashew Field Gene Bank: 603 accessions

A total of seventeen germplasm accessions were collected from Jagadalpur (11) and Goa (6) centres during the year. The collected accessions were planted in the germplasm evaluation block for characterization. One unique germplasm, i.e., Kudur cashew-1, was also collected from Kudur, Ramanagara, Karnataka, which has high flowering intensity and a high-yielding type with small apples (Table 3.1.1). Further, seven accessions of *Semecarpus anacardium* seeds were collected and sown (Fig. 3.1.1 and Fig. 3.1.2).



Fig. 3.1.1: Cashew germplasm accessions collected and planted during the year

Table 3.1.1: Details of the accession Kudur Cashew -1

Accession Name	Kudur Cashew-1
Special traits	High flowering intensity, high yielding, heavy fruit bearing and small apples with loose apple to nut attachment
Collection site	Kudur, Ramnagara, Karnataka
Latitude and longitude	13.100& 77.160
Elevation	845.62 MSL
Date of collection	09/08/2025
Type of material collected	Scion collected and grafted
Sampling method	Individual tree
Frequency	Rare
Collected and submitted by	Dr. Manjunatha., K & Dr. Siddanna Savadi

Germplasm maintenance

Unique types such as dwarf types (2), wild species (3), along with purple mutants were maintained during the year. Further, 512 germplasm accessions in the conservation block are conserved and evaluated. The core collection of 61 cashew germplasm accessions was also taken care of, during the period.

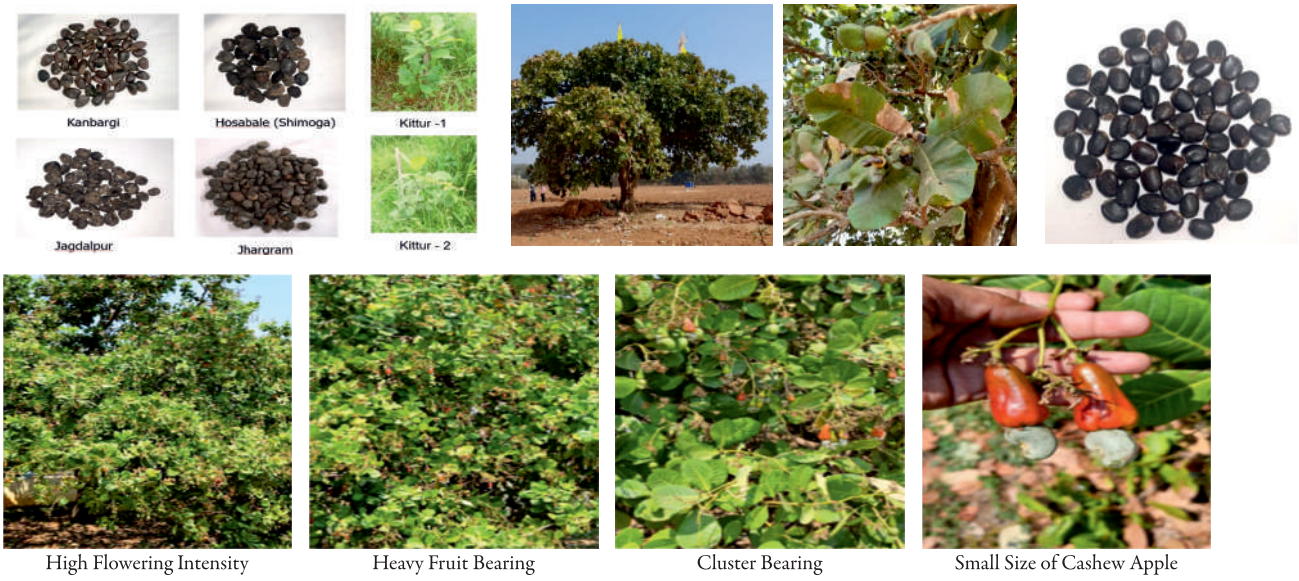


Fig. 3.1.2 : *Semecarpus anacardium* accession collected from Tegur, near Dharwad, Karnataka and Kudur Cashew -1

Cashew Shell Nut Liquid (CNSL) estimation in germplasm accessions

During 2025, the CNSL content of the 18 accessions was estimated. It was observed that the range of CNSL content varied from 15.72 to 36.86 %. Further, vitamin C content, tannin, and total sugars were estimated in 17 accessions (Table 3.1.2).

Table 3.1.2: Biochemical components in cashew accessions

Sl. No.	Accessions	NRC No.	Tannin (mg/g)	Ascorbic acid (mg/g)	Total sugars (%)
1	Madakkathara-1	NRC 14	0.103	1.975	0.939
2	BLA-39-4	NRC 15	0.169	1.650	1.146
3	VTH 168/49	NRC 17	0.089	1.675	0.857
4	BPP-5	NRC 95	0.102	1.225	1.125
5	VRI-3	NRC 99	0.135	1.950	1.354
6	Goa-1	NRC 103	0.241	1.025	1.326
7	Bhubaneswar-1	NRC 232	0.156	2.225	0.939
8	Jhargram-1	NRC 267	0.202	1.750	0.944
9	Kanaka	NRC 351	0.261	1.075	1.310
10	Ullal-1	NRC 352	0.099	1.575	1.976

Contd.

Sl. No.	Accessions	NRC No.	Tannin (mg/g)	Ascorbic acid (mg/g)	Total sugars (%)
11	Ullal-4	NRC 355	0.094	1.450	0.906
12	Vengurla-6	NRC 356	0.139	1.025	0.884
13	Vengurla-7	NRC 357	0.209	2.350	0.830
14	BPP-2	NRC 361	0.106	0.700	0.786
15	Priyanka	NRC 362	0.103	0.950	1.485
16	UN-50	NRC 363	0.097	2.425	0.917
17	Vengurla-7	NRC 364	0.251	0.950	1.059

3.1.2 Genetic improvement of Cashew through hybridization and seedling selection approaches

Nethra Samruddhi (Tree No. 480) was identified and released at the institute level, and the state varietal evaluation committee also approved it. It was developed through seedling selection (half-sib) from VTH 30/4. The variety was selected based on seedling performance that outperformed that of their parent, VTH 30/4. The variety was evaluated under replicated yield trials with a spacing of 8 x 8m at the Experimental research station Shantigodu of ICAR-DCR, Puttur, Karnataka. The prominent features of this variety (Fig.3.1.3), Nethra Samruddhi, are consistent and high-yielding, protein-rich variety compared to earlier released varieties *viz.*, Bhaskara and NRCC Sel. 2. It is also cluster-bearing in nature with 10-12 nuts per panicle, with uniform nut size of W210 grade kernels and high shelling percentage. It produces alternate flushes and flowering laterals even after TMB infestation (Table 3.1.3).

Table 3.1.3: Prominent attributes of Nethra Samruddhi

Sl. No.	Characters	Value
1	Sex Ratio	0.48
2	Nut weight (g)	8.34 g
3	Number of nuts kg^{-1}	120 nuts
4	Shelling (%)	High (30.10)
5	CNSL content	26-28%
6	Kernel weight	2.50 g
7	Whole kernel count	W210
8	Kernel sugars (%)	5.80-6.50
9	Kernel protein (%)	26%
10	Total fat (%)	38-40 %



Fig. 3.1.3: Key traits of Nethra Samruddhi

The identified variety continued to perform as the best promising type, recording the highest cumulative nut yield of 49.90 kg per tree from 7 harvests with a high shelling percentage of 30.10 %. It was found to be superior over other promising bold and medium nut types like H 32/4, NRC 493, H1616 and Bhaskara (check) for yield (Table. 3.1.4).

Table 3.1.4 : Yield performance of Nethra Samruddhi in comparison with other promising types

Varieties	2019	2020	2021	2022	2023	2024	2025	Cumulative yield	Average kg/plant
Nethra Samruddhi	4.23	2.04	3.84	4.68	7.80	12.93	14.47	49.99	7.14
H 32/4	0.69	0.22	0.14	0.18	2.12	3.73	4.12	11.20	1.60
NRC 493	0.56	0.12	0.22	0.23	2.19	2.97	3.07	9.36	1.34
H 1616	0.42	0.08	0.16	0.23	1.53	2.04	2.62	7.07	1.01
Bhaskara	0.83	0.93	0.91	1.69	3.36	4.58	5.34	17.64	2.52
CD at 5%	0.41	0.664	0.204	0.359	0.673	1.06	1.72		
CV	39.24	40.86	12.56	16.63	12.86	13.09	18.90		
Sem(±)	0.113	0.215	0.066	0.116	0.218	0.344	0.56		

Studies on Cryopreservation and Intergeneric Hybridization

Semecarpus kurzii and 10 other cashew genotypes of *Anacardium occidentale* L., were cryopreserved during the year. The cryopreserved pollen of *Semecarpus kurzii* was utilized for *in vitro* germination and an in vivo pollination. The resulting intergeneric hybrids were field-planted for evaluation, where they exhibited notable morphological variability, particularly in leaf vein patterns, young leaf colour, leaf size and plant height during their first year of growth. Molecular marker validation is currently underway to confirm hybridity (Fig. 3.1.4 and Fig. 3.1.5).



Fig. 3.1.4: Field view of the Intergeneric hybrid lines



Fig. 3.1.5: Variability in leaf shape and pigmentation of young leaves in IGH lines

Evaluation of half-sibs of HYVs

The half-sibs of jumbo nut varieties *viz.*, Nethra Ganga, Nethra Jumbo-1 and dwarf variety *viz.,* Nethra Vaaman are being maintained in the field at Shantigodu. Observations on traits such as plant height, stem girth and canopy spread were recorded. The data was subjected for descriptive statistical analysis, and the results are presented in Table 3.1.5 for Nethra Vaaman, Table 3.1.6 for Nethra Jumbo-1 and Table 3.1.7 for Nethra Ganga. The height in Nethra Vaaman ranged from 0.90 m to 4.23 m, with a mean of 2.01 m, while its average spread ranged from 0.68 m to 3.92 m, with a mean of 1.76 m. The height in Nethra Jumbo-1 ranged from 1.95 m to 3.45 m, with a mean of 2.86 m, whereas its average spread ranged from 0.92 m to 2.70 m with a mean of 1.73 m. The height in Nethra Ganga ranged from 0.90 m to 3.00 m with mean of 1.89 m, and its average spread ranged from 0.30 m to 2.10 m with a mean of 1.17 m.

Table 3.1.5 : Descriptive statistics of growth traits in half-sibs of Nethra Vaaman (n=153)

Descriptive stats	Height (m)	Girth (cm)	Canopy Spread (m)		Avg. Spread (m)
			E-W	N-S	
Mean	2.01	23.49	1.79	1.73	1.76
Standard Error	0.05	0.62	0.05	0.05	0.05
Standard Deviation	0.60	7.73	0.65	0.65	0.64
Sample Variance	0.36	59.73	0.42	0.42	0.40
Kurtosis	2.07	0.56	1.66	1.05	1.17
Skewness	1.39	0.19	1.14	1.06	1.10
Range	3.33	41.00	3.63	3.33	3.24
Minimum	0.90	2.00	0.60	0.60	0.68
Maximum	4.23	43.00	4.23	3.93	3.92

Table 3.1.6: Descriptive statistics of growth traits in half-sibs of Nethra Jumbo-1 (n=8)

Descriptive stats	Height (m)	Girth (cm)	Canopy Spread (m)		Avg. Spread (m)
			E-W	N-S	
Mean	2.86	27.88	1.73	1.73	1.73
Standard Error	0.15	2.47	0.21	0.21	0.21
Standard Deviation	0.43	6.98	0.59	0.59	0.59
Sample Variance	0.19	48.70	0.35	0.35	0.35
Kurtosis	3.09	-0.52	-0.38	-0.36	-0.37
Skewness	-1.25	0.02	0.50	0.46	0.48
Range	1.50	21.00	1.77	1.80	1.79
Minimum	1.95	17.00	0.93	0.90	0.92
Maximum	3.45	38.00	2.70	2.70	2.70

Table 3.1.7 : Descriptive statistics of growth traits in half-sibs of Nethra Ganga (n=110)

Descriptive stats	Height (m)	Girth (cm)	Canopy Spread (m)		Avg. Spread (m)
			E-W	N-S	
Mean	1.89	21.25	1.18	1.15	1.17
Standard Error	0.04	0.34	0.03	0.03	0.03
Standard Deviation	0.42	3.57	0.36	0.35	0.35
Sample Variance	0.18	12.73	0.13	0.12	0.12
Kurtosis	-0.12	-0.54	0.00	-0.10	-0.04
Skewness	0.02	0.02	-0.07	-0.06	-0.09
Range	2.10	16.00	1.80	1.80	1.80
Minimum	0.90	13.00	0.30	0.30	0.30
Maximum	3.00	29.00	2.10	2.10	2.10

3.1.3 Breeding in Cashew for Special traits

Development of dwarf and compact cashew hybrids

Replicated trial of selected hybrids of direct and reciprocal crosses

During the year 2024, 153 plants were maintained in the field (Fig. 3.1.6). There are 20 genotypes, including 10 hybrids, 6 parents and 4 checks (Table 3.1.8). Observations on traits such as tree height, stem girth, average canopy spread, nut yield and nut weight were recorded and analyzed. Genotypes differed significantly for all the traits. For plant height, H6 was shorter (1.77 m) while H3 was the tallest (2.54 m). H4 recorded the lowest average canopy spread (1.86 m), whereas H1 recorded the highest (2.35 m). Nut yield per plant in hybrids ranged from 0.024 kg/plant (H6) to 0.189 kg/plant (H10), while nut weight varied from 4.75 g (H1) to 8.61 g (H6). Nut yield in H10 was significantly higher than all four checks (Table 3.1.8).

Table 3.1.8: Growth and yield characters in hybrids of direct and reciprocal crosses (YOP: 2022)

Code	Cross	Plant height (m)	Stem girth (cm)	Average canopy spread (m)	Nut Weight. (g)	Nut yield/ plant (kg) (1st Harvest)
H1	Vengurla-4×Nethra Vaaman	2.01	25.84	2.35	4.75	0.090
H2	Vengurla-4×Nethra Vaaman	2.03	21.00	1.96	6.73	0.154
H3	Vengurla-4× Taliparamba-1	2.54	24.09	2.26	6.15	0.032
H4	Priyanka × Nethra Vaaman	1.87	23.63	1.86	7.02	0.114
H5	Dhana × Nethra Vaaman	1.77	23.25	1.94	8.61	0.165
H6	Dhana × Taliparamba-1	1.84	23.88	2.11	5.90	0.024
H7	Madakkathara-2×Nethra Vaaman	2.40	28.00	2.42	6.65	0.090
H8	Madakkathara-2×Nethra Vaaman	2.37	27.63	2.41	6.27	0.112
H9	Madakkathara-2×Nethra Vaaman	2.18	28.13	2.60	6.06	0.100

Contd.

Code	Cross	Plant height (m)	Stem girth (cm)	Average canopy spread (m)	Nut Weight. (g)	Nut yield/ plant (kg) (1st Harvest)
H10	Madakkathara-2×Nethra Vaaman	2.24	25.75	2.06	5.93	0.189
P1	Vengurla-4	2.16	21.50	2.10	6.35	0.035
P2	Nethra Vaaman	1.07	16.13	1.26	4.98	0.033
P3	Taliparamba-1	1.62	18.63	1.48	6.15	0.015
P4	Priyanka	2.50	25.88	2.38	6.39	0.111
P5	Dhana	2.23	25.63	2.21	6.86	0.044
P6	Madakkathara-2	2.67	26.25	1.96	6.85	0.209
C1	Bhaskara	2.10	22.38	1.93	5.65	0.056
C2	Nethra Ganga	1.76	21.13	1.68	12.96	0.074
C3	Nethra Jumbo-1	1.85	19.88	1.88	12.65	0.016
C4	Vengurla-7	1.63	19.25	1.79	8.75	0.015
	Mean	2.04	23.39	2.03	7.08	83.88
	SEm±	0.22	2.22	0.22	0.09	49.39
	CD@5%	0.66	6.55	0.66	0.28	145.98
	CV%	15.52	13.41	15.50	1.87	83.27



Fig. 3.1.6 : Field view of replicated trial of selected hybrids of direct and reciprocal crosses

Replicated trial of selected hybrids of backcrosses

During the year 2024, 107 plants were maintained in the field (Fig. 3.1.7). There are 13 genotypes including 6 selected hybrids, three parents and four checks (Table 3.1.9). Vegetative growth characters such as plant height, stem girth and canopy spread were recorded. All the genotypes differed significantly for the vegetative traits. For plant height, BDB-626-58 was shorter (1.08 m) while BDB-372-84 was the tallest (2.19 m). BDB-372-23 recorded the lowest average canopy spread (0.32 m), whereas BDB-372-84 recorded the highest (2.04 m). Nut yield in hybrids ranged from 0.23 kg/plant (BDB-372-60) to 0.38 kg/plant (BDB-626-97), while nut weight varied from 4.80 g (BDB-626-113) to 11.64 g (BDB-372-84).



Fig. 3.1.7 : Field view of replicated trial with backcross selections, parents, and checks

Table 3.1.9: Growth and yield characters of back cross hybrids lines (YOP: 2022)

Hybrid code/variety	Plant height (m)	Stem girth (cm)	Average canopy spread (m)	Nut Weight. (g)	Nut yield/ plant (kg) (1st Harvest)
BDB-372-23	1.62	17.25	0.32	-	-
BDB-372-60	1.98	19.00	1.93	5.35	0.23
BDB-372-84	2.19	20.50	2.04	11.64	0.43
BDB-626-113	1.61	15.68	1.67	4.80	0.05
BDB-626-58	1.08	14.62	1.47	7.20	0.15
BDB-626-97	1.66	17.25	1.56	7.60	0.38
Bhaskara (P1)	1.73	17.87	1.54	7.20	0.19
Nethra Vaaman (P2)	1.17	14.75	1.46	5.40	0.05
BDB-626 (F1)	1.48	16.25	1.65	6.45	0.19
Nehra Ganga	2.11	20.00	2.01	9.69	0.09
Nethra Jumbo-1	1.62	13.62	1.65	-	-
Vengurla-4	1.67	17.12	1.41	6.20	0.05
Vengurla-7	1.39	12.50	1.31	-	-
Mean	1.64	16.65	1.54	-	-
SEm±	0.14	1.05	0.15	-	-
CD@5%	0.43	3.24	0.47	-	-
CV%	15.9	17.8	19.6	-	-

Breeding for improvement of nut size in cluster-bearing genotypes

A total of 435 seedlings of 15 crosses were maintained in the field during the year 2025 (Fig. 3.1.8). Nut yield was recorded in some of the hybrids in each cross, parents and checks. As not all F_1 trees yielded due to heavy pruning and TMB incidence, the statistical analysis of data was not carried out. However, among the yielding hybrid lines, the nut weight ranged from 4.35 to 13.0 g while nut yield ranged from 0.06 to 2.838 kg/tree (Table 3.1.10). The data also revealed that many F_1 trees have intermediate nut weight of their parents, proving improvement in nut weight in the cross combination of small , medium parent and bold nut parents.



Fig. 3.1.8 : Field view of F_1 plants of small nut x bold nut types

Table 3.1.10: Range of nut weight and nut yield in crosses (YOP: 2018)

Sl. No.	Cross (population size)	Status of trees		Nut weight (g)		Nut yield (kg/tree)	
		Total Trees	Trees yielded	Min	Max	Min	Max
1	Nethra Ganga × Ullal-2 (n=33)	33	16	5.70	13.00	0.057	0.802
2	Ullal-2 × Nethra Ganga (n=34)	34	4	6.00	8.69	0.006	0.128
3	NRC 493 × Ullal-2 (n=34)	34	0	0.00	0.00	0.000	0.000
4	Ullal-2 × NRC 493 (n=23)	23	1	0.00	7.58	0.000	0.090
5	Bhaskara × NRC 493 (n=10)	10	0	0.00	0.00	0.00	0.000
6	NRCC Sel-2 × Bhaskara (n=51)	51	6	0.00	5.80	0.000	0.011
7	Ullal-3 × Nethra Ganga (n=22)	22	6	6.20	12.20	0.097	0.924
8	Madakkathara-2 × Nethra Ganga (n=23)	26	11	4.35	10.00	0.019	0.686
9	V-4 × Nethra Ganga (n=40)	40	14	6.50	10.80	0.006	1.278
10	Madakkathara 2 × Nethra Ganga	1	0	0.00	0.00	0.000	0.000
11	Nethra Ganga × NRC 493 (n=31)	31	13	6.00	11.74	0.163	1.527
12	NRC 493 × Nethra Ganga (n=22)	22	15	4.88	10.23	0.029	2.139
13	Nethra Ganga × Ullal 4 (n=46)	46	35	6.50	11.40	0.058	2.1
14	Vengurla 7 × Nethra Ganga (n=28)	28	24	5.80	11.00	0.089	1.748
15	Priyanka × NRC 493 (n=23)	23	8	8.00	11.00	0.225	1.476
16	VRI 3 × Nethra Ganga (n=33)	33	25	5.20	11.00	0.006	2.838

Breeding for reduced tannin content in cashew apples of popular cultivars

A total of 225 plants, including F_1s, checks and parents, planted during October 2023 at Shantigodu Experimental Station in the augmented block design were maintained with proper care during this year (Table 3.1.11).

Table 3.1.11: Crosses and number of plants maintained in field (YOP: 2023)

Cross	Number of plants in the field
Bhaskara × T.No. 81	40
Bhaskara × T.No. 83	32
Vengurla 4 × T.No. 81	56
Vengurla 4 × T.No. 83	56
Checks and parents	41
Total	**225**

Breeding for improving shelling percentage in HYVs

A total of 151 plants, including F_1s, checks and parents, planted during October 2023 at Shantigodu Experimental Station in the augmented block design were maintained with proper care during this year (Table 3.1.12).

Table 3.1.12 : Crosses and number of plants planted (YOP: 2023)

Cross	Number of plants in the field
Vengurla 3 × NRC 393	46
Madakkathara 2 × NRC 393	77
Checks and parents	28
Total	**151**

Breeding for improving nut weight in HYVs

A total of 500 plants, including F_1, checks and parents planted during October 2023 at Shantigodu in the augmented block design were maintained with proper care during this year (Table 3.1.13).

Table 3.1.13 : Crosses and number of plants maintained in field (YOP: 2023)

Cross	Number of plants in the field
Ullal-3 × Nethra Jumbo 1	55
Ullal-3 × NRC 183	40
Ullal-3 × NRC 111	15
Ullal-2 × Nethra Jumbo 1	89
Ullal-2 × NRC 183	43
Ullal-2 × NRC 111	23
Nethra Vamana × Nethra Jumbo 1	49
Bhaskara × Nethra Jumbo 1	92
Checks and parents	94
Total	**500**

Breeding for dwarf types through interspecific hybridization between *A. occidentale* and *A.pumilum*

A total of 92 plants, including F_1s, checks, and parents, planted in October 2023 at Shantigodu in the augmented block design were maintained with proper care this year (Table 3.1.14).

Table 3.1.14 : Crosses and number of plants maintained in field (YOP: 2023)

Cross	Number of plants in the field
A.occidentale var Bhaskara × *A.pumilum*	61
A.occidentale var Nethra Jumbo 1 × *A.pumilum*	4
A.occidentale var Vengurla 7 × *A.pumilum*	2
A.pumilum × *A.occidentale* var Bhaskara	1
Checks and parents	24
Total	**92**

3.1.4 Genetics of traits in cashew

During the year 2024-25, observations such as stem girth (cm), tree height (m), tree spread (m) in E-W and N-W directions were recorded in the plants of six generations (P_1, P_2, F_1, F_2., B_1, B_2). The data was analyzed as per generation mean analysis (GMA) using TNAUSTAT. Scaling test to test the presence of interaction of genes or epistasis, types of gene effects, degree of dominance, heterosis and inbreeding depression were worked out.



Fig. 3.1.9 : Field view of six generations of cashew

Genetics of Plant Height

Mean and variances of generations: The mean and variances of six generations worked out for plant height during this year are presented in (Table 3.1.15).

Table 3.1.15 : Mean and variances of six generations for plant height

Generation	Mean	Var (a)	N (b)	Mean of Var (a/b)	S.E ($\sqrt{a/b}$)
P_1	2.47	0.24	9	0.026	0.16
P_2	1.14	0.02	7	0.003	0.06
F_1	2.02	0.06	8	0.008	0.09
F_2	1.95	0.07	58	0.001	0.04
B_1	2.34	0.19	68	0.003	0.05
B_2	2.15	0.09	35	0.003	0.05

Scaling test: Scale B and D are significant at P=0.5 and P=0.01, indicating the presence of interaction of genes or epistasis (Table 3.1.16). Significance of Scale B indicates the presence of J (additive x dominance interaction), whereas scale D denotes the presence of I (additive x additive interaction).

Table 3.1.16 : Scaling test to indicate the presence or absence of epistasis for plant height

Scale	Value	Var	S.E.	Cal t Value	Table t Value (P=0.05)	Df
A	0.18NS	0.04	0.21	0.83	1.989	df(P_1+F_1+B_1)=9+8+68=85
B	1.13**	0.02	0.15	7.72	2.009	df(P_2+F_1+B_2)=7+8+35=50
C	0.13NS	0.08	0.29	0.44	1.989	df(P_1+P_2+F_1+F_2)=9+7+8+58=82
D	-0.59**	0.01	0.10	-5.78	1.975	df(F_2+B_1+B_2)=58+68+35=161

Interacting crosses: All types of gene effects are highly significant (Table 3.1.17). In general, sum of the interaction components (4.16) is higher than the combined main effects (1.59). Among the interactions, l (dominance x dominance) is larger than i (additive x additive) and j (additive x dominance), while in the main effects, dominance (h) is greater than additive (a). The h and l are in opposite directions(h is positive; l is negative), hence the nature of gene action is duplicate type. The l is negative; hence, it would tend to reduce the heterosis effect for plant height, which is desirable as dwarf plants are preferred for high-density planting.

Table 3.1.17: Estimates of gene effects for plant height in the presence of epistasis (six-parameter model, Hayman 1958)

Gene effect	Value	Var	S.E.	Cal t Value	Table t Value (P=0.05)	Df
m	1.94*	0.001	0.04	54.30	1.97	df(P_1+P_2+F_2+B_1+B_2)= 9+7+8+58+68+35=185
d	0.19*	0.005	0.07	2.54	2.12	df(P_1+P_2)=9+7=16
h	1.40*	0.058	0.24	5.84	1.97	df(P_1+P_2+F_1+F_2+B_1+B_2) =9+7+8+58+68+35=185
I	1.18*	0.04	0.20	5.78	1.97	df(B_1+B_2+F_2)=68+35+58=161
J	-0.48*	0.01	0.11	-4.24	1.98	df(B_1+B_2+P_1+P_2)= 68+35+9+7=119
l	-2.50*	0.17	0.41	-6.08	1.97	df(P_1+P_2+F_2+B_1+B_2) =9+7+58+68+35=177

Heterosis and inbreeding depression: Both positive and negative heterosis effects are non-significant, though interactions are significant (Table 3.1.18). For heterosis to be high, the first part of component (h+l) should be larger than the second part (d+i). In the present case epistasis is of duplicate type (duplicate dominant epistasis), internal cancellation of h (positive) and l (negative) in the first part could reduce the heterosis effect. However, the realized heterosis over the dwarf and better parent ($\overline{P_2}$) is very high (88%), over a tall parent ($\overline{P_1}$) it is 45% (in the negative direction) and over mid-parent ($\overline{P}$) is 22 %. A high heterosis in F_1 follows high inbreeding depression in F_2 provided overdominance is the major cause of heterosis. But, if the heterosis caused largely by non-allelic interactions, the inbreeding effect may be low. In the present case for plant height, the inbreeding depression is low (7 %), and inbreeding effect is also very low (3.46 %), indicating heterosis is caused largely by non-allelic interactions.

Table 3.1.18 : Components of heterosis when epistasis is present

Trait	Heterosis	Components of heterosis	Estimates of heterosis effect[a]	SE[b]	Cal t (a/b)	Table t Value (P=0.05)	at df[b]
Plant height	(+)F_1>P_1	|(h)+(l)|-|(d)-(i)|	|(1.40)+(-2.50)|-|(0.19)–(1.18)| =1.10 – 0.99 = 0.11^{NS}	$\sqrt{[V(h)+V(l)+V(d)+V(i)]}$ = $\sqrt{0.058+0.168+0.005+0.04}$ = $\sqrt{0.504}$ = 0.52	=0.11/0.52 **=0.21**	1.96	df[(h)+(l)+(d)+(i) =185+177+16+161 =539

Trait	Heterosis	Components of heterosis	Estimates of heterosis effect[a]	SE[b]	Cal t (a/b)	Table t Value (P=0.05)	at df[b]
	$(-)F_1<P_1$	|(h)+(l)|-|(-d)-(-I)|	|(1.40)+(-2.50)|-|(-0.19)–(-1.18)| =1.10 – 0.99 = 0.11^{NS}	$\sqrt{[V(h)+V(l)+V(d)+V(i)]}$ = $\sqrt{0.058+0.168+0.005+0.04}$ = $\sqrt{0.504}$ = 0.52	=0.11/0.52 **=0.21**	1.96	df[(h)+(l)+(d)+(i) =185+177+16+161 =539

Values in $\sqrt{[V(h)+V(l)+V(d)+V(i)]}$ are squared values of corresponding SE values

Genetics of stem girth

Mean and variances of generations: The mean and variances of six generations worked out for stem girth during this year is presented in Table 3.1.19.

Scaling test: Scale A, B and D are significant at P=0.5 and P=0.01, indicating the presence of interaction of genes or epistasis (Table 3.1.20). Significance of Scale A and B indicates the presence of J (additive x dominance interaction), whereas scale D denotes the presence of i (additive x additive interaction).

Table 3.1.19 Mean and variances of six generations

Generation	Mean	Var (a)	N (b)	Mean of Var (a/b)	S.E ($\sqrt{a/b}$)
P_1	2.19	0.14	9	0.016	0.12
P_2	0.71	0.09	7	0.013	0.11
F_1	1.94	0.08	8	0.010	0.10
F_2	1.72	0.19	58	0.003	0.06
B_1	2.31	0.20	68	0.003	0.05
B_2	1.92	0.35	35	0.010	0.10

Table 3.1.20 : Scaling test to indicate the presence or absence of epistasis

Scale	Value	Var	S.E.	Cal t Value	Table t Value (P=0.05)	Df
A	0.50**	0.04	0.19	2.597	1.989	$df(P_1+F_1+B_1)=9+8+68=85$
B	1.20**	0.06	0.25	4.813	2.00	$df(P_2+F_1+B_2)=7+8+35=50$
C	0.01NS	0.12	0.35	0.284	1.989	$df(P_1+P_2+F_1+F_2)=9+7+8+58=82$
D	-0.80**	0.03	0.16	-4.985	1.975	$df(F_2+B_1+B_2)=58+68+35=161$

Interacting crosses: All types of gene effects are highly significant (Table 3.1.21). In general, sum of the interaction components (5.27) is higher than the combined main effects (2.49). Among the interactions, l (dominance x dominance) is larger than i (additive x additive) and j (additive x dominance), while in the main effects, dominance (h) is greater than additive (a). The h and l are in opposite directions (h is positive; l is negative), hence the nature of gene action is duplicate type. The l is negative; hence, it would tend to reduce the heterosis effect for stem girth, which is not desirable as it is positively correlated with yield.

Table 3.1.21 Estimates of gene effects for stem girth in the presence of epistasis (6-parameter model, Hayman 1958)

Gene effect	Value	Var	S.E.	Cal t Value	Table t Value (P=0.05)	Df
m	1.72**	0.003	0.06	30.15	1.97	df(P_1+P_2+F_2+B_1+B_2) =9+7+8+58+68+35=185
d	0.39**	0.013	0.11	3.41	2.12	df(P_1+P_2)=9+7=16
h	2.10**	0.121	0.35	6.03	1.97	df(P_1+P_2+F_1+F_2+B_1+B_2) =9+7+8+58+68+35=185
I	1.61**	0.104	0.32	4.98	1.97	df(B_1+B_2+F_2)=68+35+58=161
J	-0.35*	0.020	0.14	-2.49	1.98	df(B_1+B_2+P_1+P_2)= 68+35+9+7=119
l	-3.31**	0.326	0.57	-5.79		1.97df(P_1+P_2+F_2+B1+B_2) =9+7+58+68+35=177

Heterosis and inbreeding depression: Both positive and negative heterosis effects are non-significant though interactions are significant (Table 3.1.22). In the present case epistasis is of the duplicate type (duplicate dominant epistasis), internal cancellation of h (positive) and l (negative) in the first part could reduce the heterosis effect. However, the realized heterosis over dwarf and better parent is very high (120 %), over tall parent ($\overline{P_1}$) it is 25 % (in negative direction) and over mid parent ($\overline{P}$) is 49 %. A high heterosis in F_1 follows high inbreeding depression in F_2 provided overdominance is the major cause of heterosis. But, if the heterosis is caused largely by non-allelic interactions, the inbreeding effect may be low. In the present case for stem girth, the inbreeding depression is moderate (22 %) and the inbreeding effect is low (11.34 %), indicating heterosis is caused largely by non-allelic interactions.

Table 3.1.22 : Components of heterosis when epistasis is present

Trait	Heterosis	Components of heterosis	Estimates of heterosis effect[a]	SE[b]	Cal t (a/b)	Table t Value (P=0.05)	at df[b]
Stem girth	$(+)\overline{F_1}>\overline{P_1}$	|(h)+(l)|-|(d)-(i)|	|(2.10)+(-3.31)|-|(0.39)–(1.61)| =1.21 – 1.22 = 0.01^{NS}	$\sqrt{[V(h)+V(l)+V(d)+V(i)]}$ = $\sqrt{0.12}$+ 0.32+ 0.01+0.10 = $\sqrt{0.504}$ = 0.74	=0.01/0.74 **=0.013**	1.96	df[(h)+(l)+(d)+(i) =185+177+16+161 =539
	$(-)\overline{F_1}<\overline{P_2}$	|(h)+(l)|-|(-d)-(-i)|	|(2.10)+(-3.31)|-|(-0.39)–(1.61)| =1.21 – 1.22 = 0.01^{NS}	$\sqrt{[V(h)+V(l)+V(d)+V(i)]}$ = $\sqrt{0.12}$+ 0.32+ 0.01+0.10 = $\sqrt{0.504}$ = 0.74	=0.01/0.74 **=0.013**	1.96	df[(h)+(l)+(d)+(i) =185+177+16+161 =539

Values in $\sqrt{[V(h)+V(l)+V(d)+V(i)]}$ are squared values of corresponding SE values

Genetics of tree spread

Mean and variances of generations: The mean and variances six generations worked out for tree spread during this year is presented in the Table 3.1.23 .

Scaling test: Scale A, B and D are significant (at P=0.5) indicating presence of interaction of genes or epistasis (Table 3.1.24.). Significance of Scale A and B indicates presence of J (additive x dominance interaction) whereas scale D denotes presence of i (additive x additive interaction).

Table 3.1.23 : Mean and variances of six generations for tree spread

Generation	Mean	Var (a)	N (b)	Mean of Var (a/b)	S.E ($\sqrt{a/b}$)
P_1	2.13	0.15	9	0.017	0.13
P_2	0.86	0.06	7	0.009	0.09
F_1	1.92	0.06	8	0.008	0.09
F_2	1.67	0.16	58	0.003	0.05
B_1	2.24	0.19	68	0.003	0.05
B_2	1.89	0.28	35	0.008	0.09

Table 3.1.24 : Scaling test to indicate presence or absence of epistasis

Scale	Value	Var	S.E.	Cal t Value	Table t Value (P=0.05)	Df
A	0.42*	0.03	0.19	2.26	1.989	df(P_1+F_1+B_1)=9+8+68=85
B	0.99**	0.05	0.22	4.51	2.009	df(P_2+F_1+B_2)=7+8+35=50
C	-0.14NS	0.10	0.31	-0.43	1.989	df(P_1+P_2+F_1+F_2)=9+7+8+58=82
D	-0.77**	0.02	0.15	-5.23	1.975	df(F_2+B_1+B_2)=58+68+35=161

Interacting crosses: All types of gene effects are highly significant (Table 3.1.25). In general, sum of the interaction components (4.79) is higher than combined main effects (2.32). Among the interactions, l (dominance x dominance) is larger than i (additive x additive) and j (additive x dominance) while in the main effects dominance (h) is greater than additive (a). The h and l are in opposite direction (h is positive; l is negative), hence the nature of gene action is duplicate type. The l is negative; hence it would tend to reduce the heterosis effect for tree spread which is desirable as low tree spread suitable for high density planting.

Table 3.1.25 : Estimates of gene effects for tree spread in the presence of epistasis (6 parameter model, Hayman 1958)

Gene effect	Value	Var	S.E.	Cal t Value	Table t Value (P=0.05)	Df
m	1.67**	0.00	0.05	31.80	1.97	df(P_1+P_2+F_2+B_1+B_2)= 9+7+8+58+68+35=185
d	0.35**	0.01	0.10	3.37	2.12	df(P_1+P_2)=9+7=16
h	1.97**	0.10	0.32	6.19	1.97	df(P_1+P_2+F_1+F_2+B_1+B_2) =9+7+8+58+68+35=185
I	1.55**	0.09	0.30	5.23	1.97	df(B_1+B_2+F_2)=68+35+58=161
J	-0.28*	0.02	0.13	-2.17	1.98	df(B_1+B_2+P_1+P_2)= 68+35+9+7=119
l	-2.96**	0.27	0.52	-5.68	1.97	df(P_1+P_2+F_2+B_1+B_2) =9+7+58+68+35=177

Heterosis and inbreeding depression: Both positive and negative heterosis effects are non-significant though interactions are significant (Table 3.1.26). In the present case epistasis is of duplicate type (duplicate dominant epistasis), internal cancellation of h (positive) and l (negative) in the first part could reduce the heterosis effect. However, the realized heterosis over dwarf and better parent (P_2) is very high (106%), over tall parent (P_1) it is 20% (in negative direction) and over mid parent (P) is 42 %. A high heterosis in

F_1 follows high inbreeding depression in F_2 provided overdominance is the major cause of heterosis. But, if the heterosis caused largely by non-allelic interactions, inbreeding effect may be low. In the present case for tree spread, the inbreeding depression is moderate (22 %) and inbreeding effect is low (13.02 %) indicating heterosis is caused largely by non-allelic interactions.

Table 3.1.26 : Components of heterosis when epistasis is present

Trait	Heterosis	Components of heterosis	Estimates of heterosis effect[a]	SE[b]	Cal t (a/b)	Table t Value (P=0.05)	at df[b]
Tree spread	$(+)\overline{F_1}>\overline{P_1}$	|(h)+(l)|-|(d)-(i)|	|(1.97)+(-2.96)|-|(0.35)–(1.55)| =0.99 – 1.20 = 0.21^{NS}	$\sqrt{[V(h)+V(l)+V(d)+V(i)]}$ = $\sqrt{0.10+0.27+0.01+0.09}$ = $\sqrt{0.504}$ = 0.69	=0.21/0.69 **=0.30**	1.96	df[(h)+(l)+(d)+(i) =185+177+16+161 =539
	$(-)\overline{F_1}<\overline{P_1}$	|(h)+(l)|-|(-d)-(-i)|	|(1.97)+(-2.96)|-|(0.35)–(1.55)| =0.99 – 1.20 = 0.21^{NS}	$\sqrt{[V(h)+V(l)+V(d)+V(i)]}$ = $\sqrt{0.10+0.27+0.01+0.09}$ = $\sqrt{0.504}$ = 0.69	=0.21/0.69 **=0.30**	1.96	df[(h)+(l)+(d)+(i) =185+177+16+161 =539

Values in $\sqrt{[V(h)+V(l)+V(d)+V(i)]}$ are squared values of corresponding SE values

3.1.5 Polyploidy breeding in Cashew

Development of polyclonal hybrids from core collections

42 polyclonal progenies from 9 core accessions, which were generated last year, were planted in the main field (Fig. 3.1.10). During this year, a total of 155 nuts were collected from 13 core accessions and sown in the nursery. Previously established 145 polyclonal hybrids in Kemminje and 907 in Shanthigodu were maintained for evaluation with checks (Table 3.1.27).





Fig. 3.1.10 : Polyclonal hybrids generated and planted during the year

Table 3.1.27 : Summary of characters in polyclonal hybrids under evaluation

Traits	Highest	Lowest	Checks
Height	3.5 m (NRC-01-1)	0.75 m (NRC-138-110)	2.57 m (Bhaskara) 1.68 m Vengurla-4
Girth	32 cm (NRC-301-45)	4.0 cm (NRC-349-136)	19.66 cm (Bhaskara) 11.5 cm Vengurla-4
Spread	3.25 m (NRC-01-3)	0.23 m (NRC-138-109)	2.21 m (Bhaskara) 1.37 m Vengurla-4
Yield	NRC-300-68: 97.8 g and 12.3 g nut weight		

Polyploidy Breeding in Cashew

A total of 458 plants (developed from treated seeds and seedlings) were planted for evaluation in an augmented block design (with six blocks) along with Bhaskara, Nethra Vaaman, and Vengurla-4 as checks (Fig. 3.1.11). It may be expected that some plants/progenies may have advantages such as high yield, improved nut and apple size, *etc.* During the year, the yield and yield-attributing characters could be recorded in some accessions. The plants are under observation to prioritize the accessions for flow cytometry analysis.



Fig. 3.1.11 : Field view of the polyploidy plot

Geitonogamy studies: 16 geitonogamous progenies from varieties, namely Nethra Vaaman and Taliparamba, were planted in the main field.

3.1.6 Evaluation of dwarf and semi-dwarf accessions and their seedling progenies for a high-density planting system

Plants of 16 dwarf and semi-dwarf accessions collated from different parts of the country are planted in the field in a split-plot design with three replications for evaluation. Spacing as the main plot (Three spacings – 3 m x 3 m, 4 m x 4 m, and 5 m x 5 m) and varieties as the subplot were taken (Fig. 3.1.12). The trial included a total of 576 plants. Surrounding the trial, the plants of high-yielding varieties such as V-7, H-126, H-130, and Bhaskara were planted for introgressions of genes to dwarf and semi-dwarf accessions. In addition to per se evaluation, Seedling selection will be done from these accessions for the identification of dwarf types with high yield. During the year, plant height, girth, and tree spread were recorded on all accessions. However, yield could not be recorded in all the accessions (Table 3.1.28) (Fig. 3.1.13).



Fig. 3.1.12 : Overview of the dwarf variety trial

Table 3.1.28 : Means of different traits in accessions

Accessions	PH (m)	GR(cm)	TS (m)	NW (g)	Yield (Kg/plant) 2025	Yield (Kg/plant) 2024	Cumulative Yield (Kg/plant)
HC-6	1.417	14.222	1.654	5.20	0.0264	-	0.026
Nethra Vaaman	0.946	11.056	1.043	5.24	0.0287	0.01	0.039
BDB-58	1.856	19.250	1.990	8.34	0.3933	0.17	0.563
DB-626	1.760	18.750	2.015	7.90	0.3587	0.03	0.389
VRI-3	1.715	15.889	1.758	6.66	0.0825	0.05	0.133
H-3831	1.558	16.056	1.665	6.00	0.0719	0.02	0.092
Taliparamba	1.278	16.278	1.449	5.00	0.0128	0.04	0.053
NRC 312	1.711	15.250	1.610	5.60	0.0490	-	0.049
NRC 314	1.797	17.194	1.767	5.12	0.0483	0.02	0.068
NRC 415	2.276	22.583	2.530	7.20	0.0301	0.04	0.070
NRC 315	1.707	19.056	1.848	5.40	0.1004	0.04	0.140
NRC 313	1.443	13.611	1.333	6.42	0.0338	-	0.034
NRC 214	2.154	23.472	2.114	7.60	0.0923	0.02	0.112
NRC 306	2.201	19.611	1.840	5.80	0.1166	0.04	0.157
B. Bonsai Kaju	1.593	15.639	1.650	6.44	0.1712	0.03	0.201



Fig. 3.1.13: Yield in BDB-58 accession

New Crosses made in the year 2025: An extensive review was made regarding the hybridisation efforts at the institute, and according few new crosses were effected involving Nethra Ganga, Bhaskara, Vengurla-7, and Nethra Jumbo-1 varieties during the year, and they were sown in the nursery to raise seedlings and subsequently planted in the field (Table 3.1.29) (Fig.3.1.14).

Table 3.1.29 : New cross combination attempted during the year 2025

Details	Nethra Ganga x Bhaskara	Bhaskara x Nethra Ganga	Bhaskara x Vengurla-7	Bhaskara x Nethra Jumbo-1	Nethra Jumbo-1 x Bhaskara
Total crosses made	224	239	286	218	252
Total nuts obtained	34	60	88	61	35
Percentage of seed setting (%)	15.76	25.10	30.77	21.70	13.49
Total number of seeds germinated	12	48	74	49	02
Germination percentage (%)	35.29	80	84.09	80.32	5.71

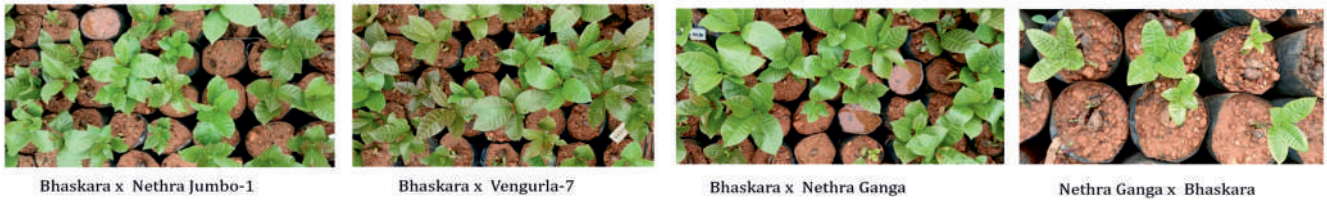


Fig. 3.1.14 : Progenies of new crosses done during the year 2025

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

In the project, identification, and expression profiling of Gibberellin 2-Oxidase (GA2OX) family genes in a set of tissues (leaf shoots, flower buds, nuts and cashew apples) at different stages of development was carried out. Among the five GA2OX genes, GA2OX2 and GA2OX3 were highly expressed in the reproductive tissues, suggesting their putative role in the transition from the vegetative to reproductive phase. Further, DNA fingerprinting of newly developed cashew varieties from DCR and AICRP centres was carried out using a set of highly polymorphic SSR markers. Genome-wide methylation patterns in 24 germplasm accessions were investigated using methylation-sensitive enzymatic digestions and the AMP-PCR technique. It provided insights into the epigenetic diversity present in cashew accessions.

Phenotypic evaluation of F_1 mapping populations was conducted for key nut yield related traits (nut/kernel weight, nut/kernel dimensions) and biochemical parameters to facilitate QTL mapping and trait selection. Rapid CNSL and Kernel oil extraction protocols useful for efficient analysis of a large number of samples in a short period of time were developed. The nut weight evaluation revealed a notable variation among the crosses. Mean values ranged from 6.52 (BD×NRC188) to 8.68 (BK×H-130), with most crosses showing intermediate performance. The range of variation was broad, particularly in V7×NRC116 (4.33–11.78) and BK×H-130 (7.01–12.57), indicating substantial within-cross variability. Further, most individuals were distributed in the 6–8 g class (59), followed by >8–10 g (34), while fewer were in the <6 g (23) and >10 g (6) categories.

New crosses targeting enhanced nut yield and unique traits [such as low apple to nut (AN) ratio, flowering intensity] were done by utilizing characterized germplasm. Crosses include: NRC580 × Bhaskara/ H-130/NRC383/NRC298; Bhaskara × NRC580 /NRC176/ NRC383, NRC298 × NRC580; H-130×NRC580 /NRC298/ Bhaskara/ NRC385/ NRC383/ NRC183/ NRC176/ NRC278.

3.1.8 Deciphering the molecular basis of Cashew-Tea Mosquito Bug (TMB) interactions to understand host response and TMB effectors

Most stable reference genes (RGs) were identified for genes expression analysis in Cashew-TMB interactions. Evaluated six candidate RGs (EF1, RPL11, LSM5, GRL, UBQ, NADH) for expression stability during Cashew–TMB interactions. EF1 was identified as the most stable RG across four time points (6, 18, 30, and 48 hours) after infestation in two cashew varieties (Bhaskara and Vengurla 4) and was used for normalization of target genes expressions in subsequent Cashew-TMB interactions studies. Further, mining and expression profiling of candidate resistance (R) genes in cashew: Candidate R genes were identified through in silico analyses of transcriptomic datasets using the DRAGO3 online tool. Temporal expression analysis of R genes at different time points (6, 18, 30, and 48 hours) after TMB infestation showed significant differential expression in cashew genotypes varying in susceptibility to TMB. One of the candidate R genes, R23, showed maximum upregulation in the highly susceptible Vengurla 4 variety (e.g., 14.67-fold at 18 hai and 34.13-fold at 48 hai) compared to the moderately susceptible Bhaskara variety (0.81-fold and 8.33-fold, respectively). These findings provide foundational insights into the potential molecular targets for enhancing TMB resistance in cashew.

3.1.9 Physiological, Biochemical and Molecular Characterization of Cashew Accessions for Drought Stress

The study identified drought tolerant cashew varieties using a multi-trait genotype ideotype distance index (MGIDI), ranking 'Priyanka' and 'Bhaskara' as drought-tolerant, while 'Ullal-2', 'Vengurla-2', and 'Madakkathara-1' were classified as drought-sensitive under water-limited conditions. It quantified significant drought-induced impacts, including a 63.2% reduction in yield and substantial physiological impairments such as a 59.7% decline in chlorophyll content, along with reduced nutrient uptake and membrane stability in sensitive varieties, thereby establishing reliable indicators of drought susceptibility. The research further elucidated key adaptive mechanisms underlying drought tolerance, demonstrating that tolerant varieties sustain higher antioxidant enzyme activities, including ascorbate peroxidase and polyphenol oxidase, and accumulate Osmo protectants such as proline and soluble sugars, which contribute to oxidative stress mitigation and osmotic adjustment. Additionally, distinct metabolic and hormonal signatures associated with drought resilience were identified, including increased levels of phenolic acids, flavonoids, and stress-responsive phytohormones such as abscisic acid, jasmonic acid, and indole-3-acetic acid, all of which showed positive correlations with nut yield under drought conditions. Overall, the study developed an integrated, trait-based selection framework that links physiological, biochemical, metabolic, and hormonal responses with yield stability, offering robust criteria for breeding and deploying climate-resilient cashew cultivars suitable for rainfed and marginal environments.

Maintenance of Water Status and Photosynthetic Stability under Drought

Priyanka consistently maintained the highest relative water content under drought stress in both years and exhibited the lowest membrane leakage, indicating superior cellular stability and drought tolerance (Table 3.1.30).

Madakkathara-1 and VTH-30/4 recorded the lowest relative water content in year 1 and year 2, respectively, while VRI-1 showed the highest membrane leakage under drought in both years, confirming its susceptibility to drought stress.

Table 3.1.30 : Effect of drought stress on relative water content and membrane leakage of seventeen cashew varieties during year 1 (2020-21) and year 2 (2021-22)

Varieties	Treatment	Relative water content (%)		Membrane leakage (%)	
		Year 1	Year 2	Year 1	Year 2
Bhaskara	Control	76.4±1.38^{bcde}	74.4± 5.05^{abc}	25.6±1.99^{mno}	29.9±2.71^{op}
	Drought	59.5±3.72^{gh}	50.2±5.58^{gh}	50.2±4.82^{hi}	66.8±3.41^{h}
Madakkathara-1	Control	72.6±2.95^{ef}	70.2±1.22^{cdef}	31.9±0.96^{kl}	43.0±2.03^{j}
	Drought	30.5±2.61^{m}	32.1±3.32^{jk}	96.7±1.49^{a}	93.2±2.08^{d}
Madakkathara-2	Control	79.7±1.38^{ab}	68.9±1.41^{def}	31.7±1.80^{kl}	42.9±4.52^{j}
	Drought	47.3±1.64^{k}	35.9±1.60^{j}	83.8±1.51^{e}	85.1±2.46^{d}
Priyanka	Control	81.4±0.78^{a}	77.5±3.48^{a}	20.1±2.58^{p}	26.7±2.19^{p}
	Drought	61.8±3.84^{g}	54.1±1.91^{g}	46.3±1.85^{ij}	66.7±2.47^{h}
Selection-2	Control	77.7±3.65^{abc}	75.7±2.13^{ab}	33.3±1.75^{k}	44.5±3.17j
	Drought	48.5±1.48^{k}	34.7±1.32jk	83.9±1.55^{de}	85.9±2.39^{cd}
Ulall-2	Control	74.4±1.22^{cde}	73.4±3.24^{abcd}	42.1±3.15^{j}	53.3±3.10^{i}
	Drought	33.6±3.47^{m}	31.5±2.40^{jk}	94.9±1.40^{ab}	93.2±4.00^{ab}
Ullal-1	Control	70.2±1.24^{f}	66.7±3.38^{ef}	30.1±2.06^{klm}	41.3±1.30^{jk}
	Drought	42.8±5.19^{l}	30.5±4.18^{k}	87.8±2.78^{cde}	88.9±2.86^{cd}
Ullal-3	Control	75.7±1.47^{bcde}	73.4±5.89^{abcd}	23.1±1.44^{nop}	33.2±0.78^{mno}
	Drought	56.5±1.55^{hi}	47.8±2.10^{hi}	52.6±1.75^{h}	76.3±2.45^{ef}
Vengurla-1	Control	76.3±2.17^{bcde}	73.3±3.07^{abcd}	33.7±3.342^{k}	44.9±2.35^{j}
	Drought	42.4±2.33^{l}	34.42.27^{jk}	88.7±2.095^{cd}	89.4±2.35^{bc}
Vengurla-2	Control	76.4±1.81^{bcde}	74.9±2.80^{bcde}	33.2±1.68^{k}	44.4±1.66^{j}
	Drought	40.1±4.481^{def}	34.3±2.48^{jk}	90.6±1.38^{bc}	89.5±1.05^{bc}
Vengurla-3	Control	73.4±0.781^{k}	71.3±1.15^{bcde}	29.5±5.071^{klm}	37.8±2.26^{kl}
	Drought	47.3±1.90^{bcde}	33.8±4.94^{jk}	60.9±7.07^{f}	72.3±1.80^{fg}
Vengurla-4	Control	76.4±1.82^{gh}	72.9±3.764^{abcd}	21.2±1.21^{op}	30.1±4.96^{nop}
	Drought	57.9±2.08^{f}	49.9±1.47^{gh}	50.8±7.37^{hi}	77.6±2.60^{e}
Vengurla-7	Control	69.8±1.22^{gh}	73.6±1.48^{abcd}	22.6±2.45^{nop}	30.2±1.41^{nop}
	Drought	58.9±1.51^{bcd}	48.9±1.24^{h}	53.1±2.15^{gh}	67.2±2.00^{h}
VRI-1	Control	77.3±0.854^{l}	73.5±1.57^{abcd}	44.2±1.05^{j}	51.0±2.10^{i}
	Drought	39.8±1.01^{f}	33.7±5.90^{jk}	95.7±2.21^{a}	95.6±4.37^{a}
VRI-3	Control	69.6±1.86^{h}	72.7±2.22^{abcd}	27.3±2.95^{lmn}	34.1±0.96^{lmn}
	Drought	56.8±0.872^{ab}	46.2±2.78^{hi}	54.8±2.27^{gh}	74.9±2.45^{ef}
VTH-174	Control	78.9±1.96^{ij}	76.3±1.30^{a}	24.5±1.15^{nop}	35.7±1.63^{lm}
	Drought	52.7±4.37^{f}	43.4±3.21^{i}	57.8±3.90^{fg}	74.3±1.80^{efg}
VTH-30/4	Control	70.1±1.78^{jk}	65.7±2.43^{f}	22.4±1.94^{op}	35.7±1.60^{lm}
	Drought	50.3±3.31^{bc}	30.1±2.05^{k}	52.8±3.21^{h}	70.3±1.80^{gh}

[Means (n=3 biological replicates) ± standard deviation with different letters are significantly different at p<0.05]

Established chlorophyll retention as a robust drought-tolerance trait in cashew, demonstrating a 35–50% drought-induced reduction in leaf chlorophyll across varieties, with Priyanka consistently maintaining the highest chlorophyll levels (Table 3.1.31) under stress, while Ullal-1 showed maximum decline, clearly distinguishing tolerant and sensitive genotypes.

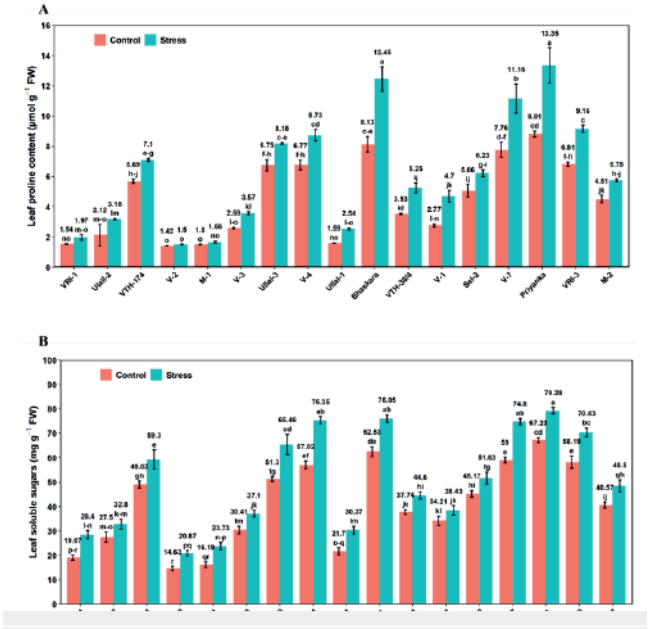
Table 3.1.31: Effect of drought stress on leaf photosynthetic pigments of seventeen cashew varieties during year 1(2020-21) and year 2 (2021-22)

Varieties	Treatment	Chlorophyll a (mg g^{-1} FW)		Chlorophyll b (mg g^{-1} FW)		Total chlorophyll (mg g^{-1}FW)	
		Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
Bhaskara	Control	1.55 ±0.026 ^{b}	1.48±0.036^{b}	1.58±0.017 ^{a}	1.42±0.053 ^{b}	2.66±0.035^{ab}	2.59±0.026^{ab}
	Drought	0.98±0.026^{lm}	0.98±0.035^{ij}	1.05±0.020 ^{hi}	0.92±0.026 ^{hi}	1.55±0.046^{lm}	1.50±0.079 ^{h}
Madakka thara-1	Control	1.13±0.044^{K}	1.16±0.053^{f}	1.17±0.026 ^{def}	0.84±0.020 ^{jk}	1.71±0.070 ^{ij}	1.69±0.061^{f}
	Drought	0.81±0.062^{O}	0.78±0.026^{lm}	0.66±0.035 ^{nop}	0.51±0.036 ^{opq}	1.06±0.020 ^{v}	0.86±0.046 ^{o}
Madakka thara-2	Control	1.42±0.017^{e}	1.09±0.017^{g}	1.22±0.026 ^{d}	1.18±0.017 ^{de}	1.94±0.017^{g}	1.83±0.026 ^{e}
	Drought	0.76±0.017^{opq}	0.80±0.026^{lm}	0.83±0.017 ^{lm}	0.68±0.020^{mn}	1.39±0.026 ^{op}	1.28±0.062 ^{k}
Priyanka	Control	1.64±0.053^{b}	1.56±0.01^{a}	1.60±0.062 ^{a}	1.52±0.087^{a}	2.70±0.061 ^{a}	2.65±0.020 ^{a}
	Drought	1.03±0.020l	1.05±0.020^{gh}	1.10±0.017 ^{gh}	0.97±0.017 ^{gh}	1.64±0.062^{jk}	1.59±0.026 ^{g}
Selection-2	Control	1.30±0.026^{fg}	1.04±0.017^{gh}	1.05±0.044 ^{hi}	1.00±0.061 ^{g}	2.16±0.017^{f}	2.09±0.070^{d}
	Drought	0.73±0.053^{q}	0.77±0.026^{m}	0.63±0.017 ^{opq}	0.48±0.044 ^{pqr}	1.30±0.072 ^{qr}	1.27±0.026 ^{k}
Ulall-2	Control	1.28±0.020^{fgh}	0.91±0.070^{k}	1.13±0.036 ^{no}	0.97±0.020 ^{gh}	1.53±0.026 ^{lm}	1.50±0.070^{h}
	Drought	0.64±0.017^{r}	0.58±0.026^{o}	0.68±0.020 ^{lm}	0.53±0.026 ^{op}	1.10±0.044 ^{uv}	0.93±0.079^{no}
Ullal-1	Control	1.33±0.079^{f}	1.29±0.053^{e}	0.79±0.036 ^{m}	0.70±0.062 ^{mn}	1.59±0.070 ^{kl}	1.49±0.026^{C}
	Drought	0.62±0.079^{r}	0.40±0.020^{p}	0.59±0.030 ^{q}	0.44±0.026^{r}	0.88±0.070 ^{w}	0.77±0.066 ^{p}
Ullal-3	Control	1.45±0.070^{de}	1.40±0.020^{d}	1.23±0.061 ^{d}	1.20±0.010 ^{d}	2.37±0.026 ^{d}	2.33±0.061^{c}
	Drought	0.92±0.036^{mn}	0.96±0.053^{jk}	0.83±0.026 ^{lm}	0.78±0.020 ^{kl}	1.30±0.062 ^{qr}	1.27±0.066^{k}
Vengurla-1	Control	1.22±0.017^{hij}	1.17±0.026^{f}	0.95±0.132 ^{jk}	0.84±0.020 ^{jk}	1.82±0.020^{h}	1.76±0.035^{ef}
	Drought	0.71±0.078^{q}	0.68±0.036^{n}	0.63±0.026 ^{opq}	0.48±0.017 ^{pqr}	1.20±0.036 st	1.12±0.020^{l}
Vengurla-2	Control	1.18±0.017^{jk}	1.06±0.053^{gh}	1.06±0.020 ^{hi}	0.90±0.026 ^{ij}	1.72±0.044^{i}	1.70±0.020 ^{f}
	Drought	0.74±0.036^{pq}	0.60±0.017^{o}	0.60±0.072 ^{pq}	0.45±0.053^{qr}	1.11±0.026 ^{uv}	0.97±0.017^{mn}
Vengurla-3	Control	1.23±0.044^{hij}	1.18±0.017^{f}	1.17±0.026 ^{def}	1.10±0.044 ^{f}	2.70±0.079 ^{a}	2.56±0.026 ^{b}
	Drought	0.73±0.026^{q}	0.60±0.070^{o}	0.69±0.026 ^{no}	0.54±0.046 ^{op}	1.11±0.026 ^{uv}	1.01±0.010 ^{m}
Vengurla-4	Control	1.47±0.026^{cde}	1.42±0.017^{cd}	1.20±0.044 ^{de}	1.19±0.036 ^{de}	2.42±0.017^{cd}	2.40±0.062 ^{c}
	Drought	0.95±0.020^{cde}	0.98±0.036^{ij}	0.88±0.017 ^{l}	0.73±0.070 ^{lm}	1.33±0.036^{pq}	1.30±0.044 ^{jk}
Vengurla-7	Control	1.52±0.026^{bc}	1.46±0.053^{bc}	1.48±0.026 ^{b}	1.39±0.026 ^{bc}	2.62±0.044 ^{b}	2.55±0.062^{b}
	Drought	0.96±0.053^{m}	0.97±0.020^{j}	1.01±0.017 ^{ij}	0.90±0.070^{ij}	1.52±0.070 ^{lm}	1.47±0.053^{h}
VRI-1	Control	1.19±0.026^{bcd}	1.03±0.017^{hi}	1.05±0.020 ^{hi}	0.93±0.017 ^{hi}	1.67±0.026 ^{ij}	1.59±0.026 ^{g}
	Drought	0.72±0.044^{q}	0.63±0.062^{no}	0.72±0.026 ^{n}	0.57±0.026 ^{o}	1.15±0.017 ^{tu}	0.97±0.020^{mn}
VRI-3	Control	1.49±0.070^{bcd}	1.41±0.036^{cd}	1.34±0.017 ^{c}	1.33±0.026 ^{c}	2.49±0.036 ^{c}	2.37±0.035 ^{c}
	Drought	0.88±0.026^{n}	0.93±0.026^{jk}	0.89±0.036 ^{kl}	0.89±0.026^{ij}	1.48±0.026 ^{mn}	1.44±0.020^{hi}
VTH-174	Control	1.32±0.020^{f}	1.26±0.026^{e}	1.15±0.030 ^{efg}	1.13±0.017 ^{ef}	1.93±0.035 ^{g}	2.12±0.036 ^{d}
	Drought	0.80±0.036^{op}	0.83±0.010^{l}	0.70±0.036^{n}	0.55±0.062 ^{o}	1.23±0.061 ^{rs}	1.18±0.017^{l}
VTH-30/4	Control	1.25±0.046^{ghi}	1.20±0.017^{f}	1.04±0.017 ^{hi}	1.01±0.017^{g}	2.29±0.046 ^{e}	2.16±0.035 ^{d}
	Drought	0.73±0.036^{q}	0.58±0.026^{o}	0.81±0.026 ^{m}	0.66±0.061 ^{n}	1.41±0.036 ^{no}	1.37±0.026 ^{ij}

[Means (n=3 biological replicates) ± standard deviation with different letters is significantly different at p<0.05]

Osmotic Adjustment and Antioxidant Defense under Drought Stress

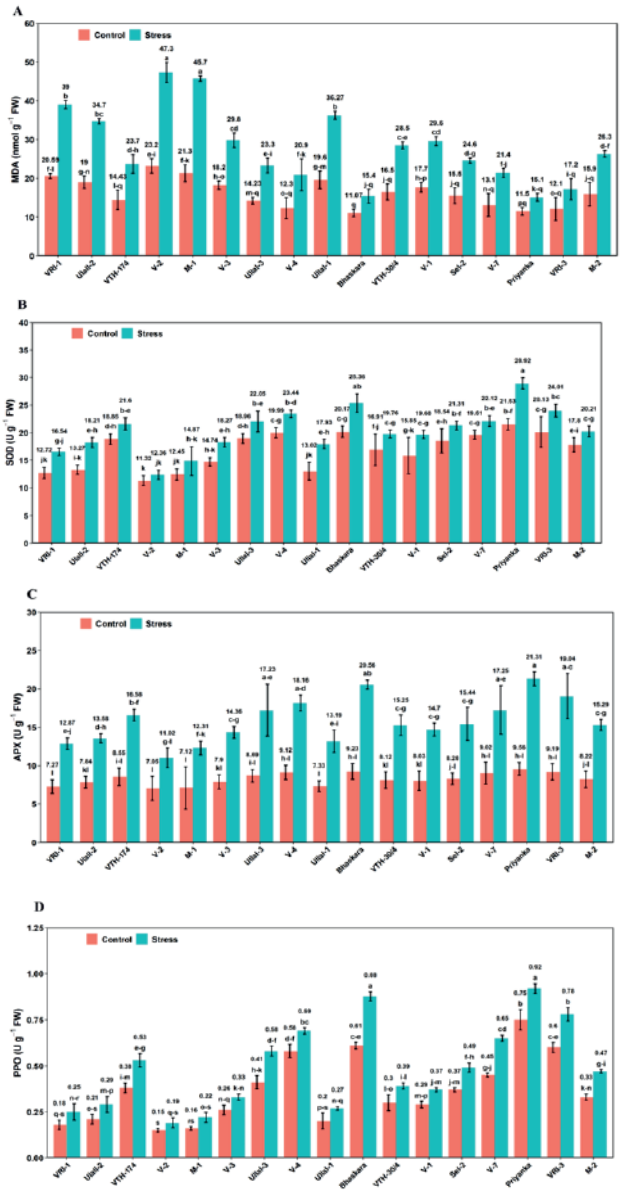
Proline accumulation: Priyanka (+33.9%) and Bhaskara (+34.6%) recorded the highest drought-induced increase in leaf proline (Fig. 3.1.15), indicating strong osmotic regulation.



Mean values (±S.E.) followed by different letters above bars are significant at p< 0.05 (n=3).

Fig. 3.1.15 : Changes in biochemical parameters of seventeen cashew varieties under control (C) and drought stress (S). A. Leaf proline content, B. Leaf soluble sugar content. M-1: Madakkathara-1, M-2: Madakkathara-2, Sel-2: Selection-2, V-1: Vengurla-1, V-2: Vengurla-2, V-3: Vengurla-3, V-4: Vengurla-4, V-7: Vengurla-7.

Soluble sugar response: Priyanka (79.3 mg g^{-1} FW) and Bhaskara (76.1 mg g^{-1} FW) accumulated the highest soluble sugars (Fig. 3.1.16) under drought, reflecting superior osmotic adjustment.



Mean values (±S.E.) followed by different letters above bars are significant at p< 0.05 (n=3).

Fig. 3.1.16 : Changes in lipid peroxidation and anti-oxidant content in leaves of seventeen cashew varieties under control (C) and drought stress (S).A. Malondialdehyde (MDA) content, B. Super oxide dismutase (SOD), C. Ascorbate peroxidase (APX) and D. Polyphenol oxidase (PO) M-1: Madakkathara-1, M-2: Madakkathara-2, Sel-2: Selection-2, V-1: Vengurla-1, V-2: Vengurla-2, V-3: Vengurla-3, V-4: Vengurla-4, V-7: Vengurla-7.

Tolerance discrimination: High proline % increase coupled with maximum sugar accumulation clearly identified Priyanka and Bhaskara as drought-tolerant varieties.

Stronger enzymatic up-regulation (tolerant varieties): Priyanka and Bhaskara showed markedly higher increases in SOD (20.4–25.5%), APX (54.3–55.1%), and PPO (31.4–35.8%) under drought (Fig. 3.1.17).

Moderate antioxidant response (sensitive varieties): Vengurla-2 and VRI-1 recorded only modest increases in SOD (8.4–23.0%), APX (36.0–41.3%), and PPO (21.0–28.0%) (Fig. 3.1.17).

Physiological implication: Greater antioxidant enzyme induction in Priyanka and Bhaskara indicates enhanced protection against drought-induced oxidative damage.

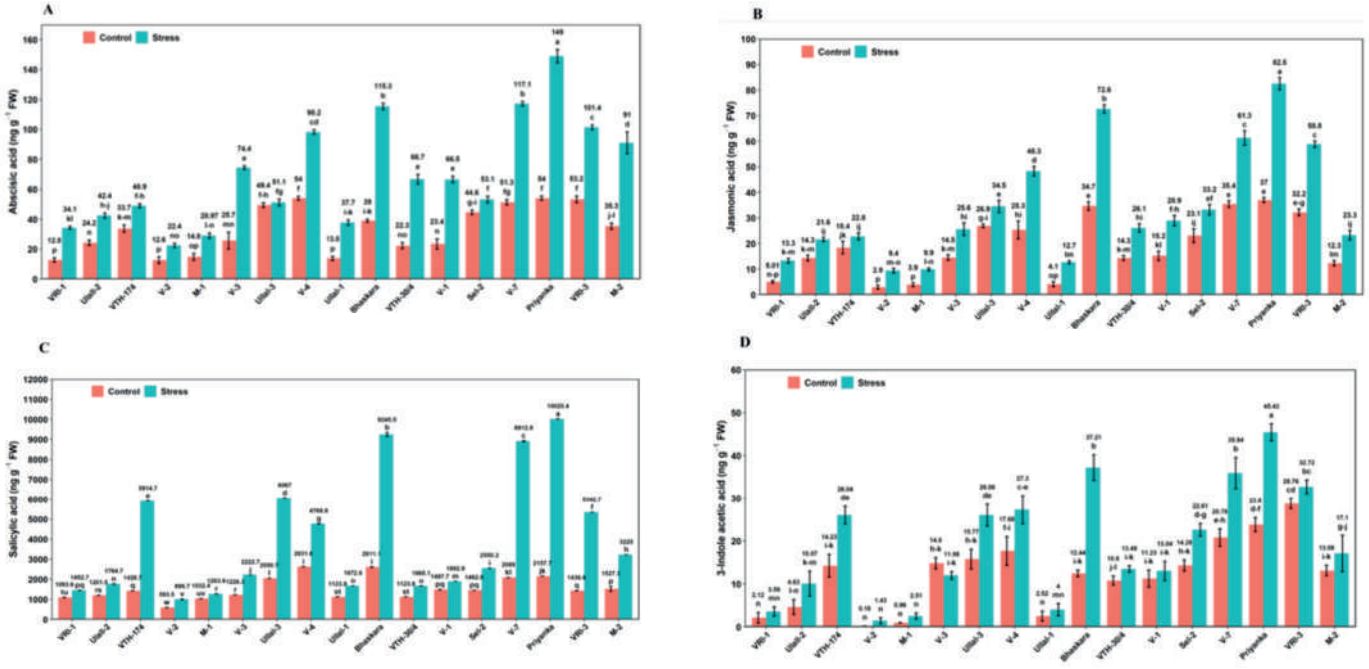


Fig. 3.1.17: Endogenous hormone profiles in leaves of seventeen cashew varieties under control (C) and drought stress (S). A. Abscisic acid, B. Jasmonic acid, C. Salicylic acid, and D. 3 Indole acetic acid.

Phytohormonal Regulation of Drought Tolerance

Key hormones upregulated: Indole-3-acetic acid (IAA), abscisic acid (ABA), jasmonic acid (JA) and salicylic acid (SA) predominantly in Priyanka (Fig. 3.1.18).

Varietal response: Highest hormone induction in Priyanka; minimal or non-significant response in sensitive varieties (Fig. 3.1.18).

Functional outcome: Coordinated hormone signalling enhances drought adaptation at the reproductive stage.

Differential Leaf Nutrient Composition

Drought stress significantly reduced leaf macro- and micronutrient contents across all varieties; however, Priyanka maintained the highest levels of N, P, K, Ca and Mg (Table 3.1.32), in sharp contrast to Vengurla-2 and Madakkathara-1, which exhibited the lowest nutrient status under stress, clearly linking nutrient homeostasis with drought tolerance.

Table 3.1.32 : Changes in leaf mineral content of seventeen cashew varieties in response to control and drought stress during year (2021-22)

Varieties	Treatment	Nitrogen (%)	Phosphorus (%)	Calcium (%)	Magnesium %	Potassium (%)
Bhaskara	Control	2.28±0.036^{a}	0.127±0.003^{ab}	0.515±0.002^{b}	0.196±0.002^{bc}	0.586±0.010^{gh}
	Drought	2.12±0.026^{c}	0.120±0.003^{c}	0.500±0.014^{c}	0.192±0.002^{bcd}	0.793±0.006^{b}
Madakkathara-1	Control	1.16±0.010^{qrs}	0.050±0.004^{rs}	0.211±0.001^{qr}	0.142±0.006^{nopq}	0.321±0.001^{rs}
	Drought	1.06±0.026^{uv}	0.028±0.003^{tu}	0.205±0.001^{rs}	0.132±0.002^{r}	0.336±0.004^{r}
Madakkathara-2	Control	1.61±0.036^{kl}	0.086±±0.002^{jk}	0.297±0.003^{kl}	0.170±0.008^{gh}	0.415±0.006^{lm}
	Drought	1.48±0.026^{m}	0.069±0.003^{mn}	0.289±0.012^{l}	0.158±0.002^{jk}	0.532±0.012^{i}
Priyanka	Control	2.33±0.026^{a}	0.132±0.003^{a}	0.577±0.002^{a}	0.207±0.004^{a}	0.609±0.017^{f}
	Drought	2.19±0.010^{b}	0.125±0.003^{bc}	0.504±0.002^{c}	0.199±0.005^{b}	0.863±0.008^{a}
Selection-2	Control	1.65±0.010^{jk}	0.092±0.005^{ij}	0.301±0.004^{k}	0.175±0.002^{fg}	0.420±0.006^{l}
	Drought	1.56±0.053^{l}	0.076±0.004^{l}	0.292±0.004^{l}	0.160±0.006^{ijk}	0.578±0.006^{h}
Ulall-2	Control	1.24±0.026^{op}	0.068±0.002^{no}	0.243±0.002^{o}	0.150±0.005^{lm}	0.377±0.010^{p}
	Drought	1.17±0.017^{qrs}	0.051±0.004^{rs}	0.241±0.003^{o}	0.146±0.005^{lmno}	0.397±0.012^{mno}
Ullal-1	Control	1.20±0.044^{pqr}	0.064±0.011^{nop}	0.220±0.002^{p}	0.148±0.004^{lmn}	0.356±0.008^{q}
	Drought	1.12±0.010^{stu}	0.045±0.002s	0.210±0.002^{qr}	0.139±0.003^{opqr}	0.386±0.012^{op}
Ullal-3	Control	2.05±0.036^{de}	0.102±0.003^{efg}	0.378±0.005^{gh}	0.179±0.007^{f}	0.512±0.022^{j}
	Drought	1.73±0.044^{hi}	0.094±0.003^{hi}	0.368±0.011^{ij}	0.171±0.004^{gh}	0.652±0.005^{e}
Vengurla-1	Control	1.37±0.036^{n}	0.075±0.003^{lm}	0.271±0.002^{m}	0.160±0.007^{ijk}	0.393±0.016^{nop}
	Drought	1.24±0.010^{op}	0.062±0.004^{op}	0.267±0.003^{m}	0.153±0.002^{kl}	0.412±0.005^{lm}
Vengurla-2	Control	1.14±0.036^{rst}	0.047±0.001^{rs}	0.200±0.004^{s}	0.138±0.003^{pqr}	0.308±0.002^{s}
	Drought	1.04±0.010^{v}	0.022±0.004^{u}	0.118±0.004^{t}	0.210±0.002^{a}	0.311±0.003^{s}
Vengurla-3	Control	1.30±0.053^{o}	0.070±0.002^{lmn}	0.252±0.003^{n}	0.158±0.006^{jk}	0.387±0.011^{op}
	Drought	1.21±0.026^{pq}	0.058±0.003^{pq}	0.249±0.007^{no}	0.149±0.005^{lmn}	0.407±0.016^{lmn}
Vengurla-4	Control	2.09±0.026^{cd}	0.105±0.003^{def}	0.389±0.003^{e}	0.180±0.007^{ef}	0.538±0.006^{i}
	Drought	1.78±0.026^{gh}	0.096±0.001^{ghi}	0.380±0.003^{fg}	0.177±0.003^{fg}	0.684±0.007^{d}
Vengurla-7	Control	2.20±0.026^{b}	0.111±0.005^{d}	0.432±0.002^{d}	0.192±0.002^{bcd}	0.575±0.009^{h}
	Drought	2.09±0.010^{cd}	0.101±0.001^{efg}	0.429±0.009^{d}	0.189±0.004^{cd}	0.712±0.004^{c}
VRI-1	Control	1.19±0.044^{pqr}	0.052±0.005^{qr}	0.217±0.003^{pq}	0.145±0.003^{mnop}	0.338±0.002^{qr}
	Drought	1.08±0.026^{tuv}	0.033±0.005^{t}	0.207±0.002^{rs}	0.137±0.004^{qr}	0.379±0.010^{op}
VRI-3	Control	1.98±0.105^{f}	0.107±0.003^{de}	0.395±0.002^{e}	0.187±0.004^{de}	0.540±0.006^{i}
	Drought	1.80±0.026^{g}	0.099±0.003^{fgh}	0.388±0.008^{ef}	0.180±0.009^{ef}	0.697±0.009^{cd}
VTH-174	Control	1.99±0.118^{ef}	0.097±0.003^{ghi}	0.371±0.003^{hi}	0.176±0.002^{fg}	0.489±0.015^{k}
	Drought	1.68±0.026^{ij}	0.085±0.001^{k}	0.360±0.006^{j}	0.161±0.008^{ij}	0.603±0.019^{fg}
VTH-30/4	Control	1.60±0.036^{kl}	0.084±0.005^{k}	0.275±0.006^{m}	0.167±0.003^{hi}	0.409±0.025^{lmn}
	Drought	1.44±0.026^{m}	0.068±0.001^{no}	0.270±0.009^{m}	0.150±0.002^{lm}	0.488±0.013^{k}

Means (n=3 biological replicates) ± standard deviation with different letters is significantly different at p<0.05

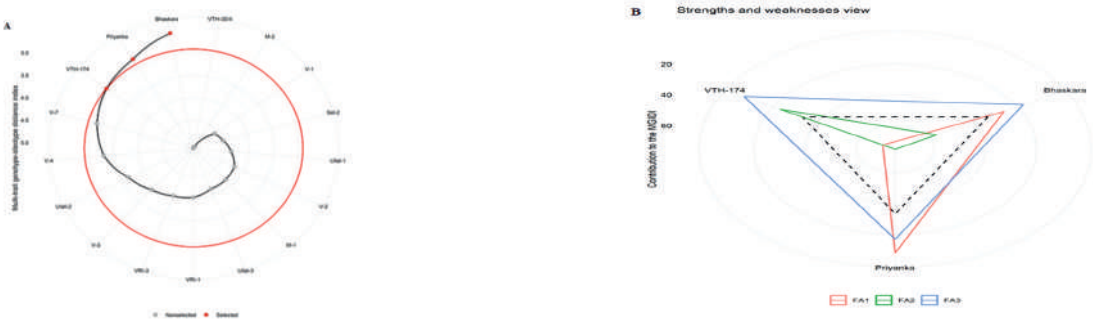


Fig. 3.1.18 : A. Ranking of 17 cashew varieties based on multi-trait index. Selected varieties are indicated in red. B. The strength and weakness of varieties are presented as proportion of each factor on the multi-trait genotype-ideotype (MGIDI) values of all the varieties. FA1: Abscisic Acid, Ellagic acid, Epigallocatechin, Epicatechin, Female flower, Gibberellic Acid 4, Gibberellic Acid 3, Gallic acid, Hesperetin, Jasmonic acid, Methyl Jasmonate, Myricetin, Ornithine, Poly phenol oxidase, Proline, Putrescine, Relative water content, Salicylic acid, Cis-Jasmone, Chlorophyll b; FA2: 2,4-dihydroxybenzoic acid, Spermine and FA3: Ascorbate Peroxidase, Benzoic acid, Catechin, Epibrasinolide, Fruit set, 3-Hydroxy benzoic acid, 3-Indole Acetic Acid, Leaf area, Leaf soluble sugar, Male flower, Number of nuts, Nut weight, Nut yield, p-Coumaric acid, Quercetin, Super oxide dismutase, Spermidine, Sex ratio, Total chlorophyll content, Total flower, Zeatin trans isomer, Chlorophyll a

Yield Stability and Reproductive Performance under Drought

Quantified severe drought impacts on cashew productivity, demonstrating a 35–65 % reduction in fruit set, nut number, nut weight, and nut yield across varieties over two years, thereby confirming strong varietal differences in reproductive sensitivity to water deficit.

Identified drought-resilient, high-yielding varieties, with Priyanka showing superior nut weight and yield stability (Table 3.1.33) under drought and VRI-3 maintaining higher fruit set and nut number, while Madakkathara-1, Ullal-1, Vengurla-1, VRI-1, and Vengurla-2 exhibited the greatest yield losses under stress.

Multi-Trait Assessment of Drought Tolerance in Cashew

Multi-trait genotype ideotype distance index (MGIDI) approach: Integrated 34 drought-responsive traits to rank 17 varieties; lower MGIDI scores indicate closer proximity to ideal drought-tolerant ideotype.

Top performers: Bhaskara, Priyanka, and VTH-174 showed superior multi-trait drought tolerance (Fig. 3.1.18) VTH-30/4 and Madakkathara-2 were most susceptible.

Trait insights: FA3 traits consistently contributed to resilience in best varieties, while FA1 and FA2 effects varied; MGIDI provides a robust ideotype-driven selection tool for breeding.

Table 3.1.33 : Effect of drought stress on yield and yield components of seventeen cashew varieties during 2020-21 (Year-1) and 2021-22 (Year-2)

Varieties	Treatment	No of fruit set per inflorescence		No of nuts/m2 canopy		Nut weight (g)		Nut yield (Kg/tree)	
		Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
Bhaskara	Control	5.8±2.62^{ab}	5.3±0.79^{ab}	10.5±2.52^{abc}	9.7±0.72^{abcde}	6.8±0.43^{ab}	6.1±1.58^{ab}	9.6±1.10^{a}	7.6±0.12^{b}
	Drought	5.3±0.13^{f}	4.9±1.12^{efg}	9.1±1.01^{i}	8.5±2.21^{i}	6.1±0.91^{ab}	5.9±0.87^{ab}	8.5±0.78^{g}	6.1±0.01^{h}
Madakkathara-1	Control	2.5±0.79^{abc}	2.2±0.62^{abc}	3.9±0.62^{efghi}	3.6±0.70^{fghi}	7.3±1.97^{ab}	6.5±2.33^{bc}	1.1±0.01^{de}	1.0±0.02^{e}
	Drought	1.3±0.10^{ab}	1.0±0.07^{abcd}	3.4±0.80^{ab}	2.7±0.47^{a}	5.5±0.70^{bc}	4.1±0.36^{abc}	0.5±0.13^{a}	0.4±0.09^{a}
Madakkathara-2	Control	5.7±1.13^{abcd}	5.1±1.51^{a}	7.3±2.55^{efgh}	6.8±0.87^{efgh}	7.9±1.51^{abc}	7.1±1.47^{a}	5.1±0.37^{g}	5.0±0.03^{de}
	Drought	4.4±0.72^{ef}	3.5±2.21^{abcde}	6.3±1.73^{fghi}	5.1±1.75^{fghi}	5.9±1.25^{efg}	4.5±0.60^{b}	3.8±1.34^{g}	2.3±0.07^{fgh}
Priyanka	Control	6.3±0.55^{f}	6.0±1.27^{defg}	12.8±1.70^{abcde}	11.9±1.57^{ghi}	8.9±0.26^{bc}	7.9±0.88^{bcd}	9.8±2.61c	9.5±2.04^{gh}
	Drought	5.9±0.52^{abc}	5.1±1.47^{g}	11.0±1.01^{ghi}	10.7±1.80^{abc}	7.2±0.55^{f}	6.9±0.98^{efg}	8.8±0.77b^{c}	8.5±0.18^{b}
Selection-2	Control	5.8±0.45^{def}	5.1±1.67^{abcd}	7.7±1.01^{i}	7.1±0.98^{ghi}	7.1±1.47^{i}	6.3±0.85^{abc}	5.8±2.41^{fg}	5.1±0.22^{fg}
	Drought	3.9±0.43^{f}	2.7±0.55^{ab}	6.6±0.65^{defg}	5.4±1.30^{hi}	5.4±2.29^{l}	4.0±0.81^{bc}	3.4±0.26^{g}	3.0±0.18^{h}
Ulall-2	Control	3.3±0.72^{def}	2.9±0.60^{cdefg}	6.8±0.87^{abc}	6.3±0.78^{cdefg}	6.4±2.10^{ghi}	5.7±2.78^{a}	2.5±0.03^{efhg}	2.3±0.09^{f}
	Drought	2.5±0.70^{ab}	1.4±0.05^{fg}	5.9±0.88^{efg}	4.7±0.85^{ab}	4.8±1.64^{abc}	3.6±1.57^{b}	1.1±0.02^{abc}	1.0±0.02^{b}
Ullal-1	Control	2.2±0.87^{abf}	1.8±0.52^{bcdefg}	6.2±1.85^{hi}	5.7±0.78^{defg}	7.3±1.85^{bcde}	6.5±0.75^{abcde}	1.5±0.01^{ab}	1.3±0.16^{c}
	Drought	1.6±0.26^{a}	1.1±0.02^{ab}	5.3±1.99^{a}	4.3±2.21^{hi}	5.5±0.60^{abcd}	4.1±1.44^{abc}	0.8±0.08^{cd}	0.7±0.05^{h}
Ullal-3	Control	5.2±1.53^{cde}	4.9±1.12^{bc}	10.7±3.40^{abcd}	9.9±0.87^{a}	7.7±0.72^{abcde}	6.9±1.05^{ab}	7.3±0.71^{g}	7.0±0.11^{a}
	Drought	4.8±0.81^{bcde}	3.9±0.55^{abc}	9.2±0.98^{def}	8.7±0.78^{abcd}	6.6±0.65^{efg}	5.5±0.70^{efg}	6.2±0.48^{ab}	5.9±1.18^{cd}
Vengurla-1	Control	3.5±0.72^{abc}	3.3±0.70^{efg}	5.6±1.15^{a}	5.2±1.70^{bcdef}	5.2±1.47^{bcd}	4.6±0.85^{i}	2.2±0.04^{cd}	2.0±0.02^{e}
	Drought	2.5±0.70^{efg}	1.9±0.30^{ab}	4.8±0.96^{ab}	3.9±0.36^{a}	4.0±1.04^{efg}	2.9±0.60^{l}	2.1±0.05d^{ef}	1.9±0.11^{ab}
Vengurla-2	Control	2.9±0.45^{cde}	2.0±0.70^{a}	4.2±1.68^{cd}	3.9±0.95^{ab}	6.5±0.65^{ab}	5.8±0.87^{ab}	1.3±0.12^{abcd}	1.1±0.02^{bcd}
	Drought	1.5±0.62^{f}	1.1±0.05^{abcdef}	3.6±0.75^{cde}	2.9±0.87^{bc}	4.9±0.98^{ab}	3.7±1.05^{abc}	0.6±0.21^{abcd}	0.4±0.03^{abc}
Vengurla-3	Control	3.8±0.55^{ab}	3.1±1.47^{abcd}	8.8±1.73^{def}	8.1±0.98^{cd}	6.4±0.91^{ab}	5.7±2.89^{bcd}	3.9±0.25^{bcd}	3.1±0.01^{efg}
	Drought	3.1±0.88^{abc}	2.8±0.12^{ijk}	7.6±0.72^{efg}	6.1±1.77^{cd}	4.8±1.22^{ghi}	3.6±0.88^{ab}	1.3±0.18^{efg}	1.2±0.03^{i}
Vengurla-4	Control	5.8±1.17^{bcd}	5.2±1.60^{abc}	11.6±0.87^{fg}	10.7±0.70^{cd}	6.5±0.60^{bc}	5.8±0.79^{b}	8.6±1.29^{i}	8.3±0.51^{ab}
	Drought	5.6±1.03^{ijk}	4.5±0.17^{a}	9.2±0.57^{fgh}	9.8±0.80^{de}	5.4±2.59^{abc}	4.5±1.15^{a}	6.5±0.35^{l}	6.1±0.41^{abc}
Vengurla-7	Control	5.9±0.36^{a}	5.5±0.65^{bcd}	7.9±0.60^{gh}	7.3±0.78^{ef}	7.3±0.65^{ab}	6.5±0.62^{abc}	5.8±1.08^{abc}	5.4±0.09^{a}
	Drought	4.9±0.43^{b}	4.2±1.60^{efgh}	6.8±2.97^{hi}	5.5±0.96^{fg}	6.8±0.95^{i}	6.0±1.31^{ab}	5.3±0.65^{ab}	4.6±0.13^{bc}
VRI-1	Control	2.4±0.26^{abc}	2.1±0.36^{abc}	4.3±0.55^{l}	4.0±1.51^{fg}	5.9±1.44l^{cdef}	5.3±2.28^{bc}	1.1±0.01^{a}	1.1±0.02^{efg}
	Drought	1.8±0.40^{bcd}	1.2±0.05^{efg}	3.7±0.75^{bc}	3.0±0.91^{fgh}	4.4±0.87d^{ef}	3.3±0.70^{bcd}	0.7±0.05^{ab}	0.5±0.01^{abc}
VRI-3	Control	6.9±0.87^{ij}	6.3±2.19^{a}	13.3±0.78^{a}	12.3±1.82^{gh}	6.7±1.41^{ef}	6.0±1.27^{cde}	7.9±1.47^{bc}	9.4±0.17^{efg}
	Drought	6.2±1.24^{efg}	5.9±0.26^{b}	11.5±1.12^{b}	11.3±1.1^{gh}	6.2±0.87^{bcde}	5.9±0.36^{de}	7.3±0.63^{abc}	8.6±0.08^{ab}
VTH-174	Control	4.8±0.78^{abc}	4.11.01^{abc}	10.9±1.60^{l}	10.1±2.72^{hi}	6.3±2.81^{abc}	5.6±1.58^{e}	6.4±0.60^{fg}	6.3±0.71^{bc}
	Drought	3.8±0.55^{bcde}	3.5±0.81^{bcd}	9.4±0.70^{abc}	8.3±1.41^{l}	4.7±0.50^{ab}	3.8±0.45^{bc}	4.5±0.68^{gh}	3.9±0.08^{abc}
VTH-30/4	Control	4.7±1.73^{abc}	4.2±1.60^{a}	9.5±0.70^{cde}	8.8±0.95^{ab}	6.9±1.19^{f}	6.2±1.60^{abc}	5.2±0.86^{h}	5.0±1.35^{bcd}
	Drought	4.1±0.30^{b}	3.8±1.41^{b}	8.2±1.80^{ab}	7.3±2.13^{bc}	5.8±0.86^{l}	5.4±1.49^{ab}	2.6±0.16^{i}	2.0±0.15^{ab}

[Means (n=3 biological replicates) ± standard deviation with different letters is significantly different at p<0.05]

3.1.10 Physiological and biochemical basis of salinity tolerance in cashew accessions

The study enabled efficient screening of 21 cashew accessions under salinity stress at 250 mM NaCl, identifying 'Indira Kaju', 'Vengurla-7', 'Priyanka', and 'Jagannath' as tolerant varieties, while 'Ullal-1' and 'VRI-1' were found to be highly sensitive. It established ionic homeostasis as a key determinant of salinity tolerance, showing that salt stress led to increased Na^+ accumulation and reduced K+ content across varieties; however, the tolerant variety 'Indira Kaju' effectively restricted Na+ uptake, maintained higher K+ levels, and exhibited a superior K+/Na+ ratio in both leaves and roots even at high salinity, unlike the sensitive 'VRI-1'. The research further demonstrated enhanced osmotic adjustment in tolerant varieties, with significant increases in proline (69.6 % in leaves and 63.0 % in roots) and soluble sugars, with 'Indira Kaju' outperforming sensitive accessions such as 'VRI-1'. Additionally, tolerant accessions showed a stronger antioxidant defense system, accumulating higher levels of total antioxidants, phenolics, and flavonoids, thereby contributing to improved resilience against salinity stress.

Growth assessment and salinity tolerance evaluation - Contrast accessions

Efficient screening of cashew accessions for salinity tolerance: twenty-one cashew accessions were evaluated at 250 mM NaCl, which identified Indira Kaju, Vengurla-7, Priyanka, and Jagannath as tolerant varieties, while Ullal-1, Nethra Vaman and VRI-1 were found to be highly sensitive, with clear phenotypic differences between tolerant and sensitive lines depicted in Fig. 3.1.19.

Ion Accumulation under Salt Stress

Na^+ accumulation: Significantly higher in sensitive VRI-1 (Leaf: 1.96 %, Root: 1.58 % DW) than tolerant Indira Kaju (Leaf: 1.77 %, Root: 1.28 % DW) at 250 mm NaCl (Table 3.1.34).

K^+ retention: Decreased with salt in all varieties; Indira Kaju maintained higher K^+ in leaves and roots compared to VRI-1

K^+/Na^+ ratio: Highest in Indira Kaju, indicating better ionic homeostasis and salt tolerance.



Fig. 3.1.19 : Phenotypic responses of salt-tolerant and salt-sensitive cashew varieties under salinity stress (250 mM NaCl) at different days of salt treatment. A. Tolerant variety (Indira Kaju) and B. Sensitive variety (Nethra Vaman).

Table 3.1.34 : Ion accumulation in leaves and roots of cashew varieties under salt stress.

Varieties	NaCl (mM)	Leaf ions (% dry weight)			Root ions (% dry weight)		
		Na+	K+	K+/Na+	Na+	K+	K+/Na+
Indira Kaju	0	0.13±0.018e	4.18±0.018 a	32.65±4.711a	0.11±0.012e	3.8±0.136a	34.78±3.12a
	250	1.77±0.048 a	3.01±0.018 e	1.70±0.054 c	1.28±0.076 a	2.01±0.026 e	1.57±0.09 d
Priyanka	0	0.15±0.018e	4.12±0.018 a	27.79±3.525 a	0.12±0.018 e	3.75±0.070 a	31.87±5.49 a
	250	1.8±0.061 a	2.96±0.115 d	1.65±0.086 c	1.34±0.052 a	1.97±0.048 e	1.47±0.08 c
Vengurla-7	0	0.16±0.018 e	4.1±0.041 a	25.87±2.899 a	0.12±0.014 e	3.73±0.101 a	31.37±3.33a
	250	1.87±0.063 a	2.85±0.048 e	1.53±0.049 d	1.39±0.029 a	1.9±0.089 e	1.37±0.06 c
Jagannath	0	0.16±0.026e	3.97±0.074a	25.29±4.069 a	0.13±0.018 e	3.61±0.137 a	28.26±4.82 a
	250	1.9±0.124 a	2.77±0.032 e	1.46±0.109 c	1.42±0.039 a	1.85±0.050 d	1.30±0.02 c
Ullal-1	0	0.17±0.032e	3.54±0.074 a	21.40±4.164 a	0.15±0.026 e	3.22±0.032 a	21.96±3.82 a
	250	1.93±0.034 a	2.51±0.037 e	1.30±0.027c	1.49±0.018 a	1.52±0.026 e	1.02±0.01 c
VRI-1	0	0.19±0.032e	3.28±0.018 a	17.65±3.135a	0.16±0.018 e	3.2±0.039 a	20.21±2.42 a
	250	1.96±0.024 a	2.31±0.032 e	1.18±0.029 c	1.58±0.018 a	1.31±0.029 d	0.83±0.02 c

Proline Accumulation under Salt Stress

Salt stress imposition significantly improved proline accumulation in leaves and roots of all cashew varieties. A higher proline content (69.6% in leaves and 63.0% in roots) was observed in Indira Kaju compared to VRI-1 (57% in leaves and 50% in roots) at a higher salt level (250mM NaCl) (Fig. 3.1.20).

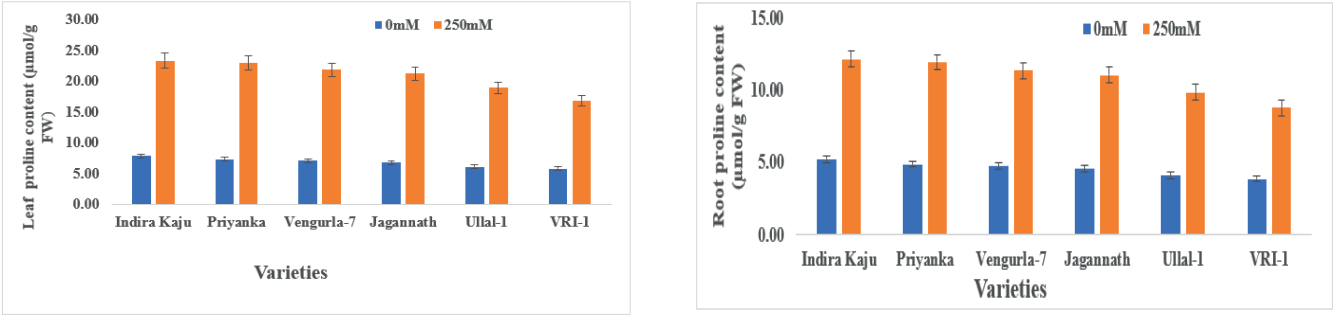


Fig. 3.1.20 : Proline accumulation in cashew varieties under salt stress

Soluble Sugar Accumulation under Salt Stress

Salt stress at 250 mM NaCl caused a gradual increase in soluble sugar content in both leaves and roots of all six cashew varieties, indicating an osmotic adjustment response under salinity. The salt-tolerant variety Indira Kaju accumulated significantly higher soluble sugars, whereas the salt-sensitive variety VRI-1 exhibited comparatively lower sugar accumulation (Fig. 3.1.21).

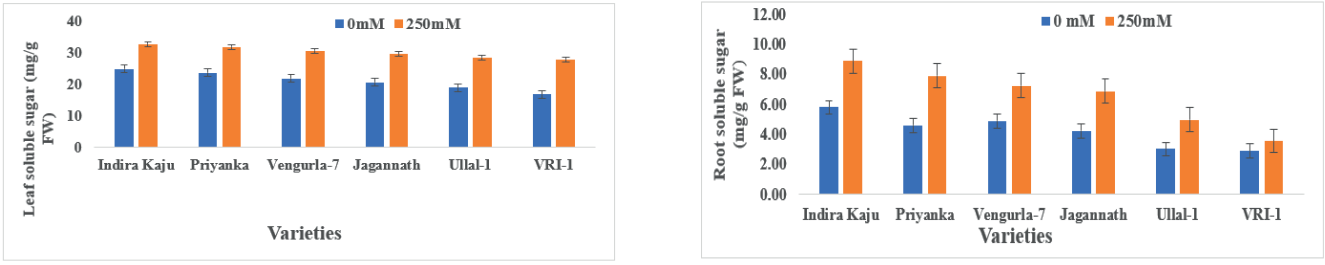


Fig. 3.1.21: Soluble sugar accumulation in cashew varieties under salt stress

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

Twenty-three cashew accessions were evaluated in vitro for high-temperature stress tolerance using pollen germination assays, enabling clear differentiation of genotypic responses to heat stress. Among these, NRC 4, 13, 14, and 15 were identified as heat-tolerant accessions, while NRC 6, 7, 17, 22, 24, 29, 34, and 43 were classified as heat-sensitive. The study further established genotype-specific cardinal temperatures for pollen germination, defining optimum temperature ranges and upper thermal tolerance limits, which provide valuable benchmarks for selecting climate-resilient cashew varieties under warming scenarios. Additionally, sugar profiling under heat stress revealed enhanced accumulation of protective sugars in tolerant accessions, emphasizing the critical role of carbohydrate metabolism in conferring high-temperature tolerance.

High-Temperature Response of Cashew Pollen (Contrast Groups)

Certain accessions exhibited a higher optimum temperature of 30 °C, with pollen germination ranging from 31.2 % in NRC 15 to 60.2 % in NRC 13, and these accessions retained appreciable germination even beyond 40 °C, reflecting broader adaptability to heat stress (Fig. 3.1.22).

In contrast, other accessions showed peak pollen germination at 25 °C (69.8 % in NRC 34 to 84.7 % in NRC 24), followed by a steep decline at elevated temperatures, with germination reducing to 21.3 % at 35°C, 4.4 % at 40°C, and complete inhibition above 40°C, indicating high temperature sensitivity (Fig. 3.1.23).

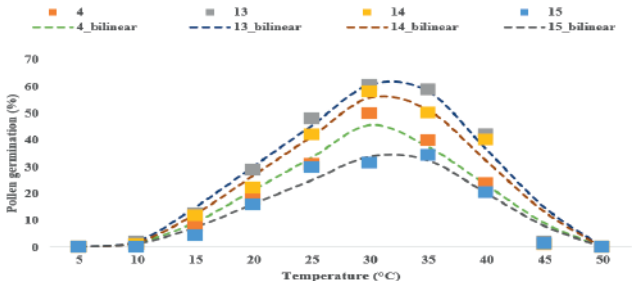


Fig. 3.1.22 : Pollen germination response of heat-tolerant cashew accessions across increasing temperature regimes

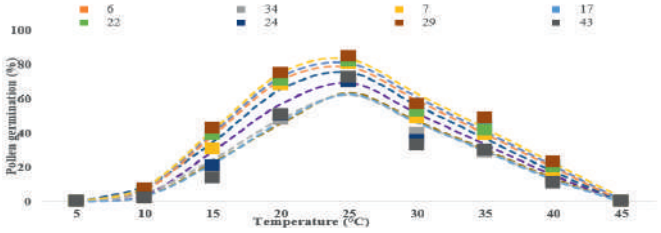


Fig. 3.1.23 : Pollen germination response of heat-sensitive cashew accessions under elevated temperature stress

Cardinal temperature (Minimum, Optimum & Maximum)

Defined cardinal temperature ranges for pollen germination in cashew varieties showed that maximum pollen germination (70–85%) occurred near an optimum temperature of 22.6–24.4 °C for most varieties, with minimum (T_{min}) and maximum (T_{max}) thresholds ranging from approximately 8.8–10.4 °C and 43.8–45.5 °C, respectively, while the heat-tolerant genotypes NRC 4, 13, 14, and 15 exhibited higher optimum temperatures (31–33 °C) and extended T_{max} values up to about 48.5 °C (Table 3.1.35), indicating substantial genotypic variation in thermal tolerance.

Table 3.1.35 : Cardinal temperature thresholds and genotypic variation in pollen germination of cashew under heat stress

Accessions	Maximum pollen germination (%)	a	b_1	b_2	R_2	T_{opt}	T_{min}	T_{max}
6	69.8±0.80	65.73	0.62	-3.95	0.97	24.4	10.0	44.1
34	75.5±1.11	75.20	0.96	-4.55	0.97	23.3	9.7	44.3
7	80.3±2.08	83.68	1.15	-5.03	0.98	22.9	9.4	44.5
17	81.9±0.64	90.33	1.28	-5.29	0.99	22.7	8.9	45.2
22	81.9±5.86	87.86	1.26	-5.18	0.99	22.6	9.0	45.0
24	70.1±2.055	66.35	0.72	-4.02	0.95	23.8	9.8	43.9
29	84.7±0.70	92.93	1.33	-5.38	0.99	22.6	8.8	45.5
43	72.5±0.91	66.11	0.77	-4.11	0.91	24.0	10.4	43.8
4	34.3±1.04	48.35	-0.21	-2.63	0.94	31.1	11.1	48.2
13	60.2±1.98	68.54	-0.64	-3.69	0.95	32.6	10.1	48.4
14	57.9±1.62	61.98	-0.45	-3.33	0.93	32.1	10.6	48.5
15	49.9±1.30	38.31	-0.34	-2.10	0.93	32.5	10.7	48.2

Sugar Profiling in Cashew Pollens

Glucose and fructose were identified as the predominant sugars in cashew pollen at 35 °C, indicating their major role in pollen metabolism under heat stress (Table 3.1.36).

Heat-tolerant accessions NRC 13, 14, and 15 accumulated higher total sugar content, with the maximum observed in NRC 13, whereas the heat-sensitive accessions NRC 6 and NRC 34 showed lower sugar levels, with NRC 34 recording the lowest total sugars.

Table 3.1.36 : Sugar Accumulation Patterns Under Heat Stress in Cashew Pollen

Total sugar	79.9e ±0.557	129.3b ±0.625	125.8c ±0.503	118.3d ±1.320	134.3a ±1.331
Ribose	0.818d ±0.016	0.557e ±0.021	2.94a ±0.063	1.545b ±0.009	1.357c ±0.038
Arabinose	0.105e ±0.001	0.289c ±0.002	0.409a ±0.003	0.313b ±0.006	0.206d ±0.002
Xylose	0.172d ±0.002	0.056e ±0.002	0.281b ±0.008	0.356a ±0.008	0.195c ±0.004
Rhamnose	0.014d ±0.001	0.019c ±0.001	0.036a ±0.001	0.027b ±0.001	0.019c ±0.001
Fucose	0.038c ±0.001	0.045b ±0.002	0.015d ±0.001	0.065a ±0.002	0.035c ±0.001
Fructose	18.059e ±0.176	51.308b ±0.016	49.363c ±0.068	27.549d ±0.339	54.903a ±0.371
Glucose	14.243e ±0.148	26.603d ±0.023	37.343a ±0.206	21.003b ±0.009	27.691c ±0.124
Mannose	1.589b ±0.054	1.437bc ±0.042	1.271c ±0.035	1.800a ±0.028	1.442bc ±0.084
Galactose	0.192d ±0.009	0.144d ±0.003	0.783a ±0.039	0.499b ±0.039	0.337c ±0.005
Inositol	1.291ab ±0.014	1.345a ±0.018	1.239b ±0.021	1.105c ±0.025	1.268b ±0.031
Sorbitol	0.836c ±0.011	0.249e ±0.021	0.966b ±0.029	0.702d ±0.012	1.098a ±0.049
Sucrose	2.555e ±0.028	3.423c ±0.006	4.955a ±0.002	2.648d ±0.002	4.253b ±0.011
Maltose	0.032e ±0.002	0.042d ±0.001	0.052c ±0.001	0.236a ±0.006	0.132b ±0.002
Trehalose	0.004e ±0.001	0.01c ±0.001	0.008d ±0.001	0.019a ±0.001	0.012b ±0.001
Lactose	0.021d ±0.001	0.015e ±0.001	0.05b ±0.001	0.054a ±0.001	0.03c ±0.001

Externally Funded Projects

Development of morphological descriptors and DUS test guidelines for cashew

Earlier, 30 reference varieties were planted for DUS testing at a spacing of 6 m x 6 m with 4 plants/variety, and these were maintained in the field. The DUS characterization of Nethra Ganga is over, and the data has been submitted to the PPV FRA, New Delhi. The testing of other candidate varieties, i.e., Nethra Jumbo-2 and Vengurla-10, is in progress. The DUS certificate for Vengurla-9, Nethra Ganga, Nethra Vaaman, Nethra Ubhaya, Nethra Jumbo-1, and Poornima varieties was given by the PPV FRA during the year (Fig. 3.1.24).


पौधा किस्म रजिस्ट्री PLANT VARIETIES REGISTRY
रजिस्ट्रीकरण प्रमाण-पत्र/Certificate of Registration

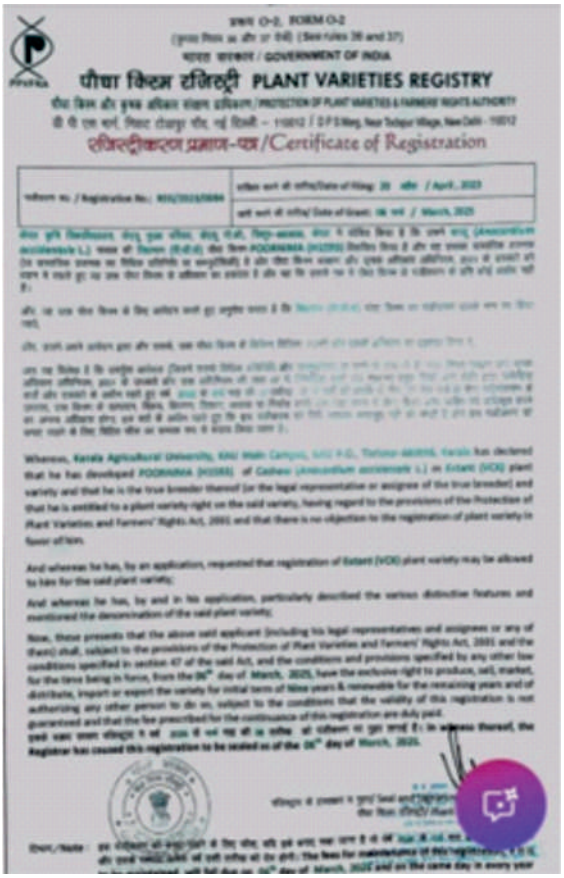

पौधा किस्म रजिस्ट्री PLANT VARIETIES REGISTRY
रजिस्ट्रीकरण प्रमाण-पत्र/Certificate of Registration

Fig. 3.1.24 : DUS Certificates received during 2025

Observational Trials

Studies on grafting success in cashew varieties

The research work was initiated during April 2024 using nuts from a single root stock genotype, namely VTH 174. Thirteen varieties of cashew will be tested for their grafting success for two consecutive years (2024 & 2025) in different seasons. During 2024, raising rootstock and grafting were carried out in two seasons, and the results are presented below.

Season 1: Sowing of seed nuts during April and grafting in July 2024

The nuts of root stock were sown on 24th April 2024 in standard-size polybags with 2k potting mixture consisting of sand, soil and FYM in equal proportion. The seedlings were raised following standard nursery practices. Observations related to growth, such as seedling height, length from cotyledon to first leaf, total number of leaves, girth and internode length in seedlings of root stock, were recorded during one month and two months after sowing. Two-month-old seedlings were used for grafting using scions of 16 cashew varieties. In each variety, twenty grafts were made with three replications in randomized block design. Observations such as height of plant, girth of scion and root stock, number of sprouts, total number of leaves were recorded in grafted plants in a monthly interval from August to December, January 2025. The observations on the success rate of grafts were recorded in each variety and presented in Table 3.1.37. The highest grafting success of 95.83 % was observed in Ullal-3, while the lowest grafting success of 66.67 % was observed in Nethra Jumbo-2.

Season 2: Sowing of seed nuts during August and grafting in October 2024

The nuts of root stock were sown on 17th August 2024 in standard-size polybags with 2 kg potting mixture consisting of sand, soil and FYM in equal proportion. The seedlings were raised following standard nursery practices. Observations related to growth such as seedling height, length from cotyledon to first leaf, total number of leaves, girth and intermodal length in seedlings of root stock were recorded during one month and two months after sowing. In the same way described in the season 1, two month old seedlings were used for grafting using scions of 16 cashew varieties. In each variety twenty grafts were made with three replications in randomized block design. Observations such as height of plant, girth of scion and root stock, number of sprouts, total number of leaves were recorded in grafted plants in monthly interval from November to December 2024. The observations on the success rate of grafts was recorded in each variety and presented in Table 3.1.37. The highest grafting success of 97.44 % was observed in Dhana while the lowest grafting success of 41.03 % was observed in Nethra Ganga.

Table 3.1.37 : Grafts survival (%) after six months of grafting in two seasons

Sl. No.	Variety	Sowing :24.04.2024 Grafting : 19.07.2024	Sowing: 17.08.2024 Grafting: 19.10.2024
1	Bhaskara	83.33	89.74
2	Madakkathara-2	77.08	92.31
3	Nethra Jumbo-1	83.33	92.31
4	Ullal-4	79.17	74.36
5	NethraVamana	85.42	92.31
6	VRI-3	85.42	94.87
7	Vengurla-4	83.33	76.92
8	Ullal-1	75.00	76.92
9	Priyanka	83.33	89.74
10	Ullal-3	95.83	87.18
11	Vengurla-7	89.58	82.05
12	Dhana	83.33	97.44
13	Nethra Ubhaya	89.58	66.67
14	NRCC Sel-2	91.67	51.28
15	Nethra Ganga	85.42	41.03
16	Nethra Jumbo-2	66.67	69.23
	SEm±	3.23	5.12
	CD(5%)	9.32	14.79
	CV(%)	6.69	11.13

3.2. CROP MANAGEMENT

Priority Area II: Development of Refinement of Production Technologies in Cashew

3.2.1 Development of cashew (*Anacardium occidentale* L.) based cropping system for the west coastal region

The morphological observation of cashew has been recorded and the data was non-significant among the treatments. The raw cashew nut yield was recorded and the data showed non-significant result for this trait also. The treatment-wise soil samples were collected and analyzed for its nutrient content.

3.2.2 Effect of inter-stocks in Cashew (*Anacardium occidentale* L.)

Successful interstock grafts from the nursery trial were planted during October 2023 in the field for further evaluation and validation in the field for its growth and yield parameters. This experiment was laid with 14 different interstock treatment including 2 controls (Normal grafts of V-4 and Bhaskara). Six different interstock *viz.* V-4(I1), Bhaskara (I2), *Anacardium Pumilum* (I3), Nethra Vaman (I4), KAU Nihara (I5) and V6 (I6) with two nationalised vigorous varieties of cashew viz. V-4 (V1) and Bhaskara (V2) as main scions, and the design of the experiment was RCBD with 3 replications. First year growth parameters (2024-25) were recorded (Table 3.2.1) and it is indicated that, height of plant (97 cm-164.58 cm), girth of plant (23.46 mm-36.22 mm), canopy spread (58.25 cm-137.96 cm) and internodal length (0.85 cm-1.17 cm). By all these parameters, it is indicating that, height of tree, Canopy spread and internodal length was less in I3V1 as compared to the interstock plants as like nursery trial and further needs to be evaluated for the yield other parameters in future (Fig. 3.2.1, Fig. 3.2.2 & Fig. 3.2.3).



Anacardium Pumilum+Vengurla-4



Anacardium Pumilum+Bhaskara



Nethra Vaman+Vengurla-4



Nethra Vaman+Bhaskara

Fig. 3.2.1 : Field view-*Anacardium Pumilum* and Nethra Vaman as interstock

Table 3.2.1: Growth parameters of interstock experiment

Treatment	Height (cm)	Height increment (cm)	Girth of Root stock (mm)	Canopy spread (cm)	Internodal length (cm)
I1V1	145.58	109.42	27.69	90.58	1.17
I1V2	119.75	118.00	24.08	90.00	1.01
I2V1	108.00	132.33	24.61	64.25	1.11
I2V2	119.08	111.75	25.73	80.13	0.98
I3V1	97.00	73.00	27.32	58.25	0.85
I3V2	119.50	160.50	23.46	98.00	1.10
I4V1	119.58	94.58	30.69	90.00	1.01
I4V2	142.50	135.00	33.25	137.96	1.06
I5V1	121.42	110.42	26.14	80.00	0.98
I5V2	145.08	124.92	31.38	135.88	1.07
I6V1	138.08	127.58	29.75	94.42	1.03
I6V2	154.17	111.00	32.69	115.92	1.06
I1	134.08	103.83	27.98	91.33	1.02
I2	164.58	134.17	36.22	134.79	1.04
SE(m)±	11.63	18.65	2.26	12.74	0.06
CD@5 %	33.99	NS	6.60	37.23	NS
CV (%)	15.42	27.46	13.66	22.68	9.47

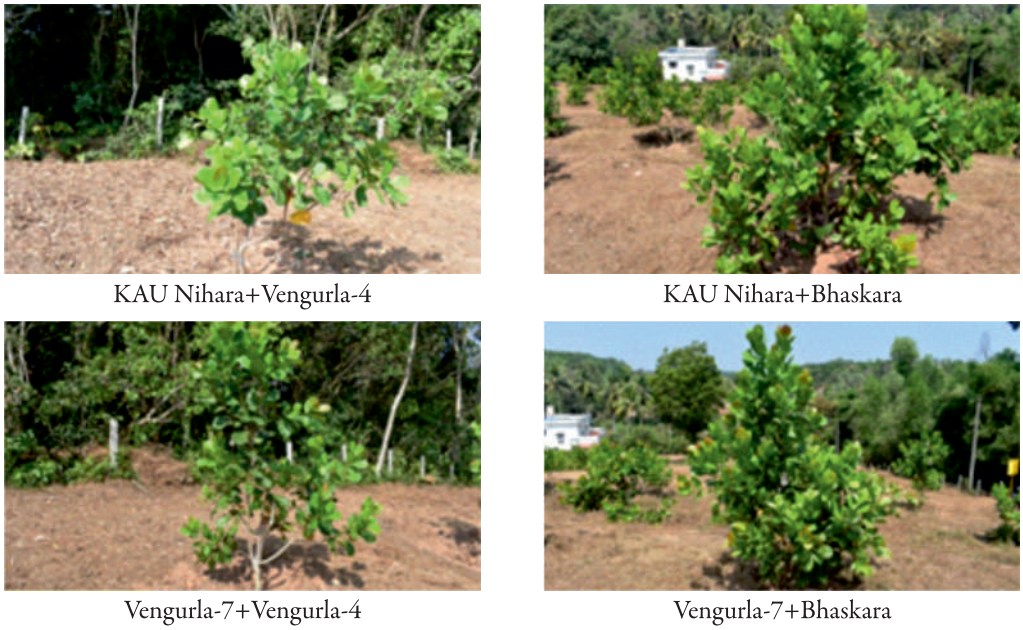


Fig. 3.2.2 : Field view-KAU Nihara and Vengurla-7 as interstock



Fig. 3.2.3 : Field view of Vengurla-4 and Bhaskara (Control)

3.2.3 Canopy management in Cashew under ultra-high density planting system

Different pruning treatments were imposed in the experiment under UHDP with VRI-3 variety and morphological and yield data for the first year 2024-25 was recorded (Table 3.2.2) and all the growth and yield parameters were statistically n. significant among the 13 different pruning treatments (including control). Height of grafts varies from 153.39 -195 cm, canopy spread 131.38-160.83 cm, number of nuts per tree varies from 1.92-9.58 and nut yield from 13.74 to 76.45 kg/hectare (Fig.3.2.4).

Table 3.2.2 : Growth parameters of canopy management under UHDP experiment

Treatments	Height (cm)	Average canopy spread(cm)	No. of nuts/tree	Nut yield (kg/ha)
T_1 (2-25-25)	165.77	143.58	7.18	57.30
T_2(2-25-50)	159.03	135.24	1.97	15.73
T_3 (2-50-25)	167.67	139.63	2.65	21.14
T_4 (2-50-50)	161.78	133.93	3.33	26.59
T_5(3-25-25)	195.00	153.58	5.72	45.65
T_6(3-25-50)	176.50	131.38	5.50	43.87
T_7(3-50-25)	165.22	144.19	1.72	13.74
T_8(3-50-50)	177.67	146.19	3.17	25.26
T_9(4-25-25)	153.39	159.78	7.33	58.50
T_{10}(4-25-50)	166.44	160.83	3.22	25.66
T_{11}(4-50-25)	179.25	157.25	7.33	58.50
T_{12}(4-50-50)	171.33	143.44	3.22	25.70
T_{13} (Control)	174.98	154.55	9.58	76.45
CD @ 5 %	NS	NS	NS	NS
SE(m)±	10.74	14.38	1.80	14.339
CV %	10.92	17.01	56.79	65.35



Fig. 3.2.4 : Experimental view of UHDP

3.2.4 Carbon sequestration in a cashew plantation

A study was carried out to determine carbon stock in an 8-year-old cashew plantation with 4 cashew varieties, viz. Bhaskara, Ullala-3, Vengurla-3, and VRI-3, which have different spacings, viz. 8 m x 8 m, 10 m x 10 m, and 5 m x 5 m at the Kadamajalu progressive farmer field located in Puttur taluk of Dakshina Kannada District of Karnataka during the 2023–24 (fruiting season). The ICAR-Directorate of Cashew Research Puttur, recommended good agricultural practices for this field's maintenance, and we provided fertilizers based on their recommendations. Due to the hilly slope, we planted these cashew trees using the contour method. Twenty trees were evaluated for assessment of the carbon stock (both below ground and above ground) with an allometric model (non-destructive method) by using the diameter of branches at 1.3 m height of ≤20 cm branches that were taken for observation in each variety and height of tree (cm). It was revealed that the Bhaskara variety with an 8 x 8 m spacing had a high carbon stock (2.68 t/ha), followed by the VRI-3 variety with a 5 m x 5 m spacing (2.41 t/ha), Ullala-3 with an 8 m x 8 m spacing (1.72 t/ha), and Vengurla-3 had the lowest carbon stock, with a spacing of 10 m × 10 m (1.68 t/ha). The highest CO_2 sequestration observed among these varieties was in Bhaskara with normal density planting (9.84 t/ha), followed by VRI-3, Ullala-3, and Vengurla-3 (Fig.3.2.5).

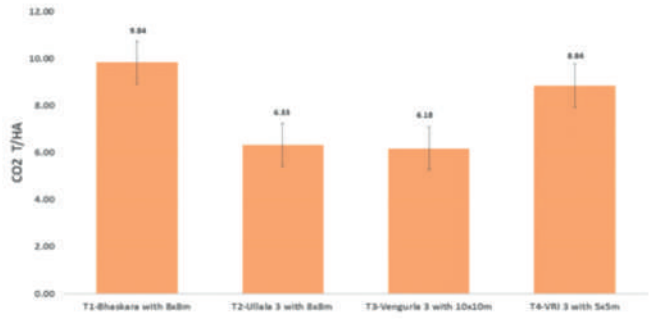


Fig. 3.2.5 : CO_2 Sequestration in cashew plantation

3.2.5 Comparative Studies on the Effect of Different Farming Systems in Sustainable Cashew Cultivation.

Although the cultivation of cashew in most part of the country is based on traditional wisdom over generations, the recent problems of soil quality deterioration and vagaries of climate are demanding the adoption of sustainable farming practices. The drawbacks of conventional agriculture in sustaining soil productivity have raised several issues of the country's farming policy. In this connection, a reorientation of the farming practices concomitant with the nature assumes practical significance. However, a detailed understanding of the pros and cons of natural farming over the period, in cashew, needs to be studied. There is a need for careful documentation of adopted practices and consequent outcomes. Quantification of the effects of this natural way of farming in comparison to the existing systems of cultivation assumes practical significance so as to fine-tune the policies on this approach, especially in horti-based systems. With this aim, the study will give insight into the critical differences between different cropping systems with respect to soil health, fertility, crop production productivity, and quality attributes.

The study was formulated with the following objectives

To evaluate natural farming with organic and the present recommended farming approaches in terms of yield, quality, soil properties, pest status, and economics in Cashew-based cropping systems.

To establish a cashew-based natural farming demonstration unit vis-à-vis the conventional farming system and organic farming practices.

3.2.6 Effect of storage duration and storage condition on seed nut viability of cashew (*Anacardium occidentale* L.) for quality planting material production

Cashew cultivation relies heavily on the availability of healthy and vigorous planting material, with seed nuts serving as the primary source for raising rootstocks. The viability and germination potential of cashew seed nuts are critical factors that directly influence the success of nursery production and subsequent field establishment. However, cashew seeds are known to have a relatively short viability period, and their germination is significantly affected by storage duration, environmental conditions, and packaging materials.

Despite the importance of these factors, systematic studies addressing the influence of different storage conditions and packaging materials on seed nut viability and germinability in cashew are limited. Understanding these aspects is essential to minimising seed deterioration, maintaining physiological quality, and ensuring uniform germination.

Therefore, this study aims to evaluate the viability of cashew seed nuts for producing quality rootstocks and to assess their germination performance under different storage conditions and packaging materials. The findings will contribute to the development of improved storage practices, ultimately supporting the production of high-quality planting material and enhancing the overall productivity of the cashew sector. The specific objectives of the study include-

To study the seed nut viability for producing quality rootstocks

To study the germinability with different storage condition and packaging material.

3.2.7. Influence of weather parameters on growth dynamics of apple and nut in selected varieties of Cashew.

Adopting the technique of the modified BBCH scale in cashew varieties (Vengurla-4, Vengurla-7, Vridhachalam3, NRCC Selection-2, Madakathara-2, and Bhaskara), the growth dynamics of cashew nut and apple (developmental stages- BBCH code 711 to 719 and maturity stages- BBCH code 811 to 819) were studied. The nut and apple parameters were recorded for all the early, mid, and late varieties. Further, the mineral composition at phenological stages was analyzed for major nutrients.

The pattern of accumulation of Nitrogen (N) range (3.94%) showed a similar trend of increased content of N at stage 811 in most of the varieties, slightly reduced during the growth stages, and finally increased at stage 819. It was observed that the P content varied at different stages of nut maturity. The highest concentration of P at final maturity (819) was recorded in variety NRCC Selection 2 (0.60%). Potassium (K) content was found in the range of 0.37 %. The distribution of K varied across maturity stages. However, the minimum and maximum content were 0.34 and 0.72%, respectively. The Variety Nethra Ganga showed a higher K content at the final maturity stage 819 (0.52%). The flowering pattern and sex ratio of all varieties were recorded to relate to weather variables.

Observational Trials

Studies on eco-friendly pots for cashew graft production

The study was taken up on biodegradable bags for cashew root stock raising and graft production. In this study, two types of eco-friendly pots were used: Kalpa eco pots (Arecanut stem pot) and biodegradable poly bags, as well as standard poly bags (Control). Among these, the typical

poly bag root stock and grafts survival and growth performance is good as compared to Kalpa eco pots, although biodegradable pots growth was also seen to be considerably good in growth, poly bags began disintegrating after 2 months, and again added one more bag to the root stock. This study indicated that, high gauge biodegradable bags can be used in future study to know the performance of cashew graft production (Fig.3.2.6).



Fig. 3.2.6 : Ecofriendly experimental cashew graft view

Coir pith compost as an alternate media for cashew graft production

Various soil-less media were tested for cashew graft production, including a control (M1-Soil: Sand: FYM-1:1:1), and coir pith compost (M3) produced the best results in terms of graft quality and survival percentage when compared to vermicompost (M2) and a combination of vermicompost and coir pith compost (M4), whereas soil media had the highest survival percentage (Fig.3.2.7). Among soilless media, coir pith compost with a pH of 6.5-7 and a strong nutritional status had a high success rate, and growth and root parameters were monitored for two years. Coir pith compost consistently had a lower production cost than other soilless media. It may be concluded that coir pith compost media is an alternative media for high-quality cashew graft production, which is disease-free with lightweight media and can be suitable for long transport with less mortality.



Fig. 3.2.7 : View of cashew grafts in soilless media

Unravelling the causes and developing mitigation strategies for flower drying in Cashew

The flowering habit of cashew is controlled by both internal and external factors. Climatic conditions play an important role in the induction of flowering. Usually, flowering occurs after the growth of a new flush at the end of the rainy season. The inflorescence is produced terminally on newly formed shoots. Identifying the key factors that mainly influence flower drying and mitigation strategies to overcome flower drying in cashew to increase the yield. An observational study has been taken up to record the number of flowers dried in North, South, East and West directions from the month of January to April. The observations showed that the number of male and female flowers drying increased with an increase in temperature from January to April in the control compared to the sprayed plants. Variability with respect to sex ratio and nut set was recorded in sprayed and unsprayed plants. The number of Male and hermaphrodite flowers was increased in sprayed panicles. The percentage of neuter flowers count was reduced in sprayed panicles (Table 3.2.3).

Table 3.2.3 : Percentage of male, hermaphrodite, neuter flowers count during the season

Flower type	Bhaskara			
	With spray	Without spray	Difference	Percent Increase
Hermaphrodite	699	520	179	34.42
Male	1313	660	653	98.93
Neuter	99	170	71	41.76

3.3. CROP PROTECTION

Priority area III: Integrated Insect Pests and Diseases Management in Cashew

3.3.1 Characterization and synthesis of female sex pheromone of Tea Mosquito Bug; (*Helopeltis antonii*) and its bioassay

The trials for volatile profiling of TMB sex pheromones of virgin females was continued during 2024-25 cropping season, using standardized protocol for collection from calling virgin females. Laboratory-raised TMB females aged 4-5 days were caged and placed in sticky traps in pest-prone plots. Females attracted to male TMB males within 30-60 minutes were transferred to the lab, collected in a volatile collection apparatus, and operated with a vacuum pump, volatiles from TMB females were adsorbed onto locally fabricated cartridges using Tenax® or Porapak®.

It was opined that the adsorbents needed to be thermo-activated so as to enhance their efficacy. To this end the adsorbents were heated up to 250°C, cooled to room temperature for 12 -48 h and used for collection of the volatiles released from calling females. Alternately, repeated washings with di-chloromethane [4-5 times] were also attempted and then used for volatile collection from calling TMB females. Both the samples were later eluted with Di-chloromethane and eluate was collected, labelled, and stored for further analysis. The results showed that repeated washings with DCM improved adsorption considerably, compared to dry heating (250 °C) wherein EAG and GC-MS showed similar results for eluted volatiles of virgin TMB females in terms of peak heights of benzene groups and alcohol groups for similar compounds (Table 3.3.1 & Fig. 3.3.1).

Table 3.3.1 : Comparative efficacy of methods for enhancing adsorption

[Peak heights x 10^5] Dry-heating at 250°C		[Peak heights x 10^5] Repeated washings [4-5] with DCM	
Alcohol groups	**Benzene groups**	**Alcohol groups**	**Benzene groups**
17.556	16.958	22.165	23.551
17.607	17.566	25.309	25.399
18.229	17.215	26.011	24.558

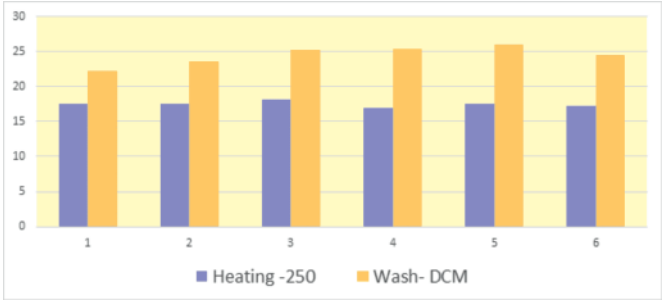


Fig. 3.3.1 : Influence of different treatments on the mean peak heights of alcohol & benzene groups

The eluted samples were analyzed at ICAR-NBAIR, Bengaluru and it was noticed that a total of 12 compounds, comprising of chloro-benzenes, ethyl-benzenes, ethyl alcohols like octonol-decanol, and ethyl acetophenones were traced which have pheromonal pre-cursor / pheromone status. This needs further analysis using more insects [i.e., virgin TMB females].

Further, 6 sets of virgin female TMB were subject to volatile collection using the set-up at ICAR-NBAIR, Bengaluru and the samples have been subjected to EAG and GC-MS analysis at NCBS laboratories.

3.3.2 Assessing the field effectiveness of entomopathogenic nematodes (EPN) and indigenous strain of entomopathogenic fungus (EPF) in management of cashew stem and root borers (*Plocaederus ferrugineus* and *Plocaederus obesus*)

The trials for evaluation of EPN were conducted in the identified plots of Karnataka Cashew Development Corporation [KCDC] plantations at Sowthadka division; [Onithaaru, Mastikallu and Kadeera] which have different edaphic characteristics and also with a varied topography; in order to determine the effect of these parameters on the survival and retention of virulence by the IJs of the different test EPN species (Coleopteran strains).

A total of 20 soil samples from all the KCDC plots and DCR plots were analyzed at Soil Science Lab, DCR. All the soil samples were found to be acidic (pH 4.72 – 5.64) and had normal EC values (0.031-0.074); however, the organic carbon and organic N varied significantly (Fig. 3.3.2 and Fig.3.3.3). The survival durations of the EPN and their virulence was observed to be higher (>150 days & M % > 90 per cent in 48h) in soils with higher Organic Carbon [OC] percentage (0.846 -2.003 %) and with higher Organic Nitrogen [ON] (kg/ha) [601.63-1079.22]. The above parameters were found to be considerably lower (<120 days & M% < 50 per cent in 48h) in soils with low OC percentage (0.113-0.484 %) and with a medium ON (Kg/ha) [376.32 – 551.94].

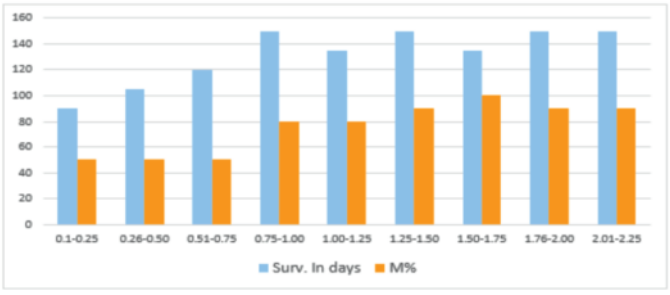


Fig. 3.3.2 : Survival and mortality levels induced at different organic C levels

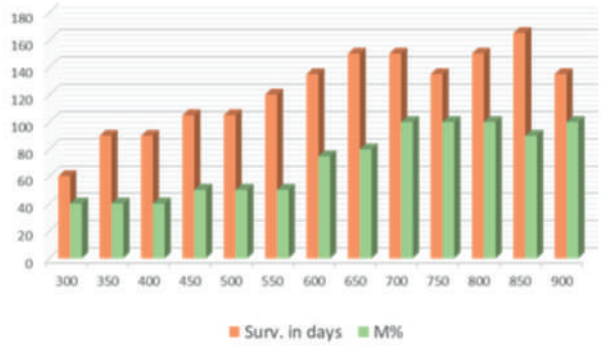


Fig. 3.3.3 : Survival of EPN and mortality levels induced at different organic levels

The test solutions of the IJs of EPN of two different species *viz.*, *Heterorhabditis indica* and *Steinernema carpocapsae* were used for the evaluations, at 10 LE /L applied to the rhizosphere of the healthy and trees in initial stages of CSRB incidence. The pest stages in the infested trees were removed physically and the soil samples were collected after 30 – 45 days after treatment and the retention of virulence by the EPN species was recorded (Table 3.3.2).

The results indicated cent per cent mortality at 24 hrs after release of bait insect till 90 DAT. Mortality levels were on par for all the dosages of both the EPN species during 120 DAT. *H. indica* induced significantly higher mortality than that of *S. carpocapsae* at150 DAT and all the tested dosages of both the EPN performed on par during the 150 DAT sampling. During 180 DAT lower test insect mortality was recorded which was on par for all the treatments (Table 3.3.3 and Fig.3.3.4).

Table 3.3.2 : Bait insect mortality at 24 hr after release at different EPN doses

Treatments		KCDC -1 2024-2025			KCDC-II 2024-2025		
		120 DAT	150 DAT	180 DAT	120 DAT	150 DAT	180 DAT
T1	H.i =500 ml /tr	90.26	88.54[a]	58.75	91.27	90.74 [a]	55.25
T2	H.i =1000 ml/tr	94.50	91.50[a]	62.23	90.25	92.52[a]	55.06
T3	H.i =2500 ml/tr	89.75	91.75[a]	62.00	93.24	88.50 [a]	54.73
T4	S.c =500 ml/tr	92.34	73.25 [b]	60.74	89.75	72.75 [b]	55.00
T5	S.c =1000 ml/tr	92.77	72.08 [b]	59.75	90.51	70.74 [b]	56.22
T6	S.c =2500 ml/tr	90.50	69.75 [b]	61.76	94.50	69.25 [b]	54.74
CD@5%		NS	4.33	NS	NS	3.81	NS
CV %		18.20	19.55	22.54	19.78	18.32	21.05
Total number of cashew trees treated: CSRB infested = 18±1 Healthy = 24±1							

Table 3.3.3 : Bait insect mortality at 24 hr after release at different EPN doses of commercial samples

Treatments		Commercial Sample -1 2024-2025			Commercial Sample -2 2024-2025		
		120 DAT	150 DAT	180 DAT	120 DAT	150 DAT	180 DAT
T1	500 ml /tr	90.51	91.75 a	59.24	91.26	88.72 a	55.23
T2	1000 ml/tr	92.17	88.74 a	58.75	90.55	87.75 a	54.75
T3	2500 ml/tr	93.50	88.72 a	60.23	93.50	87.23 a	55.44
T4	500 ml/tr	94.22	72.22 b	58.75	92.54	69.54 b	55.29
T5	1000 ml/tr	90.50	69.75 b	58.60	91.75	71.53 b	56.23
T6	2500 ml/tr	94.50	71.25 b	59.33	94.58	69.50 b	56.07
CD @5%		NS	3.21	NS	NS	2.16	NS
CV (%)		15.56	18.72	19.65	18.87	19.91	20.11
Total number of cashew trees treated: CSRB infested=24±2 Healthy = 30±2 number of bait insects released/ soil sample - 8							

The trials indicated cent per cent mortality @24 hrs after release of bait insect till 90 DAT mortality levels were on par for all the dosages of both the EPN species during 120 DAT. *H. indica* induced significantly higher mortality than that of *S. carpocapsae* @150 DAT. All the tested dosages of both the EPN performed on par during the 150 DAT sampling. During 180 DAT lower test insect mortality was recorded which was on par for all the treatments.

Further, it was noticed that none of the EPN treated trees in any of the experimental plots had any fresh infestation by the CSRB over the past two years, however the recovery of EPN IJs from most of the treated trees was moderate (104 – 105 per 10 LE (infected wax moth cadavers) indicating the necessity for repeated inundative application to sustain the resident/native populations in the rhizosphere of cashew trees apart from adding organic matter on a regular basis (Fig. 3.3.4). Also, a new strain of *S. abbasi* infecting coleopteran insects has been obtained from Nematology laboratory of ICAR-CPCRI, Kasaragod which have been included in the field evaluations, apart from the commercial formulations.

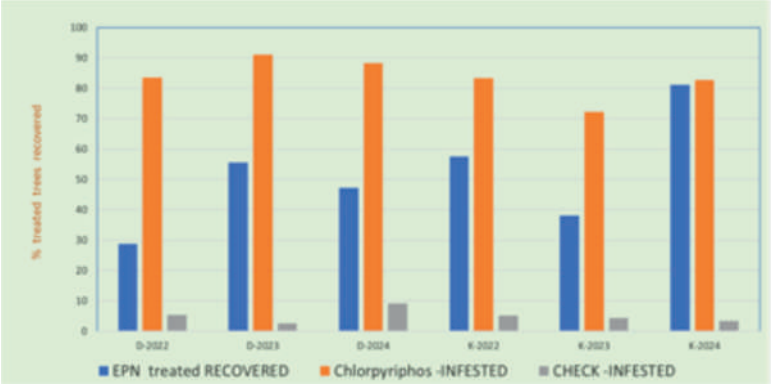


Fig. 3.3.4 : Recovery levels in EPN/Chlorpyriphos/ untreated CSRB infested tress

3.3.3 Species complex of thrips infesting cashew, molecular characterization, and their management measures

Species complex of thrips occurring in cashew

Surveys over three-years period (2022-2025) at different plots of ICAR-DCR, Puttur resulted in collection of over 8000 thrips specimens. Identification of the collected specimens revealed occurrence of 23 species of thrips in cashew belonging to the sub orders Terebrantia and Tubulifera under three families viz., Thripidae, Phlaeothripidae and Aeolothripidae. Three species viz., *Retithrips syriacus, Selenothrips rubrocinctus* and *Mecynothrips simplex* on the cashew leaves were collected from leaves, while remaining 20 were from the cashew flowers.

Occurrence of Thrips hanifahi Mound and Azidah 2009 (Thysanoptera, Thripidae) is reported for the first time in India., based on the collections on cashew flowers. Similarly, one more new species *Rhamphothrips tenuirostris* Karny (Thysanoptera, Thripidae) has been collected from Cenchrus sp. in the cashew plantations, and reported for the first time from India (Fig. 3.3.5).



Fig. 3.3.5 : New thrips species reported in India. a. *Thrips hanifahi*, b. *Rhamphothrips tenuirostris* Karny

In addition, the extensive surveys resulted in record of 15 new species on cashew viz., *T. parvispinus, T. palmi, T. subnudula* etc. Amongst the genus, Thrips was the predominant with seven species followed by *Scirtothrips* and *Haplothrips* with two species each, and the rest 12 genera had single species each. Most of the species recorded are polyphahous in nature. Thrips specimens were also collected from different cashew growing regions of the country through the centres of AICRP on cashew and a total of 16 species were documented.

A variety of predatory insects like lace wing bugs, coccinellids, ants, anthocorid and geocorid bugs were found in cashew inflorescences during the collections. During these extensive collections, only one predatory thrips species, *Aduncothrips asiaticus* (Ramakrishana and Margabandhu) (Thysanoptera: Aeolothripidae) has been recorded, but only in very less numbers. The role of different thrips species on cashew as pest or detrivore or pollinator needs to be studied thoroughly to understand their interactions.

Molecular characterization of four common species

The DNA sequence of the mitochondrial COX1 gene of the four common thrips species of cashew were submitted to NCBI (National Center for Biotechnology Information) and assigned with a unique accession number namely Accession No. OR145051 for S. dorsalis, PV643445 for *T. subnudula,* PV644258 for *Haplothrips sp.* and PV029932 for *R. syriacus.* The edited sequence results of these thrips specimens were matched with 98-100 % identity with the species available in NCBI database. This will aid in distinguishing closely related and morphologically similar species.

Abundance of thrips in cashew

The relative abundance of thrips species during the first two years indicated more abundance by *T. subnudula* (36.81 %) followed by *H. gowdeyi* (25.88 %), *H. ganglbaueri* (23.26 %) and *S. dorsalis* (8.2 %). The important observation is that, *S. dorsalis* which was recorded as most abundant species in the study region in the previous years, was not found abundant in the present study as a new species, *T. subnudula* has become abundant. Hence, the present investigation indicates that there is a shift in thrips species complex in cashew.

Alternate host plants for thrips species

Surveys conducted on other plant species in the cashew plantations indicated occurrence of 13 thrips species that were recorded on cashew. On *Semecarpus kurzii* (Anacardiaceae), which is a wild relative of five thrips species were recorded in which, four were common in cashew *viz., H. gowdeyi, T. subnudula, T. coloratus, S. rubrocinctus* except *Heliothrips haemorrhoidalis. T. subnudula* was present in seven plant species including the common weed species like *Calycopteris floribunda, Lantana camara* and *Calotropis sp.* In addition to *T. subnudula,* three more species namely *H. gowdeyi, T. florum* and *T. hawaiiensis* were found on *L. camara.* Thus, thrips can survive on the weed species during the non-flowering period of cashew and subsequently infest cashew. The information on alternate host plants will be helpful when management measures are targeted against thrips on cashew.

Nature of damage by thrips

Leaf thrips were seen occasionally in field conditions and in very less numbers. However, a few young plants were infested by *R. syriacus* during 2024-25, and upon severe infestation, severe pre mature leaf fall was noticed. Under polyhouse conditions, occurrence of *S. rubrocinctus* was regularly noticed and the infested leaves develop discoloured specks and fall prematurely.

On the nuts and apples, infestation by thrips results in development of corky patches (Fig. 3.3.6). The infested apples develop cracks upon maturity and ripening. Severe feeding results in malformation of nuts.

During 2024-25 random sampling of nuts from the cashew blocks indicated that, 56.1 % of harvested nuts were free of thrips infestation, while 25 % with slight infestation (G1) and 3.4 % with severe infestation (G4). Significant reduction in size and weight of nuts and apples with increase in the rate of thrips infestation was recorded. Besides, upon severe feeding damage, a reduction in sugars to a tune of 80 %, and reduction up to 50 % in protein, fat and CNSL was recorded. However, there was an increase in the secondary metabolites viz., tannins and flavonoids in the infested nuts over the uninfested nuts.



Fig. 3.3.6 : Damage symptoms caused by thrips.
a. Brown specks and discolouration by leaf thrips, *S. rubrocinctus,*
b. Scabby apple with cracks due to *S. dorsalis*

Table 3.3.4 : Influence of thrips infestation on nut physical parameters in VTH-174

Thrips infestation (grade)	Nut weight (g)	Kernel wt (g)	Nut length (cm)	Nut width (cm)	Nut breadth (cm)
No infestation	6.61±0.61a	1.60±0.29a	3.45±0.19a	1.80±1.16	2.14±0.11b
G1	6.57±0.43a	1.55±0.25ab	3.47±0.15a	1.72±0.10	2.29±0.17a
G2	6.43±0.73a	1.45±0.17bc	3.38±0.14ab	1.78±0.14	2.25±0.21a
G3	5.84±0.71b	1.33±0.32cd	3.28±0.15bc	1.75±0.23	2.12±0.17b
G4	5.22±0.72c	1.21±0.29d	3.18±0.16c	1.72±0.17	2.10±0.12b
CD	0.42	0.14	0.11	NS	0.11
CV	10.74	18.59	5.31		7.33

Management measures

A set of 11 treatments were imposed on cashew with a control (Table 3.3.5.) during the flowering stage and three sprays were taken up at 15 days intervals. After three sprays, comparatively less population was recorded in the trees treated with Raichur bio-consortia II, herbal liquid soap, pongamia soap solution, neem azal & Raichur microbial consortia I. The insect population was nil in insecticide treated trees. However, after three rounds of sprays, no significant differences in the mean yield were observed in the treated trees compared to control.

Table 3.3.5 : Efficacy of different botanical formulations and entomopathogenic fungi on the population of flower thrips of cashew

Treatment	No. of thrips/ inflorescence			
	PTC	7 DAS-I	7 DAS -II	7 DAS -III
Neem soap -7g/L	6.3	10.0	2.0	8.3
Pongamia soap -7g/L	6.3	4.0	1.7	5.7
Neem Azal -1.5 ml/L	5.7	3.3	5.7	16.7
Multiplex *Beauveria bassiana* -5 g/L	6.7	6.3	0.0	11.3
Rashvi Herbal Liquid soap -1ml/L	7.3	3.3	5.3	14.7
Raichur microbial consortia I -5 g/L	6.3	3.3	5.0	13.7
Raichur microbial consortia II -5 g/L	5.7	0.7	5.0	7.3
NABIR Microbial consortia -10 ml/L	6.7	4.7	1.3	9.0
NBAIR *Beauveria bassiana* -10 ml/L	5.7	7.3	2.7	12.3
NBAIR *Bacillus* sp. -10 ml/L	6.3	11.0	3.7	19.7
Lambda cyhalothrin 5 EC 0.6 ml/L	6.3	0.0	0.0	0.0
Control	6.3	10.3	9.0	12.3
CD	-	3.72	2.26	3.01
CV	14.781	40.93	38.71	16.28

PTC- Pretreatment count, DAS – Days after spray

3.3.4 Development of an eco-friendly and cost-effective pest management strategy for cashew using plant and microbial-based pesticides

The project was initiated in 2025 with the following objectives,

To evaluate the response inducing herbivore induced plant volatiles (HIPVs) of TMB for its attraction/ deterrence to TMB under field conditions and to investigate on HIPVs for other important pests of cashew.

To develop microbial-based volatile (mVOCs) formulations to manage major pests of cashew and to attract natural enemies of cashew pests.

To evaluate entomopathogenic fungi, horticultural mineral oils and botanical formulations for their efficacy against important cashew pests and their natural enemies.

The responsive HIPV compounds are being identified based on bioassays. Later, the synthetic analogues need to be procured for further laboratory bioassays and field evaluation.

Different samples of microbial volatiles (14 numbers) were obtained from ICAR-CICR, Nagpur and tested in field conditions for their attraction to cashew pests using yellow sticky traps. Attraction of bibionid flies, jassids, white flies, chrysomelid beetles, cicadellids, coccinellids, thrips, mirids, TMB etc were recorded. Though there was high incidence of tea mosquito bug and leaf miner in the field, attraction of TMB was very less on the traps, and attraction of leaf miner was nil, indicating these volatiles have no attraction for these pests. Different microbial volatiles and/or combinations will be evaluated in the subsequent trials.

Pot culture trails were initiated under net house conditions for evaluation of botanical formulations and EPFs. Initial trials with neem azal 10000 ppm (1.0 ml/L) demonstrated very low effect on TMB nymphs and adults, where only 5-8 % mortality was recorded (Fig. 3.3.7). Preliminary trials with Nanma (a bio product developed by ICAR-CTCRI, herbal liquid soap (Rashvee) exhibited moderate effectiveness on 1st instar nymphs of TMB causing 60 – 70% mortality. However, there was no ovicidal effect. Further evaluations are required to confirm the efficacy. Similarly, Nanma, herbal liquid soap and pongamia soap were found very effective on aphids causing up to 100 % mortality.



Fig. 3.3.7 : A view of pot culture studies
a. Evaluation of botanicals on TMB, b. Dead aphids seen on pongamia soap treated plants.

3.3.5 Survey and diagnosis of diseases occurring in cashew through morphological and molecular characterization and their management

Survey and collection disease infected samples

During 2025, the disease infected samples were collected from different cashew growing regions and samples were stored at 4° for further studies (Table 3.3.6). The suspected disease symptoms were put for isolation of associated pathogen/s. The isolated pathogens characterized through cultural, morphological and molecular approaches for species level identification of associated pathogens.

Table 3.3.6 : Collection of disease infected samples from different regions

Sl. No.	Disease Name	Place of Collection
1	Gummosis	Regional Research Station, Jhargram, West Bengal
2	Gummosis	SG College of Agriculture and Research Station, Kumharwand, Jagdalpur, Chhattisgarh
3	Wilt	SG College of Agriculture and Research Station, Kumharwand, Jagdalpur, Chhattisgarh
4	Gummosis	Cashew Research Station, Bapatla, Andhra Pradesh
5	Leaf blight	ICAR - Central Coastal Agricultural Research Institute, Goa
6	Anthracnose	Cashew Research Station, Madakkathara, Kerala
7	Blossom blight	Agricultural Experimental Station, Paria, Gujarat

TMB-disease complex

To know the association of TMB infested shoots and pathogen/s in cashew, the TMB infested shoots from Nethra Ganga and NRCC Selection-2 varieties from Keminjje Farm and Bhaskara and Ullal-4 varieties from Shantigodu Farm were collected in15 days intervals starting from second fort night of October, 2024 to first fortnight of April, 2025 (Fig. 3.3.8). The periodic isolations at 15 days interval from TMB infested shoots collected from cashew varieties from both farms were carried out to identify the pathogen/s from TMB infested shoots. The cultural and morphological characterization revealed that, pathogens are associated with TMB infested shoots. The most predominant pathogen associated with TMB infested shoots identified as *Pestalotiopsis* spp. followed by Colletotrichum spp. *Lasiodiplodia* spp. and other pathogens were also observed viz., *Fusarium* spp. and *Curvularia* spp. (Table 3.3.7 and Fig. 3.3.9)



Fig. 3.3.8 Symptoms of TMB infestation and collection of infected samples

Table 3.3.7 : Details of pathogen isolates established from TMB infested shoots from Kemminje and Shantigodu Farms

Pathogen identified	Kemminje		Shantigodu		Nos. of isolates
	H-130	NRC Sel- 2	Bhaskara	Ullal-4	
Colletotrichum spp.	3	1	6	6	16
Pestalotiopsis spp.	12	10	7	3	32
Lasiodiplodia spp.	7	5	1	1	14
Curvularia spp.	1	0	0	4	5
Fusarium spp.	2	6	2	1	11
Unknown	23	10	20	22	75

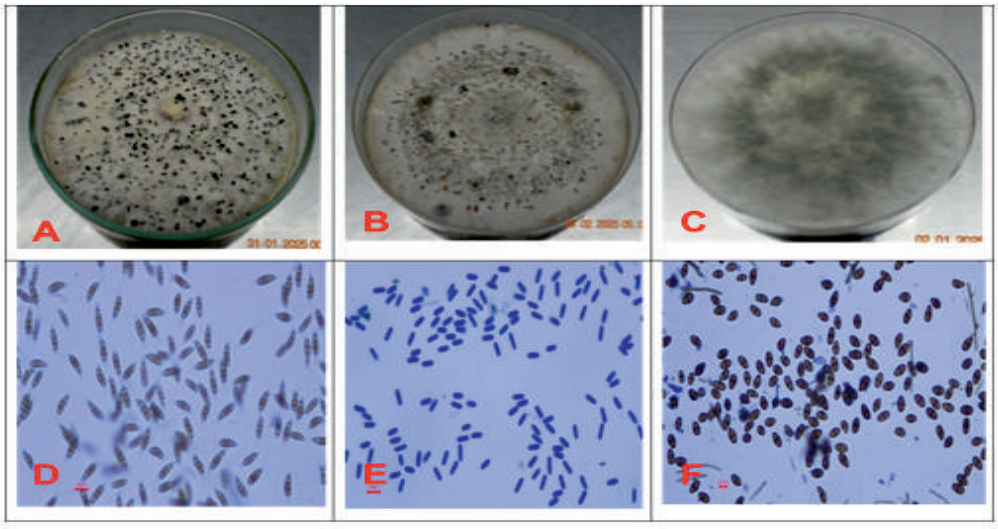


Fig. 3.3.9 : A) *Pestalotiopsis* spp. growth on medium;
B) *Colletotrichum* spp. growth on medium; C) *Lasiodiplodia* spp. growth on medium;
D) conidia of *Pestalotiopsis* spp.; E) conidia of *Colletotrichum* spp.; F) conidia of *Lasiodiplodia* spp.

Further, to confirm the identified pathogens associated with TMB infested shoots, pathogenicity tests were carried out to prove its causal role of *Pestalotiopsis* spp., *Colletotrichum* spp., *Lasiodiplodia* spp. under artificial conditions. The healthy seedlings of NRCC Selection-2 (n=5) were raised in glass house and 30 days old seedlings were individually inoculated with identified pathogens. Typical symptoms were observed after 12-15 days after inoculation (DAI) for *Pestalotiopsis* spp., *Colletotrichum* spp., *Lasiodiplodia* spp. (Fig.3.3.10).

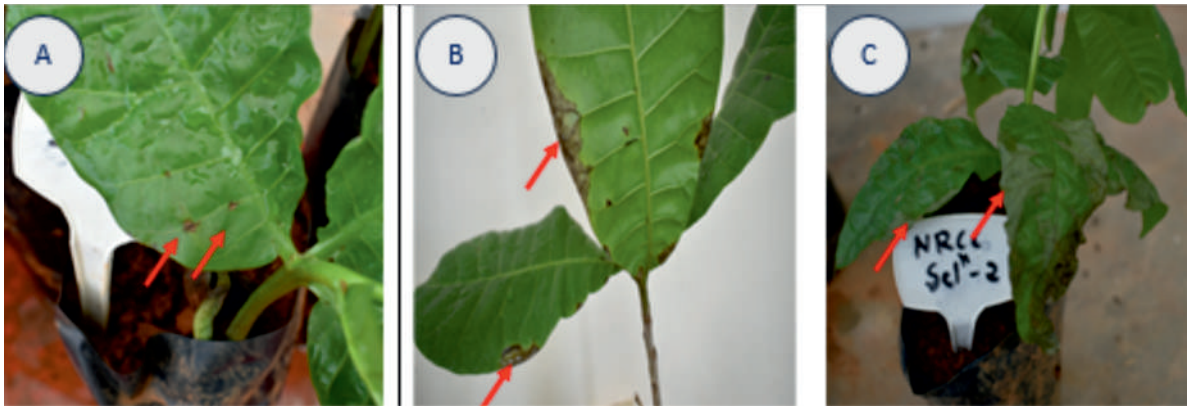


Fig. 3.3.10 : Disease symptom development under artificial conditions, A) *Pestalotiopsis* spp.; B) *Colletotrichum* spp.; C) *Lasiodiplodia* spp.

Pathogenicity and multigene analysis of seedling rot disease

Establishment of pathogenicity under artificial conditions

The pathogenicity was performed on healthy seedlings (n=5) of cashew and inoculated with conidial suspension on the surface of cashew seedling leaves. The *B. rhombica* isolate BRPtC1 consistently induced disease symptoms on cashew seedlings under controlled environmental conditions. The initial symptoms were observed from 7 days of post inoculation and further, the symptoms on inoculated leaves became apparent at 10-12 days post-inoculation (DPI), initially appearing as small, light brown spots surrounded by a yellow halo. These lesions gradually expanded into large, irregular necrotic patches over time and the symptoms were observed in all inoculated cashew seedlings (Fig 3.3.11). similarly, in negative control, the seedlings sprayed with sterile distilled water remained symptom-free throughout the observation period.

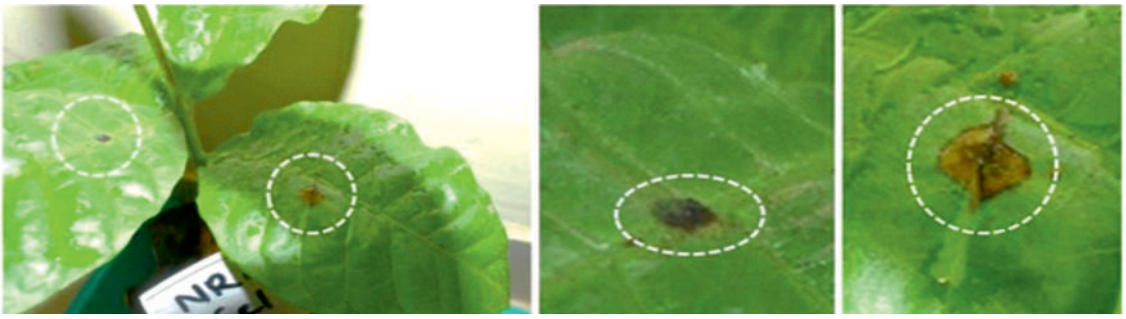


Fig 3.3.11 : Disease symptom expressions under artificial conditions against *Beltrania rhombica*

Molecular confirmation and phylogeny

Further, molecular characterization with targeted two genomic loci *i.e.* the internal transcribed spacer (ITS) region with ITS1/ITS4 primers and the large subunit (LSU) of the nuclear ribosomal RNA with LR0R/LR5 primers were done to confirm the species identity. The sequences obtained from the representative isolate, B. *rhombica* isolate BRPtC1, were deposited in the

NCBI GenBank database under the accession numbers PV639794 (ITS) and PV643879 (LSU). NCBI BLASTn analysis of the ITS region revealed a 99.83% sequence similarity with B. *rhombica* CBS 144521 (GenBank: MK442571) and 99.31% similarity with B. *pseudorhombica* CBS 138003 (NR_148074). The LSU region showed 99.55% similarity to B. *rhombica* CBS 144521 (MK442513) and 99.21 % similarity to *Beltrania sinensis* strain JS260 (MN077264). The cashew isolate, BRPtC1 was clustered within a well-supported, distinct clade alongside B. *rhombica*, supported by high bootstrap values, thus confirming its identity as B. *rhombica* (Fig. 3.3.12).

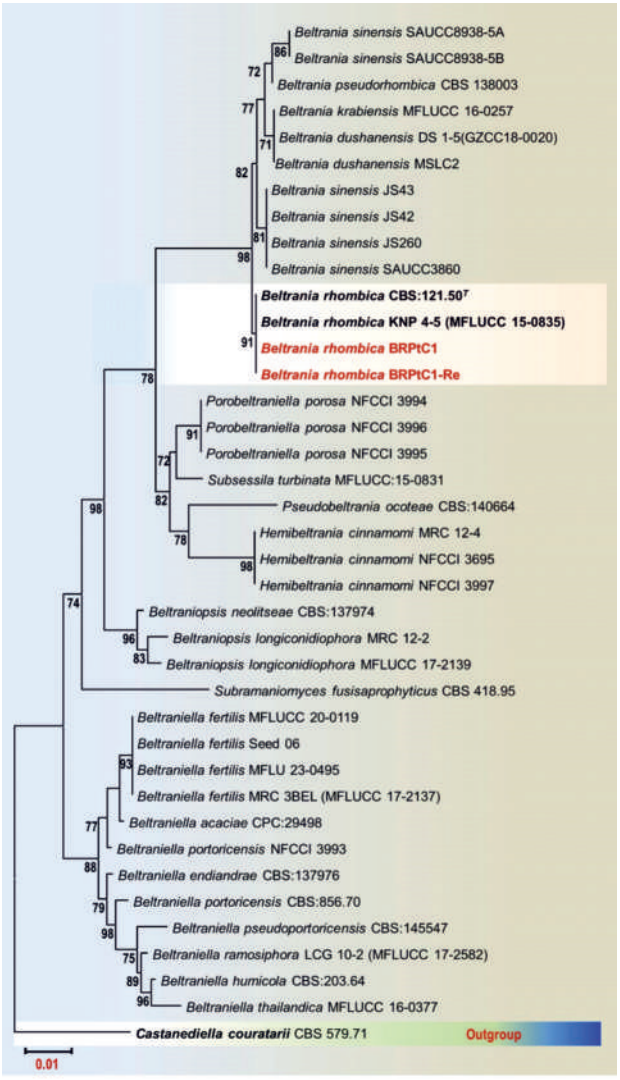


Fig. 3.3.12 : Phylogenetic tree produced using partial ribosomal DNA (rDNA) and larger sub unit (LSU) genes sequences showing the phylogenetic relationship of *Beltrania rhombica* isolated from cashew (Bold with asterisk mark) with other *Beltrania rhombica* isolates and *Castanediella couratarii* as out-group retrieved from GenBank, using the Maximum-likelihood (ML) method.

3.3.6 Deciphering the role of core floral microbiome in enhancing productivity in cashew

The metagenomic analysis of both male and hermaphrodite flowers of early and late maturing varieties *viz*., Bhaskara and Madakkathara respectively were used for the study (Fig . 3.3.13) The internal transcribed spacer (ITS) region and 16S rRNA are used for microbiome analysis of fungus (Fig. 3.3.14) and bacteria (Fig. 3.3.15) respectively . The primer details for bothreverse and forward are provided in table 3.3.8.



Fig. 3.3.13 : Sample collection of cashew flowers from Bhaskara and Madakkathara-2 varieties for metagenomic sequencing

Table 3.3.8 : Details of primers used for metagenomic analysis

Gene	Primer	Primer Sequence
ITS region	ITS1-F	TCCGTAGGTGAACCTGCG
	ITS4-R	TCCTCCGCTTATTGATATGC
16S rRNA	16S rRNA F	GCCTACGGGNGGCWGCAG
	16S rRNA R	ACTACHVGGGTATCTAATCC

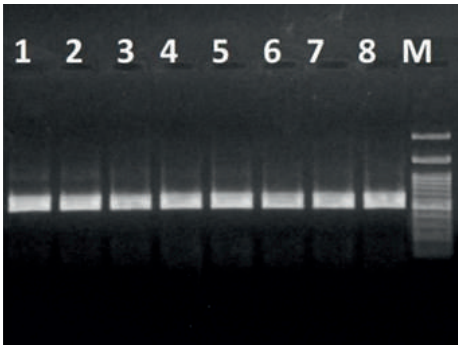


Fig. 3.3.14 : Quantity and quality check (QC) of of first amplicons generated on 1.2% agarose gel for 16s RNA

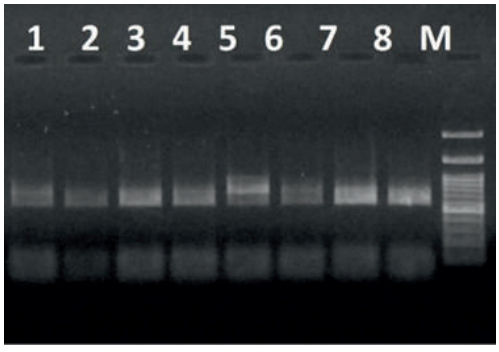


Fig. 3.3.15 : QC of first amplicons generated on agarose gel for ITS

Based on 16S rRNA metagenomic sequencing analysis, the most abundant bacteria were *Rosenbergiella* spp. followed by *Lactococcus* spp. and *Bacillus* spp. belongs to phylum proteobacteria were identified in both hermaphrodite and male flowers of Bhaskara (Table 3.3.9) and Madakkathara-2 (Table 3.3.10) varieties.

Based on ITS gene metagenomic sequencing analysis, the most abundant fungal species was *Mycosphaerella tassania* followed by *Sclerotinia* spp. are identified belonging to phylum Ascomycota.

Table 3.3.9 : Most abundant taxonomy identified in samples at different taxonomic levels in Bhaskara

	BH-1 (%)	BH-2 (%)	BM-1 (%)	BM-2 (%)
Phylum	Proteobacteria (49.16)	Proteobacteria (88.83)	Proteobacteria (59.48)	Proteobacteria (75.22)
Class	Gammaproteobacteria (40.79)	Gammaproteobacteria (61.86)	Gammaproteobacteria (33.26)	Gammaproteobacteria (51.03)
Order	Lactobacillales (32.77)	Enterobacterales (42.53)	Enterobacterales (29.98)	Enterobacterales (40.71)
Family	Sterptococcaceae (31.22)	Erwiniaceae (34.90)	Erwiniaceae (25.76)	Erwiniaceae (35.80)
Genus	*Lactococcus* (31.22)	*Rosenbergiella* (33.85)	*Rosenbergiella* (23.42)	*Rosenbergiella* (35.28)
Species	Unidentified species from genus *Lactococcus* (31.22)	Unidentified species from genus *Rosenbergiella* (33.85)	Unidentified species from *Rosenbergiella* (23.42)	Unidentified species from genus *Rosenbergiella* (35.28)

Table 3.3.10 : Most abundant bacterial taxonomy identified in samples at different taxonomic levels in Madakkathara-2

	MH-1 (%)	MH-2 (%)	MM-1 (%)	MM-2 (%)
Phylum	Proteobacteria (78.16)	Proteobacteria (39.59)	Proteobacteria (46.17)	Proteobacteria (76.81)
Class	Gammaproteobacteria (67.31)	Gammaproteobacteria (25.77)	Gammaproteobacteria (24.60)	Gammaproteobacteria (71.57)
Order	Enterobacterales (57.55)	Enterobacterales (23.51)	Enterobacterales (12.94)	Enterobacterales (64.13)
Family	Erwiniaceae (46.84)	Erwiniaceae (12.78)	Moraxellaceae (9.27)	Morganellaceae (56.91)

Contd.

	MH-1 (%)	MH-2 (%)	MM-1 (%)	MM-2 (%)
Genus	*Rosenbergiella* (46.84)	Unidentified genus (10.31)	*Bacillus* (8.79)	*Buchnera* (36.70)
Species	Unidentified species from genus *Rosenbergiella* (46.84)	Unidentified species from genus *Rosenbergiella* (10.31)	Unidentified species from genus *Rhizobium* (8.79)	Bacterium endosymbiont (35.51)

Based on ITS gene metagenomic sequencing analysis, the most abundant fungal species was *Mycosphaerella tassania* followed by *Sclerotinia* spp. are identified belonging to phylum Ascomycota were identified in both Bhaskara (Table 3.3.11) and Madakkathara-2 (Table 3.3.12) flowers of cashew varieties.

Table 3.3.11 : Most abundant fungal taxonomy identified in samples at different taxonomic levels in Bhaskara

	BH-1 (%)	BH-2 (%)	BM-1 (%)	BM-2 (%)
Phylum	Ascomycota (90.15)	Ascomycota (97.16)	Ascomycota (95.56)	Ascomycota (96.86)
Class	Dothideomycetes (55.39)	Dothideomycetes (49.02)	Dothideomycetes (51.17)	Dothideomycetes (65.06)
Order	Capnodiales (53.03)	Helotiales (44.45)	Capnodiales (49.50)	Capnodiales (61.80)
Family	Sclerotiniaceae (33.17)	Sclerotiniaceae (44.45)	Sclerotiniaceae (42.31)	Mycosphaerellaceae (40.23)
Genus	*Mycosphaerella* (26.99)	Unidentified genus from family Scerotiniaceae (29.21)	*Mycosphaerella* (27.82)	*Mycosphaerella* (39.97)
Species	*Mycosphaerella tassiana* (26.99)	Unidentified genus from family Scerotiniaceae (29.21)	*Mycosphaerella tassiana* (27.82)	*Mycosphaerella tassiana* (39.97)

TABLE 3.3.12 : Most abundant fungal taxonomy identified in samples at different taxonomic levels in Madakkathara-2

	MH-1 (%)	MH-2 (%)	MM-1 (%)	MM-2 (%)
Phylum	Ascomycota (89.19)	Ascomycota (96.37)	Ascomycota (93.3)	Ascomycota (95.82)
Class	Letiomycetes (54.79)	Letiomycetes (54.87)	Dothideomycetes (53. 76)	Letiomycetes (60.26)
Order	Helotiales (54.77)	Helotiales (54.87)	Capnodiales (52.56)	Helotiales (60.26)
Family	Sclerotiniaceae (54.77)	Sclerotiniaceae (54.87)	Mycosphaerellaceae (51.47)	Sclerotiniaceae (60.26)
Genus	Unidentified genus from family Scerotiniaceae (39.09)	Unidentified genus from family (36.79)	Mycosphaerella (51.43)	
Species	Mycosphaerella tassiana (39.09)	Unidentified genus from family Scerotiniaceae (36.79)	Mycosphaerella tassiana (51.43)	Unidentified genus from family Scerotiniaceae (31.24)

Externally Funded Project

3.3.7 Establishment of state of art facilities for chemical ecology studies targeting ecofriendly pest management and demonstration in cashew (2024-26) (PM-RKVY)

A chemical ecology laboratory has been established (Fig. 3.3.16) with the funding by PM-RKVY, Karnataka with the facilities like GC-EAD (Gas Chromatography coupled Electro Antennography Detector), air entrainment units, y tubes for bioassays, heat block, microscope etc. The consumables and other minor equipment's are being purchased for taking up the trials on insect olfactory responses.



Fig. 3.3.16 : Chemical ecology laboratory with facilities a. GC EAD, b. Air entrainment unit

3.4 POST-HARVEST TECHNOLOGY

Priority Area IV: Development of Food Products and Machinery for Pre- and Post-harvest Management and Processing

3.4.1 Development of ready-to-eat alternative snack food using cashew apple-Extrusion and Vacuum frying approach

A vacuum frying unit with operational capacity of 7-10 kg, suitable for varied moisture foods fabricated, installed and commissioned (Fig. 3.4.1).

Basic trials conducted with cashew apple slices (~2-3 mm thickness) to evaluate its performance in terms of machinery parameters viz., frying oil temperature, frying time and deoiling duration for its end product quality. Higher oil temperature, resulted in reduced frying time and more crispiness in the end product, but change in the surface colour is observed. On the other hand, lower temperature enhanced frying time and more absorption in oil leading to leathery feel. Preliminary experiments indicated that synergic effect of all three crucial parameters *viz.,* oil temperature (63°C), roasting time (33 min) and deoiling time (20 Min) resulted in better textural property in terms of crispiness (<0.7 N) and Redness index (11.68) and / or Browning index (57.08) with moisture loss to the extent of 74.6% (Table 3.4.1). Due to technical issue, further experiments to be conducted to evaluate retention of surface colour, nutritional value of vacuum fried snack food and investigation on its shelf life.



Fig. 3.4.1 : Small-scale vacuum frying unit for high-moisture fruits

Table 3.4.1 : Influence of critical processing parameters on quality of end product in vacuum frying of cashew apple slices

Oil Temperature ^{0}C	Frying time (min)	Deoiling time (min.)	Weight loss (%)	Quality of the end product
120	6	2.5	82.9	Brown and scorched
90	15	10	69.2	Brown and scorched
85	15	5	65.0	Improper frying, Oily
75	19	7	72.8	Slightly scorched and moderate crispy
70	15	2.5	70.5	>70% chips retained its colour, crispy and more oil adherence
65	10	5	67.2	Insufficient frying
65	33	15	64.2	Crispy, but oily
Cold blast (-80^{0}C)				
110	3	0.5	73.2	Completely scorched
75	15	8	86.6	Scorched due to heating coil issue
65	33	20	74.6	Better colour and crispiness

Thickness of slices: 2-3 mm; Moisture content of slices:80-85% d.b; Frying oil: Rice bran based

3.4.2 Optimizing processing parameters in cashew for enhancing whole kernel recovery

Viewing the energy intensity to produce steam compared to wood or cashewnut shell as fuel, an electrically powered steam generating cum nut cooking systems, i.e., Static and Rotary cooker installed and commissioned recently to optimize steam conditioning of raw cashewnuts for better whole kernel recovery (Fig. 3.4.2). Basic investigation on comparative evaluation of thermal use efficiency of three different fuel used for steaming process for raw cashewnuts confirmed that 69.31 % for electricity; 4.66 % for cashewnut shell, and 4.47 % for wood. Total energy required for steaming unit weight of raw cashewnuts found to be 246.95 KJ Kg^{-1} for electricity, 3835.64 KJ Kg^{-1} for Cashewnut shell, and 3829.96 KJ Kg^{-1} for wood. Lower efficiency in the case of CNS and Wood is primarily due to flue gas generation, wind velocity and feed rate of fuel.

Major parameters identified are steam pressure and duration of exposure related to the machine and size of the raw cashewnuts and its moisture content as material parameters towards maximizing whole kernel recovery through optimization and 'Design of Experiments' prepared using RSM technique. Due to administrative reasons, freshly harvested nuts could not be made available for trials. Basic trials conducted with large (Intermediate axis dimension > 25 mm) and medium size nuts (<25 mm up to 23 mm) having moisture content <8.0% d.b indicated that the rotary cooker requires lesser exposure time compared to the static cooker, ensuring uniform treatment, saving energy consumed. Variation in whole kernel recovery was observed. Due to technical problems associated with the 'Humidity chamber', optimization of drying unpeeled cashew kernels could not be conducted.

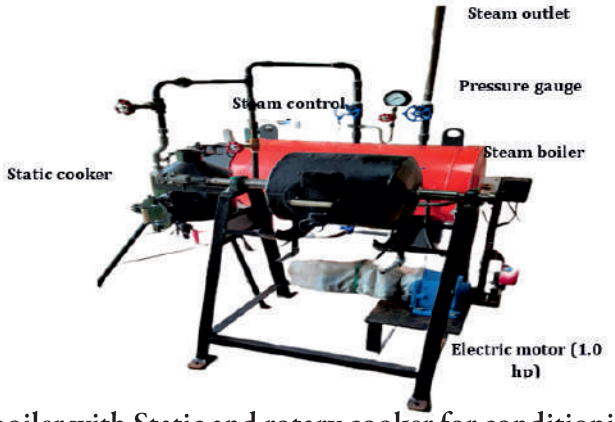


Fig. 3.4.2 : Steam boiler with Static and rotary cooker for conditioning raw cashewnuts

3.4.3: Enhancing the shelf life of cashew apple to increase the market potential and development of functional foods

With the aim of increasing the shelf life of cashew apples for table purposes, and processing, and storage studies were conducted, where the effect of different storage temperatures and packaging materials was studied. For optimization of storage temperature, unwashed cashew apples were stored with and without the nut at different temperatures, viz., room temperature (25°C), 5°C, 10°C, and 15°C at a relative humidity in the range of 85-90 % (Fig. 3.4.3). The samples were evaluated for different physical and biochemical parameters. Results revealed that cashew apples stored at 5°C showed less spoilage (10 %) from 9 Days After Storage (DAS) as compared to 10°C (80 % spoilage) and 15°C (100 % spoilage). Therefore, 5°C was used for further study with different packaging materials. Ventilated punnet box, non-ventilated punnet box, micro-perforated punnet box, and trays with cling wrap were used for storing the apples (Fig. 3.4.4). For control treatment, cashew apples were stored in open trays. Non-ventilated punnet box and micro-perforated punnet box resulted in less physiological loss (0.80 %, 0.44 %) and low electrical conductivity (14 & 18µS/s) over ventilated punnet box (5.26 % PL & 35 µS/s) from 14 DAS in control samples (stored at 5°C in open conditions) 1.5 times increase in physiological loss in weight was observed from 7 DAS, indicating low shelf life as compared to fruits packed in box and tray. Future studies will be conducted to validate the previous findings and evaluating the effect of pretreatments such as washing and ozonation on the shelf life.

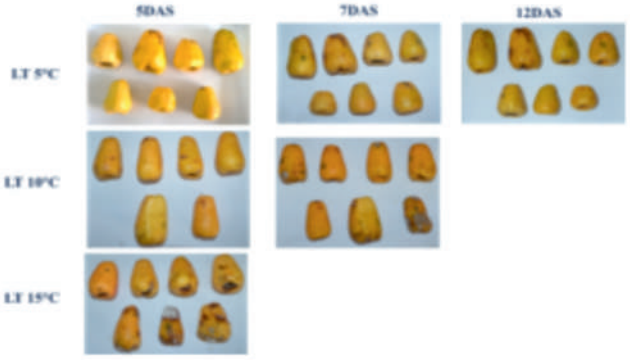


Fig. 3.4.3 : Effect of different storage temperatures on shelf life of cashew apples

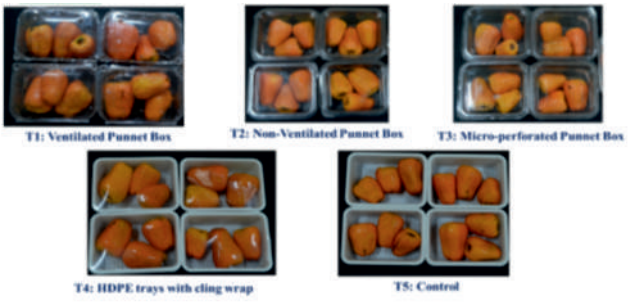


Fig. 3.4.4 : Effect of different packaging on shelf life of cashew apples

Development of technology for cashew apple liquid sweetener

A technology was developed to remove the astringency from the cashew apples and to develop a sweetener from the resulting cashew apple. Cashew apple liquid sweetener (Fig. 3.4.5) has various minerals like potassium, zinc and iron and is high in soluble fibre and antioxidant activity. The glycemic index of this liquid sweetener comes under the moderate category (58.30), providing a good alternative for people who are looking for healthy sweeteners. It is constituted of 81.91 % total carbohydrates, 75.48 % of reducing sugar, 13.43 % moisture, 2.02 % protein, and 0.97 % fat. It has a shelf life of more than 1 year at room temperature. With its unique sugar profile (high fructose and glucose) cashew apple liquid sweetener has huge potential in confectionery and bakery industries. The natural sugars present in this (mainly fructose and glucose) provide a quick source of energy, making it a good option for athletes or those needing a fast energy boost from whole food sources. It is free from additives, preservatives, and artificial ingredients, making it a cleaner option compared to many processed sweeteners.



Fig. 3.4.5: Cashew Apple Liquid Sweetener

3.4.4 : Development of value-added products from cashew apple and sprouts

Following value added products from cashew apple, and sprouts were developed.

Protein- and Mineral-Rich Cashew Sprout-Based Functional Snack: Cashew Sprout Healthy Bites

Cashew nuts contain antinutritional factors such as phytic acid, which reduce mineral bioavailability and may cause gastrointestinal discomfort; however, sprouting enzymatically degrades these compounds and enhances nutrient availability. In parallel with growing demand for nutrient-dense, functional, and convenient foods, sprouted cashews present potential for incorporation into compact nutrition formats such as energy or health bars, which provide concentrated sources of energy, protein, fiber, and bioactive compounds across age groups. Cashew sprout healthy bites (Fig. 3.4.6) have been prepared from cashew sprouts and rich source of protein (9.7%- 16% RDA), iron (8.6 mg- 41 % RDA), calcium (85.88 mg - 14% RDA) and fibre (7.93 %- 26% RDA), it has no added sugar, and is completely vegan. It has goodness of cashew sprout and cashew nut butter and 14.22 % moisture, 2.13%ash, 224.74mg/100g total phenols and 14.55 µmol/g antioxidant activity. The benefit–cost ratio for the product was worked out to be 5.0, indicating strong economic viability and significant potential for commercialization.



Fig. 3.4.6 : Cashew Sprout Healthy Bites

Cashew Apple Milk Confection- Cashew Apple Milk Delight

Cashew apple milk delight (Fig. 3.4.7) is fruity and sweet confectionary product with creamy texture. It has a moisture content of 15.08%, ash content of 2.61%, 117.47mg/100g vitamin C, 7.764 µmol/g antioxidant and total phenolic content of 142.5 mg/100g. The sugar content of this delight is less than the market available confectionary products.



Fig. 3.4.7 : Cashew Apple Milk Delight

Cashew Herbal Tea

Cashew apples and leaves are a rich source of bioactive compounds such as polyphenols, vitamins, and antioxidants, making them ideal components for herbal tea. Cashew apples are rich in vitamin C and polyphenols, which help protect the body from oxidative stress caused by free radicals. Cashew leaves contain flavonoids and phenolic compounds that may help fight infections and reduce inflammation in the body. Therefore, a herbal tea from cashew apple and leaf would help to manage sore throats, minor wounds, and digestive discomfort.

Cashew herbal tea (Fig. 3.4.8) has good quantity of polyphenols (551.52-620.23 mgGAE/100g), ascorbic acid (0.3-0.75 mg/100g), flavonoid content (118.82- 125.83 mg/100g) and antioxidant activity of 28.20-32.16 (µmol trolox/g). This product not only addresses modern consumer demand for plant-based health solutions but also positions cashew as a powerhouse in promoting holistic well-being.



Fig 3.4.8: Cashew Herbal Tea

Standardization of cashew apple wine, cashew apple vinegar, cashew sprout malt mix, cashew apple pomace rusk, cashew apple ketchup, and cashew apple pomace powder masala cookies is in progress.

3.4.5: Development of Probiotic Food Products from Cashew Apple, Sprouts and Kernels

Different blends of cashew apple juice (CAJ) and other fruit juices were used for optimization of probiotic drink and to study the growth rate of cultures. The multiplication of probiotic bacteria *Lactobacillus helveticus* was observed in CAJ -muskmelon blend, and CAJ-pomegranate blend. Among the two combinations, pomegranate juice (CAJ+PG) blend supported the faster growth, as the doubling time is low (Table 3.4.2). As pure CAJ and CAJ+WM does not support the growth of lactobacilli, incorporation of other fruit juices may be required to enhance the microbial viability.

Table 3.4.2 : Growth kinetics of *Lactobacillus helveticus* in different juice blends

Sample	Initial Population	Final population (CFU/mL)	Specific growth rate (μh^{-1})	t_d (h min)
CAJ + MM	1.00×10^5	2.0×10^7	0.1104	6 h 17 min
CAJ + PG	1.00×10^5	2.2×10^9	0.2089	3 h 19 min
CAJ+WM	1.00×10^5	$<10^5$	-	-
100%CAJ	1.00×10^5	$<10^5$	-	-

(CAJ- Cashew Apple Juice; MM-Muskmelon Juice; PG-Pomegranate Juice; WM-Qatermelon Juice)
CFU-Colony Forming Unit; t_d: Doubling Time

3.4.6: Phytochemical characterization of cashew (leaf and apple) nutraceuticals for their utilization in the development of functional foods.

The targeted metabolite profiling employing LC-MS/MS, coupled with multivariate statistical analyses, was applied to quantify fifteen flavonoid metabolites in leaves and pseudo fruits of five Indian cashew cultivars. Clear tissue-specific variation was observed, with flavonols being more abundant in pseudo fruits, while flavan-3-ols dominated in leaves. Further, Principal Component Analysis (PCA) performed on fifteen targeted flavonoid metabolites revealed significant compositional variability among cashew cultivars and between tissues (leaves and pseudofruits). The scree plot and PCA models demonstrated that PC1 explained 32.71% of the total variance, while PC2 accounted for 28.71%, cumulatively explaining over 61% of the variability (Fig. 3.4.9).

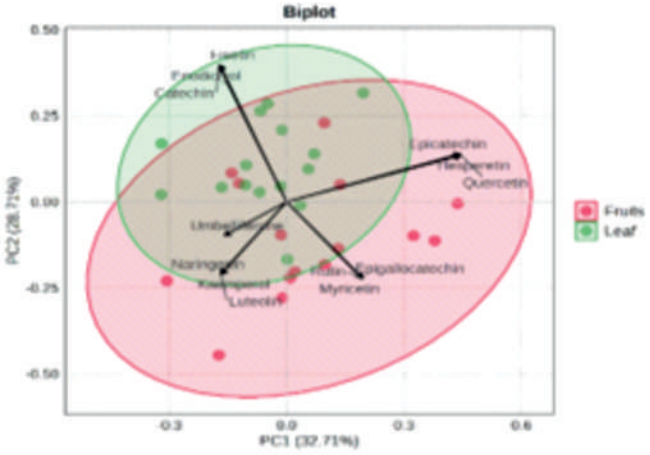


Fig. 3.4.9 : Principal component analysis (PCA) of biplot explaining the variability for flavonoid metabolites in different tissues (cashew leaf and cashew apple) among the cultivars

Metabolic pathway enrichment analysis mapped the fifteen flavonoid metabolites into three major biosynthetic pathways, such as Flavonoid biosynthesis, Flavone and flavonol biosynthesis and Isoflavonoid biosynthesis (Fig. 3.4.10 & 3.4.11).In the flavonoid biosynthesis pathway, ten metabolites were mapped, including apigenin, naringin, riodictyol, kaempferol, quercetin, myricetin, luteolin, catechin, epicatechin, and galangin. Significant metabolites within this pathway were catechin (P = 0.0009), riodictyol (P = 0.0008), and myricetin (P = 0.00086), indicating strong contributions to antioxidant-associated metabolic functions.The flavone and flavonol biosynthesis pathway included kaempferol, quercetin, myricetin, luteolin, rutin, and apigenin. Among these, myricetin (P = 0.0008) and rutin (P = 0.00089) were statistically significant, suggesting their role in stress protection and flavonoid accumulation.

The isoflavonoid biosynthesis pathway involved naringin and apigenin, with naringin showing a non-significant trend (P = 0.528), indicating a comparatively minor contribution to overall flavonoid diversity. Overall, the pathway analysis confirms that flavonoid metabolism in cashew leaves and pseudo fruits is actively regulated through major biosynthetic routes, supporting tissue-specific accumulation patterns and cultivar-dependent biochemical diversity.

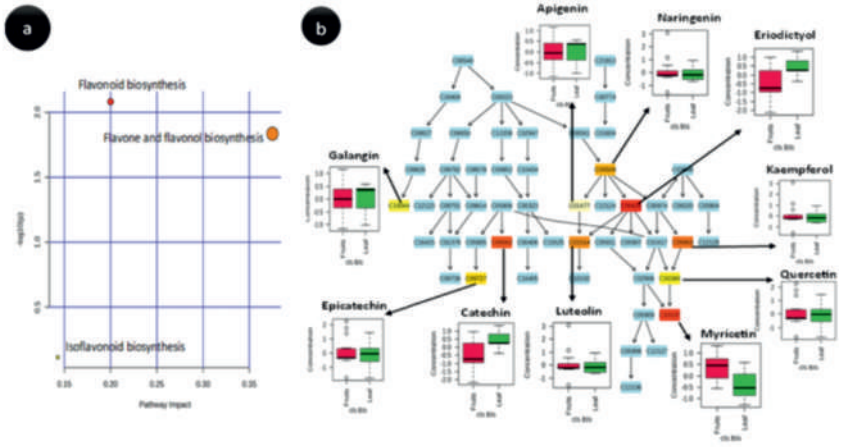


Fig. 3.4.10 : a) Pathway impact and annotation of flavonoid metabolites of cashew (leaves and apple) in various pathways (varying from yellow to red indicate the metabolites are in the KEGG data with different levels of significance), b) flavonoid biosynthesis.

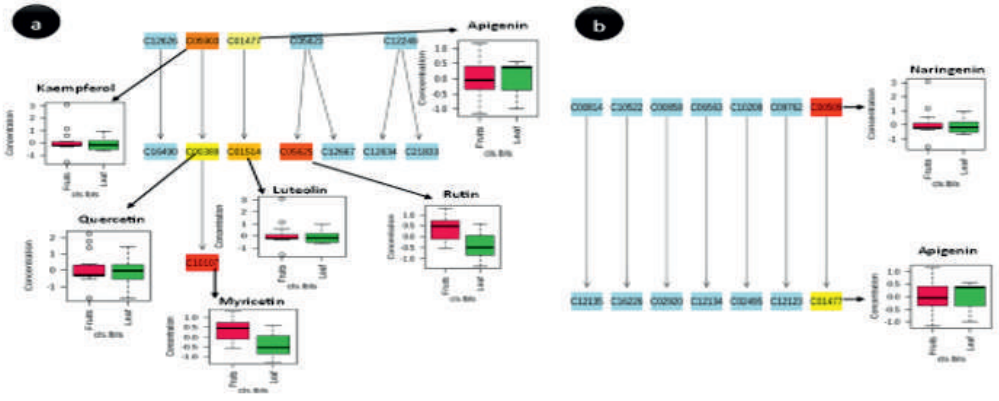


Fig. 3.4.11 : a) flavone and flavonol biosynthesis, and b) isoflavonoid biosynthesis (varying from yellow to red indicates the metabolites are in the KEGG data with different levels of significance).

Externally Funded Project

3.4.7 Establishing the honey testing laboratory at ICAR-Directorate of Cashew Research, Puttur, Karnataka

A project to establish a mini honey testing facility at ICAR- Directorate of Cashew Research was approved and sanctioned by the National Bee Board, Delhi. Various instruments, including a Flame Atomic Absorption Spectrophotometer, incubator, microscope, laminar air flow unit, and texture analyzer, have been procured. The procurement and installation of the remaining proposed instruments are currently in progress for the establishment of the honey testing laboratory.

Observation Trials

Comparative evaluation of qualitative parameters of Cashew kernels: Steam treated Vs Drum roasted

Whole Kernel Recovery (WKR) after deshelling, steam-treated nuts found to be on par with Drum roasted nuts, but colour values in terms of Whiteness index, Yellowness index and Browning index differed significantly w.r.t grades ascertained, i.e., WW210 and SW 210. Assessed the changes in the proximate composition, viz., Protein, Fat, Free fatty acids (FFA) and total sugar of cashew kernels (White wholes and Scorched wholes kernels) processed by Drum roasting and Steam boiling modes. Statistical analysis indicated that Fat, FFA and Total sugars of cashew kernels obtained by DR and SB are significant (Fig.3.4.12) and protein found to be non-significant. Changes in the vitamin and minerals could not be carried out due to technical issues

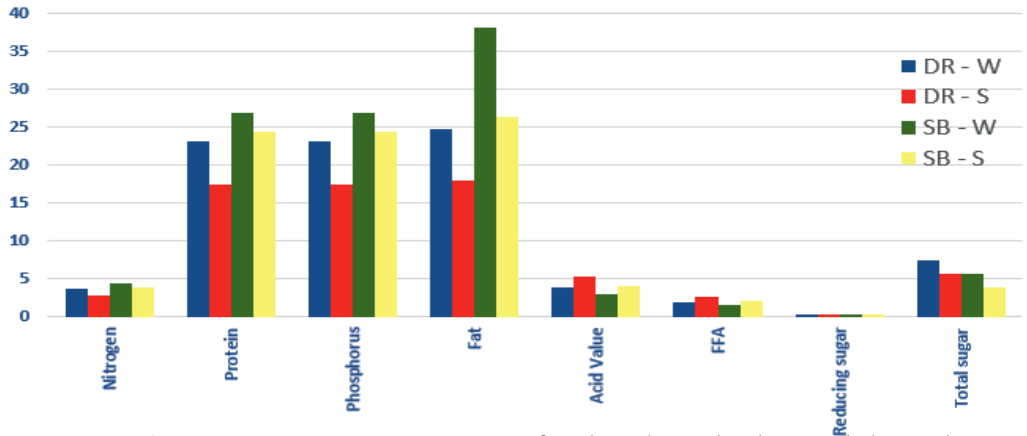


Fig. 3.4.12 : Proximate composition of cashew kernels obtained through Drum roasted and Steaming of raw cashewnuts

3.5 TRANSFER OF TECHNOLOGY

Priority Area V: Developing Methodologies and ICT Tools for Capacity Building and Transfer of Technologies in Cashew

3.5.1 Knowledge Management and Technology Transfer in Cashew

An AI-integrated Telegram-based chatbot and a dedicated website have been developed to provide advisory services and comprehensive information on cashew cultivation to farmers, extension personnel, and other stakeholders. The menu-driven chatbot enables users to easily access information on region-specific cashew varieties, fertilizer application, crop protection practices, cashew nut processing, value addition of cashew apple, and details of nurseries and processing units. The platform also provides weather updates and relevant advisories to support informed decision-making in cashew farming. The database for the system has been developed, and the chatbot is currently being trained to deliver responses in English, Kannada, Malayalam, and Hindi, ensuring wider accessibility across major cashew-growing regions of the country. Additional regional languages will also be incorporated in a phased manner to meet the information needs of cashew growers in other cashew-producing regions. The integration of the Telegram chatbot and the web-based interface will facilitate easy access to reliable and timely information for stakeholders in the cashew sector.

The outreach activities organised under the project includes

Cashew Day was organised on 11.03.2025 on the theme "Mechanisation in Cashew." The event highlighted recent advancements aimed at improving efficiency and reducing drudgery in cashew processing. A major highlight of the programme was the release and licensing of a cutting-edge cashew apple and nut separation technology, which is expected to facilitate efficient utilisation of cashew apple and improve processing efficiency.

An exhibition was also organised to create awareness among farmers, entrepreneurs and other stakeholders about high-yielding cashew varieties and the potential for value addition in cashew apple, thereby promoting enhanced income opportunities in the cashew sector.

A radio talk series on scientific cashew production and post-harvest processing titled *"Geru Maradha Gaana – Namma Nade Geruvinede"* was organised in collaboration with All India Radio, Mangalore, with the objective of disseminating scientific knowledge on cashew cultivation to farmers and other stakeholders in an accessible and engaging manner. The series featured expert talks by scientists of the institute, covering various aspects of cashew cultivation including selection of suitable varieties, nursery management, scientific planting and crop management practices, nutrient and pest management, harvesting techniques, and post-harvest handling. Special emphasis was also given to include success stories of farmer and entrepreneur, highlighting opportunities for income enhancement and entrepreneurship in the cashew sector.

3.5.2 Socio-economic and innovation system analysis in Cashew sector

Case analysis of Safalam Cashew Processing Unit in Kasaragod

The case analysis of the Safalam Cashew Processing Society in Kasaragod highlights a successful women-led enterprise developed under the Samagra Project of the Kudumbashree programme. The units were established in 2009 with technical training support from ICAR-DCR, Puttur, Karnatak and currently, there are 11 processing units with a centralized grading and packing centre, providing employment to 68 women. The members, with an average age of 46 years and

around 12 years of experience, are predominantly engaged in processing activities such as shelling (38 %) and peeling (46 %), indicating strong skill specialization within the enterprise (Table 3.5.1.).

Table 3.5.1 : Socio-demographic profile of the members

n=68

Parameter	Details
Average age	46 years
Education	54 % up to 10th standard
Experience	~12 years
Work allocation	Boiling (13.24 %), Shelling (38.24 %), Peeling (45.59 %), Grading & packing (10.29 %)

Financial analysis shows steady growth in gross returns over the years despite fluctuations in profitability, largely influenced by high raw nut procurement costs (constituting ~69 % of total expenditure), loan repayments, and operational expenses. The enterprise has established stable market linkages within Kasaragod and nearby districts (Fig. 3.5.1). However, constraints such as inconsistent raw nut supply, quality issues, and equipment maintenance persist. Importantly, the initiative demonstrates significant social impact through women empowerment, with ongoing assessment using the pro-WEAI+MI framework, alongside identification of occupational health concerns such as musculoskeletal disorders and mild respiratory issues among workers—highlighting the need for improved workplace ergonomics and health interventions.

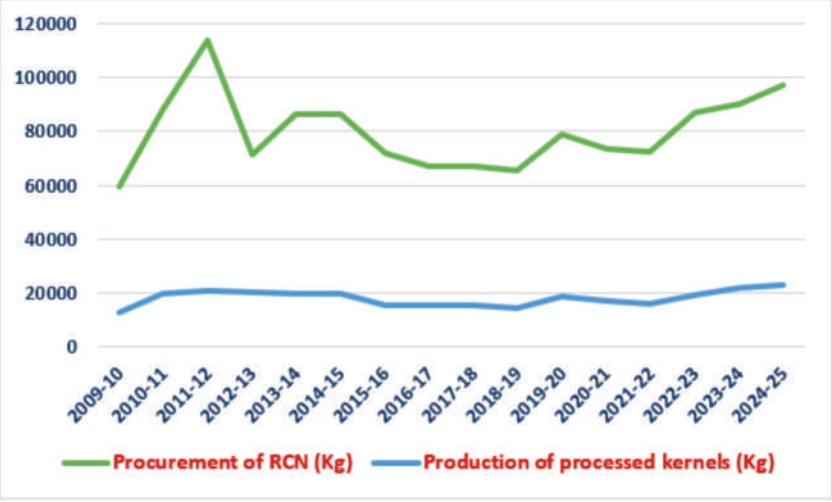


Fig. 3.5.1: Quantity of RCN procured and production of processed kernels year-wise

Musculoskeletal Disorders (MSD) and Occupational Health Analysis

The study also assessed occupational health issues among 68 women workers using standardized tools (Nordic Questionnaire for MSD, INSEARCH for respiratory symptoms, and dermatological assessments). Findings indicate that repetitive, labour-intensive tasks such as shelling and peeling expose workers to significant ergonomic stress (Table 3.5.2).

Table 3.5.2: Prevalence of Musculoskeletal Disorders (MSD)

n=68

Body Region	Last 12 Months (%)	Last 7 Days (%)
Shoulders	36.76	38.23
Upper back	29.41	26.47
Neck	23.53	19.12
Wrists/Hands	23.53	17.65
Lower back	25.00	23.53
Elbows	16.18	22.06
Ankles/Feet	13.23	14.70
Knees	7.35	8.82
Hips/Thighs	5.88	2.94

3.5.3 Cashew Farmer's Tracking System (CFTS)

A simple software CFTS was developed during the year 2024. During the year 2025, it was fine-tuned and relaunched as Farmer Tracking System (FTS), and made available in three languages.

An analysis of the data captured in CFTS showed, for instance, the reach of cashew grafts to various states and districts during the period from 2019 to 2024 and the number of grafts of varieties reaching various farmers from the cashew nursery at the Directorate was accessed. It was evident that the cashew grafts from the institute have reached 9 states, 50 districts, and more than three lakh grafts have been sold to farmers and stakeholders. Among the states, Karnataka stands first with 29 districts, followed by Kerala with 7 districts (Table 3.5.3). Bhaskara variety has reached 37 districts where whereas Vengurla-7 variety could reach 26 districts, followed by Nethra Ganga, which has reached 25 districts. These three varieties are also the most sold in that order. A total of 3030 farmers have taken the grafts from the institute during the period of six years. From the software, it is possible to get all the details of these farmers, including the coordinates of the planting location. The data on grafts sold, month and year-wise indicates the demand for the grafts is more during June-July and this is because it coincides with the planting time due to the rainy season in the Indian subcontinent. The google my map of a variety say Bhasakara, developed using the data gives the location of the farmers who have taken the Bhaskara cashew variety. Upon clicking on a geo tag, the details of the farmers, varieties, year of purchase, etc. will be obtained (Fig. 3.5.2).

It is possible to assess the spread of a specific variety during a particular period at the district/taluk/village level. It appears from the data that the Bhaskara variety tops the list with its spread in 37 districts in 10 states during 2019-2024 (Fig. 3.5.3.). From the six-year data, it is evident that Bhaskara and Vengurla-7, followed by Nethra Ganga, are the most sought-after cashew varieties. The sales statistics for a year and the demand during particular months can provide crucial insights into the future demand for the production and sale period of the planting material.

The farmers' data in the CFTS can be used for various purposes. For instance, we have created WhatsApp groups of farmers year-wise for continuous interaction. The data can also be used to develop geo-tagged maps, as is done here for farmers who have taken the Bhaskara variety of cashew. Since the farmers' village is known, it is easy to visit the set of required farmers' fields for either inspection of the plots or direct dissemination of technical information. This can also be used to gather cashew farmers from a particular village or set of villages for mass awareness campaigns and programs. Further, the developmental activities of the Government can easily be directed towards a set of farmers or villages. Moreover, clustering of cashew farmer villages will help to develop processing and value addition units by the concerned agencies. This paves the way for the income augmentation of the cashew farmers.

The area covered by the cashew grafts sourced is an important measure of the impact of the nursery or the institute selling planting material. In perennial crops such as cashew, after a few years of planting, the survival

percentage of grafts, along with spacing details, can be obtained. With this data, it is possible to estimate the area under each variety in each state/district/taluk/village. This will have implications for issues such as carbon sequestration, production forecasts in an area where cashew grafts from a nursery are established. This can also offer leverage for channeling efforts toward further area expansion in areas that are not covered so far. In essence, this software serves as a useful tool for making policy decisions. However, ground truthing is essential to ascertain such area estimations, as planting dynamics - removal of trees and/or the planting of new crop/tree species is expected to happen depending on the economic considerations by the farmer.

The QR code facility provided via software for the farmers can help in avoiding the spurious planting material. Because both the farmer and the institute/firm selling plants can trace the planting material purchased/sold. The farmer is sure of the place of purchase of planting material. In most cases, farmers over the years tend to forget the nursery from which they have sourced the planting material. Here, through a QR code or WhatsApp message, he can retrieve the correct information. Nurseries will also be careful while selling the plants because farmers can always come back to them to ascertain the genuineness of the planting material sold.

Currently, the software is implemented in the cashew nursery of ICAR- Directorate of Cashew Research, Puttur, Karnataka, India, and it's All India Coordinated Research Project centers spread across the country. So, the Directorate can assess the demand and spread of different varieties along with other datasets at the national level. In other words, it is possible to assess the impact of the institute at the national level. The software can also be profitably deployed by the Directorate of Cashew and Cocoa Development (DCCD), Kochi, India accredited cashew nurseries in different states, as this agency is involved in the development of the cashew sector in the country.

Table 3.5.3 : Spread of Cashew grafts across states and districts during 2019-2024

State/Union Territory	Number of districts	Districts
Karnataka	29	Bagalkot, Bellary, Bangalore Rural, Bangalore Urban, Belagavi, Bidar, Chamarajanagar, Chikkaballapura, Chikkamagaluru, Chitradurga, Dakshina Kannada, Davangere, Dharwad, Gadag, Hassan, Haveri, Kodagu, Kolar, Koppala, Mandya, Mysore, Raichur, Ramanagara, Shivamogga, Tumkur, Udupi, Uttara Kannada, Vijayanagar and Vijayapura
Kerala	7	Alappuzha, Kannur, Kasaragod, Kottayam, Kozhikode, Palakkad and Thrissur
Andhra Pradesh	4	Anantapuram, Kadapa, Krishna and Vizianagaram
Telangana	2	Bhadradri Kothagudem and Hyderabad
Tamil Nadu	3	Cuddalore, Krishnagiri and Tiruchirappalli
Goa	1	North Goa
Maharashtra	2	Raigad and Ratnagiri
Bihar	1	Bhagalpur
Delhi	1	New Delhi
TOTAL	**50**	

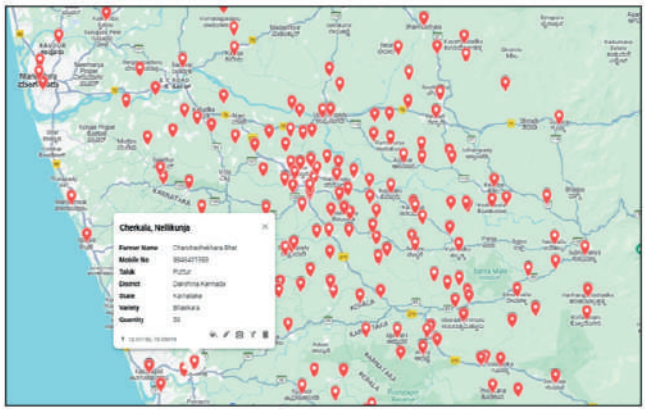


Fig. 3.5.2 : Geo tags of the farmers taking Bhaskara variety (2019-2024)

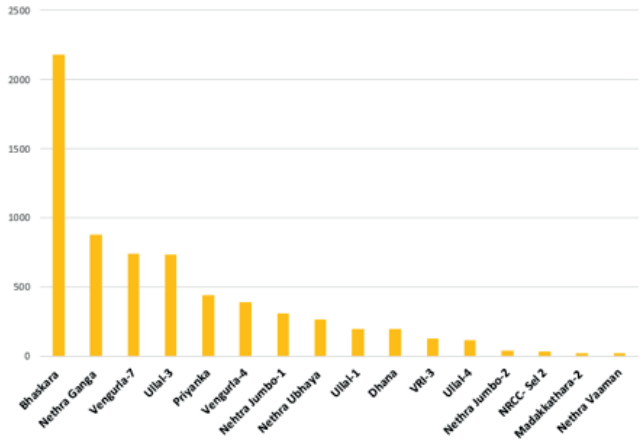


Fig. 3.5.3 : Number of farmers taking different varieties of cashew

Installation of QR code boards in the nursery of the institute:

During the year, QR code (Quick Response) boards were installed, giving information on varieties sold from nursery. It is possible to access the number of visitors who have used the QR codes, along with the exact time of access. A booklet on QR codes of different varieties sold at the institute was also published during the period (Fig. 3.5.4).



Fig. 3.5.4: Implementation of QR code System in the nursery of ICAR-DCR

3.5.4 Integrated Farming Approaches for Socio-Economic Resilience of Scheduled Caste Farmers

Under the Scheduled Caste Sub Plan (SCSP), 13 capacity-building programmes were organised across Karnataka and Tamil Nadu focusing on horticulture-based integrated farming systems, plantation crops, and livelihood enhancement. These trainings combined technical knowledge dissemination, field exposure, and strategic input distribution to strengthen income and livelihood security of Scheduled Caste farmers (Table 3.5.4).

Table 3.5.4 : Details of training programmes and input distributions conducted under SCSP

Sl. No	Details of the programme	No. of participants	Co-ordinators
1	Training program on Horticulture-based Integrated Farming System (Sub-tropical and Temperate fruit crops) organised in collaboration with Horticultural and Forestry Research Station, TNAU, Kodaikanal at HRS, Kodaikanal, Dindigul district of Tamil Nadu on 22.01.2025	75	Drs. Manjesh GN and Veena G.L.
2	Training and input distribution program for the Promotion of Horticulture-Based Integrated Farming System organised in collaboration with UHS-Horticulture Extension Education Unit, Regional Horticulture Research, and Extension Centre, Bangalore, Karnataka on 28.01.2025	50	Drs. Manjesh GN, Rajashekara H., Veena GL., and Babli M.
3	Training programme on "Integrated Farming System in Horticulture"and input distribution organised in collaboration withthe UHS- Horticulture, Mysore, Karnataka College of Horticulture, Mysore, Karnataka on 20.03.2025	55	Drs. Manjesh GN., Rajashekara H., Veena GL., and Babli M.
4	Two days Training programme on "Establishment of a model Horticulture nursery" organised in collaboration with K.S.N. UAHS-MAHRS, Iruvakki, Shivamogga on 19-20 March 2025	55	Drs. Manjesh GN., Babli. M., Jyoti, N., and Veena GL
5	Two days Training programme on "Plantation Crops" was organized at ICAR-DCR Puttur on 26-27 March 2025	40	Drs. Manjesh GN., Babli M., Veena GL., Thondaiman V., Jyoti, N., Aswathy C., and Mr. Rahul Yadav
6	Training programme on "Promotion of Horticulture-based Integrated Farming System" organized in collaboration with UHS-CoH, Mysore on 30.06.2025	40	Drs. Manjesh GN., Veena GL., Babli M., and Jyoti, N
7	Three-days training programme on "Cultivation of important Plantation crops" organised in collaboration with K.S.N. UAHS-MAHRS, Iruvakki, Shivamogga on 27-30 June 2025	40	Drs. Manjesh GN., Veena GL., Babli M., and Jyoti, N

Contd.

Sl. No	Details of the programme	No. of participants	Co-ordinators
8	Integrated production systems in cashew and cocoa, organised in collaboration with K.S.N. UAHS-MAHRS, Iruvakki, Shivamogga, from 30 July to 01 August 2025 Inputs distributed- Soil amendment/ nutrient 2000kg	50	Drs. Manjesh G. N., Rajashekara H., M. S. Venkatesh Veena GL., and Babli M.
9	Modern Horticultural Practices for Enhancing Yield and Income among Schedule Caste Farmers through New Innovation and Input Distribution, conducted in collaboration with CoH Mysuru on 22.09.2025	80	Drs. Manjesh GN., Rajashekara H., Veena GL., and Babli M.
10	Inputs distributed – Trichoderma (1260 kg), Micronutrients (180 kg) and Graft (1710 nos), Veg. seed kit (90 nos) Modern horticultural practices: To enhance yield and income among scheduled caste farmers through innovations and input distribution conducted in collaboration with CoH Mysuru on 14.10.2025. Inputs distributed- FYM (4000 kg) and Graft (1280 nos), Seedling (200 nos.), Water apple 40nos, Veg. Seed Kit (40 nos.)	40	Drs. Manjesh GN., Veena GL. and Rajashekara H.
11	Training cum Input Distribution Program on Promotion of Horticulture-based Integrated Farming Systems in collaboration with CoH, Bengaluru, Karnataka, on 06.10.2025. input distributed- Trichoderma (420 kg), Micronutrient (60 kg) and Grafts (570 nos.), Veg seed Kit (30 nos.)	30	Drs. Manjesh GN., Rajashekara H., and Veena GL
12	Training on Enhancing the income and livelihood security among SC farmers of north Karnataka through capacity building on adoption of Horticulture innovations in collaboration with College of Horticulture, Bagalkot on 11.11.2025 and input distributed- Compost (1875 kg), MC (750 kg) and Graft (2400 nos.)	75	Drs. Manjesh GN., Veena GL., Rajashekara H., Babli M., and Jyoti N.
13	Enhancing farmers income and resource efficiency through Horticulture based Integrated farming system in collaboration with ICAR–KVK Ramanagara, University of Agricultural Sciences, Bangalore in Bengaluru South (Ramanagara) District, Karnataka on 28-12-2025 Inputs distributed- Trichoderma (400 kg) and Graft (4080 nos.), Veg seed Kit (160 nos.), Battery Operated 2-in sprayer (80 nos.), garden tool kit (80 nos.).	80	Drs. Manjesh GN., and Veena GL

3.5.5 Improving the livelihoods of tribal farmers through cashew-based technologies and capacity building under TSP

Under the TSP project, several initiatives have been taken up to support the livelihood of tribal farmers. These include area expansion under cashew, trainings and capacity building, demonstrations and input distribution. During the year, 2025 following interventions (Table 3.5.5) were carried out-

Table 3.5.5 : Details of training programmes and input distributions conducted under TSP

Sl. No	Details of training and input distribution	No. of participants	Co-ordinators
1	Three days Training Programme on "Cashew Production and Processing Technologies organised in collaboration with Tribal Welfare Department, Directorate of Tribal Welfare, Chennai, Tamil Nadu at CREED KVK, Ariyalur District, Tamil Nadu on 18-20 March 2025	64	Drs. Aswathy Chandrakumar, Manjunatha K, Bhagya H P, Siddanna Savadi and Thondaiman V
2	Distribution of brush cutters to selected beneficiaries of Dakshina Kannada at ICAR-DCR, Puttur on 21.03.2025	35	
3	Distribution of solar lights, battery operated knapsack sprayers, tarpaulins, kitchen garden tools and brush cutter on 18.06.2025 to the selected beneficiaries of Dakshina Kannada district	22	
4	Training Programme on Rejuvenation, Top Working and Pineapple intercropping in Cashew Orchards in collaboration with KVK Rastakuntubai in Parvathipuram Maniyam district, Andhra Pradesh on 11th, 13th, 14th and 15th October, 2025	100	
5	Distribution of pineapple suckers (300 Nos.) for establishment of Demonstration plots (50 Nos.) of pineapple intercropping in cashew orchards in collaboration with KVK Rastakuntubai in Parvathipuram Maniyam district, Andhra Pradesh on 11th, 13th, 14th and 15th October, 2025	50	
6	Training and distribution of agricultural implements for economic and social empowerment of tribal community farmers in collaboration with Horticulture Extension Education Unit, UHS Campus, GKVK, Bengaluru at Hiriyur taluk, Chitradurga district, Karnataka on 19.12.2025	30	
7	Training programme on "Scientific cashew cultivation" for ST farmers and input distribution in collaboration with KVK, Kasaragod at Enmakaje panchayat, Kasaragod, Kerala on 23.12.2025	40	

Area expansion under Cashew to support the livelihood of cashew farmers

The institute in collaboration with WASSAN NGO, Andhra Pradesh distributed 10000 cashew grafts of high yielding varieties to 123 tribal farmers of Andhra Pradesh. Also, 24000 cashew grafts were distributed to 250 tribal farmers of Garo Hills, Meghalaya in collaboration with All Garo Hills Multi purpose Co-operative Society.

Distribution of Arecanut seedlings to support livelihoods of farmers

The institute in collaboration with Bharat Agri farmers Development Company Ltd., Vittal, Karnataka distributed 1120 arecanut seedlings to support the livelihood of farmers.

Licensing of Cashew Apple based products

Nine products namely Cashew Apple Jam, Jelly, Cider, Cashew Sprout Cookies, Cashew Apple Pomace cookies, Cashew Apple Jaggery, Cashew Apple Fruit Bar, Cashlime, Diet Cashew Apple muffin and Cashew Prash were licensed to Amalu women Self Help Group, a tribal group of Parvathipuram Maniyam district of Andhra Pradesh to support their livelihood.

Externally Funded Projects

3.5.6 Drone Technology Demonstration (DTD)

During 2025, a total of 86 field demonstrations were organized to showcase the application of unmanned aerial vehicles (UAVs) for spraying agrochemicals, micronutrients, and organic pesticides under real farm conditions. These demonstrations collectively covered 118.5 acres and directly involved 513 farmers (Fig.3.5.5). Feedback from participants indicated a high level of interest in adopting drone-based spraying for crop protection operations. Farmers acknowledged several advantages of UAV spraying, notably substantial savings in time and labour, reduced operational costs, precise and efficient use of inputs such as water and chemicals, and improved safety by minimizing direct human exposure to pesticides.

Despite these advantages, farmers also identified certain constraints limiting large-scale adoption. Key concerns included frequent battery charging requirements, limited spray tank capacity, short flight endurance, the need for trained and skilled operators, and the high cost associated with obtaining drone pilot certification. Overall, the demonstrations offered valuable practical insights into both the prospects and challenges of UAV-based spraying, highlighting the need for continued technological refinement, capacity building, and policy support to enhance adoption among farming communities.



Fig. 3.5.5 : Drone demonstration at field

3.5.7 Frontline demonstration of newly developed cashew varieties of ICAR-DCR Puttur

During the year 2025, planting material (grafts) were taken by two farmers from Puttur taluk in Dakshina Kannada district, each with one-acre area. The two farmers have already planted plants in their fields and established the demonstration plots. With this, achieved the target of 175 FLTD plots in this project.

3.5.8 Frontline demonstration of the latest cashew varieties of ICAR-DCR Puttur under normal density and other old /new suitable varieties under high-density systems

FLTD of varieties under normal density planting (with drip irrigation): Planting material (grafts) was taken by 11 farmers from Chitradurga, Tumakuru, Shivamogga, Uttara Kannada, Gadag, and Anantapur districts of Karnataka and Andhra Pradesh, covering an area of 8 ha out of the targeted area of 10 ha. All the farmers have already planted in their fields and established the demonstration plots. The firm for the installation of drip irrigation has been finalised and will be installed during the ensuing season in all the farmers' fields.

FLTD of varieties under high density planting (with drip irrigation): Planting material (grafts) was taken by one farmers from Chitradurga covering an area of 1 ha out of the targeted area of 10 ha. The farmer has already planted plants in his field and established the demonstration plot. The firm identified for the installation of drip irrigation has been finalized and will be installed during the ensuing season.

3.5.9 Development of model cashew villages for transforming farm livelihoods of Karnataka

The project aims to establish a replicable model for sustainable rural development by fostering entrepreneurial opportunities and creating resilient cashew farming system. It has been operationalised through the development of linkages between different organisations such as Local Self Government (LSG), Horticulture Department, Women Self Help Groups (SHGs) and Farmer Producer Company Ltd. (FPCL). Key interventions include- demonstration of High Yielding Varieties (HYV) of cashew and area expansion, farmer participatory demonstrations, capacity building of the farmers and extension workers, establishment of cashew nursery and cashew apple processing unit.

Under this initiative, 2000 nos. of cashew grafts of high yielding varieties (Bhaskara, Nethra Ganga, Nethra Jumbo-1, Nethra Jumbo-2 and Nethra Ubhaya) released from this Directorate were distributed to 50 nos. of farmers in Sampaje village of Sullia taluk of Dakshina Kannada district, covering an area of 10 ha. Soil health cards were also distributed to 34 farmers under the project. Also, machineries have been procured for establishment of cashew apple processing units in Sullia taluk and Kolar region of Karnataka. The Cashew Apple and Nut separator developed by the institute have been distributed to the Custom Hiring Centre of Gadag and Bharat Agri Development Farmers Producer Company Ltd. in Vittal for the benefit of farmers. The other interventions carried out under the project include in Table 3.5.6 and 3.5.7.

Table 3.5.6: Details of extension activities conducted under the programme

Sl. No	Details of training/field day/ capacity development workshops/demonstrations	No. of Participants
1	Field day organised in Sampaje village to demonstrate canopy management in Cashew on 24.06.2025	10
2	Two days Skill Development Training on Nursery Management Techniques in Cashew from 18.08.2025-19.08.2025	10
3	Three Days Capacity Development Workshop for Krishi Sakhis on Cashew Production and Post Harvest Technologies from 20.08.2025 – 22.08.2025	25
4	Training cum Distribution of Cashew Grafts in Sampaje village on 24.09.2025	50
5	Demonstration on soil sampling at ICAR-DCR, Puttur on 05.12.2025	25

Table 3.5.7: Technologies commercialised under the project includes

Sl. No	Technologies licensed	Name of firm
1	Nethra Ganga, Nethra Jumbo-1, Nethra Jumbo-2 and Nethra Ubhaya for development of cashew nursery	Bharat Agri Farmers Development Company Ltd. Vittal, Dakshina Kannada district, Karnataka
2	Cashew Apple Jaggery	Sri Vaishnavi Mahila SHG, Mulbagal, Kolar district, Karnataka
3	Value added products of Cashew Apple- Cashew Apple Jam, Jelly, Cider, Cashew Sprout Cookies, Cashew Apple Pomace cookies, Cashew Apple Jaggery, Cashew Apple Fruit Bar, Cashlime, Diet Cashew Apple muffin and Cashew Prash	Taj Self Help Group, Sullia taluk, Dakshina Kannada district, Karnataka

3.6. CONCLUDED PROJECTS

3.6.1 Biochemical and mineral composition studies in relation to the phenology of fruit development and maturity in cashew

Institute Project Code : IXX16364 / IXX20036

Keywords : Phenology, Biochemical, mineral, nut and apple

Name of the Lead Institute : ICAR-Directorate of Cashew Research, Puttur, Karnataka

Name of Division/ Regional Center/ Section : Crop Management

Name of the Collaborating Institute (s) : N/A

Name of Division / Regional Centre / Section of Collaborating Institute (s) : NA

Project Team(Name(s) and designation of PI, CC-PI and all project Co-PIs

PI : Dr. Veena G L., Senior Scientist (SPM&AP), ICAR-DCR Puttur

CO-PIs : Dr. J.D. Adiga, Director, ICAR-DCR, Puttur

Dr. Shamsudheen Mangalassery,(Transferred), Sr. Scientist, ICAR-DCR, Puttur

Dr. V. Thondaiman, Sr. Scientist (SPM&AP), ICAR-DCR, Puttur

Dr. Manjesh, G N., Scientist (SPM&AP), ICAR-DCR, Puttur

Dr. Manjunath, K. Scientist, ICAR-DCR, Puttur

Dr. Bhagya, H. P., Scientist (SPM&AP), ICAR-DCR, Puttur

Dr. B. M. Muralidhara, Senior Scientist (Fruit Science) (Transferred), ICAR- DCR, Puttur

Project duration: September 2019 to December 2024

Cashew has a different growth pattern with respect to fruit and nut development. First, the nut will develop, and later the apple growth will be completed. There are 10 different phenological stages according to the BBCH scale, differentiating the growth stages of fruit and nut, where the synthesis and accumulation of the important bioactive components will take place. There is a lack of knowledge about the biosynthesis of important bioactive components in cashew with respect to its phenological stages. Being an economically and nutritionally important nut crop, cashew is gaining popularity across the world. Understanding the phenological stages and biosynthesis of important bioactive components will serve as baseline information for the advanced research programme. Therefore, the project mainly aims at screening of selected varieties throughout the phenological stages to understand the biosynthetic pathway. This will give an understanding and for further research ideas to minimize the tannin content or to increase the TSS etc.

Objectives

To understand the biosynthesis of important biochemical compounds and mineral composition in the cashew apple and nut

To understand the biosynthesis of CNSL in the cashew nut

Materials and Methods

Varieties viz., Bhaskara, VRI-3, Sel-2 and CNSL free type was selected for this study.

phenological growth stages like 5 developmental stages and 5 maturation stages (Fig. 3.6.1) were selected to understand the accumulation and synthesis pattern of important bioactive components in fruits as well as in nut.

Biochemical analysis

Total phenols, flavonoids, antioxidants, tannins, vitamin C, TSS, were analysed in fruits (pseudo fruit)

Protein, Fat, phenols, moisture content and mineral compositions were studied in Nut developmental stages

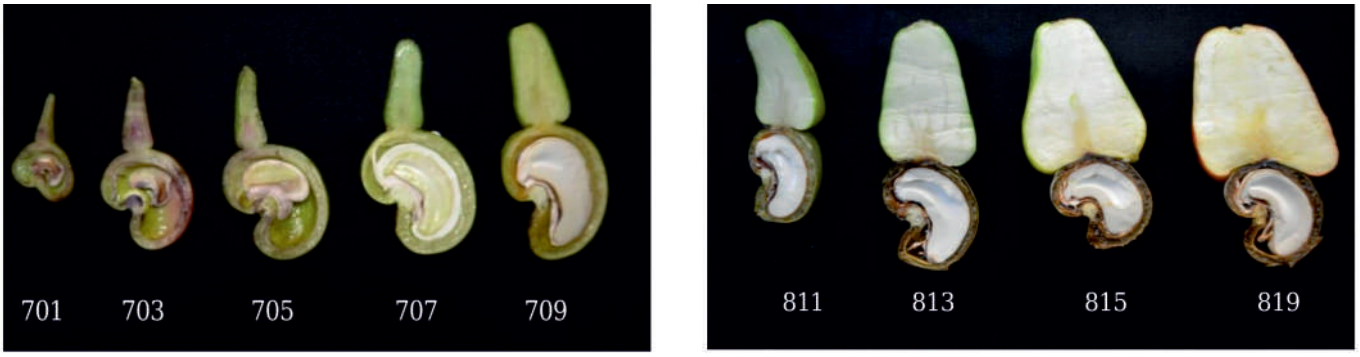


Fig. 3.6.1 : Phenological growth stages in cashew

Achievements/Output of the project

The main aim of the study is to understand the biosynthesis of some of the important bioactive components in different phenological growth stages of cashew. Important bioactive components like total phenols, flavonoids, total antioxidant activity, tannins, and vitamin C in the five fruit development and fruit maturity stages of cashew. The protein and CNSL content was also recorded in these phenological stages. The analysis was done in three different varieties: viz, VRI-3, CNSL free type, and NRC selection-2.

The total phenols showed a decreasing trend throughout the fruit maturity period as in other fruit crops, because of the oxidation of phenols by the enzyme polyphenol oxidase. A similar trend was noticed with respect to antioxidant activity and total phenols, the tannin. Vitamin C concentration increases with increasing fruit maturity stages in both the varieties VRI-3 and NRC Selection -2. whereas in the case of CNSL free type with respect to tannin concentration, starting from the first stage to the last phenological stages, it remained zero, as there was no synthesis of CNSL. In other varieties, after flavonoids synthesis through condensation and polymerization phases, the condensed tannins are formed, but these hydrolysable tannins are the derivatives of gallic acids, which were completely absent in CNSL-free types (Fig. 3.6.2).

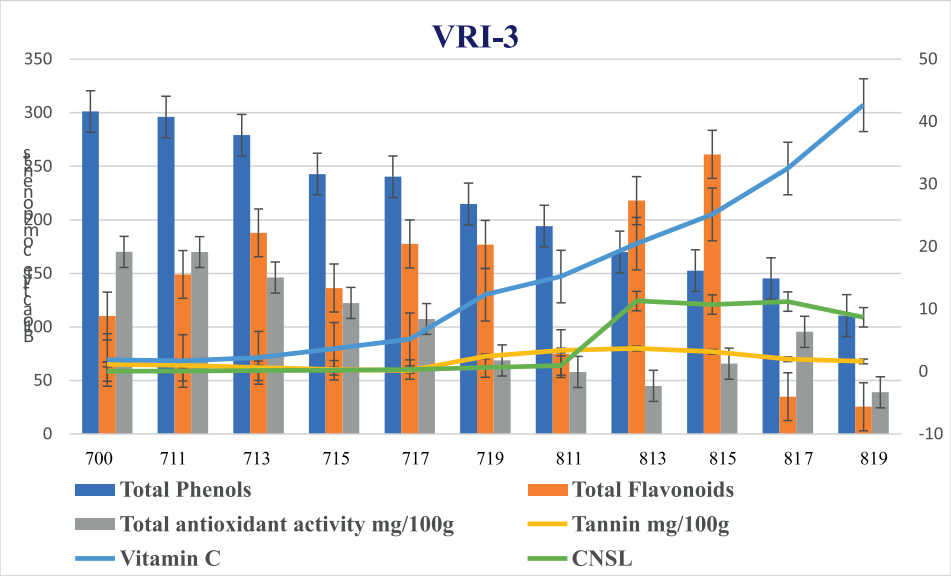


Fig. 3.6.2 : Accumulation pattern of important bioactive components across the phenological stages of Cashew apple and nut of VRI-3

Tannin accumulation throughout the phenological growth stages of cashewApple

The protein and fat content showed an increasing trend with respect to nut developmental stages. The protein content was varied between 11-15% in 711 stage and it was 15-18 % at nut maturity stage 719. But the accumulation of kernel protein content was observed to be highest between 817 and 819 stage with a range of 25-30 % (Fig. 3.6.3).

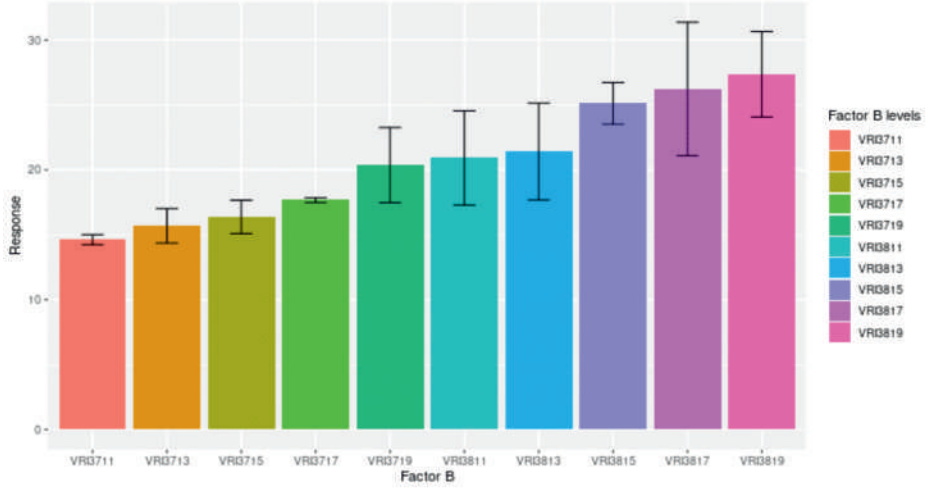


Fig. 3.6.3 : Accumulation of protein content throughout the phenological growth stages of cashew kernel

Expected benefits and economic impact

Provided the basic information with respect to the biosynthesis of major bioactive components from cashew apple and nut which will serve as a baseline information for the advanced research programme.

Output

Study will give insight into the pattern of synthesis and accumulation of various bioactive compounds, CNSL and minerals composition during various fruit development and maturity stages

3.6.2 Establishment of Centre of Excellence for profiling of bioactive components in Cashew apple and nut

Externally funded Project Code : KA/RKVY AGRE/2022/1344

Project Duration : June 2021 to December 2024

Keywords : Profiling, Cashew apple, Nut, Bioactive components

Name of the Lead Institute : ICAR-Directorate of Cashew Research, Puttur, Karnataka

Name of Division/ Regional Center/ Section : Crop Management

Project Team:

PI : Dr. Veena G. L., Senior Scientist (SPM&AP), ICAR-DCR Puttur

CO-PIs : Dr. J. D. Adiga, Director, ICAR-DCR, Puttur

Dr. Shamsudheen Mangalassery (Transferred), Sr. Scientist, ICAR-DCR, Puttur

Dr. Siddanna Savadi, Scientist (Ag. Biotechnology), ICAR-DCR, Puttur

Objectives

To establish a center of excellence for Cashew apple and nut profiling with state of art facilities for the selection of superior types in cashew

Identification/ Selection or development of nutritionally rich cultivars of Cashew nut.

Practical utility

Create modern state-of-the-art facilities needed for faster and more efficient selection in cashew and also for advanced research programmes.

Achievements/ Output

Plant phytochemicals have been reported to prolong life by their protection against numerous human health and metabolic conditions. Cashew plant, being a potential source of bioactive compounds, can ameliorate various lifestyle-related diseases. The plant is reported to have anti-bacterial, antifungal, and antioxidant activities and is a rich source of diverse groups of plant chemicals. Even though many of the farmers are in cashew cultivation, they are not well aware of the medicinal uses and nutritive properties available in cashew apple and nuts. Farmers are mainly involved in the processing of nuts and selling it for a better price. There is lack of awareness about the use and importance of cashew apple, which is also a nutritive power house of many of the bio actively rich components.

Therefore, this project mainly aims at screening the majority of the available germplasm at ICAR-DCR Puttur, particularly for the nutraceutical profile, and aims to establish a center of excellence for cashew nutrients profiling. The proposed project with state-of-the-art facilities for the extraction of important bioactive components both in cashew apple and nut, which not only increases selection efficiency but also aids in the identification of nutrient-rich genotypes for further utilization in breeding and for conservation purposes. This will allow cashew researchers to screen and identify genotypes with specific components like Anacardic acid, protein, fat, etc., rich types at a faster pace, which will benefit the cashew community.

Output of the Project

The laboratory is strengthened with High Pressure liquid chromatography (Fig. 3.6.4), Spectrophotometer (Fig. 3.6.5), Gas chromatography mass spectrometry (Fig. 3.6.6) and other necessary equipment, and lab set-up like work tables (Fig.3.6.7) and power backups were installed (Table 3.6.1).

Till now more than 30 genotypes of cashew have been analysed for total phenols, total flavonoids, total antioxidant activity, tannins, and vitamin C.

Utilization of cashew apple is one of the primary objectives in the cashew sector. Therefore, the products developed from cashew apple were analyzed for different biochemical components.

Table 3.6.1 : Infrastructure and facilities developed under the project

Sl. No	Laboratory instruments Facility/purchased/upgraded	Cost [Rs. In Lakhs]
1	High-Pressure Liquid Chromatography	41.95
2	Gas Chromatography Mass Spectrometry	40.00
3	UV-Visible spectrophotometer and other lab accessories	13.05



Fig. 3.6.4 : High-Pressure Liquid Chromatography Unit



Fig. 3.6.5 : UV-Visible Spectrophotometer



Fig. 3.6.6 : Gas Chromatography Mass Spectrometry Unit





Fig. 3.6.7 : Working unit established

Expected benefits and economic impact

The infrastructural facilities developed under the project will be available to further support all the biochemical estimation and other institutional activities.

Future line of research work

The established facility will be utilised for qualitative analysis of the samples and also for outside samples on a payment basis.

3.6.3 : Developing nutrient management strategies for cashew based on soil and leaf status

Institute Project Code: PIMS Number: IXX16218

Project Duration : 5 years [10/2020-12/2025]

Keywords:

Name of the Lead Institute : ICAR-Directorate of Cashew Research, Puttur, Karnataka

Name of Division/ Regional Centre/ Section : Crop Management

Project Team:

PI : Dr. Veena G. L., Senior Scientist (SPM&AP), ICAR-DCR Puttur

CO-PIs : Dr. Shamsudheen Mangalassery (Transferred), Pr. Scientist, ICAR-DCR, Puttur

Dr. V. Thondaiman, Senior Scientist (SPM&AP), ICAR-DCR, Puttur

Dr. Babli Mog, Senior Scientist (Pl. Physiology), ICAR-DCR, Puttur

Dr. Manjesh. G. N., Scientist (SPM&AP), ICAR-DCR, Puttur

Dr. Aswathy Chandrakumar (Ag. Extension), ICAR-DCR, Puttur

The nutrient management problem in cashew plantations occurs throughout the cashew orchards of the country. Non-replenishment of tapped nutrients leads to further land degradation apart from the direct impact on crop yield. Nutrient status and imbalances will be known only after the appearance of deficiency symptoms on the plant, and by that period, the plant growth and yield levels would have been adversely affected. Adequate nutrient management is also important to maintain the fertility levels of soil. The bio-availability of nutrients toperennial crops such as cashew can be best judged by leaf analysis, especially during periods of active growth and peak nutrient removal. Foliar application of nutrients is considered one of the quickest and easy way of supplementing nutrients to the crop during peak nutrient demand. The project aims to develop technologies for addressing nutrient management issues in cashew, which will have implications on land productivity and the livelihood of farmers.

Objectives:

a. To study the pattern of nutrient uptake and allocation of nutrients in cashew

b. To develop leaf analysis-based nutrient management for cashew

Practical utility

a. Information on the nutrient pattern in cashew.

b. Leaf analysis-based nutrient management schedule for cashew

Expected Output

Information on the nutrient pattern in cashew.

Leaf analysis-based nutrient management schedule for cashew

The nutrient management problem in cashew plantations occurs throughout the cashew orchards of the country. Non-replenishment of tapped nutrients

leads to further land degradation apart from the direct impact on crop yield. Nutrient status and imbalances will be known only after the appearance of deficiency symptoms on the plant, and by that period, the plant growth and yield levels would have been adversely affected. Adequate nutrient management is also important to maintain the fertility levels ofthesoil.

The bioavailability of nutrients to perennial crops such as cashew can be best judged by leaf analysis, especially during periods of active growth and peak nutrient removal. Foliar application of nutrients is considered one of the quick and easy way of supplementing nutrients to the crop during peak nutrient demand. The project aims to develop technologies for addressing nutrient management issues in cashew, which will have implications on land productivity and the livelihood of farmers.

Achievements/Output

Standardised and developed a foliar formulation as a nutrient supplement to cashew and named it "Cashew Special". This Cashew special micronutrient composition comprises specific, well-defined compounds selected for their solubility, compatibility, and efficacy in foliar application to cashew (Table 3.6.2).

The micronutrient composition of the present invention is formulated as a dry powder, and when dissolved in water, the composition maintains a pH in the range of 6.0 to 6.5, and is intended for foliar application in cashew. The micronutrient composition is highly water-soluble, with solubility ranging from about 95 % to 100 %.

- Cashew micro nutrient special trial was initiated in 14 AICRP Centres and 5 farmers' plots of Karnataka
- The encouraging results were observed with respect to per cent fruit retention, Apple, and nut yield.
- The application of foliar multi-nutrient sprays significantl y enhanced the nutrient density of cashew kernels, particularly in terms of nitrogen, potassium, zinc, and boron, suggesting a positive impact on kernel quality as well as it enhances the accumulation of key nutrients in cashew apples, particularly potassium, zinc, copper, and boron, which are essential for improved fruit quality and nutritional value.
- Absence of fruit cracking was observed
- Emergence of additional flowering laterals was observed
- The Cashew micronutrient special was filed for patent at Patent office of India (Appln. No. 202541049738 filed on 23.05.2025).

The micronutrient compositions were applied as a foliar spray during the flushing cum flowering stage to the early nut formation stage to the cashew plants (N= 15 plants) grown in lateritic soil. The micronutrient composition was applied as a foliar spray to the cashew at the rate of 0.5 %. The micronutrient composition was applied in combination with standard fertilizer compositions containing nitrogen, phosphorus, and potassium to cashew plants. The cashew plants fertilized with the standard fertilizer compositions but without the micronutrient compositions served as control (N= 15 plants).

Table 3.6.2 : Effect of the micronutrient composition of the present disclosure and standard fertilizer on the yield of cashew

Details of the experiment	Raw cashewnut yield (kg/tree)	Fresh cashew apple yield (kg/tree)
Control Plants applied with Standard	4.79	47.14
Fertilizers alone	4.87	45.89
(Total=15)	4.73	45.87
Cashew plants applied with	6.35	62.43
Micronutrient composition + **Standard fertilisers**	6.41	61.80
(Total=15)	6.38	62.44
% increase in yield with Micronutrient composition	**31.6 to 34.9%**	**32.4 to 36.1%**

The foliar application of the micronutrient composition significantly influenced the floral and yield attributes of cashew (var. Nethra Ganga). A steady increase in the number of male and female flowers per panicle was observed with increasing spray concentrations, with the highest values recorded at 1.0 %; however, the most statistically significant improvement was observed at the 0.5 % concentration, which produced 429.36 male flowers and 94.70 female flowers per panicle. The number of panicles per tree, number of nuts per panicle, nut weight per tree, and yield (t/ha) all increased with nutrient application. The 0.5 % concentration resulted in the highest nut retention (76.93 %), and a significantly higher nut yield of 6.21 kg per tree (2.48 t/ha), compared to the control (4.61 kg/tree; 1.84 t/ha) (Table 3.6.2). While higher concentrations (0.6 % to 1.0 %) showed slightly higher numerical values, they were statistically at par with the 0.5 % concentration for most yield parameters. This indicates that 0.5 % is an optimal concentration for improving productivity, beyond which no significant gains are achieved (Fig. 3.6.8 and Fig. 3.6.9).

The advantages of the nutrient composition provided by the present invention are as follows:

1. It provides an optimized blend of essential nutrients tailored to the specific physiological needs of cashews.
2. It improves absorption and translocation, ensuring better bio-availability of nutrients.
3. It boosts flowering, fruit set and nut development, resulting in increased yield pertree.
4. It enhances kernel size, weight, and uniformity, improving the market value of cashews.
5. It minimizes nutrient losses and reduces dependency on excessive chemical fertilizers.
6. It can be adapted for precision agriculture using drone-based nutrient delivery systems.

Expected Benefits and Economic Impact

- Leaf tissue-based nutrient norms shall fasten the in-season nutrient programmes in cashew.
- An Effective foliar spray to supplement soil nutrition and optimize performance of cashew.



Fig. 3.6.8 : Field Testing of 'Cashew Special at the research station and Farmer's Plot



Fig. 3.6.9 : Effect of Cashew special on Nut set

3.6.4 Effect of growth regulator in combination with flower and fruit-set enhancing chemicals on cashew (*Anacardium occidentale* L.)

Institute Project code : IXX16215

Key words : Cashew, Growth Regulator, Chemical, Flower enhancing, Sex ratio, fruit drop

Name of the Lead Institute: ICAR- Directorate of Cashew Research, Puttur

Name of the Division / Regional Centre / Section: Crop Management

Name of the Collaborating Institute(s), if any: -

Name of Division / Regional Centre / Section of Collaborating Institute(s): -

Project Team Name(s) and designation : PI – Dr. V. Thondaiman, Sr. Scientist, ICAR-DCR, Puttur

Co-PIs : Dr. Babli Mog, Sr. Scientist (Plant Physiology), ICAR-DCR, Puttur
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Dr. Bhagya H. P., Scientist (SPMAP), ICAR-DCR, Puttur

Project duration : October 2020 to September 2025

In cashew plants, there are very meagre researches have been carried out to increase the hermaphrodite flowers and very few attempts have been made related to nut drop studies. Besides, new plant growth hormones and chemicals are gaining the momentum in other commercially important horticultural crops like mango, orange, guava, etc. Despite the importance of growth hormones to increase yield, their uses on cashew are limited even with daunting production challenges. Hence, this experiment is proposed to study the role of plant growth regulators and chemicals for growth and yield of cashew.

Objectives

1. To study the influence of growth regulator in combination with flower and fruit-set enhancing chemicals on flowering, fruiting and yield of cashew
2. To study the influence of growth regulator and chemicals on apple and nut quality
3. To work-out the cost benefit ratio

Technical programme (brief)

(a) Material and (b)Techniques/Methodology

During the first year, the established field var. NRC Selection 2 will be prepared to implement the treatments. This experiment comprises seven treatments viz.,

T_1-Control

T_2-BAP-100ppm

T_3-Ethrel-50ppm

T_4-2,4,D-10ppm

T_5-Spermine-0.01mM

T_6-T_2+T_3

T_7-T_2+T_3+T_4

T_8-T_2+T_3+T_5

No.of replications : 3

No.of treatments: 8

Name of the design : Randomized block design

Achievements/output of the project

The results obtained in the project are given in Table 3.6.3. The number of panicles per tree was highest (15.09) in T_2 followed by T_6 (14.97) and the lowest numbers (12.17) were recorded in control. With respect to sex ratio, the treatment T_6 registered the highest ratio (0.27) which was on par with T_8(0.24) and T_3(0.23); the lowest sex ratio was registered with the unsprayed plants (Control). Among the treatments, the treatment T_8 showed more nut retention per panicle (9.33) which was on par with T_7(9.15) and the lowest nut retention was recorded with control (4.58). In case of nut weight, the treatments showed non-significant results. The yield per tree and yield per hectare was recorded highest in the plants treated with T_8 (1.16 kg/tree and 1.85 t/ ha respectively) and results were on par with T_7 (1.19 kg/ tree and 1.91 t/ ha respectively) and the lowest yield per tree and yield per hectare was recorded with the untreated plants (0.5 kg/tree and 0.80 t/ha respectively). At the outset, the spray combination of BAP - 100 ppm + Ethrel - 50 ppm + 2,4,D - 10 ppm is recommended for achieving profitable income to the farmers.

Table 3.6.3 : Effect of growth regulator in combination with flower and fruit-set enhancing chemicals on flowering and yield traits

Treatments	No. of panicles per tree	Sex ratio	Nuts retention per panicle	Nut weight (g)	Yield per tree (kg)	Yield per ha (t/ha)
T_1 - Control	12.17	0.15	4.58	8.80	0.50	0.80
T_2 - BAP - 100 ppm	15.09	0.17	6.25	9.23	0.88	1.41
T_3 - Ethrel - 50 ppm	12.25	0.23	6.87	9.37	0.82	1.30
T_4 - 2,4, D - 10 ppm	12.58	0.18	6.67	8.92	0.75	1.21
T_5 - Spermine - 0.01 mM	12.25	0.16	6.60	9.31	0.78	1.24
T_6 - T_2 + T_3	14.97	0.27	7.10	8.88	0.96	1.54
T_7 - T_2 + T_3 + T_4	13.93	0.21	9.15	9.38	1.16	1.85
T_8 - T_2 + T_3 + T_5	13.98	0.24	9.33	9.31	1.19	1.91
C.D.	0.974	0.06	0.842	NS	0.057	0.092
SE(m)	0.318	0.02	0.2370	-	0.019	0.030
SE(d)	0.450	0.03	0.382	-	0.026	0.042
C.V.	4.111	15.68	6.808	-	3.629	3.627

3.6.5 Design, development and performance evaluation of cashew fruit and nut separator

Institute Project code : IXX15634

Key words : Cashew, separation mechanism, feed rate, separation efficiency, percentage of damage

Name of the Lead Institute : ICAR-Directorate of Cashew Research, Puttur

Name of the Division / Regional Centre / Section : Farm Machinery and Power

Name of the Collaborating Institute(s), if any : ICAR – Central Institute of Agricultural Engineering

Name of Division / Regional Centre / Section of Collaborating Institute(s) : ICAR-CIAE Regional Centre Coimbatore

Project Team Name(s) and designation : PI - Dr. Manjunatha, K., Scientist, ICAR-DCR

Co-PIs: Dr. D. Balasubramanian, Principal Scientist, ICAR-DCR

Dr. Ravindra Naik, Principal Scientist, ICAR-CIAE Regional center, Coimbatore

Project duration : October 2020 to September 2024

The cashew produces both the economically important nut and the nutritionally rich cashew apple. Although the cashew apple is rich in vitamin C and suitable for various value-added products, its utilization remains limited due to rapid post-harvest deterioration. Effective utilization of the apple requires immediate separation of the nut after harvest. At present, cashew fruit and nut separation is largely carried out manually, making the process labour-intensive and time-consuming. Delays in separation adversely affect apple quality and lead to increased post-harvest losses. Mechanization of this operation can substantially reduce labour requirements and improve processing efficiency. In this context, the design and development of a mechanical cashew fruit and nut separator become essential. The present study focuses on the design, development, and performance evaluation of a cashew fruit and nut separator aimed at improving operational efficiency, processing capacity, and overall productivity.

Objectives

1. To study the engineering properties of cashew apple and nut.
2. To design and develop the cashew fruit and nut separator.
3. Performance evaluation of the developed machine.
4. To work out the economics of the developed machine.

Achievements / output of the project

The present study, determine the physical, mechanical, and frictional properties of cashew apple and nut in six varieties viz., Bhaskara, Nethra Ganga, Ullal-3, Vengurla-7, Vengurla-4 and Dhana. The cashew apple and nuts' arithmetic and geometric mean diameters were 44.58 to 52.11 mm, 43.41 to 51.41 mm and 24.96 to 28.81 mm, 23.89 to 28.11 mm, respectively. The sphericity of the cashew apple was found to be in the range of 0.76 to 0.89, whereas that of nut ranged between 0.71 and 0.80. Bulk density of cashew apple ranged from 495.15 to 581.50 kg m-3, whereas that of nuts ranged from 451.66 to 531.47 kg m-3. The static coefficient of friction of cashew apple and nuts varied on different surfaces. The mean values of the compression test in longitudinal and lateral directions were found to be in the range of 80.54 to 179.38 N and 90.92 to

139.40 N. The shearing force was found to be in the range of 20.36 to 53.08 N and 26.52 to 40.46 N in longitudinal and lateral directions, respectively. Statistically significant differences were observed in the physical properties of cashew apple and nuts among the varieties. These findings would be pertinent for designing the post-harvest machinery in cashew.

Investigated the detachment forces of fruits at ten different stages of development according to the BBCH (BiologischeBundesanstalt, Bundessortenamt und Chemische Industrie) scale, a uniform coding system for different growth or phenological stages (701, 703, 705, 707, 709, 811, 813, 815, 817, 819) in ten cashew cultivars. Fruit weight (FW), FDF/FW ratio, and fruit firmness (FF) for different fruit development stages and fruit stalk scar area (SSA) of matured (819 stage) fruits were also studied. FDF, FW, FDW/FW and FF varied significantly at the different stages of fruit development among the studied cultivars. The FDF increased from 701 to 709 stages and then decreased from 709 to 819 stages in all the studied cultivars. The FDW/FW ratio reduced with the development and maturity of the fruit. In matured fruits (811–819 stages), FW and FF showed significant negative (p value = 0.028) and positive (p value = 0.015.) correlations, respectively, with the FDF. In contrast, the SSA had no significant influence on the FDFs. As the FDF has direct implications on the fruit removal efficiency, the results of this study will be useful for designing harvesting machines, screening genotypes for stress tolerance, and identifying the optimal harvesting stage incashew.

In this study, the torsional/twisting forces (TF) required for separating the nuts from the cashew apples (CA) were analyzed at the nut pedicel junction (NPJ) in different cultivars at different fruit developmental stages [BBCH (Biologische Bundesanstalt, Bundessortenamt und Chemische Industrie) stage code: 711, 713, 715, 717, 719, 811, 813, 815, 817, 819] and days after fall to devise strategies for efficient separation of nuts and CAs. The TF and torsional/twisting angle (TA) were measured using a novel strain gauge-based reaction type torque transducer and a customized fixture. The CA firmness (CAF), and CA cavity depth, length, and width at the NPJ were also measured. Significant variations were observed in the TF and the TA at different fruit developmental stages and days after fall (DAF) in the studied cultivars. The TFs increased from 711 to 813 stages and subsequently declined from 813 to 819 stages and with increasing DAF. Further, the TA increased significantly with the development of fruits from 711 to 819 stages and days after fall. The analysis of the relationship between TF and the physical properties of CA showed that CA firmness and CA cavity depth at the NPJ had significant positive correlations. Further, the analysis of the relationship between the TA and the CA properties showed that CA firmness has significantly negative correlations. The findings of this study are valuable for the development of new cashew cultivars with low TF and TA suitable for mechanical separation and the designing of machinery with versatile end-effectors and twisting mechanisms for efficient separation of nuts from Cashew apples.

Developed three types of machines for cashew apple and nut separation, catering to the needs of farmers ranging from small holders to large-scale operations. The details of the developed technologies are as follows:

a) Pedal-operated cashew fruit and nut separator

A prototype pedal-operated cashew nut and fruit separator was designed and developed (Fig. 3.6.10). The machine consists of a main frame, shear cutting blades, a spring-retractable mechanism, and separate outlets for nuts and apples. The overall length, width and height of the nut separator were 770, 771 and 1030 mm, respectively. Performance evaluations showed that the pedal-operated separator has an average separation capacity of 15.0 kg h^{-1} (RCN) with a separation

efficiency of 82.74 %. The nut damage was found to be less than 5 %, making it an effective and farmer-friendly solution.



Fig. 3.6.10 : Pedal-operated cashew apple and nut separator

b) Portable semi-automatic cashew apple and nut separator

A portable semi-automatic cashew apple and nut separator (Fig. 3.6.11) prototype was also developed, featuring a twisting mechanism. This machine comprises of main frame, a prime mover, a power transmission system, and a nut separating mechanism. The overall length, width and height of the semi-automatic cashew apple and nut separator were 1170, 705 and 925 mm, respectively. Performance evaluations revealed an average separation capacity of 29.48 kg h^{-1} with a separation efficiency of 91.45 %.



Fig. 3.6.11 : Portable semi-automatic cashew apple and nut separator

c) Fully automatic 3-in-1 cashew nut separator

A versatile 3-in-1 machine (Fig. 3.6.12) was developed to perform three operations viz: nut separation, pulp extraction, and fibrous material separation. This fully automatic machine demonstrated exceptional performance during evaluations, achieving an average separation capacity of 307 kg h^{-1} (RCN) with a separation efficiency of 99.32 %. Additionally, the nut damage was remarkably low, at just 0.57 %, highlighting its suitability for large-scale cashew processing operations.



Fig. 3.6.12 : 3-in-1 cashew nut separator, juice & pulp extractor, and fibrous material separator

Expected benefits and economic impact

Expected benefits

1. Increased Efficiency and Productivity

Reduces time and labour required for separation, especially during peak harvest.

Enables faster processing, reducing spoilage and maintaining quality.

2. Reduced Post-Harvest Losses

Minimizes handling damage and contamination by mechanizing the process.

Enhances recovery of both cashew nuts and apples for value-added uses.

3. Improved Income for Farmers

Allows farmers to utilize cashew apples, which are often discarded, for processing into products like juice, jam, jelly, vinegar, or biofuel.

Reduces dependence on manual labour, saving operational costs in the long term.

4. Scalability and Accessibility

The availability of machines tailored to small, medium, and large-scale users ensures inclusive benefits across farmer segments.

Facilitates decentralized processing, encouraging rural entrepreneurship.

5. Support for Sustainable Agriculture

Promotes full utilization of agricultural produce (both nut and apple).

Encourages eco-friendly and zero-waste farming practices.

Economic Impact

1. Enhanced Farm Profitability

Farmers can earn additional income from cashew apple-based products.

Mechanization reduces the cost per unit of output, increasing net returns.

2. Job Creation and Skill Development

New jobs in manufacturing, maintenance, and operation of machines.

Training and capacity-building initiatives foster technical skills in rural areas.

3. Boost to Agro-Processing Industry

Encourages the growth of small and medium agro-processing units.

Strengthens value chains for both cashew nuts and apple-based derivatives.

4. Market Expansion and Export Potential

Standardized processing improves quality, making products more competitive in national and international markets.

Opportunities for branding and marketing of cashew-based products.

Future Line of Research Work

Design a scaled-down version of the 3-in-1 cashew nut separator to cater to individual or smallholder-level use, based on farmer demand.

Compact, lightweight, and cost-effective models are needed for easy handling and local mobility.

Focus on sound dampening technologies for improved operator comfort, particularly in the 3-in-1 nut separator.

Commercialization/Technology Transfer

In a major step toward commercialization, ICAR-CIAE-DCR signed an Umbrella Memorandum of Agreement (MoA) with M/s Phison Agritech Private Limited, Ramanagara, Karnataka, facilitated by Agrinnovate India Limited, New Delhi for licensing of this advanced technology on 11.03.2025.

3.6.6 Design and development of gadgets for cashew fruit harvesting and collection

Institute Project code (to be provided by the PME cell : IXX15635

Key words : Cashew, separation mechanism, feed rate, separation efficiency, percentage of damage

Name of the Lead Institute : ICAR- Directorate of Cashew Research, Puttur

Name of the Division / Regional Centre / Section : Farm Machinery and Power

Name of the Collaborating Institute(s), if any : ICAR – Central Institute of Agricultural Engineering

Name of Division / Regional Centre / Section of Collaborating Institute(s) : ICAR-CIAE Regional Centre, Coimbatore

Project Team Name(s) and Designation : PI - Dr. Manjunatha, K., Scientist, ICAR-DCR

Co-PIs: Dr. D. Balasubramanian, Principal Scientist, ICAR-DCR

Dr. Ravindra Naik, Principal Scientist, ICAR-CIAE Regional center, Coimbatore

Dr. J. D. Adiga, Director, ICAR-DCR

Project duration : 10/2020 to 09/2025

Cashew is an economically important plantation crop, valued for its kernels, apples, and various by-products, all of which have significant commercial potential. During harvesting, a considerable portion of cashew apples and nuts naturally falls to the ground, either due to physiological drop or during manual harvesting operations. These fallen produce components constitute a substantial share of the total yield and must be efficiently collected to minimize losses and ensure better utilization.

At present, the collection of cashew apples and nuts is predominantly carried out through manual methods such as hand picking. These practices are highly labour-intensive, time-consuming, and physically strenuous, often causing fatigue and discomfort due to repetitive bending, squatting, and standing movements. The high labour requirement and associated costs significantly increase the overall cost of production. Therefore, there is a pressing need to mechanize the collection process to enhance efficiency, reduce drudgery, and optimize labour utilization. In this context, the present study focuses on the development of a cashew apple and nut collector aimed at simplifying field collection operations while minimizing laborious effort.

Objectives

1. To study the engineering properties of cashew apple and nut
2. To design and develop the gadgets for cashew apple and nut collection
3. Performance evaluation of the developed gadgets
4. To work out the economics

Achievements / output of the project

Determination of engineering properties of cashew apple and nut

In this study various engineering properties such as physical characteristics, mechanical and frictional properties of cashew apple and nut for six varieties viz.,

Bhaskara, H-130, Ullal-3, Vengurla-7, Vengurla-4 and Dhana were determined and compared using Duncan's multiple ranges test. The results showed that the average length, width and thickness of the freshly harvested cashew apple and nut ranged from 54.15 to 60.74 mm, 40.62 to 50.77 mm, 35.63 to 44.81 mm and 32.88 to 38.27 mm, 23.97 to 27.22 mm, 16.83 to 23.93 mm respectively. The arithmetic and geometric mean diameters of the cashew apple and nuts were determined to be 44.58 to 52.11 mm, 43.41 to 51.41 mm and 24.96 to 28.81 mm, 23.89 to 28.11 mm respectively. The sphericity of the cashew apple was found to be in the range of 0.76 to 0.89 resembled a conical-obovate whereas the nut resembled as kidney shape having sphericity value ranged between 0.71 to 0.80. The bulk density of cashew apple was found to be maximum for H-130 (581.50 kg m^{-3}) while it was minimum for Ullal-3 variety (495.15 kg m^{-3}). The true density of the cashew apple ranged from 1013.33 to 1133.64 kg m^{-3} whereas corresponding values of bulk density and true density of nuts ranged from 451.66 to 531.47 kg m^{-3} and 1108.60 to 1228.06 kg m^{-3} respectively. Static coefficient of friction of cashew apple and nuts varied on different base surfaces. In examining mechanical properties, the mean values of the measured properties in the compression test in both longitudinal and lateral directions were found to be in the range of 80.54±12.46 to 179.38±14.51 N and 90.92±7.26 to 139.40±1.09 N. Whereas, in the shearing test it was found to be in the range of 20.36±1.88 to 53.08±8.07 N and 26.52±4.50 to 40.46±9.53N in both longitudinal and lateral directions. Statistical analysis revealed that the factors considered under physical characteristics found to be significant ($p<0.01$). This scientific investigation was undertaken to generate essential data on cashew apples and their corresponding nuts, with the objective of supporting the design and development of machinery for cashew apple–nut separation, as well as harvesting and collection devices.

Evaluation of fruit detachment forces (FDF) and related characteristics

Cashew is an edible tree nut having a great nutritional and industrial importance. Cashew fruit is unique where the true fruit (nut) grows attached to a swollen flower pedicel known as hypocarp or cashew apple. The fruit detachment force (FDF), quantitative measurement of detachment of fruits from stalk, is considered as an important parameter for the evaluation of harvesting efficiency of machines, and cultivar's potential for machine harvesting and tolerances to the biotic and abiotic stresses. Till date, there are no studies on evaluation of FDF in cashew. In the current study, we investigated the FDFs of fruits at ten different stages of development according to the BBCH scale (701, 703, 705, 707, 709, 811, 813, 815, 817, 819) in ten cultivars. Fruit weight (FW), FDF/FW ratio, and fruit firmness (FF) for different fruit development stages and fruit stalk scar length (SSL) and fruit stalk scar width (SSW) of matured (819 stage) fruits were also studied. FDF, FW, FDW/FW and FF varied significantly at the different stages of fruit development among the studied cultivars. The FDF increased from 701 to 709 stage and then decreased from 709 to 819 stages in all the studied cultivars. FDW/FW ratio reduced with the development and maturity of the fruit. In matured fruits (811–819 stages), FW and FF showed significant negative and positive correlations, respectively, with the FDF suggesting FW and FF significantly influence harvesting efficiency. In contrast, the other two fruit characters, SSL and SSW, had no significant influence on the FDFs. As the FDF has direct implications on the fruit removal efficiency, the results of this study will be useful for the designing harvesting machines, screening of genotypes for stress tolerance and identification of optimal harvesting stage in cashew.

Development of gadgets for cashew fruit harvesting and collection

Harvesting and collection of cashew apple is one of the most labour-intensive operations in cashew production. Mature cashew fruits naturally fall to the ground and are traditionally collected manually from the orchard floor. This method involves continuous bending, leading to significant physical strain for workers, and often results in contamination of the fruits with soil and debris. To address these challenges, several improved gadgets and mechanized solutions have been developed to facilitate efficient collection, reduce drudgery, and maintain better hygiene of the harvested produce. The details of these technologies are presented below.

1) Battery operated telescopic cashew fruit harvester (Fig. 3.6.13)

Key Features & Benefits

Length: 18 ft

Weight: 2.8 kg

Harvesting capacity: 44 kg h-1

Fruit damage: Nil

Lightweight and easy to carry



Fig. 3.6.13 : Battery operated telescopic cashew fruit harvester

2) Roller type cashew fruit collector (Fig. 3.6.14)

Key Features & Benefits

Weight: 1.10 kg

Collection capacity: 55 to 60 kg h-1

Fruit damage: Nil

Picking efficiency: >80%

Percentage of debris: <1%

Gender friendly tool

Reduces drudgery

Lightweight and easy to carry



Fig. 3.6.14 : Roller type cashew fruit collector

3) Jaw type cashew fruit collector (Fig. 3.6.15)

Key Features & Benefits

Weight: 1.2 kg and 0.8 kg

Collection capacity: >25 kg h-1

Fruit damage: Nil

Picking efficiency: >90%

Percentage of debris: <3%



Fig. 3.6.15 : Jaw type cashew fruit collector

Expected Benefits

Mechanized harvesting and collection significantly reduce manual effort, addressing labour shortages during peak season and improving worker safety and efficiency.

Faster collection of fallen cashew fruits minimizes delays, reducing field losses and ensuring better quality raw material.

Efficient picking systems increase collection percentage from the field, reducing wastage and enabling better utilization of cashew apples for value-added products.

Gadgets can be adapted for different plantation layouts, improving accessibility under dense canopies and uneven field conditions.

Economic Impact

Lower labour requirement leads to a significant decrease in per-unit harvesting cost.

Higher recovery of fruits and nuts, along with better quality produce, results in improved market returns.

Efficient collection of cashew apples supports processing into various value-added products.

3.6.7 Mechanization of pesticide and nutrient sprays in cashew orchards through drones (KA/RKVY-AGRE/2021/1272)

Project code (Externally Funded): OXX5543

Key words: Unmanned aerial vehicle; volume mean diameter (VMD); droplet density; distribution uniformity; cashew orchard

Name of the Lead Institute: ICAR- Directorate of Cashew Research, Puttur

Name of the Division / Regional Centre / Section: Farm Machinery and Power

Project Team Name(s) and designation :

PI : Dr. Manjunatha, K., Scientist, ICAR-DCR

Co-PI : Dr. Vanitha K., Senior Scientist (Entomology), ICAR-DCR

Project duration : 2021-22 to 2024-25

Cashew (*Anacardium occidentale* L.) is a major commercial edible nut tree grown mainly in tropical regions. Cashew nuts are ranked first among the edible tree nuts in the global market worth USD 7.7 billion. Besides, cashew industry provides employment to the rural women and youth in the developing countries. However, the productivity levels of cashew nuts are very low in many countries. In recent years, concerted efforts have been made to enhance the productivity through introduction high-yielding varieties, mechanized cultural operations and harvesting methods. In cashew orchards management, spraying of agrochemicals for nutrient management and control of pests and diseases is the major challenge especially in the high-density planting (HDP) orchards. Conventional spraying methods are inefficient due to the low operating speed, high labour requirements, low operating efficiency, and off target losses in cashew orchards. Besides, they pose health risks to operators and need more labours making the crop management expensive.

In the recent years, Unmanned Aerial Vehicles (UAVs) are gaining importance in precision agriculture, logistics, and disaster management, which has arisen the need for evaluation of optimized flight dynamics and payload interactions. In precision agriculture, UAV spraying technology has been widely used for application of agrochemicals such as pesticides, fungicides, and foliar nutrients. UAV assisted spraying has advantages of operational efficiency, need of ultra-low volume of spray liquid, easier and flexible spray operations, especially where human intervention is difficult or dangerous. Further, the advanced UAVs enable smart and targeted applications of chemicals that maximizes the efficacy of pesticide and are also found useful for surveillance of pest and diseases. UAVs have proven highly effective in controlling diseases, insect pests, and nutrient applications in different crops.

Despite great economic significance, the effect of UAV operational parameters on spray performance and off-target losses have not been unexplored in cashew. Further, cashew tree has heterogeneous canopy and foliage density compared to other tree crops making adoption of UAV protocols from other tree crops to cashew difficult. As result optimized UAV spray protocols are not available for commercial use in cashew orchards. In this study, the effect of UAV operational parameters viz., flight speed, flight height and spray volume on spray performance in terms of droplet size,

spectrum, droplet density, penetrability, distribution uniformity and ground losses in cashew orchard were investigated using an hexacopter UAV. In cashew, this is a first report on the optimal operational parameters for UAV-based spray applications and results of this study provide the optimized operational parameters of UAV for efficient and effective spraying method for orchard management using drones for enhancing the cashew productivity.

Objectives

1. Development of drone mounted sprayer for application of pesticide and nutrients
2. Performance evaluation of the developed drone sprayer for application of pesticides and nutrients in cashew orchards.
3. Demonstration of the developed drone mounted sprayer for larger adoption through field trials in farmer's fields and working out the cost of operation.

Achievements / output of the project

Established a state-of-the-art Drone Technology Laboratory & Farm Machinery Laboratory (Fig. 3.6.16).

A Drone Technology Laboratory was established, aiming to explore, develop, and promote the use of drone technology in plantation crops. The laboratory is equipped with state-of-the-art, cutting-edge technologies, viz., drones, sensors, and software, providing a platform for research, experimentation, and training. Also established a state-of-the-art farm machinery laboratory with the aim of mechanizing cashew cultivation practices. The Drone Technology Laboratory was inaugurated by Dr. Himanshu Pathak, Former Director General of the Indian Council of Agricultural Research, on 01 January 2025 (Fig. 3.6.17).



Fig. 3.6.16 : A view of Drone Technology Laboratory



Fig. 3.6.17 : Inauguration of the Drone Technology Laboratory by Dr. Himanshu Pathak, Former Director General of Indian Council of Agricultural Research, on 01 January 2025.

Development of standard operating procedures (SOPs) for application of pesticide and nutrient sprays in cashew orchards through drones

In the present study, spray experiments were conducted in cashew orchard using hexacopter drone with Box–Behnken design (BBD) for three factors [flight speed (FS), flight height (FH), and spray volume (SV)] at three levels forming a total of 17 treatment combinations. The spray performance of the UAV was evaluated based on response variables viz., volume mean diameter (VMD), droplet density (DD), droplet deposition penetration (DDP) and droplet distribution uniformity (DDU) by using water sensitive papers combined with an image processing software. The results showed that FS, FH and SV had a significant effect on all the studied parameters ($p<0.001$). The effects of three factors on VMD, DD, DDP, DDU were in the order of FS > SV > FH, FS > SV > FH, FH > SV > FS, FS > FH > SV, respectively. The most optimal combination for spray performance was FS2-FH1-SV3 (flight speed 3 m/s, height 7 m (above ground level), and spray volume 60 L/ha) having a VMD of 308.48 µm, droplet density of 57.28 drops/cm^2, droplet penetration of 44.57%, and distribution uniformity of 77.21%. The results of this study showed the great potential of UAVs in enhancing the spray efficiency and sustainability of crop protection in cashew orchards and provides valuable data for future innovation in this area.

Expected benefits and economic impact

Expected Benefits

Standardized procedures ensure uniform droplet distribution and better canopy penetration in dense cashew orchards.

Timely and precise application improves effectiveness against major pests and pathogens, reducing crop losses.

Proper calibration and dosage reduce wastage of pesticides and micronutrients, improving resource-use efficiency.

Economic Impact

Efficient use of chemicals lowers expenditure on pesticides and nutrients.

Improved plant health and reduced losses lead to higher marketable yield.

Standardized procedures reduce repeat spraying and unnecessary operations.

Future Line of Research Work

In the present study only water-based sprays were evaluated. Therefore, future works could explore the use of additives or adjuvants in various combinations to enhance droplet deposition, reduce drift, and minimize off-target losses, thereby improving the overall efficiency of UAV spraying in cashew orchards.

3.6.8 Cashew - Tea mosquito bug interactions and the defensive responses

Institute Project Code : IXX14975

Key words : Cashew flowers, bees, pollinators, pollination efficiency

Name of the Lead Institute : Directorate of Cashew Research, Puttur, Karnataka

Project Team : PI : Dr. K. Vanitha, Sr. Scientist (Agric. Entomology), ICAR-DCR, Puttur

Co-PI: Dr. T. N. Raviprasad, Principal Scientist, ICAR-DCR, Puttur

Dr. P. Preethi, Scientist, Fruit Science, ICAR-DCR), till 2020

Dr. Veena, G.L. Scientist (Fruit Science), ICAR-DCR, Puttur.

Dr. Shamsudheen, M., Senior Scientist (Soil Science), ICAR-DCR(Since 10/2020 till 12/2024).

Dr. V. Thondaiman, Scientist (Spices, Medicinal, Aromatic and Plantation Crops), ICAR-DCR, Puttur (Since 10/2020)

Project Duration Date of Start : 17.06.2019

Date of Completion : 16.06.2024

Objectives

To identify the traits of TMB tolerance in specific cashew varieties to understand their interaction.

To record the plant phenological stages after TMB infestation in early, mid and late varieties at different periods.

To assess the response of insect resistance induced by application of nutrients (Si) / Elicitors (SA/JA/Ca etc.) on TMB.

To examine the ability of plants in compensating TMB damage through application of nutrients / PGRs.

Compatibility study of insecticides with promising PGRs.

Achievements/ Output of the project

a. Traits of TMB tolerance

In the plots under high TMB pressureduring2019-20,MDK-2 sustained lesser TMB attack, as its flushing and flowering was delayed. But, Ullal-3, Ullal-4, V-4, V-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. During 2020-21,the observations indicated that spraying during initial build-up of TMB population (*i.e.* Nov. end or early Dec.) was imperative to avoid yield loss especially in the early flowering varieties (eg., Ullal-4, V-4 and V-7). Nut set/inflorescence was 0-3 in trees where initial spraying was skipped, whereas in timely sprayed ones, it was 1-6 (350-560 nuts/tree). Inflorescences with G2 and G3 damage grade of TMB yielded 2-3 nuts. Weather factors especially extended rains resulted in early flowering in all varieties and unseasonal rain during flowering season hampered specific observations.

The plant phenological stages after TMB infestation for production of second flushes and flowering were recorded in the reference cashew varieties. During 2023, the plot suffered severe TMB infestation till December 2023, and almost all 29 reference varieties had TMB damage grade of 2.0 to 4.0 depending on the plant phenological stage. After prolonged infestation, Brazil dwarf>VRI-3>Bhaskara>Dhana, MDK-2 and V-7 produced inflorescences to some extent at later period. Thus, differential response of varieties to TMB infestation is seen depending on the period of infestation and the plant phenological stage during the infestation.

b. Response of nutrient and PGR application on TMB infestation levels

Nutrient treatments including Potassium silicate, calcium silicate, KCl, B and Zn showed no marked difference in TMB feeding damage (0-4 grading) in seedlings under pot culture. In all the treatments, damage grade of 3-4 was recorded hence, all were highly susceptible without any nutritional effect in seedling stage. During 2022-23, seven nutrient treatments including K_2SO_4, KNO_3, Mono Potassium Phosphate, B, Zn, $MgSO_4$ were taken up in a cashew plantation where TMB is of regular occurrence and three varieties viz., Ullal-4, Dhana and Bhaskara were selected for this treatment studies.

Three rounds of nutrient sprays were done at monthly intervals starting from November, 2021. The concentrations of nutrients higher than the recommended sprays were used. After three rounds of sprays, TMB damage grade varied from 0.39 (insecticide treatment) to 2.5 among the treatments. None of the nutrient treatments tested were found effective in reducing TMB damage compared to lambda cyhalothrin. Nut yield was high in insecticide treated trees followed by combined nutrient sprays.

Physical parameters and shelling percentage of nuts under treatments showed significant differences. Nut weight was more in T5 (K_2SO_4+$MgSO_4$) in Bhaskara and Ullal-4, followed by T1 (K_2SO_4) in Dhana. However, a spray with Lambda cyhalothrin was taken up during the last week of February as TMB population flared up. Shelling percentage was high in T5 (K2SO4+MgSO4) - Dhana (29.05), L-cyhalothrin 5 EC- Bhaskara (32.64) and Ullal-4 (30.05).Apart from nutrients, sprays of plant growth regulators namely, NAA @20 and 40 ppm, GA3 @ 25 and 50 ppm and BAP @ 75 and 100 ppm were tested on infested cashew seedlings to check any difference in growth pattern of plants compared to the ones in which shoot tips were clipped manually. Though time taken to produce regrowth after TMB damage was almost same among treatments, number of shoots produced was more in GA3 treated seedlings. SA did not show any difference in TMB infestation levels compared to other nutrient treatments. However, no differences in regrowth pattern of the severely infested trees of Bhaskara on which PGRs were sprayed after the panicles were severely infested by TMB under field conditions (2022-23 & 2023-24). Application of KSi did not show marked difference in TMB infestation compared to other treatments.

c. Biochemical changes

Changes in chlorophyll, total phenols and tannins in the cashew grafts upon 24 and 48 h of infestation with TMB nymphs was estimated. No significant changes in chlorophyll content and tannins in the leaf samples, but significant increase in phenol content ($P<0.0001$ %) was evident upon TMB damage. Changes in biochemical constituents like phenols, tannins and flavonoids upon TMB infestation under different nutrient treatments were also analyzed. Phenol content was maximum under calcium silicate treated infested plants (557.44 mg/100g), while tannins was high in combined spray of potassium silicate, calcium silicate, Borax and ZnSO4 treated plants, while flavonoids was more in calcium silicate treated plants. Though increase in secondary metabolites were recorded in nutrient treated plants compared to untreated control, corresponding damage grades showed no influence of secondary metabolites on the level of TMB infestation.

i. Changes in biochemical quality parameters on shoots

Compared to the uninfested shoots, there was increase in the content of total phenols, total flavonoids and total anti-oxidant activity in the shoots of Bhaskara after 24 hours of TMB infestation, but no significant difference was recorded in total tannin content. Highest phenol content was recorded in infested semi matured shoots (95.14 GAE mg/100g) of Bhaskara, highest flavonoids was recorded in infested tender shoots (60.68 QE mg/100g) and highest total antioxidant activity was recorded in infested tender shoots (159.6 mg/100g).

The profile of phenolic acids and flavonoids of tender and semi matured shoots of Bhaskara were also recorded in the uninfested and TMB infested shoots (24 hours after infestation). A total of 15 phenolic acids were detected in the cashew shoots. In the infested tender shoots, increased gallic acid content of 10.65 µg/g was recorded. Whereas in the uninfested semi-matured shoots, 3-hydroxy benzoic acid (8.14 µg/g) and p-hydroxy benzoic acid (8.64 µg/g) were more among the phenolic acids, and after TMB infestation, their levels were 17.21 µg/g and 7.81 µg/g, respectively. The flavonoids profile indicated higher content of quercetin, luteolin and myricetin in the cashew shoots among the 13 flavonoids recorded. Among the flavonoids, quercetin was recorded high in the infested tender shoots (1080.3 ug/g) and in infested semi-matured shoots (350.05 ug/g). In general, tender shoots had higher phenyl alanine ammonia lyase (PAL), polyphenol oxidase (PPO), catalase and superoxide dismutase (SOD) content compared to semi-matured ones. There was significant increase in phenyl alanine ammonia lyase and polyphenol oxidase in the infested shoots after 24 hours of infestation but no such increase in SOD and catalase activity.

ii. Changes in biochemical quality parameters on nuts

The phenological nut (BBCH scale) stages of 619, 711 and 713 were found to be highly vulnerable to TMB infestation, which upon TMB infestation fell prematurely. The stages of 715 and 717 sustained TMB infestation and matured, while the nuts of 719 stage were not damaged by TMB. Hence, the nuts of 715 stage of VTH 30/4 were subjected for TMB infestation and those infested nuts upon maturity were analysed for physico-chemical qualities. In the infested nuts, kernels remained free of any damage symptoms. There was reduction in apple weight and nut weight by 15-25 % and 6-10 %, respectively in the infested nuts compared to the uninfested ones. Similarly, reduction in total sugars, protein, fat and CNSL content was observed in the infested cashew nuts compared to the uninfested ones.

d. Herbivore induced plant volatiles (HIPVs) in cashew

For examining the herbivore induced plant volatiles (HIPVs) dur to TMB, two cashew varieties viz., NRCC Sel-2 and Bhaskara were selected and all the studies starting from extraction till bioassays are carried out at IIHR, Bengaluru. The chromatograms of volatiles from healthy plants as well as the HIPVs of infested plants were quite different for both varieties. The EAG response also indicated peak spikes in HIPVs. This particular study needs replication for confirmation of findings and bioassays need to be taken up to check the attraction of TMB females to the volatiles.Olfactory bioassays were carried out with the available synthetic compounds of the response inducing chemicals for the response of TMB under dual choice at IIHR, Bengaluru. GC-EAD analysis indicated differential response in virgin female TMB to different HIPV compounds. Dual choice bioassays showed significant attraction of gravid TMB females towards healthy plant volatiles. There was significant attraction of gravid TMB females to beta caryophyllene, p-xylene, carene and cuminaldehyde. Further extensive studies with the synthetic analogues and the blends of HIPVs will lead to formulate attractants / deterrents for TMB.

e. Influence of PGRs on TMB infestation

Spray of PGRs could induce production of shoots in infested cashew seedlings but sprays could not induce further flowering when sprayed on trees where inflorescences were severely infested by TMB. The effect of plant growth regulators (GA3 and BAP) on the plant phenology upon TMB infestation was tested again under pot culture as well as field conditions. There was no significant difference in production of number of new shoots among the treatments and on par with the control treatment.

3.6.9 Establishment of Farmer-Centric Pest Diagnostic and Bio-Control Laboratory to Achieve Sustainable Cashew Health Management

Institute Project Code : PIMS Number: OXX5545
(KA/RKVY-AGRE/2022/1345)

Keywords : Cashew, Pest diagnostic, Bio-control, Diseases, Management

Name of the lead Institute : ICAR-Directorate of Cashew Research, Puttur

Project Team : **Principal Investigator (PI):** Dr. H. Rajashekara, Senior Scientist (Plant Pathology)

Co-PIs: Drs. T. N. Raviprasad, Principal Scientist (Agricultural Entomology)
Dr. K. Vanitha, Senior Scientist (Agricultural Entomology)
Dr. Siddanna S., Senior Scientist (Plant Biochemistry)

Project Duration : Start date: 09/2022
End date: 03/2025

Objectives

Establishment of centralized pest diagnostic facility for rapid and early diagnosis of plant pathogens and insects in cashew.

To establish bio-control laboratory, exploration, multiplication and supply of different bio-control formulations to achieve eco-friendly plant health management.

To develop infrastructure and lab facilities for botanical extraction and chemical ecology studies.

To create awareness about the different diseases and pest associated with cashew and to sensitize IDM/IPM practices towards the sustainability in cashew.

Achievements/ Output of the project

Establishment of Pest Diagnostic Laboratory

Established a pest diagnostic laboratory by procuring and installation in the project funding. The various capital items were purchased and list is attached in the below (Table 3.6.4). The pest diagnostic laboratory is equipped with workbenches and island table for carrying out molecular related works (Fig. 3.6.18). The laminar air flow unit is provided with separate cabin for isolation, subculturing and mass multiplication of pathogens and bio-control agents under aseptic conditions. The established facility will be effectively utilized for diagnosis of pathogens associated with cashew through isolation, morphological and microscopic confirmation of pathogens. The molecular facilities will be used for molecular identification of pathogens.



Fig. 3.6.18 : Pest diagnostic laboratory with different facilities

Table 3.6.4 : List of capital items procured in the project for establishment of pest diagnostic laboratory

Sl. No	Capital Item name	Sl. No	Capital Item name
1.	Compounded microscope with camera attachments and accessories	13	Gel Documentation system
2	Laminar air flow	14	PCR Machine
3	BOD incubators	15	Gel electrophoresis assembly
4	Vertical autoclave	16	Nano drop
5	Weighing balance	17	Milli Q water unit
6	Hot air oven	18	Refrigerated Centrifuge
7	Refrigerator	19	Computer with accessories
8	Air conditioners	20	pH meter
9	Deep freezer (-20°C)	21	Online UPS for laboratory
10	Air entrainment unit	22	Water bath
11	Vortex	23	Micro oven
12	Microcentrifuge	24	Bead sterilizer

Establishment of insect-proof net house and glass house

The insect proof net house and glass house facilities for pest and diseases screening under artificial conditions were created under the project (Fig. 3.6.19).



Fig. 3.6.19 : Insect proof net house and glass house facilities for insect and disease screening

Details of training programs conducted for skill development of cashew farmers under RKVY Project

One day training program at AICRP on Cashew center, Kanabargi, Belagavi

A training program was conducted on 21.02.2024 for farmers on 'Improved cashew production technologies: Scientist-Farmers interaction at AICRP on cashew, Kanabargi, Belgavi. Dr. Laxman Kuknoor, ADRE, RHREC, Dharwad was the Chief Guest for the program and he highlighted the importance of growing cashew crop and stressed on cashew nut processing to get additional income. Immediately after the program, the training lectures were delivered on Improved cashew varieties for doubling the farm income of cashew farmers by Dr. Eradasappa E. Sr. Scientist (Pl. Breeding) as resource person followed by Dr. Naveen M., delivered a lecture on soil, water and nutrient management in cashew for enhancing productivity and Dr. Laxman

Kuknoor., ADRE delivered lecture on cashew nut processing and value addition. Dr. T. N. Raviprasad Prin. Sci. (Agri. Ento.) delivered lecture on major pests of cashew and their management. Dr. Rajashekara H. Sr. Sci (Pl. Pathology) delivered lecture on disease of cashew and their management. A total 100 nos. of farmers from Belagavi, Dharwad and some farmers from Maharashtra were attended a program. Display panels and samples regarding various improved production technologies developed and recommended by Directorate were also exhibited for the benefit of farmers which led to good interaction with the scientists (Fig. 3.6.20).



Fig. 3.6.20 : Glimpses of training program conducted at Kanabargi, Belgavi, Karnataka

One day training program at Krishi Vigyan Kendra, Chintamani, Chikkaballapura

A training program was conducted on 26.07.2024 for farmers on 'Improved cashew production technologies: Scientist-Farmers interaction at Thippenahalli Village near Shidlaghatta in collaboration with College of Horticulture, Bengaluru and ICAR-KVK, Chintamani, Chikaballapura. Dr. G. S. K. Swamy, Dean, College of Horticulture, Bengaluru was the Chief Guest for the program and he highlighted the importance of growing cashew crop and stressed on cashew apple utilization for getting additional benefit. Dr. Papireddy, Senior Scientist & Head KVK, Chintamani was the Guest of Honor for the program and he highlighted on adoption of improved varieties suitable to the region and proper drying and storage of cashew rawnuts for getting higher rates for the produce. Immediately after the program, the training lectures were delivered on Improved varieties and suitability with production practices by Dr. Eradasappa E. Sr. Scientist (Pl. Breeding) as resource person followed by Dr. T. N. Raviprasad Prin. Sci. (Agri. Ento.) delivered lecture on important pests of cashew: identification and their management. Dr. Rajashekara H. Sr. Sci (Pl. Pathology) delivered lecture on different disease of cashew and their management. Dr. Itigi Prabhakar Asst. Prof. (Agri. Ext.) briefed about the importance of FPO for the benefit of cashew farmers. The major two problems expressed by the farmers during the ensuing discussions included less flowering and fruit set which observed after 10 years of crop establishment and getting less prices for raw cashewnuts. Dr. Tanveer Ahmed, Scientist (Agri. Ext.), ICAR-KVK, Chintamani involved in coordination the training program. A total of 87 farmers from Thippenahalli and nearby villages attended the training: Display panels and samples regarding various improved production technologies developed and recommended by Directorate were also exhibited for the benefit of farmers which led to good interaction with the scientists (Fig. 3.6.21).



Fig. 3.6.21 : Glimpses of training program conducted at KVK, Chintamani, Chikkaballapura, Karnataka

4. EXTENSION AND OUTREACH

Sl. No	Details of the Programme	Scientists involved
	On Campus Trainings	
1	Training programme on "Establishment and Management of cashew Nursery" for farmers and officials (22 Nos.) of Directorate of Horticulture, Shillong, Meghalaya during 05.05.2025-07.05.2025	Drs. Balasubramanian, D, E Eradasappa, H P Bhagya
2	One-day training program on 'Good Agricultural Practices and Entrepreneurship related to Cashew' for the 35 students of College of Agricultural Engineering, SNS College of Technology, Coimbatore Tamil Nadu on 11.09.2025	Drs. Balasubramanian, D, Veena G L and Jyoti Nishad
3	21 days training on Cashew Production technology for 5 students of College of Agriculture, Padannakkad, Kerala, during 21.07.2025 – 18.08.2025 at ICAR-DCR, Puttur	Drs. Aswathy Chandrakumar and Bhagya H P
	Off Campus Trainings	
1	Training program on Cashew cultivation and Primary value addition for the farmers (80 Nos.) located in North East Hilly areas, Tinsukia, Dibrugarh, Assam during 27.03.2025-28.03.2025	Drs. Balasubramanian, D and E Eradasappa
2	Three days Capacity Development Workshop on Cashew Production and Post-harvest Technologies for 25 Krishi Sakhis from 20.02.2025-22.08.2025 at Sullia taluk, Dakshina Kannada, Karnataka	Drs. Aswathy Chandrakumar, Bhagya H P and Manjunatha K
3	Awareness campaign cum Training programme on Cashew area expansion and input distribution organised in collaboration with AAU-Citrus and Plantations Crop Research institute in Ghormora, Sadiya, Tinsukia on 27.03.2025 for 40 farmers	Drs. T N Raviprasad, Bhagya H P and Venugopal
4	Awareness campaign cum Training programme on Cashew area expansion and input distribution organised in collaboration with AAU-Citrus and Plantations Crop Research institute in Seuji Pam, Dholla Sadiya, Tinsukia on 28.03.2025 for 80 farmers	Drs. T N Raviprasad, Bhagya H P and Venugopal

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Sl. No	Details of the Programme	Scientists involved
5	Awareness campaign cum Training programme on Cashew area expansion organised in collaboration with KVK, South Garo Hills, Meghalaya and College of Post Graduate Studies in Agricultural Sciences, Umiam, from 20.03.2025 to 24.03.2025, in Meghalaya for 100 farmers	Dr. S. Balasubramanian, D. J. Dinakara Adiga & T. N. Raviprasad
	Awareness Seminars	
1	One-day awareness seminar on "Entrepreneurial Opportunities in Raw Cashewnut Processing" for scholars from Vivekananda College (20 Nos.) under the Student Connect Programme of Agri Business Incubation Centre, ICAR-DCR on 16.04.2025	Dr. Balasubramanian, D.
	Field Days	
1	Demonstration of Canopy Management in Cashew for 10 farmers in Sampaje village, Sullia taluk, Dakshina Kannada, Karnataka on 24.06.2025	Drs. Bhagya H. P., Thondaiman V., Aswathy Chandrakumar and Jyoti Nishad
	Demonstrations	
1	Demonstration on soil testing for 24 farmers from Sullia taluk, Dakshina Kannada, Karnataka on 05.12.2025	Drs. Venkatesh M. S., Bhagya H. P. and Aswathy Chandrakumar
	Advisory Visits	
1	Advisory visit to Rajapuram estate under Kerala Plantation Corporation Ltd. located in Kasaragod on 01.10.2025 and advisories were given regarding fertilizer dosage and application method, canopy management, weeding, spacing and plant protection measures for improving yield of plantation.	Drs. Vanitha K and Bhagya H P
2	Technical guidance on cashew cultivation and nursery development was given during the advisory visits to farmers at Tura, Meghalaya during 12.10.2025 to 16.10.2025	Drs. Balasubramanian, D., Raviprasad, T. N., Eradasappa, E .and Bhagya, H. P.

Sl. No	Title	Name of Scientist	Date of Broadcast
	Radio talks/TV Programmes		
1.	Scope of Cashew Cultivation (*Kashumaavu krishiyile Saadhyathakal*) in Malayalam in All India Radio, Kannur	Dr. Aswathy Chandrakumar	14.08.2025
2.	Ultra-High-Density plantation in cashew (Geru beleyalli ati ghanasandhra paddati) in All India Radio, Mangalore	Dr. Bhagya H P	18.08.2025
3.	Canopy management in cashew plantation in Kannada (Geru beleyalli savaruvike mattu akara koduvike) in All India Radio, Mangalore		29.09.2025
4.	Contribution of ICAR-DCR to cashew sector in the country in Kannada in All India Radio, Mangalore	Dr. J Dinakara Adiga	14.07.2025
5.	Latest Cashew varieties released by ICAR-DCR in Kannada in All India Radio, Mangalore	Dr. Eradasappa E	04.08.2025
6.	Nursery management techniques in Cashew in Kannada in All India Radio, Mangalore	Dr. Manjesh G N	01.09.2025
7.	Cashew Nut Separator Technologies developed at ICAR DCR, Puttur in Farm TV	Dr. Manjunatha K	28.04.2025
8.	Drone Spraying in Cashew Orchard" in Farm TV		29.04.2025
9.	Mechanization in cashew in All India Radio, Mangalore		28.07.2025
10.	Useful websites and apps for farmers in All India Radio, Mangalore	Dr. Mohana G S	10.11.2025
11.	Diseases of Cashew and Their Management in Kannada in All India Radio, Mangalore	Dr. Rajashekara H	13.10.2025
12.	IPM Strategies in cashew with emphasis on novel approaches for management of CSRB	Dr. T N Raviprasad	21.07.2025
13.	IPM Strategies in cashew with emphasis on novel approaches for management of TM		22.09.2025
14.	Orientation about ITMU; ABIC activities of ICAR-DCR	Dr. Thondaiman V	25.08.2025
15.	Cashew Based Cropping System		27.10.2025
16.	Role of beneficial insects in cashew pest management	Dr. Vanitha K	15.09.2025
17.	Valorization of Cashew apple in Kannada in All India Radio, Mangalore	Dr. Veena G L	08.09.2025
18.	Soil and Water management in cashew in Kannada in All India Radio, Mangalore	Dr. Venkatesh M S	11.08.2025

5. AGRI BUSINESS INCUBATION CENTRE

The Agri-Business Incubation Centre (ABIC) at ICAR-Directorate of Cashew Research (ICAR-DCR), Puttur, was established with the objective of promoting entrepreneurship in the cashew sector by nurturing innovative agri-based startups and strengthening the cashew value chain. The Centre functions under the guidance of the Indian Council of Agricultural Research (ICAR) and is supported through the Intellectual Property and Technology Management (IP&TM) – National Agricultural Innovation Fund (NAIF) Scheme. ABIC provides comprehensive support to entrepreneurs, startups, farmers, and agribusiness professionals by facilitating access to advanced technologies, skill development, infrastructure, and continuous mentoring services.

Incubations and MoUs signed

During 2025, a total of three incubatees/companies registered with ABIC and attended a three days intensive incubation training programme on raw cashew nut processing and value addition, aimed at enhancing their knowledge of scientific, technical, and financial aspects of the cashew industry. Among the registered incubatees, Mr. N. S. Sreenivas signed a Memorandum of Understanding (MoU) for the utilization of the processing facilities for a period of six months, reflecting a successful transition from training to enterprise engagement. The details of the incubatees are presented below:

Sl. No	Name of the Incubatee	Place	Date of Registration
1	N. S. Sreenivas	Karnataka	14th -16th July 2025
2	Sharath P. N.	Karnataka	14th -16th July 2025
3	Chakali Narasimhulu	Karnataka	14th -16th July 2025

Exhibitions attended

The ABI centre attended and exhibited ICAR-DCR technologies in six programmes with an aim to attract aspiring entrepreneurs, the details of which is given below -

Sl. No	Venue and Date
1.	*Sasya Jatre* conducted at Puttur, Dakshina Kannada, Karnataka from 10.01.2025-12.01.2025
2.	National Horticulture Fair at ICAR-IIHR, Bangalore, Karnataka from 27.02.2025 – 01.03.2025
3.	Grand Fruit and Food Fest at Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences (KSNAHU), Shivamogga, Karnataka from 27.04.2025-29.04.2025
4.	11th Indian Horticulture congress 2025 organized Indian Academy of Horticultural Sciences (IAHS) at the University of Agricultural Sciences (UAS), Bengaluru, Karnataka from 06.11.2025 – 09.11.2025

Contd.

Sl. No	Venue and Date
5.	Vendors Development Program organized by MSME Development & Facilitation Office in association with other Industries at Town Hall, Mangalore, Karnataka from 18.09.2025 - 19.09.2025
6.	Cashew Fest-2025 jointly organized by Karnataka Cashew Manufacturer Association (KCMA) in collaboration with Fiza Mall at Mangalore, Karnataka from 08.08.2025-10.08.2025

EDPs and Awareness Programmes

Two Entrepreneurship Development Programs (EDPs) on Cashew Value Chain Development were organised for final-year B.Sc. students from the College of Horticulture, Koppal (13.03. 2025 to 28.03.2025), and the College of Horticulture, Bidar, Karnataka (09.06.2025 to 23.06.2025) under the Student Connect Programme of the Directorate. An Entrepreneurship Development Program on "Cashew Apple Utilization and Value Addition" was conducted exclusively for the Krishi Sakhis of Puttur and Kadaba taluk, Karnataka on 19.11.2025. Student awareness programs on entrepreneurial opportunities in cashew were organized for undergraduate scholars of Vivekananda College, Puttur, and lectures on entrepreneurial opportunities within the cashew ecosystem were delivered during capacity development workshops for Krishi Sakhis, in Sullia, Karnataka and training cum distribution programme for the Particularly Vulnerable Tribal Group (PVTG) of Kasaragod, Kerala.



Fig. 1 : Best Stall award during National Horticulture Fair at ICAR-IIHR, Bengaluru from 27.02.2025 - 01.03.2025



Fig. 2 : Participation in the 11th Indian Horticulture Congress, 2025 at UAS, Bengaluru from 06.11.2025-09.11.2025



Fig. 3 : Participation in Cashew Fest-2025 at Fiza mall from 08.08.2025-10.08.2025



Fig. 4 : EDP organised for Krishi Sakhis of Puttur and Kadaba taluk of Dakshina Kannada district on 19.11.2025

6. Consultancies, Patents and Technology Commercialisation

6.1 Consultancies

Consultancy project on 'Scaling up of value chain in cashew through area expansion and improving value addition processes' (Nodal Officer: D Balasubramanian)

A Memorandum of Agreement is signed between the Directorate of Horticulture, Govt of Meghalaya, to engage the services and ICAR–Directorate of Cashew Research, Puttur, Karnataka to work for successful implementation of the consultancy project on 'Scaling up of Cashew Value Chain through Area Expansion and Improving Value Addition Processes' in selected regions of Meghalaya state on 12th July, 2024 for a period of two years. An expert team visited the project areas to assess the status of cashew grafts planted during 2024 and 2025 and to provide technical consultancy on post-planting care and establishment of cashew nurseries for ensuring self-reliance in quality planting material. Under the project, 38,180 cashew grafts during 2024–25 and 25,100 grafts during 2025–26 were distributed. The intervention benefitted 705 farmers, covering an area of 144 ha in 2024 and 128 ha in 2025, implemented in two phases. Recommended early-yielding varieties such as Bhaskara, Dhana, Vengurla-7, Vengurla-4, and Vridhachalam-3 were procured in consultation with the institute and distributed to beneficiaries. In addition, Jaganath and H-2/16 (BPP) varieties were procured by the counterpart agency, Department of Horticulture (DoH), Meghalaya, for distribution. Cashew grafts were primarily distributed across East, West, South and South-West Garo Hills, and East and South-West Khasi Hills. Efforts were also initiated to evaluate varietal performance in East Jaintia Hills. The survival rate of grafts planted during 2024 was poor, mainly due to delayed supply followed by dry weather conditions. Based on these learnings, grafts were procured and planted during the monsoon season in the subsequent phase to improve establishment. Field-level workers are currently assessing graft survival and field performance. A structured questionnaire was developed for different target groups to capture relevant field information and shared with the Department of Horticulture for further action. A virtual review meeting held on 12.11.2025 with DoH officials reviewed project progress, identified implementation gaps, and emphasized strict adherence to technical recommendations.

6.2 Technology commercialisation and revenue generation

During the year 2025, 15 technologies were licensed to the entrepreneurs ICAR institute, generating a revenue of - 10,76,750 lakhs. The details of the technologies licensed and the firms have been given below-

1. Memorandum of Understanding (MoU) was signed with Mr. Radhakrishna I., Mukkwe, Narimogaru, Puttur for licensing the production and sale of "Cashew sprout Cookies" on 03.01.2025 (Fig. 6.1).
2. Phison Agritech Private Limited, Ramanagara, Karnataka signed a license agreement for ICAR-CIAE-DCR 3 in 1 Cashew Nut Separator, Pulp Extractor and fibrous Material Separating Machine in collaboration with AgriInnovate India Limted, New Delhi dated 11.03.2025 (Fig. 6.2).
3. Ammalu Self Help Group, is a Group of ST women promoted by Punarvi FPO, Parvathipuram, Andra Pradesh- 535501 signed a license agreement for

nive cashew apple and nut based products i.e., Cashew Apple Cider, Cashew Apple Jam, Cashew Apple Jelly, Cashlime-RTS, Cashew Apple Pomace powder Cookies, Diet Cashew Apple Muffin, Cashew Sprout Cookies, Cashew Prash dated 18.06.2025 (Fig. 6.3).

4. Bharath Agri Development Farmers Producer Company Limited, Mangalore, Karnataka signed a technology license agreement for Nethra Jumbo-1, Nethra Ubhaya and Nethra Jumbo-2 on 11.10.2025 (Fig. 6.4).
5. ICAR- Indian Institute of Millets Research (IIMR), Hyderabad, Telangana signed a technology license agreement for Farmers Tracking System Version- 1 on 30.10.2025.

6.3 Patents/Copyrights/Trademark/Design Registration:

The Institute Technology Management Unit (ITMU) facilitated the following Copyrights/ Patent/ Design Registration processes. During the period, 5 patents and 11 copyrights were filed. A total of six copyrights were granted by the Copyrights office, Govt. of India during the year.

Patents filed

1. ICAR-CIAE-DCR- 3 IN 1 CASHEW NUT SEPARATOR, PULP EXTRACTOR AND FIBROUS MATERIAL SEPARATING MACHINE (202521011709) filed on 12.02.2025.
2. A MICRONUTRIENT COMPOSITION FOR CASHEW CULTIVATION AND PROCESS FOR PREPARATION THEREOF (202541049738) filed on 23.05.2025.
3. CASHEW SPROUT BASED COOKIES AND METHOD OF PREPARATION THEREOF (202541086458) filed on 11.09.2025.
4. A METHOD FOR PREPARATION OF LIQUID SWEETENER FROM CASHEW APPLE (202541088501) filed on 17.09.2025.
5. A POLY-HERBAL ANTIOXIDANT-RICH NUTRACEUTICAL FORMULATION (202541099120) filed on 14.10.2025.

Copyrights granted

1. AICRP-cashew website (SW-20403/2025) granted on 17.04.2025.
2. Cashew Protect App and Website (SW-2025020627) granted on 28.05.2025.
3. Cashew India App (SW-2025020697) granted on 11.06.2025.
4. Portable semi-automatic cashew nut separator (CF-202506058) granted on 12.08.2025
5. Drone spraying in cashew orchard (CF-202506116) granted on 19.09.2025
6. Cashew Fruit Pickers (CF-202506090) granted on 10.09.2025

Copyrights filed

1. ICAR-DCR website (728/2025-CO/L) filed on 08.01.2025.
2. Cashew Germplasm Database Management System (3020/2025-CO/SW) filed on 27.01.2025.
3. Cashew India App (8893/2025-CO/SW) filed on 12.03.2025.
4. Cashew Protect App and Website (9624/2025-CO/SW) filed on 17.03.2025.
5. ICAR-CIAE-DCR 3-in-1 Cashew Nut Separator, Pulp Extractor and Fibrous Material Separator (CF-20810/2025-CO) filed on 23.05.2025.

6. Portable semi-automatic cashew nut separator (CF-20812/2025-CO) filed on 23.05.2025.
7. Portable pedal operated cashew nut separator (CF-20811/2025-CO) filed on 23.05.2025.
8. Drone spraying in cashew orchard (CF-20809/2025-CO) filed on 23.05.2025.
9. Cashew Fruit Pickers (CF-21681/2025-CO) filed on 29.05.2025.
10. Geru Beleyalli Paushtikamshagala Korathe - Lakshanagalu Matthu Nirvahane (LD-46754/2025-CO) filed on 12.11.2025.
11. Nutrient Deficiency in Cashew - Symptoms and Management (LD-46751/2025-CO) filed on 12.11.2025.



Fig. 6.1 - MoU signed with Mr. Radhakrishna, Puttur, Karnataka



Fig. 6.2 - MoU signed with Phison Agritech Private Ltd., Ramanagara, Karnataka



Fig. 6.3- MoU signed with Amalu Self Help Group, Parvathipuram Maniyam district, Andhra Pradesh



Fig. 6.4- MoU signed with Bharat Agri Development Farmers Producer Company Ltd., Mangalore, Karnataka

7. Linkages and Collaborations

During the year 2025-26, the Institute significantly strengthened its research and development initiatives through collaborative partnerships with following national and regional organizations, universities, research institutions, development agencies, and stakeholder groups. These collaborations facilitated interdisciplinary research, technology development, capacity building, knowledge exchange, field-level validation of technologies, and implementation of need-based programmes aimed at enhancing the sustainability and productivity of the cashew sector.

Sl. No	Name of the Collaborating institute
1.	Directorate of Horticulture, Government of Meghalaya, Meghalaya
2.	ICAR-Central Institute of Agriculture Engineering, Regional Centre, Tamil Nadu
3.	ICAR-Indian Institute of Horticulture Research, (ICAR-IIHR) Hesaraghatta Lake Post, Bengaluru - 560 089, Karnataka
4.	ICAR - Central Plantation Crops Research Institute (ICAR-CPCRI) Kudlu P.O, Kasaragod-671124, Kerala
5.	ICAR - Central Coastal Agricultural Research Institute (ICAR-CCARI), Ela, Old Goa - 403 402, Goa
6.	Keladi Shivappa Nayaka University of Agricultural & Horticultural Sciences Iruvakki, Sagar Taluk, Shivamogga, Karnataka
7.	NITTE (Deemed to be University), Mangalore-575008, Karnataka
8.	CSIR- Indian Institute of Chemical Technology, Hyderabad-500 007, Telangana
9.	Department of Agriculture, Government of Karnataka, No.01, Sheshadri road, Bengaluru - 560 001, Karnataka
10.	ICAR- National Bureau of Agricultural Insect Resources (ICAR-NBAIR) Bellary Road, Bengaluru - 560 024, Karnataka
11.	Directorate of Cashew & Cocoa Development, Kochi, Kerala

8. Human Resource Development

Seminars/Symposiums/Conferences attended

Name of the Scientist	Details of Seminar/Symposium/Conference/Workshop
Dr. Aswathy Chandrakumar	Participated and presented on "Bearing Fruit or Falling Flat-The changing scenario of cashewnut production and trade in India" during the National Seminar on "Harnessing Plantation Sector for Sustainable Development Goals" organized by ICAR-CPCRI, Kasaragod during 03.01.2025 – 05.01.2025.
	Attended Stakeholder meeting on "Formulating strategies for self-reliance in Cashew" jointly organized by IAHS, New Delhi and ICAR-DCR, Puttur, Karnataka on 29.09.2025
	Participated and attended the Workshop on Kisan Sarathi organized as a part of the 11th Indian Horticultural Congress and International Meet on 'Horticulture for Inclusive, Equitable and Sustainable Growth' conducted at University of Agricultural Sciences, Bangalore during 05.11.2025-09.11.2025
Dr. Balasubramanian D	Attended Stakeholder meeting on "Formulating strategies for self-reliance in Cashew" jointly organized by IAHS, New Delhi and ICAR-DCR, Puttur, Karnataka on 29.09.2025
	Participated in the 11th Indian Horticultural Congress and International Meet on 'Horticulture for Inclusive, Equitable and Sustainable Growth' conducted at University of Agricultural Sciences, Bangalore during 05.11.2025 - 09.11.2025
Dr. Bhagya H P	Participated and presented in the Global Conference on Smart Horticulture for Prosperity and Nutritional Security (GCSH-2025) held at College of Horticulture, University of Horticultural Sciences, Bagalkot, Karnataka (India) during 12.02.2025 – 14.02.2025
Dr. Jyoti Nishad	Participated in the 31st Indian Convention of Food Scientists & Technologists (ICFoST) at NIFTEM, Thanjavur, Tamil Nadu, India during 18.12.2025 - 20.12.2025
	Participated in the 11th Indian Horticulture Congress at University of Agricultural Sciences, Bengaluru, Karnataka, India and given oral presentation on "Microwave Treatment for Improving Fat-Replacing Properties of Cashew Apple Pomace." during 05.11.2025-09.11.2025

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Name of the Scientist	Details of Seminar/Symposium/Conference/Workshop
	Presented work on "Harnessing the antioxidant potential of citrus peels, an underutilized agro-industrial waste, as a natural phytochemical to improve antioxidant activity and oxidative stability of mustard oil" during webinar on Innovation Work by Winners of SHRI SOMALAL INNOVATION AWARDS 2025 on 15.10.2025
	Participated in 11th Meeting of FAD 29 (Alcoholic Drinks Sectional Committee) scheduled at CSIR-CFTRI, Mysuru in physical mode on 27.02.2025
Dr. Manjesh G.N.	Participated and delivered an oral presentation on Exploring phenolic diversity in Indian Cashew (Anacardium occidentalae L.) cultivars through LC–MS/MS and multivariate analysis for functional utilisation during the International Conference on Innovations in Horticulture, Agriculture, Veterinary, Fisheries, and Allied Sciences for Sustainable Development and Environment [IHASE-2025-41] held at Goa. India during 16.11.2025-18.11.2025
Dr. Manjunatha K	Attended National Seminar on Harnessing Plantation Sector for Sustainable Development Goals held at ICAR-CPCRI, Kasaragod, Kerala during 03.01.2025-05.01.2025
	Attended National Conference on Digital Technologies for Transforming the Horticulture Sector held at ICAR-IARI, Pusa Campus, New Delhi during 28.01.2025-30.01.2025
	Attended Stakeholder meeting on "Formulating strategies for self-reliance in Cashew" jointly organized by IAHS, New Delhi and ICAR-DCR, Puttur, Karnataka on 29.09.2025
	Attended 11th Indian Horticulture Congress–2025 & International Meet, IAHS, New Delhi, UAS Bengaluru, India. 06.11.2025 - 09.11.2025
Dr. Rajashekara H	Participated and delivered an oral presentation on seedling rot disease of cashew caused by Beltrania rhombica- A first report from India" in the National Conference on 'Transforming plant health management: integrating traditional practices with modern innovations for global food security' held at Pandit Jawaharlal Nehru College of Agriculture and Research Institute (PAJANCOA & RI), Karaikal, UT of Puducherry, India during 18.12.2025-19.12.2025

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Name of the Scientist	Details of Seminar/Symposium/Conference/Workshop
	Participated and delivered a talk on Cashew Diseases in India-Status and Challenges in "Annual Group Meeting of Scientists of AICRP on Cashew - 2024" at College of Horticulture, (UHS; Bagalkot), GKVK, Bengaluru, India during 16.01.2025 – 18.01.2025
Dr. Vanitha K	Attended International Conference on "One Health Perspectives in Global Plant Protection Research - 2025 (OHPGPR-2025)" at TNAU, Coimbatore, Tamil Nadu, India during 19.02.2025-21.02.2025
	Attended National Conference on "New Frontiers in Apiculture" at GKVK, UAS, Bengaluru, India during 06.03.2025-07.03.2025
Dr. Veena G L	Participated and delivered an oral presentation on Dynamics of bioactive components during cashew apple development and maturity stages at 12th International Conference on Agriculture and Veterinary: Transformative approach Research and Innovations forum (ICAVRI - 2025) during 16.11.2025 -18.11.2025 at the Goa College of Agriculture.

Training attended

Name of the Scientist	Details of Seminar/Symposium/Conference/Workshop
Dr. Aswathy Chandrakumar	Attended 10 days Online Winter School on "Data Driven Al & Analysis using SPSS & R" organized by Agricultural Research Applied Technology and Environmental Science, India from 06.12.2025 – 15.12.2025
Dr. Bhagya H P	Participated in 21 days online training programme on Advances Statistical and Machine Learning Techniques for Data Analysis Using Open-Source Software for Abiotic Stress Management in Agriculture during 16.07.2025 to 05.08.2025 organized by ICAR-National Institute of Abiotic Stress Management, Baramati.
Dr. Manjunatha K	Attended 5-days training programme on "Precision Agriculture Using Drones and Remote Sensing Data" organized by ICAR-NAARM, Hyderabad during 15.12.2025 -19.12.2025

Students guided

Guide / Mentor Name	Number of students	Degree	Duration
Dr. Siddanna Savadi	02	MSC. (biotechnology), Shrikrishna College, Coimbatore	03.01.2025 to 21.03. 2025
	03	B.Tech Biotechnology, College of Hassan, UAS, Bengaluru	18.02.2025 to 18.05.2025
	01	NITTE University Centre for Science and Research, Mangalore	01.06.2025 to 30.06.2025
Dr. Mohana G S	01	M.Sc. (Biotechnology), Sri Krishna Arts and Science College, Coimbatore	03.01.2025 - 31.03.2025
Dr. Rajashekara H	01	M.Sc (Microbiology) JSS Academy of Higher Education & Research, Mysore	17.02.2025 to 17.05.2025
Dr. Veena G L	03	M.Sc. Food Science and Technology, St. Aloysius (Deemed to be University), Mangalore	03.05.2025 to 04.08.2025
	01	BSc. Sri Dharmasthala Manjunatheswara College Ujire	01.06.2025 to 30.07.2025
	01	M.Sc Food Technology, Mangalore University	01.08.2025 to 31.08.2025
	01	M.Sc. Biochemistry, Mangalore University	01.08.2025 to 31.09.2025
Dr. Jyoti Nishad	04	B. Voc. Food processing & Technology, Modern College of Arts, Science and Commerce, Maharashtra	10.11.2025 to10.12.2025
	01	M.Sc. (Food Technology), Renaissance University, Indore, Madhya Pradesh	10.03.2025 to 10.09.2025
	03	M.Sc. (Food Science and Nutrition), St. Aloysius College (Deemed to be University)	28.04.2025 to 28.06.2025
	01	M.Sc. Food Science and Technology, Mahatma Gandhi Rural Development and Panchayat Raj University, GADAG, Karnataka.	01.06.2025 to 30.09.2025
	01	Ph.D Scholar, Amity Institute of Food Technology, Amity University, Noida, Uttar Pradesh	19.02.2025 onwards

9. Awards and Recognitions

Name of the Scientist	Details of the award/recognition
Dr. Aswathy Chandrakumar	Received the Best Oral Presentation Award for the paper entitled "Bearing Fruit or Falling Flat-The changing scenario of cashewnut production and trade in India" during the National Seminar on "Harnessing Plantation Sector for Sustainable Development Goals" organized by ICAR-CPCRI, Kasaragod during 03.01.2025 – 05.01.2025.
	Nominated in the team for showcasing the ICAR -DCR technologies during the National Horticulture Fair organised by ICAR-IIHR, Bengaluru from 27.02.2025 - 01.03.2025 and the stall was awarded the "Best Stall award" in ICAR institutes category.
	Co-ordinator for the National Stakeholders' meeting on "Formulating strategies for self-reliance in Cashew" organised by IAHS, New Delhi and ICAR-DCR, Puttur at New Delhi on 29.09.2025.
Dr. Balasubramanian, D	Serving as Nodal Officer for the consultancy project on 'Scaling up of Cashew Value Chain through Area Expansion and Improving Value addition Process' for the Meghalaya state financially supported by Directorate of Horticultural and Meghalaya Basin Management Agency (MBMA), Meghalaya (MoU Signed).
	Serving as Expert Committee member for the consultancy project on 'Scaling up of Cashew Value Chain through Area Expansion and Improving Value addition Process' for the Meghalaya state financially supported by Directorate of Horticultural and Meghalaya Basin Management Agency (MBMA), Meghalaya.
	Acted as nominee for the Assessment Committee for the promotion of Dr. Eradasappa, ICAR-DCR under the revised CAS held on 20.05.2025 at ASRB, New Delhi
	Acted as External Member for the selection of Business Manager under the project Establishment of Agri. Business Incubation for NAIF (ABI)" held at ICAR-CPCRI, Kasaragod, Kerala on 22.01.2025
Dr. Bhagya H.P.	Received Best Research Paper award for "Influence of dwarf interstock in cashew for inducing dwarfness" in the Global Conference on Smart Horticulture for Prosperity and Nutritional Security (GCSH-2025) held at College of Horticulture, University of Horticultural Sciences, Bagalkot, Karnataka (India), during 12-02-2025-14-02-2025.

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Name of the Scientist	Details of the award/recognition
	Recognized as a Post Graduate teacher in the department of Spices, Plantation, Medicinal and Aromatic plants from Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga.
	Recognized as a research guide in biosciences at Mangalore University from 09.07.2025
	Received Best Woman Young Scientist Award from National Gladiolus Trust on the occasion of Global Conference on Smart Horticulture for Prosperity and Nutritional Security (GCSH-2025) organized by College of Horticulture, University of Horticultural Sciences, Bagalkot, Karnataka (India), during 12.02.2025 - 14.02.2025.
	Served as Rapporteur for poster session for theme area ICTs and AI in Horticulture in the Global Conference on Smart Horticulture for Prosperity and Nutritional Security (GCSH-2025) held at College of Horticulture, University of Horticultural Sciences, Bagalkot, Karnataka (India), during 12.02.2025-14.02.2025.
	Deputed as expert for technical guidance in yield improvement in cashew at Mundott block, Panikkar Division of Rajapuram Estate, the Plantation, Corporation of Kerala Limited, Kerala.
	Participated in ICAR-South Zone Sports at Coimbatore held during 08.04.2025-11.04.2025 and won silver medal in women discuss throw event.
	Acted as external expert for walk in interview for young professional and Project assistant under the CSR project Titled' A comparative study on the performance of cocoa (Theobroma cacao L.) on 24.03.2025 at ICAR-CPCRI Vittal.
	Nominated as member in subcommittee for Standardizing the Term Sheet for identified crops viz. cashew under Restructured Weather based Crop insurance Scheme (RWBCIS) from Department of Agriculture and farmer welfare, Ministry of Agriculture and Farmer Welfare, Government of India
	Deputed as inspection committee member constituted by DCCD for inspection of the Navaneet Nursery, located at Kolady, Mundoor road, Puttur, Karnataka for obtaining accreditation certification for his cashew nursery and discharged the duties on 21.05.2025
	Nominated as Co-Nodal Officer for gender research in agriculture and to provide the information on women friendly technologies in agriculture and allied sector that have been developed/ refined at this Directorate including AICRP Centre/ Units.
	Discharged the duties as expert committee member for selecting project fellow under the CSR project titled "A comparative study on performance of cocoa (Theobroma cocoa L.) in intensive monocropping and mixed cropping system at ICAR-CPCRI, Regional Station, Vittal on 16.12.2025.

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Name of the Scientist	Details of the award/recognition
Dr. Jyoti Nishad	Conferred with Dr JS Pruthi Award on 18.12.2025 by AFSTI, India.
	Conferred with the first SHRI SOMALAL VYAS - SEA INNOVATION AWARDS 2025 under research category on 24.09.25 by The Solvent Extractors' Association of India.
	Recognized as Member for Alcoholic Drinks Sectional Committee (FAD 29) of BIS from ICAR-DCR, Puttur
	Recognized as Post Graduate Teacher in Karnataka Veterinary, Animal and Fisheries Sciences University (KVAFSU), Shivamogga, Karnataka.
Dr Manjesh, G.N.	Recognised and inducted as a research guide for the P.G. programme of IARI-Bengaluru, Hub in the discipline of Fruit Science. (28.03.2025)
	Recognized as an external expert on the topic "Rejuvenation/top-working of old cashew orchard' at a programme organised by ICAR-IISWC, Koraput, Orissa. (06.03.2025)
	Recognized and deputed as an expert on the topic "Varietal wealth of Cashew, focusing on recent varieties and Cashew production," organised by K.S.N. UA&HS, Shivamogga, Karnataka. (27.06.2025)
	Recipient of the Young Researcher Award during the International Conference on Innovations in Horticulture, Agriculture, Veterinary, Fisheries, and Allied Sciences for Sustainable Development and Environment [IHASE-2025-41] held at Goa. India.
	Recognised as an Invited Speaker for the National Conference on Agricultural Science and Technology (NCAST-2025) held on 22.08.2025-23.08.2025 at Bharatiya Engineering Science and Technology Innovation University, Gorantla, Andhra Pradesh.
	Deputed to coordinate Viksit Krishi Sankalp Abhiyan (pre-Kharif) in collaboration with ICAR-KVK, Tumakuru-II, Karnataka, India, from 29.05.2025 -12.06.2025.
Dr. Manjunatha, K.	Received Best Research Paper Award for the research paper entitled "Investigation on torsional forces and angles at the nut and pedicel junction (NPJ) revealed varying cashew apple (hypocarp) and nut separation efficiency at different developmental stages in cashew" published in Industrial Crops and Products" (Authored by Drs. Manjunatha, K., Savadi, S., Naik, R., Balasubramanian, D., Adiga, J.D., Muralidhara, B.M., Chethan, C.R. and Anilkumar, C.) during Foundation Day of ICAR-DCR held on 18.06.2025.

Contd.

Name of the Scientist	Details of the award/recognition
	Best poster presentation award for "Digital innovations in cashew cultivation for enhanced productivity." National Conference on Digital Technologies for Transforming the Horticultural Sectors, Indian Academy of Horticultural Sciences, ICAR–Indian Agricultural Research Institute, New Delhi, India held on 28-01-2025 - 30-01-2025.
	Attended the Board of Studies (BoS) meeting as a member of the Board for the Department of Agricultural Engineering, Alvas Institute of Engineering & Technology, Moodbidri on 14-06-2025.
	Acted as an expert to provide the service of drone imaging of YLD affected arecanut gardens in Sullia District on 16.10.2025.
Dr. Manjunatha K Dr. Ravindra Naik Dr. D. Balasubramanian Dr. J. Dinakara Adiga	Received ICAR technology certification for the technology developed titled "Portable pedal operated shear type cashew apple and nut separator" (Technology Certification No. ICAR-AE-CIAE-Technology-2025-013) from the Indian Council of Agricultural Research (ICAR) on 16.07.2025 at New Delhi.
	Received ICAR technology certification for the technology developed titled "Portable semi-automatic cashew apple and nut separator with twisting mechanism" (Technology Certification No. ICAR-AE-CIAE-Technology-2025-012) from the Indian Council of Agricultural Research (ICAR) on 16.07.202 at New Delhi.
Dr. Ravindra Naik Dr. Manjunatha K Dr. D. Balasubramanian Dr. J. Dinakara Adiga	Received ICAR technology certification for the technology developed titled "ICAR-CIAE-DCR-3 in 1 Cashew nut separator, pulp extractor and fibrous material separating machine" (Technology Certification No. ICAR-AE-CIAE -Technology-2025-004) from the Indian Council of Agricultural Research (ICAR) on 16.07.2025, New Delhi.
Dr. Mohana, G.S.	External Expert in the Selection Committee for the selection of one Young Professional-ll (YP-ll) under the project 'DUS Center for Arecanut (*Areca catechu* L.)' funded by PPV&FRA, New Delhi at CPCRI Regional Station, Vittal on 16.04.2025
	Recognised as a PG teacher from UHS, Bagalkot. 25.03.2025
	Best oral presentation award in the Advances in climate-conscious crop science: genetics, genomics and breeding conference held at UAS, GKVK, Bangalore during 31.10.2025 - 02.11.2025.

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Name of the Scientist	Details of the award/recognition
Dr. Rajashekhara, H.	Associated as Nodal Scientist for Third Party Evaluation of Central Sector Schemes during 2021-26 of ICAR-DCR and AICRP on Cashew
	Nominated as external member in selection committee for the selection of Project Fellow (Nos. 2), for setting of the question papers for the written test and also permitted him to attend the Selection Committee Meeting to be held on 23.04.2025 at ICAR-CPCRI, Regional Station, Vittal.
	Nominated as external expert in the Selection Committee for the selection of one Skilled Supervisory Staff under the DASD project "Demonstration of management of yellow leaf disease of arecanut using plastic mulching"
Dr. Siddanna Savadi	Recognized as a member of Board of Studies (BOS) of Botany of Vivekananda College of Arts. Science and Commerce (Autonomous), Puttur, D.K., Karnataka from 03.09.2025.
	Awarded the best paper in the 7th International conference on Bioenergy, Environmental and Sustainable Technologies organized by Arunai Engineering College, Tiruvannamalai, Tamil Nadu, India during 29.01.2025-31.01.2025.
Dr. Thondaiman V	Nominated in the team for showcasing the ICAR -DCR technologies during the National Horticulture Fair organised by IIHR, Bengaluru, from 27.02.2025-01.03.2025 and the stall was awarded the "Best Stall award" in ICAR institutes category.
	Nominated as member in subcommittee for Standardizing the Term Sheet for identified crops *viz*. cashew under Restructured Weather based Crop insurance Scheme (RWBCIS) from Department of Agriculture and farmer welfare, Ministry of agriculture and farmer welfare, Government of India
Dr. Vanitha, K.	Received best Oral Presentation Award for the presentation entitled 'Thrips species occurring on cashew in Puttur, Karnataka with new host records' in: 'International Conference on "One Health Perspectives in Global Plant Protection Research - 2025 (OHPGPR-2025)" during 19.02.2025 - 21.02.2025 at TNAU, Coimbatore, Tamil Nadu, India.
	Received best oral award for the presentation entitled 'Conservation strategies for Braunsapis spp. and Ceratina spp., native pollinators of cashew' In: National Conference on "New Frontiers in Apiculture" on 06.03.2025 - 07.03.2025 at GKVK, UAS, Bengaluru, India.
	Bagged 'Scientist of the year award' conferred by Entomological Research Association, Department of Entomology, MPUAT, Udaipur during the National conference on "Advances in Sustainable Plant Protection under

Contd.

Name of the Scientist	Details of the award/recognition
	Changing Agriculture Scenario" 18-09-2025 -20-09-2025 at Rajasthan College of Agriculture, MPUAT, Udaipur.
	Recognized as research guide for supervising the research work leading to Ph.D. degree in the field of applied Zoology at Mangalore University, Karnataka during 23.04.2025.
	Rapporteur in 'International Conference on "One Health Perspectives in Global Plant Protection Research - 2025 (OHPGPR-2025)" (Technical session 2) held during 19-21 February 2025 at TNAU, Coimbatore, Tamil Nadu, India.
	Rapporteur in "National Conference on "New Frontiers in Apiculture" (Technical session 2) held during 06-03-2025 - 07-03-2025 at GKVK, UAS, Bengaluru, India.
	External examiner for the poster evaluation (CT 03) during the International Conference on "One Health Perspectives in Global Plant Protection Research - 2025 (OHPGPR-2025)" during 19-02-2025 - 21-02-2025 at TNAU, Coimbatore, Tamil Nadu, India.
	Member of Editorial Advisory Board (2026-2030), Journal of Applied Zoological Researches, Applied Zoological Research Association, (AZRA)
Dr. Veena, G.L.	Nominated as a Member of the Executive Committee of the Indian Society lor Plantation Crops journal biennium 2024-25.
	Nominated as Member of the Board of Examiners for MSc (Food Science and Nutrition) the examination in the Department of Biosciences Mangalore University 2025.
	Awarded as Young Women Scientist Award 2025 at 12th International Conference organized during 12-11-2025-16-11-2025 by Indian Society of Agricultural Sciences and Technology Research
	Recognized as Post Graduate Teacher in the Department of Fruit Science, by Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shimoga on 18.09.2025.
	Recognized as a research guide for supervising the research work leading to PhD degree in the field of Biosciences at Mangalore University on 09.07.2025
	Received Second Best Research Paper award for the year 2025 for the paper entitled " The impact of Cashew on biological activity, nutrient cycling and carbon sequestration in tropical soil published in the Journal of Plant Nutrition.
	Participated as a member in the Joint Executive Council meeting of the Indian Society for Plantation Crops on 12-08-2025.

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Name of the Scientist	Details of the award/recognition
	Nominated as nodal scientist responsible for the preparation of the Horticulture Crop Atlas of India.
	Nominated as Invited Speaker for National Conference on Agricultural Science and Technology (NCAST-2025) held on 22-08-2025-23-08-2025 at Bharatiya Engineering Science and Technology Innovation University Gorantla, Andhra Pradesh.
	Nominated as a resource person for delivering a lecture under NTRIHUB, the Association of Food Science and Nutrition Programme under the Department of Biosciences, Mangalore University, held on 27-06-2025.
Dr. Venkatesh, M.S.	Recognized as Post Graduate Teacher in the Department of Soil Science, by Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga on 20-08-2025.
	Resource person for DAESI programme at KVK- Mangaluru and delivered talk on soil profile characteristics and management on 22-08-2025.
	Acted as Chairman of YP-I selection committee of DUS testing Project on 15-10-2025.

10. Publications

10.1 Research publication:

International

Mangalassery, S., Mog, B., Manjunatha, K., Adiga, J.D., Manjesh, G.N., Veena, G.L., Bhagya, H.P., Thondaiman, V. and Preethi, P., 2025. Sustainable cashew plantation management on weathered tropical soils through biomass and nutrient cycling. Cleaner and Circular Bioeconomy, p.100175.

Mangalassery, S., Mog, B., Manjunatha, K., Muralidhara, B. M., Adiga, J. D., Veena, G. L., & Chandran, K. P., 2025. The impact of cashew (*Anacardium occidentale* L.) on biological activity, nutrient cycling and carbon sequestration in tropical soil. Journal of Plant Nutrition, 48(14), 2388–2404.

Manjesh, G. N., Veena, G. L., Dagadkhair, R. A., Mangalassery, S., Adiga, J. D., Chowdhury, B., Manjunathagowda, D. C., Madhu, T. N., Narayanashetty, L. A. (2025). Targeted metabolomic approach to elucidate flavonoid profiles employing LC-MSA4S in leaves and pseudo-fruit of Indian cashew cultivars (Anacardium occidentale L.). South African Journal of Botany. 189: 361-373.

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Dinakara Adiga J, Jyoti Nishad, Veena G L, Mohana G S, Siddanna S, Eradasappa, E., Manjesh G N, Bhagya H P, Babli mog, Aswathy, C., Thondaiman V. March, 2025. Nethra Jumbo 2 in Hindi. Published by Director, ICAR-Directorate of Cashew Research, Puttur, Dakshina Kannada, Karnataka -574202. Pp 1-6

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Veena G L, Manjesh G N, Shamshudeen, M, Babli Mog, Bhagya H P, Thondaiman V, Aswathy C, Vijetha K, and Prajna, 2025, *Geru Beleyalli poushtikamshagala korathe-lakshanagalu mattu nirvahane* (Nutrient deficiencies in cashew-Kannada). Published by Dr. J Dinakara Adiga, Director, ICAR-Directorate of Cashew Research, Puttur, Dakshina Kannada, Karnataka -574202.Pp 1-6

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10.5 Technical/Popular articles/ customized instruction materials

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10.6 e-publications

Bhagya H P. 2025 Cashew technologies and value-added products in cashew apple. Suddi Bidugadypatrike. Viksit Krishi Sankalpa Abhiyaan. 4 June, 2025

Savadi, S., Manuel, M., Manjunatha K., Muralidhara B.M. (2025) Challenges in enhancing Cashew Crop Production and Modern technological solutions to address the challenges. Kerala Karshakan, 13 (2), 46-50

11. Ongoing and Concluded Projects

List of ongoing projects as per 38th IRC

Code	Title	Investigators	Date of start
Priority area 01: Genetic improvement of cashew for productivity, quality and resistance to biotic and abiotic stresses through conventional and biotechnological approaches Sub-Projects			
01 (1)	Collection, conservation, characterisation and evaluation of cashew genetic resources [1986 – Long term] PIMS Number: IXX19622	Mohana. G.S. (PI) Vanitha. K Eradasappa. E Veena. G.L. Rajashekara. H	From 30-07-21 as PI (06/2012 to 29.07.2021 as Co-PI) 10/2015 onwards 06/2012 to 2013-14 06/2018 onwards 09/2021 09/2021
01 (2)	Genetic improvement of cashew through hybridisation and seedling selection approaches [1986 -Long Term] PIMS Number: IXX00393	J D Adiga Mohana, G.S. Eradasappa, E Veena. G.L. Siddanna Savadi Manjesh G.N. Bhagya. H.P. Thondaiman V Babli Mog	PI: 2007-08 to 2014-15; PI: 2017-18 onwards 2015-16 and 2016-17 as PI; 2012-13 to 2014-15 & 2017-18 onwards as Co-PI Co-PI from 10/2014 to 10/2015 & November /2017 onwards 12-10-20 09/2017 onwards 27-09-2022 27-09-2022 09/2025 09/2025

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Code	Title	Investigators	Date of start
01 (3)	Breeding in cashew for special traits [06/2012-05/2027] PIMS Number: IXX09323	Eradasappa, E. (PI) Mohana, G.S. Veena. G.L. Vanitha. K Raviprasad. T.N. Rajashekara. H Bhagya H P Jyoti Nishad	06/2012 to 2014-15; (till 15th Aug 2015)and November/2017 onwards onwardsPI; 2015-16 to November/2017; Co-PI; November/2017 09/2021 onwards 10-08-2023 onwards 10-08-2023 onwards 10-08-2023 onwards 09/2025 09/2025
01 (4)	Breeding approaches for developing TMB tolerance [09/2017-08/2030] PIMS Number: IXX13687	Mohana, G.S. (PI) Eradasappa, E. K. Vanitha	09/2017 06/2018 09/2017
01 (5)	Genetics of traits in cashew [05/2019 – 04/2025] Extended upto 04/2027 PIMS Number: IXX15237	Eradasappa, E. (PI) Mohana, G.S. Siddanna Savadi	05/2019 05/2019 27-09-2022
01 (6)	Polyploidy breeding in cashew [10/2020-09/2030] PIMS Number: IXX17064	Mohana, G.S. (PI) Eradasappa, E.	10/2020 10/2020
01 (7)	Evaluation of dwarf and semi dwarf accessions and their seedling progenies for high density planting system [09/2021-08/2032] PIMS Number: IXX17065	Mohana G.S (PI) Eradasappa, E	09/2021 09/2021

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Code	Title	Investigators	Date of start
01 (8)	Genetic dissection of QTLs governing nut yield and cashew nut shell liquid (CNSL) content in cashew [06/2018-05/2025] Extended upto 05/2027 PIMS Number: IXX14347	Siddanna Savadi (PI) Eradasappa, E Mohana, G.S. Manjunatha. K Manjesh. G.N Veena. G.L.	06/2018 06/2018 06/2018 27-09-2022 27-09-2022 10-08-2023
01 (9)	Deciphering the molecular basis of Cashew-Tea Mosquito Bug (TMB) interactions to understand host response and TMB effectors (09/2022-09/2026) PIMS Number: IXX17066	Siddanna Savadi (PI) T.N. Raviprasad K. Vanitha Rajashekara H	09/2022 09/2022 09/2022 10-08-2023
01 (10)	In-vitro pollen germination and pollen tube growth of cashew varieties in response to high temperature stress [05/2019 – 04/2027] PIMS Number: IXX15130	Babli Mog (PI) Eradasappa, E. Veena. G.L. V. Thondaiman Manjesh. G. N Bhagya H P	05/2019 05/2019 12-10-2020 27-09-2022 27-09-2022 Not mentioned in IRC proceedings for inclusion
01 (11)	Physiological and biochemical basis of salinity tolerance in cashew accessions [09/2021-08/2026] PIMS Number: IXX16223	Babli Mog (PI) Shamsudheen M Manjesh. G.N. Veena. G.L. V. Thondaiman Bhagya. H.P.	09/2021 09/2021 09/2021 27-09-22 27-09-22 27-09-22

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Code	Title	Investigators	Date of start
01 (12)	Physiological, biochemical and molecular characterization of cashew accessions for drought stress [10/2024-10/2027]	Babli Mog (PI) Mohana G.S. Veena G.L. Bhagya H.P. Manjesh G.N. Thondaiman V Siddanna Savadi	08/10/2024 08/10/2024 08/10/2024 08/10/2024 08/10/2024 08/10/2024 08/10/2024
01 (13)	Profiling of important biochemicals in cashew cultivars and germplasm and exploration of biofuel production potential from cashew tree wastes [10/2025-09/2029]	Siddanna Savadi (PI) Manjunatha K Jyoti Nishad	10/2025 10/2025 10/2025
Priority area 02: Development of Refinement of Production Technologies in Cashew Sub-Projects			
02 (1)	Development of cashew (*Anacardium occidentale* L.) based cropping system for west coastal region [10/2020-09/2025] Extended upto 09/2030 PIMS Number: IXX16363	V. Thondaiman (PI) Shamsudheen Mangalassery K. Vanitha Babli Mog H. Rajashekahara Bhagya H. P	10/2020 10/2020 to 10/2020 10/2020 09/2021 14.11.2022 to 26.07.2024 as PI
02 (2)	Effectof inter-stocks in Cashew (Anacardium occidentale) [09/2022-08/2029] PIMS Number: IXX16474	H.P. Bhagya (PI) V. Thondaiman J.D. Adiga Veena. G.L. Manjesh G.N. Babli Mog	09/2022 09/2022 09/2022 09/2022 09/2022 09/2022

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Code	Title	Investigators	Date of start
02 (3)	Canopy manaement in Cashew under ultra-high density planting system [08/2023 – 08/2029] PIMS Number: IXX20151	Bhagya. H.P. (PI) J.D. Adiga Shamsudheen M Thondaiman, V Veena, G.L. Manjesh, G.N. Babli Mog	08/2023 08/2023 08/2023 to 08/2023 08/2023 08/2023 08/2023
02 (4)	Carbon cycling, sequestration and nutrient dynamics in cashew orchards [10/2020-09/2025] Extended upto 09/2026 PIMS Number: IXX16199	Bhagya. H.P. Babli Mog	PI since 8-10-2024 and CO-PI from 27-9-2022 to 07.10.2024 CO-PI from 10.10.2020 to 25.10.2023 and 08.102024 to till date and PI from 26.10.2023 to 07.10.2024
02 (5)	Comparative Studies on Effect of Different Farming system in Sustainable Cashew cultivation. [08/2023-long term]	Veena G.L. (PI) Babli Mog Thondaiman V Manjesh G.N. Vanitha K Rajashekara H	08/10/2024 08/10/2024 08/10/2024 08/10/2024 08/10/2024 08/10/2024
02 (6)	Effect of storage duration and storage condition on seed nut viability of cashew (*Anacardium occidentale* L.) for quality planting material production [10/2025-09/2027]	Thondaiman V (PI) Bhagya. H.P. Veena G.L.	10/2025 10/2025 10/2025
02 (7)	Influence of weather parameters on growth dynamics of apple and nut in selected varieties of Cashew [09/2021-08/2024] Extended upto 09/2025 PIMS Number: IXX16942	Manjesh, G.N. (PI) Babli Mog K. Vanitha Siddanna Savadi Bhagya. H.P.	09/2021 09/2021 09/2021 27-09-2022 27-09-2022

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Code	Title	Investigators	Date of start
	Priority area 03: Integrated insect pest and disease management in cashew		
	Sub-Projects		
03 (1)	Characterization and synthesis of female sex pheromone of Tea Mosquito Bug; (Helopeltis antonii) and its bioassay [10/2020-09/2025] Extended upto 09/2027 PIMS Number: IXX16224	T N Raviprasad (PI) K. Vanitha K. Subaharan	10/2020 10/2020 14-09-2021 Approved by Director, NBAIR
03 (2)	Assessing the field effectiveness of entomopathogenic nematodes (EPN) and indigenous strain of entomopathogenic fungus (EPF) in management of cashew stem and root borers (Plocaederus ferrugineus and Plocaederus obesus) [09/2021-08/2026] PIMS Number: IXX16225	T.N. Raviprasad, (PI) Vanitha K Rajkumar CPCRI, Kasaragod	09/2021 09/2021 Permitted vide CPCRI-PME F.N. 50.15/DCR/T dated 25-11-2022.
03 (3)	Species complex of thrips infesting cashew, their role and management measures [09/2022-09/2025] Extended upto 09/2026 PIMS Number: IXX17067	K. Vanitha (PI) T.N. Raviprasad Rachana, R. (ICAR-NBAIR) Rajashekara, H Mohana, G.S.	09/2022 09/2022 Permitted the inclusion of Dr. R.R. Rachana vide communication dated 22.11.2022 from ICAR-NBAIR, Bengaluru by e-mail 09/2022 09/2022
03 (4)	Development of an eco-friendly and cost-effective pest management strategy for cashew using plant and microbial-based pesticides [09/2024-09/2028]	Vanitha K (PI) T. N. Raviprasad K. Velmourougane ICAR-Central Institute of Cotton Research, Nagpur	09.10.2024 09.10.2024 09.10.2024

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Code	Title	Investigators	Date of start
		A. Kandan ICAR-NBAIR, Bengaluru H. Rajashekara T. N. Madhu (ICAR-CPCRi, Vittal)	09.10.2024 09.10.2024 09/2025
03 (5)	Survey and diagnosis of diseases occurring in cashew through morphological and molecular characterization and their management [09/2021-08/2027] PIMS Number:IXX17045	H. Rajashekara (PI) T N Raviprasad Siddanna Savadi RTP Pandian, ICAR-CPCRI, RS, Vittal	09/2021 09/2021 09/2021 CPCRI-PME F. No. 50.15/DCR/T dated 11.11.2 in response to DCR request F.No. DCR-PME(IRC)/2020 dated 03-11-2022.
03 (6)	Deciphering the role of core floral microbiome in enhancing productivity in cashew [09/2024-08/2027]	Rajasekhara H (PI) Vanitha K Veena G.L.	9.10.2024 9.10.2024 9.10.2024
Priority area 04: Developoment of Food Products and Machinery for Pre and Post Harvest Management and Processing Sub-Projects			
04 (1)	Optimizing processing parameters in cashew for enhancing whole kernel recovery [09/2022-09/2025] PIMS Number: IXX17068	D.Balasubramanian(PI)	10/2020
04 (2)	Development of ready to eat alternate snack food using cashew apple - extrusion and vacuum frying approach [09/2022-08/2026] PIMS Number: IXX17069	D.Balasubramanian(PI) M R Manikandan	09/2022 Approved vide Letter CPCRI F.No. 50.15/DCR/T dated 06-10-2022 in response to DCR letter F.No. DCR PME(IRC)/2020 dt. 22.09.2022

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Code	Title	Investigators	Date of start
04 (3)	Development of value-added products from cashew apple and sprouts [06/2018-long term] PIMS Number: IXX20034	Jyoti Nishad (PI)	Co-PI from 25-07-2023 (F.No. 2/2023-PME (IRC-Inst-Proj dt 26.07.23) PI from 09/2025
		Veena. G.L.	Co-PI from 09/2021 to 03-03-2022 PI from 03-03-2022 to 09/2025
		Shamsudheen Mangalassery	Co-PI from 06/2018 to 08/2020 & 09/2021 onwards; PI from 10-08-2020 to 09/2021
		Rajashekara H	Co-PI from 9/2024
		Manjesh G.N	Co-PI from 9/2024
		Renjitha. K; IIHR, Bengaluru	F.No. IIHR/PMEC/1.2.5 & 44 (a)/2022 dated 13.09.2022 & F.No. IIHR/PME Cell/44.0(a)/ 2022 dated 28 November 2022 in response to F.No. DCR-PME(Res.Collabn) /2020 dt 06-08-2022
		Mathala Juliet Gupta, ICAR-CCARI, Goa	F.No. 10(2)/2020 dated 02.01.2025 in response to F.No. 02/2023 -PME(IRC-Inst-Proj) dated 26-12-2024
		Bhagya H P	09/2025

Contd.

Code	Title	Investigators	Date of start
04 (4)	Phytochemical characterization of cashew (leaf and apple) nutraceuticals for its utilization in development of functional foods [09/2021-08/2025] Extended upto 08/2027 PIMS Number: IXX16286	Manjesh. G.N (PI)	Co-PI from 09/2021 to 03-03-2022 PI from 03-03-2022 [Ref: DCR-PME(IRC)/2020 dt 07-03-2022)
		Veena. G.L.	09/2021
		Bhagya. H. P	27-09-2022
		Jyoti Nishad	10-08-2023
		Shabbir A	NRC Grapes F.No. 2(3)/TC/2022-23 dated 21.11.2022 in response to F.N. DCR-PME (Research collaboration) /2020 dt 11-10-2021
		Rajkumar. A.D, DOGR, Pune	DOGR, permission Letter F. No. PME/General/ 2020/2616 dt 20-02-2023
		Babli Mog	09/2024
04 (5)	Enhancing the shelf life of cashew apple to increase the market potential [08/2023-08/2026] PIMS Number: IXX20122	Jyoti Nishad (PI)	08/2023
		D. Balasubramanian	08/2023
		Veena GL	08/2023
		Rajashekara, H	08/2023
		Vijay Rakesh Reddy S., ICAR-IIHR, Bengaluru	F.No. 02/2023-PME(IRC-Inst-Proj) dated 29-10-2024
04 (6)	Precision Pest and Disease Surveillance in Cashew Using UAV-Based Multispectral Imaging [10/2025-09/2028]	Manjunatha. K (PI)	10/2025
		Siddana Savadi,	10/2025
		K. Vanitha	10/2025
		Rajashekara H	10/2025

Contd.

Code	Title	Investigators	Date of start
04 (7)	Innovative mechanized system for collection of cashew fruits – A dual approach using Pneumatic and Remote-Controlled Technologies [10/2025-09/2027]	Manjunatha. K (PI) D. Balasubramanian	10/2025 10/2025
04 (8)	Development of an Innovative, Low-Cost, Farm-Level Cashew Fruit–Nut Separator [10/2025-09/2027]	Manjunatha. K (PI) D. Balasubramanian J.D. Adiga	10/2025 10/2025 10/2025
Priority area 05: Developing Methodologies and ICT Tools for Capacity Building and Transfer of Technologies in Cashew **Sub-Projects**			
05 (1)	Knowledge management and technology transfer in cashew [09/2021-Long term] PIMS Number: IXX17070	Aswathy Chandrakumar (PI) T N Raviprasad Mohan G S Manjesh. G. N Bhagya. H. P	 09/2021 09/2021 09/2021 09/2021 27-09-2022
05 (2)	Socio-economic and innovation system analysis in Cashew sector [09/2021-Long term] PIMS Number: IXX17071	Aswathy Chandrakumar (PI) D Balasubramanian Eradasappa E V Thondaiman C Thamban, CPCRI Jayasekhar S, CPCRI	 09/2021 09/2021 09/2021 09/2021 Permission letter received from CPCRI vide F.No. 50.15/NRCC/T dt 16.03.2022 [Ref: DCR-PME (IRC)/2020 dated 16-03-2022] Permission letter received from CPCRI vide /NRCC/T dt 16-03-2022 [Ref: DCR-PME(IRC) /2020 dated 16-03-2022]

Contd.

Code	Title	Investigators	Date of start
05 (3)	Cashew Farmer's Tracking System [04/2024- 08/2027]	Mohana G.S. (PI)	04/2024
05 (4)	Integrated Farming Approaches for Socio-Economic Resilience of Scheduled Caste Farmers [2025/Long-term]	Manjesh. G. N (PI) Rajasekhara H, Veena GL, Babli Mog Jyoti Nishad	09/2025 09/2025 09/2025 09/2025 09/2025
05 (5)	Improving the livelihoods of tribal farmers through cashew-based technologies and capacity building	Aswathy Chandrakumar (PI) Siddana Savadi, Bhagya H P, Thondaiman V Manjunatha K	04/2025 04/2025 04/2025 04/2025 04/2025

List of Projects concluded in the 38th IRC

Code	Title	Investigators	Date of start
Priority area 02: Development of Refinement of Production Technologies in Cashew			
02 (1)	Effect of growth regulator in combination with flower and fruit-set enhancing chemicals on cashew (Anacardium occidentale L.) [10/2020-09/2025] PIMS Number: IXX16215	V. Thondaiman (PI) K. Vanitha Babli Mog Veena. G.L. Bhagya. H.P.	10/2020 10/2020 Co PI from 10.10. 2020 to 25.10.2023 PI from 26.10.2023 to 15.08.2024 10/2020 27-09-2022
02 (3)	Developing nutrient management strategies for cashew based on soil and leaf status [10/2020-09/2024] PIMS Number: IXX16218	Veena G.L. V. Thondaiman Babli Mog Manjesh. G. N Aswathy Chandrakumar	PI since 11.12.2023 10/2020 09/2021 09/2021 09/2021

Contd.

Code	Title	Investigators	Date of start
Priority area 04: Development of Food Products and Machinery for Pre and Post Harvest Management and Processing			
04 (1)	Design and development of gadgets for cashew fruit harvesting and collection [10/2020-09/2025] PIMS Number: IXX15635	Manjunatha. K (PI) D. Balasubramanian Ravindra Naik J.D. Adiga	10/2020 10/2020 10/2020 10/2020

List of Ongoing Externally Funded Projects as per 38th IRC

Code	Title	Investigators	Date of start
1.	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 [04/2015-03/2025] PIMS Number: OXX03473	Mohana, G.S. (PI)	30/07/2021
2.	Demonstration of Drone Technology [24-06-2022 to 31-03-2025] PIMS Number: OXX5457	Manjunatha. K (PI) T.N. Raviprasad J.D. Adiga Shamsudheen M Siddanna Savadi Aswathy Chandrakumar Manjesh. G.N.	06/2022 08/2022 08/2022 08/2022 08/2022 08/2022 From 16-05-2023
3.	Front line demonstration of newly developed cashew varieties of ICAR-DCR Puttur, Funded by: DCCD, Kochi Budget: Rs. 10.0 lakhs [20-06-2023 to 31-03-2024] PIMS Number: OXX7285	E. Eradasappa (PI) Aswathy Chanda Kumar Mohana. G.S. J.D. Adiga Bhagya H.P.	20/06/2023 20/06/2023 20/06/2023 20/06/2023 13/02/2024

Contd.

Code	Title	Investigators	Date of start
4.	Establishment of state of art facilities for chemical ecology studies targeting eco-friendly pest management and demonstration in cashew. Funded by: RKVY-RAFTAAR, [12/2024-12/2026] PIMS Number: OXX7287	Vanitha K (PI) T.N. Raviprasad Veena G.L. H Rajashekara Babli Mog V. Thondaiman	12/2024 12/2024 12/2024 12/2024 12/2024
5.	Establishing the honey testing laboratory at ICAR-Directorate of Cashew Research, Puttur, Karnataka Funded by: National Bee Board [05/2025-05/2027]	Dr. Jyoti Nishad. (PI) Vanitha K, Veena G.L. H Rajashekara	05/2025 05/2025 05/2025 05/2025
6.	Front line demonstration of latest cashew varieties of ICAR-DCR Puttur under normal density and other old /new suitable varieties under high density systems' [2024-2026]	E. Eradasappa (PI) Aswathy C, Mohana G. S., Bhagya, H.P., Thondaiman V J. D. Adiga	
7.	Development of model cashew villages for transforming farm livelihoods in Karnataka (2025-2027)	Aswathy Chandrakumar (PI) Dr. T N Raviprasad Dr. Eradasappa E, Dr. Bhagya H P, Dr. Veena G L, Dr. Thondaiman V, Dr. Rajashekara H Dr. Jyoti Nishad	
8.	Establishment of state of art facilities for Speed Breeding and Omics resources for accelerating cashew breeding [10/2024-09/2026]	Dr Siddanna Savadi Dr. J.D. Adiga, Dr. Manjunatha K. Dr. Bhagya H.P	10/2024 10/2024 10/2024 10/2024

Contd.

List of Externally Funded Projects concluded in the 38th IRC

Code	Title	Investigators	Date of start
1	Mechanization of pesticide and nutrient sprays in cashew orchards through drones, Funded by: RKVY-RAFTAAR, Budget Rs. 83 lakhs; [2021-22 to 2023-24] PIMS Number: OXX5543	Manjunatha. K (PI) Vanitha. K Shamsudheen Mangalassery	04/2021 04/2021 04/2021
2	Establishment of farmer-centric pest diagnostic and bio-control laboratory to achieve sustainable cashew health management, (KA/RKVY-AGRE/2022/1345) Funded by: RKVY-RAFTAAR, Budget Rs. 100 lakhs; [2022-23 to 2023-24] Extended Up to 03/2025 PIMS Number: OXX5545	H. Rajashekara (PI) T.N. Raviprasad K. Vanitha Siddanna Savadi	04/2022 04/2022 04/2022 04/2022

12. RAC/IRC/IMC/IJSC Meetings

12.1 Research Advisory Committee (RAC) meeting

The 29th Meeting of RAC (second meeting of 10th Research Advisory Committee) of ICAR-DCR, Puttur was held during 20 and 21 January, 2026 at the Video Conference Hall of ICAR-DCR, Puttur in hybrid mode. The meeting started on 20.01.2026 at 9.30 am with the field visits by the Chairman Dr. S. B. Dandin and member Dr. G.K. Mukunda up to 12.00 pm. During the visits, experimental plots of canopy management, showcasing of Nethra Ganga in different planting densities, newly released varieties / advance stage, replicated trials of hybrids at Kemminje Farm and nursery and experimental fields at Shantigodu Farm were visited and scientists of respective fields explained about the works being carried out.

At 12.30 pm the meeting started with the welcome address by Dr. J. Dinakara Adiga, Director, ICAR-DCR Puttur. This was followed by the introductory remarks of the Chairman, Dr. S. B. Dandin, Former VC, UHS Bagalkot. Following this, brief introductory remarks were made by the RAC members, Dr. G.K. Mukunda, Former Professor of Horticulture and Head, University of Agricultural Sciences, GKVK, Bengaluru, Dr. P.L. Saroj (online), Principal Scientist, CISH, Lucknow and Former Director, ICAR-DCR and ICAR-CIAH, Dr N Bakthavatsalam (online), Former Head, ICAR-NBAIR, Bengaluru, Sri Sanjiv Balaji Kunkalienkar (online) and Dr. V.B. PateI (online), ADG (F&PC), ICAR, KAB-II, New Delhi. In the opening remarks the Chairman and Members appreciated the research achievements and progress made by DCR since last meeting.

Thereafter, action taken report on the recommendations of 29th RAC Meeting (1st meeting of 10th RAC) was presented by Dr. Eradasappa, E Member Secretary (10th RAC). He informed that all the recommendations of the previous RAC were accepted by the ICAR, and then the action taken on the recommendations was discussed. The Chairman and Members of RAC appreciated the efforts of ICAR - DCR in taking prompt action on the recommendations of the previous RAC meeting. Subsequently, there were presentations by the scientists of ICAR-DCR on their ongoing research projects under Crop Improvement, Crop Management and Farm Machinery, Crop Protection, Post-Harvest Technology and Transfer of Technology sections. On the same day (20th January 2026), presentations under Crop Improvement, Crop Management & Crop Protection were completed. The next day (21st January 2026) presentations under Post-Harvest Technology and Transfer of Technology sections were presented. The research progress and the accomplishments of 43 research projects including nine external projects were presented during the meeting under six mega projects. There were critical observations by the RAC on the research outcomes and the suggestions to improve further were discussed in detail. Following the concluding remarks by the RAC Chairman and members, the recommendations were finalized in the afternoon. The meeting ended at 4.30 pm with the vote of thanks by the Member Secretary.

12.2 Institute Research Committee (IRC) meeting

The meeting of the 38th Institute Research Committee (IRC) was held during 3-4 September, 2025 under the Chairmanship of Dr. J.D. Adiga, Director, ICAR-DCR, Puttur in hybrid mode at Video conference hall of Silver Jubilee Building, DCR, Puttur and through

Zoom platform. Dr. Babli Mog, Member Secretary, IRC welcomed the Chairman, members of IRC and the resource persons.

In a brief address, Dr. J.D. Adiga, the Chairman, IRC, welcomed the scientists and appreciated the efforts of the scientists. He briefed about the ICAR guidelines on project implementation. The scientists presented the achievements made under various ongoing projects and presented some new project proposals also.

Dr. Ramesh Bhat, Professor, Professor, Genetics and Plant Breeding and Biotechnology, University of Agricultural Sciences, Dharwad, India served as resource person for the Crop Improvement section. Dr. Sridhara, S, Professor and Coordinator Centre for Climate Resilient Agriculture, KSN University of Agricultural and Horticultural Sciences, Savalanga Road, Shivamoggaserved as resource person for Crop Management section. Dr. T M Shivalingaswamy, Former Principal Scientist (Entomology), ICAR-NBAIR, Bengaluru and Dr. A. Ishwara Bhat, Principal Scientist (Plant Pathology), ICAR-IISR, Kozhikode served as resource persons for Crop Protection and Plant Pathology sections respectively.

Dr. M. Balakrishna, Professor and Head, Dept. of Food Process Engineering, ACCARI, Tamil Nadu served as resource person for Post harvest technology, Farm Machinery and Food technology sections. Dr. P Sethuraman Sivakumar, Principal Scientist (Agril. Extension), ICAR-CTCRI, Thiruvananthapuram served as resource person for the Transfer of Technology section.

12.3 Institute Management Committee (IMC) meeting

The 54th meeting of the Institute Management Committee (IMC) of the ICAR–Directorate of Cashew Research, Puttur, was held on 23rd December 2025 in virtual mode under the chairmanship of Dr. J. Dinakara Adiga. The committee reviewed and approved the action taken report of the previous (53rd) IMC meeting, noting that there were no pending actions. A detailed presentation on the progress of research and institutional activities highlighted significant achievements across crop improvement, crop management, crop protection, post-harvest technology, and technology commercialization. Notable accomplishments included the development and registration of new germplasm, release of a high-yielding variety (Nethra Samruddhi), advancements in drought and stress tolerance studies, development of innovative machinery and micronutrient formulations, commercialization of cashew-based value-added products, and expansion of extension activities such as trainings, demonstrations, and digital advisory tools.

The committee appreciated the overall research progress and technology dissemination efforts of the Directorate. It also reviewed administrative and financial aspects, including manpower status and budget utilization. While expenditure under various grants was found satisfactory, the committee expressed concern over staff shortages and recommended taking up the matter with higher authorities. Additionally, the IMC recommended approval of healthcare facilities at Adarsha Hospital and City Hospital, Puttur, for staff and pensioners. The meeting concluded with a vote of thanks by the Member Secretary.

Institute Management Committee (IMC)
IMC Meeting held on 19.12.2025

Sl. No.	Name and address	Position
1	Dr. J. Dinakara Adiga Director, ICAR- DCR, Puttur, Karnataka – 574 202	Chairman
2	Director of Horticulture Directorate of Horticulture, Govt. of Karnataka, Lalbagh, Bengaluru	Member
3	Director Dept. of Agricultural Development and Farmers Welfare, Govt. of Kerala, Vikas Bhavan, Thiruvananthapuram-33	Member
4	Vice - Chancellor Keladi Shivappa Nayak University of Agricultural & Horticultural Sciences, Iruvakki, Sagar Taluk, Shivamogga – 574412 Karnataka	Member
5	Dr. M K Rajesh Head, ICAR-CPCRI RS, Vittal-574243, Karnataka	Member
6	Dr. D K. Singh Professor and Principal Scientist Division of Agricultural Engineering, IARI, New Delhi - 110 0012.	Member
7	Dr. Arun Kumar Sit Principal Scientist & Scientist In charge - ICAR - CPCRI, Research Centre, Mohit nagar, West Bengal	Member
8	Dr. Om Prakash Awasthi Head, Division of Fruits and Horticulture Technology Indian Agril Research Institute, New Delhi-110083	Member
9	Dr. V B Patel ADG (Fruits & Plantation of Crops), ICAR, New Delhi.	Member
10	The Comptroller ICAR-CPCRI, Kasaragod	Member
11	Mr. Gopalakrishna Kamath Mangalore Cashew Industries, Siddapur, Kundapur, 576 229	Non Official Member
12	Mr. Sanjeev Balaji Kunkalienkar Sita Niwas, Mangeshi, Mardol Post, Ponda Taluk, South Goa Dist.Goa, 403 401	Non Official Member
13	Mr. Ashwin G Finance & Accounts Officer, ICAR - DCR, Puttur, Karnataka – 574 202	Special Invitee
14	Mr. Pradeep Kumar Vasu Administrative Officer, ICAR - DCR, Puttur, Karnataka – 574 202	Member Secretary

XII th IJSC Members

IJSC Meeting held on 10.06.2025

1.	Dr. J. Dinakara Adiga, Director	Chairman
2.	Dr. Eradasappa.E, Principal Scientist	Member, Official side
3.	Dr. Raghurama Kukkude, Assistant Chief Technical Officer	Member, Official side
4.	Sri. Ashwin.G Finance & Accounts Officer	Member, Official side
5.	Sri. Pradeep Kumar Vasu Administrative Officer	Secretary, Official side
6.	Mrs. Leela. M, Assistant Administrative Officer	Member, Staff side
7.	Sri. Ravishankar Prasad Technical Officer	Member, Staff side
8.	Sri. Sundara. V, Skilled Support Staff	Member, Staff side
9.	Sri. Seetharama. B, Skilled Support staff	Member, Staff side
10.	Mr. Umashankar, Assistant	Secretary, Staff side

13. Rajbhasha

राजभाषा कार्यान्वयन समिति

1.	डा. जे. दिनकर अडिगा	अध्यक्ष
2.	डा. राजशेकर	सदस्य
3.	डा. अश्वती चंद्रकुमार	सदस्य
4.	डा. ज्योती निषाद	सदस्य
5.	डा. रघुराम कुक्कडे	सदस्य
6.	श्री अश्विनी कुमार सिंह	सदस्य
7.	श्री राहुलयादव	सदस्य
8.	श्रीमती लीला एम.	सदस्य
9.	श्री विजय आचारी (दिसंबर 2025 तक)	सदस्य
10.	श्री प्रकाश जी भट् (मई 2025 तक)	सदस्य सचिव

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 है। प्रत्येक बैठक के कार्यवृत्त की समीक्षा निदेशक (राजभाषा) भारतीय कृषि अनुसंधान परिषद की ओर से की जाती है और दनुसार 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 पूर्ण रूप से हिंदी में भी तैयार कर अधिनियम का अनुपालन किया जा रहा है। राजभाषा के प्रति जागरुकता पैदा कराने हेतु राजभाषा विभाग की ओर से जारी किए गए वार्षिक कार्यक्रम के अनुसार 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, प्रारुप, टिप्पणी एवं मसौदा लेखन प्रतियोगिता, क्विझ प्रतियोगिता आदी आयोजित की जाती है।

इस वर्ष भी पुत्तूर नगर राजभाषा कार्यान्वयन समिति की दो अर्धवार्षिक बैठक और चार तिमाहि बैठकों को आयोजित किया गया। इन बैठकों में निदेशालय की हिन्दी गतिविधियों के बारे में विस्तृत रूप से चर्चा की गई। राजभाषा में कार्यालय के कामकाज करने के बारे में जरूरी कदम उठाने के बारे में और कर्मचारियों को हिन्दी ज्ञान दिलाने के लिए आवश्यक कदम उठाने के बारे में योजना बनाई गई। सितंबर महिने में दिनांक 14–21 तक हिन्दी सप्ताह मनाया गया। इस के अवसर पर विध्यार्थियों और कर्मचारियों के लिए भाषण, निबंद लेखन और सामान्य ज्ञान प्रतियोगिता आदी आयोजन किया गया।

हिन्दी में कार्यालयीन काम करने वाले निदेशालय के कर्मचारियों को नकद पुरस्कार से सम्मान किया गया। राजभाषा की कार्यन्वयन को बढ़ावा देने के लिए पूरी कोशिश की गई।

राजभाषा नियम 1976 नियम 11 के अनुपालन हेतु आवश्यक सामग्रियों जैसे प्रपत्र, रबड़ की मोहरें, नामपट्ट आवश्यकतानुसार द्विभाषी में तैयार कर समय समय पर मार्ग निर्देश दिया जाता है। सम्मेलनों का बैनर एवं निमंत्रण पत्र द्विभाषा में ही प्रदर्शित किया जाता है। हिंदी पत्रों की आवति के लिए प्रत्येक रजिस्टर रखकर राजभाषा नियम 1976 नियम 5 का अनुपालन पूर्ण रूप से शत प्रतिशत किया जाता है।

वेबसाइट का प्रदर्शन

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

हिंदी कार्यशाला

सरकारी कामकाज में हिंदी का प्रयोग बढ़ाने एवं हिंदी कार्य का उपयोगी ज्ञान प्राप्त कराने हेतु निदेशालय में कार्यशालाओं को आयोजन किया जा रहा है। इस वर्ष भी अनुभवी मर्गदर्शकों की मार्ग दर्शन में मसौदालेखन, टिप्पणीलेखन, अनुवाद, राजभाषा नियम एवं

अधिनियम पर जनवरी में हिंदी कार्यशाला आयोजित की गई और उन्हें अभ्यास भी कराया गया है। उपर्युकत 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 आसपास के केन्द्र सरकारी कार्यलयों में राजभाषा हिन्दी का कार्यान्वयन सुनिश्चित करने की दृष्टी से पुत्तूर और विट्ट्ल में स्थित केंद्रीय सरकार के कार्यालय, उपक्रम, बैंक सहित 12 सदस्य कार्यालय सम्मिलित नगर राजभाषा कार्यान्वयन समिति (नराकास) का घटन किया गया है।

पुत्तूर नराकास की अर्धवार्षिक बैठक 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 सेआयोजन किया गया।

निदेशालय में निम्नलिखित रिपोर्ट हिंदी में प्रकाशित किया गया:

1. निदेशालय का वार्षिक प्रतिवेदन का सारांश (वर्ष 2024)
2. अखिल भारतीय समन्वित काजू अनुसंधान परियोजना की वार्षिक प्रतिवेदन सारांश
3. अर्धवार्षिक, पत्रिका 'काजू समाचार' में हिंदी समिती की गति विधियों के बारे में प्रतिवेदन।
4. दैनिक प्रयोग में आने वाले प्रपत्रों का हिंदी रूपान्तरण।

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

14. Programmes/Events organized

14.1 Inauguration of Drone Technology lab and Centre of Excellence for profiling and bioactive components by Dr. Himanshu Pathak, Honarable Secretary DARE and Director General, ICAR

Hon'ble Secretary of the Department of Agricultural Research and Education (DARE) and Director General of the Indian Council of Agricultural Research, New Delhi, Dr Himanshu Pathak, inaugurated the Drone Technology lab and Horticulture lab of the Directorate of Cashew Research, Puttur, on 03.01.2025. Dr. V B Patel, ADG (Horticulture), Dr. J Dinakara Adiga, Director, ICAR-DCR and staff of ICAR-DCR were also present on the occasion. The Drone Technology lab and Centre of Excellence for profiling and bioactive components were established in the Directorate with funding from the Department of Agriculture and Farmers' Welfare, Govt. of India through RKVY-RAFTAAR, Govt. of Karnataka.

The state-of-the-art Drone Technology Lab provides cutting-edge facilities to drive innovation in Unmanned Aerial Vehicle (UAV) applications for plantation crops, empowering research and fostering sustainable practices. The lab is equipped with advanced drone systems and data processing tools, providing a platform for transformative solutions in smart farming and beyond. Centre of Excellence for profiling and bioactive components was established with the aim of exploring the phytochemicals which are present in cashew apple, cashew nut, kernel, shell and leaves. It is equipped with state-of-the-art equipments like HPLC, GCMS and UV visible spectrophotometer.

During the occasion, a newly developed product Cashew sprout cookies was licensed to Mr. Radhakrishna, Proprieter, Nidhi Food Products, Puttur by Dr. Pathak.

14.2 Cashew Day-2025

The Cashew Day-2025, an annual event of the Directorate was organized on 11th March, 2025 on the theme "Mechanisation in Cashew". The event was jointly sponsored by DCCD, Kochi and RKVY-RAFTAAR, Govt. of Karnataka. Dr. C.R. Mehta, Director, ICAR-CIAE, Bhopal was the chief guest and Dr. Praveen Malik, CEO, Agrinnovate India Limited, New Delhi and Dr. V Venkatasubramanian, Director, ATARI, Bengaluru were the Guests of Honour for the programme. A total of 150 people which includes farmers, entrepreneurs and officials from various Govt. departments attended the programme. The major highlights of the event were release and licensing of a cashew apple and nut separator to M/s Phison Agritech Private Limited, Ramanagara, Karnataka, demonstration to showcase and create awareness among the farmers about the working of Cashew Apple and Nut Separator and 3-in-1 moisturemeter, and an exhibition was also organised to display the cashew apples and nuts of various high yielding varieties and different value added products developed from cashew apple by the Directorate. Dr. Manjunatha K, Scientist (Farm Machinery and Power), delivered a lecture on the status of mechanisation in Cashew and explained in brief about the various equipments developed in the Directorate for harvesting and separation of raw nuts from the cashew apple. During the programme Shri Praveen Nayak from Gadag, Karnataka and Shri Brijith Krishna from Kannur, Kerala were felicitated and awarded for Innovative Entrepreneur and Innovative Cashew farmer respectively. The event also featured the release of some publications like Cashew News, the half yearly newsletter of the institute and extension folders on value added products of

cashew apple, nutrient deficiency in cashew, Nethra jumbo-2 and Farmers tracking system.

14.3 Foundation Day-2025

The institute celebrated the 40th Foundation Day on 18-06-2025. Dr. Sanjay Kumar, Chairman, Agricultural Scientists Recruitment Board (ASRB), New Delhi, participated as the Chief Guest. Dr. K. Balachandra Hebbar, Director, Central Plantation Crops Research Institute (CPCRI), Kasaragod, participated as the Guest of Honor. Dr. S.K. Singh, Deputy Director General (Horticulture), and Dr. V.B. Patel, Assistant Director General (Fruits and Horticultural Crops) from New Delhi, also participated in the program online. Dr. J Dinakara Adiga, Director, ICAR-DCR, Puttur highlighted the salient achievements of the institute during 2024-25 in his inaugural address. The chief guest, Dr. Sanjay Kumar, delivered the Foundation Day lecture on the topic "Horticulture for Sustainable Bioeconomy: Innovation and Emerging Opportunities. The Best Paper award was given to Dr. Manjunatha and team. The event also featured the licensing of cashew apple based value added products to Amalu SHG promoted by Punarvi FPO of Parvathipuram Maniyam district of Andhra Pradesh and distribution of inputs to the ST beneficiaries. Publications including annual report, extension folders were released during the event.

14.4 *Viksit Krishi Sankalp Abhiyan* - 2025

A team of scientists comprising of Dr. SiddannaSavadi (Nodal officer), Dr. Manjunatha K, Dr. Dr. Vanitha K, Dr. Bhagya H P, Dr. Manjesh G N, Dr. Jyoti Nishad and Dr. Aswathy Chandrakumar were deputed to participate in the Viksit Krishi Sankalp Abhiyan organized jointly with the KVKs. The different teams of scientists were deputed to Gadag, Tumakuru and Dakshina Kannada during the period to disseminate information about cashew, showcase the technologies developed by the institute and understand the researcheable issues.

14.5 PM-Kisan Utsav Diwas-2025

The Directorate hosted a training programme on "Scientific Cultivation of Cashew" as a part of PM-KISAN UTSAV DIWASon 02.08.2025, during which the Hon'ble PM Shri Narendra Modi released the 20th financial instalment of PM-KISAN from Varanasi, Uttar Pradesh. The release was streamed live at the Directorate in which farmers and staff of the Directorate participated.

Dr. T.N. Raviprasad, Director-In-charge, ICAR-DCR, Puttur gave the introductory remarks in which he emphasized the importance of farmers and their involvement in attaining more ambitious economic goals for the country. He also discussed about the imperative role of this Directorate in educating farmers about cashew cultivation. Technical sessions were organized to create awareness on the scientific cultivation of cashew for the farmers. The significance of using cashew cultivation techniques, such as choosing appropriate varieties, high density planting systems, and pruning responsive varieties suitable for high density and ultra-high density planting systems for yield enhancement was discussed by Dr. E. Eradasappa, Senior Scientist (Plant Breeding). Dr. Manjesh G.N., Scientist (Spices, Plantation, Medicinal and Aromatic Plants) gave a lecture on cashew nursery management and explained the significance of the grafting technique and aftercare for successful graft establishment. Dr. Vanitha K. Senior Scientist (Agriculture Entomology) highlighted about the major pests of cashew and their management which was followed by a lecture on important diseases of cashew and management by Dr. Rajashekara H., Senior Scientist (Plant Pathology). Subsequent to the technical sessions, scientists interacted with the farmers about the field

problems faced by them during cultivation and management.

After the technical sessions, the live streaming of Hon'ble PM Programme was held at 11:00 AM. Inputs were distributed to the ST farmers after the programme and a total of 100 participants attended the training cum live streaming of PM-Kisan Utsav.





14.6 Workshop on Revitalizing the Indian Cashew Sector for Building Competitiveness and Enhancing Prosperity

A national-level workshop on "Revitalising the Indian Cashew Sector for Building Competitiveness and Enhancing Prosperity" was jointly organised by the Indian Academy of Horticultural Sciences (IAHS), New Delhi, ICAR–Directorate of Cashew Research (DCR), Puttur and the National Horticulture Board (NHB), Gurugram, in hybrid mode on 29.09.2025 at New Delhi. The workshop was co-chaired by Dr. Sanjay Kumar Singh, President, IAHS and DDG (Horticultural Science), ICAR, and Shri Priya Ranjan, Joint Secretary (Horticulture). The deliberations highlighted the need for a mission-mode approach, technological interventions in production and processing, and community-based pest management strategies to enhance productivity and align Indian cashew with global quality standards.

The technical sessions and panel discussions brought together scientists, policymakers, industry representatives, and farmers to deliberate on scaling up raw cashewnut production and revitalising the sector. Emphasis was laid on high-yielding and climate-resilient varieties, mechanisation to reduce drudgery, modernisation of processing units, improved market intelligence, and value addition of cashew apple for enhancing farmers' income. Farmer success stories demonstrated the impact of scientific management and entrepreneurship, reinforcing the need for translational research and a coordinated, multi-pronged strategy to achieve self-sufficiency in cashew and strengthen India's global competitiveness. A total of 40 delegates attended the workshop physically.





14.7 Live Telecast of the launch of PMDDKY and Pulses Mission by the Hon'ble PM

The Hon'ble Prime Minister Shri Narendra Modi in a special Krishi programme organised at the Indian Agricultural Research Institute in New Delhi on 11.10.2025, launched Pradhan Mantri Dhan Dhanya Krishi Yojana (PM-DDKY), a landmark initiative for transforming India's agricultural landscape. The event was livestreamed at the Directorate and as a part of the programme, farmers were invited and technical sessions were arranged to familiarise the farmers about PM-DDKY and about scientific cashew cultivation and technologies developed at the Directorate. The programme commenced with the welcome by Dr. Eradasappa E, Principal scientist (Genetics and Plant Breeding), followed by a brief lecture about



PM-DDKY by Dr. Manjesh G N, scientist (Spices, Plantation, Medicinal and Aromatic Plants). Dr. Veena G L, Senior Scientist (Spices, Plantation, Medicinal and Aromatic Plants) gave a detailed presentation on the newly developed varieties, planting and after care, cashew apple processing and about newly develop machines for cashew apple and nut separation.

This was followed by the live telecasting of the PM Programme. After the telecast, the Memorandum of Agreement (MoA) was signed with Bharat Agri Farmer Producer Company Ltd. Mangalore for licensing of cashew varieties Nethra Jumbo-1, Nethra Ubhaya and Nethra Jumbo-2 for multiplication and commercialisation through nursery establishment under the approved RKVY project "Development of model cashew villages for transforming farm livelihoods in Karnataka". Shri Prasad Shetty and the other board of Directors received the MoA from the Director on behalf of the FPCL. Dr. J Dinakara Adiga, Director, ICAR-DCR, Puttur gave the presidential address in which he emphasized the importance of such schemes and ended his remarks with a positive hope that a mission mode approach will be adopted in cashew for achieving self sufficiency. A total of 100 participants attended the programme in which 32 were farmers.

14.8 Commemoration of 150 years of Vande Mataram

An event on 'Inauguration of mass singing of "Vande Mataram", the National Song', was organized on 07.11.2025 at ICAR-DCR, Puttur. Dr. M.S. Venkatesh, Director (in-Charge), scientists, technical and administrative staff of DCR including contractual staff have actively participated in this event. The event banner was displayed and the short film about the event was played on www.vandemataram 150.in. Dr. K. Vanitha, Nodal Officer of this event briefed about the programme, and the year-long activities to be organized. A total of 42 participants attended this mass singing event.



14.9 Constitution Day

Samvidhan Diwaswas observed on 26.11.2025 as part of the nation-wide celebrations commemorating the 75th year of the adoption of the Constitution of India. The programme began with the National Song, marking the start of the day's events. Dr. K. Vanitha, Senior Scientist (Agricultural Entomology) and Nodal Officer for the programme, welcomed the staff and outlined the activities planned for the occasion. At 11:00 a.m., all staff members participated in the Reading of the Preamble to the Constitution and took the Constitution Day pledge.

As part of the observance, Mr. G. Ashwin, Finance and Accounts Officer, ICAR-DCR, delivered an enlightening talk on Constitutional Values, highlighting the history of the Constitution's framing and emphasizing the significance of fundamental rights. Dr. J. D. Adiga, Director, ICAR-DCR, addressed the gathering and spoke on the importance of the Indian Constitution in shaping the nation. A Constitution Day film was also screened to enrich the participants' understanding. Dr. Babli Mog, Senior Scientist (Plant Physiology), proposed the vote of thanks. The programme concluded with the National Anthem. A total of 70 participants took part in this programme.

In addition to the on-campus activities, the staff of ICAR-DCR actively participated in the online Reading of the Preamble at Constitution75.com and the online quiz hosted on MyGov.in. Certificates of participation were received for these activities.



14.10 World Soil Day

World Soil Day was celebrated on 5.12.2025. The theme of World Soil Day 2025 was "Healthy cities from Healthy Soils which shows that healthy and green cities are possible only if the soils are kept healthy.The Chief Guest of this year's World Soil Day was Dr C.A. Shreenivasa Murthy, Retired Professor and Head (Soil Science), UAS, GKVK, Bengaluru & Former Dean, CAU, Imphal, who spoke about soil management for successful Horticultural enterprises and ways to improve the productivity of horticultural crops, including cashew by nutrients and soil management.



Dr Venkatesh M.S., Principal Scientist (Soil Science) and co-ordinator of the event, in his welcome address, mentioned the background and history of the celebration of World Soil Day. Dr J. DinakaraAdiga, Director, ICAR-DCRin his presidential address mentioned the importance of healthy soils and organic management of soils. About 100 participants attended the event, and soil health cards were distributed to the farmers of Puttur and Sullia taluk. Two leaflets, viz., Nutrient management in cashew and green manuring in cashew orchards, were released during the function. A demonstration was conducted to show the farmers the scientific way of collecting soil samples in cashew orchards.

14.11 Kisan Diwas

Kisan Diwas was celebrated on 23rd December with a training cum input distribution programme organised by the Directorate, in collaboration with the Tribal Development Department and KVK, Kasaragod, for the Koraga community residing in Enmakaje Panchayat, Kasaragod district. The programme commenced with introductory remarks by Mrs Veena, Tribal Extension Officer, who highlighted the importance of livelihood-



oriented interventions for tribal communities. MrsSoudabi Haneef, Standing Committee Chairperson from the panchayat, briefed the participants about the importance of such programs in uplifting them and advised them to make the best use of such opportunities. Dr. Aswathy Chandrakumar, Scientist (Agricultural Extension), and nodal officer Tribal Sub Plan (TSP) briefed the participants about the newly launched Government initiative "Viksit Bharat – Guarantee Rozgar and Ajeevan Mission", focusing on employment and livelihood security. She also took a lecture on scientific cashew cultivation and informed the beneficiaries about the support and benefits available under the TSP scheme of the Directorate. Ms. Divya Shekhar, Young Professional, Agri Business Incubation (ABI) Centre, elaborated on the value-added products developed from cashew apple and introduced the participants to the activities and entrepreneurship support services offered by the ABI Centre.



As part of the programme, to support their livelihoods, agricultural inputs, including chainsaws, sprayers, palm climbers, and spray hoses, were distributed to the beneficiary households to enhance their income.The programme effectively combined capacity building, awareness creation, and input support, reinforcing the Directorate's commitment to inclusive agricultural development and livelihood enhancement of PVTG communities. A total of 40 participants attended the programme, including farmers and ST promoters.

14.12 Swachhta Hi Seva campaign 2025

The ICAR-Directorate of Cashew Research, Puttur, organized various activities as part of the Swachhata Hi Seva campaign 2025 from 17.09.2025 – 01.10.2025, based on the theme "Swachhotsava". The activities included webinars and workshops to sensitize the public about the importance of Cashew apple, walkathons, plantation drive, cleanliness drives, health camp for sanitation workers, distribution of PPE kits to farm staff and rangoli competitions. During the valedictory function, a talk on communicable diseases was delivered by Shri Yachcharesh V. H., Health Inspector, Urban Primary Health Centre, Puttur, who explained the causes, preventive measures, and significance of sanitation in controlling the spread of diseases. This was followed by a talk on health and hygiene by Smt. Lakshmi, Senior Primary Health Officer, Eshwaramagala.

14.13 Swachhta Special campaign 5.0

A special swachhta campaign 5.0 was organised at the Directorate from 2nd October, 2025 – 31st October, 2025. During the campaign, cleanliness drives and scrap disposal were initiated.



14.14 SwachhtaPakhwada 2025

The ICAR-Directorate of Cashew Research, Puttur organized SwachhtaPakhwada campaign from 16th December, 2025 – 31st December, 2025. The activities were planned and implemented according to the tentative activity schedule given from the council ensuring the active participation of ICAR-DCR staff, school students, youths and local residents of nearby villages. Various activities were organized which includes cleanliness drives within and outside the institute, pledge taking by the ICAR-DCR staff, local residents of villages and school students, short video contests and tagline competitions, awareness talks by experts and distribution of dustbins to local residents of nearby village for creating awareness on the importance of swachhta.



14.15 Participation of ICAR-DCR Contingent in South Zonal Sports Meet-2024

A total of 21 participants (18 Nos of men and 3 Nos. of women) from this Directorate had participated in ICAR South Zonal Sports Meet-2024 held at ICAR-Sugarcane Breeding Institute, Coimbatore, Tamil Nadu from 08.04.2025 to 11.04.2025. Mr. Prince Kumar,



Technician (T-1), has won three medals in the event viz., gold medal in 800 m race, silver medal in 1500 m race and bronze medal in high jump and also bagged the overall Individual Champion in athletics of South Zonal Sports Meet-2024 in Men's category. Dr. Bhagya H. P. Scientist (SPM&AP) has won silver medal in Discus throw. During the event, the retiring staff of this Directorate Sri. Nithianandan. K. R., Administrative Officer, Sri. Prakash G Bhat Chief Technical Officer and Sri. B. Kushalappa, Skilled Supporting Staff were felicitated in the valedictory program.

15. Distinguished Visitors

Sl. No	Name and Designation	Address	Date of Visit
1.	Dr. Himanshu Pathak, Hon'ble Secretary (DARE) and Director General of the Indian Council of Agricultural Research, New Delhi	ICAR, New Delhi	03.01.2025
2.	Dr V. B. Patel Assistant Director General (Fruits and Plantation Crops), Horticultural Science, Indian Council of Agricultural Research, New Delhi	ICAR, New Delhi	03.01.2026
3.	Dr. S.K. Singh, DDG (Horti.Science) ICAR, New Delhi	ICAR, New Delhi	06-01-2025
4.	Dr. M. Kochu Babu Former Director, IIOPR, Pedavengi, AP	IIOPR, Pedavengi, AP	16-01-2025
5.	Dr. R. P. Rai Ex head, CPCRI (ICAR)	IIOPR, Pedavengi, AP	03-02-2025
6.	Dr. James Jacob MD, PCK Ltd, Kerla & Farmers Director RRII Kerla	PCK Ltd, Kerla & Farmers Director RRII Kerla	31-01-2025
7.	Dr. C R Mehta Director CIAE, Bhopal	CIAE, Bhopal	11-03-2025
8.	Praveen Malik, CEO, Agrinnovate India Ltd, New Delhi	Agrinnovate India Ltd, New Delhi	11-03-2025

16. PERSONNEL

Research Management Position	
1. Dr. J. Dinakara Adiga	Director
Scientific	
1. Dr. T.N.Raviprasad	Principal Scientist (Agricultural Entomology)
2. Dr.D.Balasubramanian	Principal Scientist (Agricultural Structures and Processing Engineering)
3. Dr. M.S.Venkatesh	Principal Scientist (Soil Science)
4. Dr. Mohana G.S.	Principal Scientist (Genetics & Cytogenetic)
5. Dr. Eradasappa E	Principal Scientist (Plant Breeding)
6. Dr. K. Vanitha	Senior Scientist (Agricultural Entomology)
7. Dr. Siddanna Savadi	Senior Scientist (Plant Biochemistry)
8. Dr. Veena G.L.	Senior Scientist (Spices, Plantation, Medicinal & Aromatic Plants)
9. Dr. Babli Mog	Senior Scientist (Plant Physiology)
10. Dr. Rajashekara H	Senior Scientist (Plant Pathology)
11. Dr. V.Thondaiman	Senior Scientist (Spices, Plantation, Medicinal & Aromatic Plants)
12. Dr. H.P.Bhagya	Scientist (Spices, Plantation, Medicinal & Aromatic Plants)
13. Dr. Manjesh G.N	Scientist (Spices, Plantation, Medicinal & Aromatic Plants)
14. Dr. Manjunatha.K	Scientist (Farm Machinery & Power)
15. Dr. Aswathy Chandrakumar	Scientist (Agricultural Extension)
16. Dr. Jyoti Nishad	Scientist (Food Technology)
Technical	
1. Sri.N.Manikandan	Assistant Chief Technical Officer
2. Dr. Raghurama Kukkude	Assistant Chief Technical Officer
3. Sri. Ravishankar Prasad	Technical Officer
4. Sri. Ashvini Kumar Singh	Technician
5. Sri.Rahul Yadav	Technician
6. Sri. Lalan Kumar	Technician

Administration	
1. Sri. Pradeep Kumar Vasu	Administrative Officer
2. Sri. Ashwin G	Finance & Account Officer
3. Smt. M. Leela	Assistant Administrative Officer
4. Smt. Reshma K	Private Secretary
5. Sri. Umashankar	Assistant
6. Sri. Jayarajan.V. V	Upper Division Clerk
Skilled Supporting Staff	
1. Sri. N. Narayana Naik	
2. Sri. Vijaya Achari	
3. Sri. V. Sundara	
4. Sri. C.H. Hariya Naik	
5. Sri. K. Narayana	
6. Sri. S. Monappa	
7. Sri. B. Seetharama	
8. Sri. K. Gopalakrishna	
9. Smt. S. Kasturi	

Inter – Institutional Transfer with Promotion

1. Sri. Pradeep Kumar Vasu, AAO, from ICAR-CPCRI, Kasaragod with promotion to the post of Administrative Officer w.e.f. 26.05.2025.

Inter- Institutional Transfers -Join

1. Dr. Venkatesh. M.S, Principal Scientist Transferred from ICAR-IIPR, Dharwad and joined ICAR-DCR, Puttur on 23.06.2025.

Inter- Institutional Transfers – re-allocation

1. Sri. Prateek Tewari, Assistant was relieved from this Directorate 20.08.2025(AN), consequent on his transfer to ICAR-Indian Institute of Rice Research, (IIRR), Rajendranagar, Hyderabad.
2. Sri. Sandeep Joshi, Assistant was relieved from this Directorate 28.08.2025(AN), consequent on his transfer to ICAR-National Research Centre on Pomegranate, Solapur, Maharashtra

Inter- Institutional Transfers – Technical Resigned

1. Sri. Prince Kumar, Technician (T-1)-Technical Resignation from this Directorate on 26.12.2025 (AN).

Retirement

1. Sri. B. Narayana Poojari, SSS retired on superannuation w.e.f. 31.03.2025.
2. Sri. B. Babu Gowda, SSS retired on superannuation w.e.f. 30.04.2025.
3. Sri. Nithianandan. K. R., AO retired on superannuation w.e.f. 31.05.2025.
4. Sri. Prakash G Bhat, CTO retired on superannuation w.e.f. 31.05.2025.
5. Sri. B. Kushalappa, SSS retired on superannuation w.e.f. 31.05.2025.

Appointment

1. Sri. Prince Kumar, appointed as Technician (T-1) w.e.f.14.02.2025.
2. Dr. Veena. G.L, Scientist (Fruit Science) appointed in the post of Senior Scientist (Spices, Plantation, Medicinal & Aromatic Plants) in the Research Pay Level 13A w.e.f. 02.06.2025
3. Dr. Siddanna Savadi, Scientist (Agricultural Biotechnology) appointed in the post of Senior Scientist (Plant Biochemistry) in the Research Pay Level 13A w.e.f. 02.06.2025.

Promotion

1. Dr. E. Eradasappa, Senior Scientist (Plant Breeding) has been promoted from the Research pay level -13 A to the next higher grade of Principal Scientist Research pay level -14 w.e.f 26.02.2024.
2. Dr. Manjunatha .K, Scientist (Farm Machinery & Power) has been promoted from the Research pay level -10 to next higher grade Research pay level -11 w.e.f 07.01.2024.
3. Dr. Aswathy Chandrakumar, Scientist (Agricultural Extension) has been promoted from the Research pay level - 10 to next higher grade Research pay level-11 w.e.f 07.01.2024.

17. WEATHER DATA 2025

	Avg. Temp (°C)	Avg. RH (%)	Rainfall (mm)	Cumulative Rainfall (mm)
April	29.74	74.45	9.40	9.40
May	27.53	84.32	990.72	1000.12
June	25.95	90.76	805.17	1805.29
July	24.80	91.66	1110.92	2916.21
August	25.25	88.69	516.50	3432.71
September	26.24	84.85	327.60	3760.31
October	26.60	84.71	419.60	4179.91
November	27.28	77.71	33.90	4213.81

Due to a technical issue information for December not available.



Cashew Day-2025: Address by
Dr. Sanjay Kumar, Chairman, ASRB, New Delhi.



Interaction of Dr. C.R. Mehta, Director, ICAR-CIAE, Bhopal (M.P) during demonstration of 3 in 1 Cashew Apple and Nut Separator



Viskit Krishi Sankalp Abhiyan Programme - Pavagada, Tumkur, Karnataka



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किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

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