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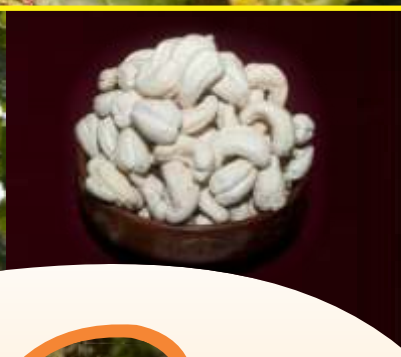
2017-18








भा.कृ.अनु.प.- काजू अनुसंधान निदेशालय

पुत्तूर 574 202, कर्नाटक

ICAR-Directorate of Cashew Research

Puttur - 574 202, Karnataka

Release of H-130, a jumbo nut hybrid by the dignitaries

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Back Cover : **Ultra high density planting in farmer's field**

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प्रस्तावना

मैं आईसीएआर- काजू अनुसंधान निदेशालय द्वारा की गई शोध प्रगति और उपलब्धियों पर प्रकाश डालने वाले काजू रिसर्च की वार्षिक रिपोर्ट 2017-18 लाने में प्रसन्न हूँ। आईसीएआर-डीसीआर काजू के गतिविधियाँ उत्पादकता, गुणवत्ता, प्रसंस्करण दक्षता और मूल्यवर्धन को बढ़ाने पर केंद्रित है। 2017-18 के दौरान, मूल्यांकन ब्लॉक में 11 जर्मप्लाज्म एक्सेसन्शामिल किया गया हैं। विशेषता वाली तीन अभिगमों के निरूपण पूरा करने के बाद उन्हें संरक्षण ब्लॉक में संरक्षित कर दि है। काजू में पहली बार, 61 अभिगमों का मूल संग्रह पहचान कर दिया गया है। इसके अलावा, 60 आम ईएसटी आधारित एसएसआर आर्थिक लक्षणों से जुड़े आण्विक मार्करों की पहचान के हिस्से के रूप में संश्लेषित किया गया हैं। एक जंबो काजू संकर जिसमें उच्च उपज और फूलों में सटीकता के साथ छंटनी के लिए सकारात्मक प्रतिक्रिया की पहचान की गई है, तथा किसानों के क्षेत्र में आगे के मूल्यांकन के लिए जारी किया गया हैं। बौने सह कॉम्पैक्ट हाइब्रिड, बौने सह उच्च उपज वाले प्रजनन, बड़े सेब सह उच्च उपज लाइनों और विभिन्न काजू खोल तरल सामग्री के साथ लाइनों के विकास में अच्छी प्रगति की गई है। चाय मच्छर बग (टीएमबी) सहिष्णु जीनोटाइप विकसित करने के लिए अनुसंधान कार्य शुरू किए गए हैं। इस परीक्षण के प्रयोजन के लिए, 30 संदर्भ किस्मों की स्थापना की गई है।

काजू में अल्ट्रा घनत्व रोपण तकनीक, वीआरआई-3, एनआरसीसी-2, के -22-01 और एच -130 जैसे पूर्ववर्ती काजू किस्मों का उपयोग से विकसित करके किसानों के क्षेत्र में प्रदर्शित किया गया है जिसके साथ 3 टन / हेक्टेयर की रिकॉर्ड उपज 3-4 साल में हो सकती है। बीबीसीएच पैमाने का उपयोग करके किए गए फेनोलॉजिकल अध्ययनों के परिणामस्वरूप काजू के प्रमुख विकास चरणों की पहचान हुई। विभिन्न काजू क्षेत्रों की मृदा पोषकों की स्थिति का मूल्यांकन तथा पोषक नैदानिक मानदंड स्थापित किया गया है। मिट्टी नमी संरक्षण प्रथाओं को अपनाने से काजू की पैदावार 12.9% बढ़ सकती है। मेटारिज़ियम एनीसोप्लीया प्रयोगशाला में सीएसआरबी ग्रब्स में 100 प्रतिशत मृत्यु दर का कारण बन सकती है। फेरोमोन जाल पर प्रयोग में, उद्भव के 4 और 5 दिनों की उम्र के टीएमबी मादा ने नर को अधिकतम प्रतिक्रिया प्राप्त की और सिलेंडर चिपचिपा जाल की दक्षता डेल्टा चिपचिपा जाल की तुलना में अधिक थी। प्रयोगशाला में, थियैमेथेक्सॉम टीएमबी के खिलाफ लैम्ब्डा सिहलोथ्रिन के बराबर था, और सीएसआरबी के खिलाफ क्लोरपीरिफोस के साथ इमिडाक्लोप्रिड था। दो आम जंगली मधुमक्खी के घोंसले के व्यवहार का अध्ययन किया गया था और कृत्रिम मधुमक्खियों के घोंसले को मधुमक्खियों द्वारा सफलतापूर्वक कब्जा कर लिया गया है। इनफ्लोरसेन्स कीटों का नुकसान 7-9% था। छः कठायी उपरांत प्रौद्योगिकियों को एमओयू के साथ मे॥ प्रो बी प्रोडक्ट्स, बैंगलोर में वाणिज्यिकीकृत किया गया है। संस्थान की लोगो ट्रेडमार्क के रूप में पंजीकृत किया गया है। कच्चे काजू की इंगित करने वाला एक प्रयोगसिद्ध संबंध विकसित किया गया है। मूल्यवर्धित काजू सेब उत्पादों का मूल्यांकन उनके पोषक तत्व संरचना और भंडारण जीवन के लिए किया गया है।

डिफैटेड सोयाबीन (2%) काजू सेब के रस में टैनिन को कम करने में प्रभावी पाया गया है। प्रौद्योगिकी कार्यक्रमों के हस्तांतरण के तहत, काजू की खेती को प्रोत्साहित करने के लिए 71 टीएसपी किसानों को तकनीकी मार्गदर्शन और वित्तीय सहायता प्रदान की गई। नर्सरी प्रबंधन और काजू उत्पादन प्रौद्योगिकी पर प्रशिक्षण कार्यक्रम आयोजित किए गए हैं। विश्व पर्यावरण दिवस, विश्व मिट्टी दिवस, डीसीआर स्थापना दिवस और कृषि शिक्षा दिवस निदेशालय में मनाया गया।।

वर्ष के दौरान, डीसीआर ने प्रदर्शनी, किसान मेला और बागवानी मेले में भाग लिया । इसके अलावा, किसानों को कुलीन किस्मों के 4.25 लाख काजू के कलमों को प्रदान किए गए है। काजू की खेती पर तकनीकी सलाह किसानों और परिदर्शकों को दी गई है।

मैं समग्र शोध उपलब्धियाँ और वार्षिक रिपोर्ट 2017-18 प्रस्तुत करने के लिए संपादकीय समिति के सदस्यों को, उनके योगदान के लिए सभी डीसीआर कर्मचारियों को बहुत आभारी हूँ।

स्थान : पुत्तूर, कर्नाटक
दिनांक: 15 जून 2018

(एम. जी. नायक)
निदेशक (प्रभारी)

PREFACE

I am glad to bring out the Annual Report 2017-18 of ICAR-Directorate of Cashew Research, Puttur, highlighting the research progress and achievements made by this Directorate. ICAR-DCR focuses on enhancing productivity, quality, processing efficiency and value addition of cashew. During 2017-18, 11 germplasm accessions are included in the evaluation block. The characterization is completed for three accessions and they are conserved in the conservation block. For the first time in cashew, a core collection of 61 accessions was identified. Further, efforts are being to develop molecular markers suitable for characterisation of germplasm and marker trait association. A Jumbo nut hybrid having high yield and precocity in flowering with positive response for pruning has been identified and released for further evaluation in farmers' field. Good progress has been made in development of dwarf & compact hybrids, dwarf & high yielding progenies, identification of large apple cum high yielding lines and lines with varied cashew nut shell liquid content. Research works have been initiated to develop Tea Mosquito Bug (TMB) tolerant genotypes. For the purpose of DUS testing, 30 reference varieties have been established.

Ultra density planting in cashew using precocious cashew varieties such as VRI-3, NRCC Sel-2, K-22-1 and H-130 was developed and demonstrated in farmers' field with which a record yield of more than 3 tonnes/ha could be achieved in 3-4 years. Phenological studies carried out using BBCH scale resulted in identification of principal growth stages of cashew. Soil nutrient status of different cashew growing regions was assessed to establish nutrient diagnostic norms. Adoption of soil moisture conservation practices can increase cashew nut yield by 12.9 %. *Metarhizium anisopliae* could cause complete mortality in CSRB grubs in lab. In the experiment on pheromone traps, virgin TMB females aged 4 and 5 days after emergence elicited maximum response to males and the efficiency of cylinder sticky trap was more compared to delta sticky traps. In lab, thiamethaxom was on par with lambda cyhalothrin against TMB, and imidacloprid with chlorpyriphos against CSRB. Nesting behaviour of two common wild bees was studied and artificial bee nests designed were successfully occupied by the bees. The level of inflorescence pests damage was to the tune of 7-9 per cent. Six post harvest technologies were commercialized with a MoU to M/s Pro B Products, Bengaluru. Institute logo was registered as trademark. An empirical relationship to represent the quality of raw cashewnuts was developed. Value added cashew apple products were assessed for their nutrient composition and storage life. Defatted soybean meal (2%) was effective in reducing the tannin content in cashew apple juice. Under transfer of technology programs, technical guidance and financial assistance was extended to 71 TSP farmers for encouraging cashew cultivation. The training programs on nursery management and cashew production technology were conducted. World environment day, World soil day, DCR foundation day and Agricultural education day were celebrated at the directorate. During the year, DCR had participated in the exhibitions, Kisan Melas and Horticulture fairs. Further, 4.25 lakhs of cashew grafts of elite varieties were supplied to farmers. Technological advice on cashew cultivation was given to farmers and visitors.

I am highly thankful to all DCR staff for their contribution in overall research achievements and members of Editorial Committee in bringing out the Annual Report 2017-18 in time.

Place : ICAR-DCR, Puttur
Date : 15th June, 2018

(M. Gangadhara Nayak)
Director (Acting)

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INTRODUCTION

Research on cashew was first initiated in the early 1950s with Indian Council of Agricultural Research (ICAR), sanctioning ad-hoc schemes for Research Centres located at Kottarakkara (Kerala), Ullal (Karnataka), Bapatla (Andhra Pradesh), Daregaon (Assam) and Vengurla (Maharashtra). In 1971, ICAR started sanctioned All India Coordinated Spices and Cashew Improvement Project (AICS and CIP) with its Headquarters located at CPCRI, Kasaragod. The CPCRI Regional Station, Vittal (Karnataka) was given the mandate to carry out research work on cashew while four centres under Universities (Bapatla, Vridhachalam, Anakkayam and Vengurla) were assigned the research component on cashew under AICS and CIP. During the V and VI plan periods, three more centres (Bhubaneswar, Jhargram and Chintamani) came under the fold of AICS and CIP and with shifting of research work of Anakkayam centre to Madakkathara. The recommendations made by the Quinquennial Review Team (QRT) constituted by ICAR in 1982, working group on Agricultural Research and Education constituted by the Planning Commission for VII Plan Proposals and the Task Force on Horticulture constituted by ICAR resulted in the establishment of National Research Centre for Cashew at Puttur on June 18, 1986 which was upgraded and renamed by ICAR in 2009 under XI Plan as **ICAR-Directorate of Cashew Research (ICAR-DCR)**. Subsequent to the bifurcation of AICS and CIP, the Headquarters of All India Coordinated Research Project on Cashew was shifted to ICAR-DCR, Puttur. At present, this Coordinated Research Project is operating at 14 centres distributed in major cashew growing areas of the country.

The main campus of ICAR-DCR is situated 5 km away from Puttur town at Mottethadka village of Kemminje (12.45^{o} N latitude, 75.15^{o} E longitude and 90 m above MSL). The main campus has an area of 68 ha with an administrative block, laboratories & field experimental plots. Besides, ICAR-DCR as an Experimental Station at Shantigodu, located 13 km away from the main campus and has an area of 80 ha. At main campus, the Horticulture, Soil Science, Plant Breeding, Plant Physiology, Biotechnology, Plant Protection, Post Harvest Management and Audio-Visual Laboratory sections with laboratories have been established. Besides, Project Coordination Cell of AICRP on Cashew, PME Cell, ITMU, AKMU, Museum etc are also established.

The Directorate has got well-established library in the field of cashew research. The library is serving as an Information Centre on all aspects of cashew research and development in the country. The CD database *viz.,* CABHORT, CABPEST, AGRICOLA and AGRIS, SOIL CD, CROP CD, PLANTGENE CD and TROPAG CD and online CAB database, are also available. The library is equipped with automation software and bar coding facility. The library has 1920 books and 2030 back volumes of various journals. The library subscribes 35 national and 9 international journals. The library is a member of Consortium of Electronic Resources on Agriculture (CeRA), New Delhi. Tech-Focuz digital library software is also available for CD database search.

Vision

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

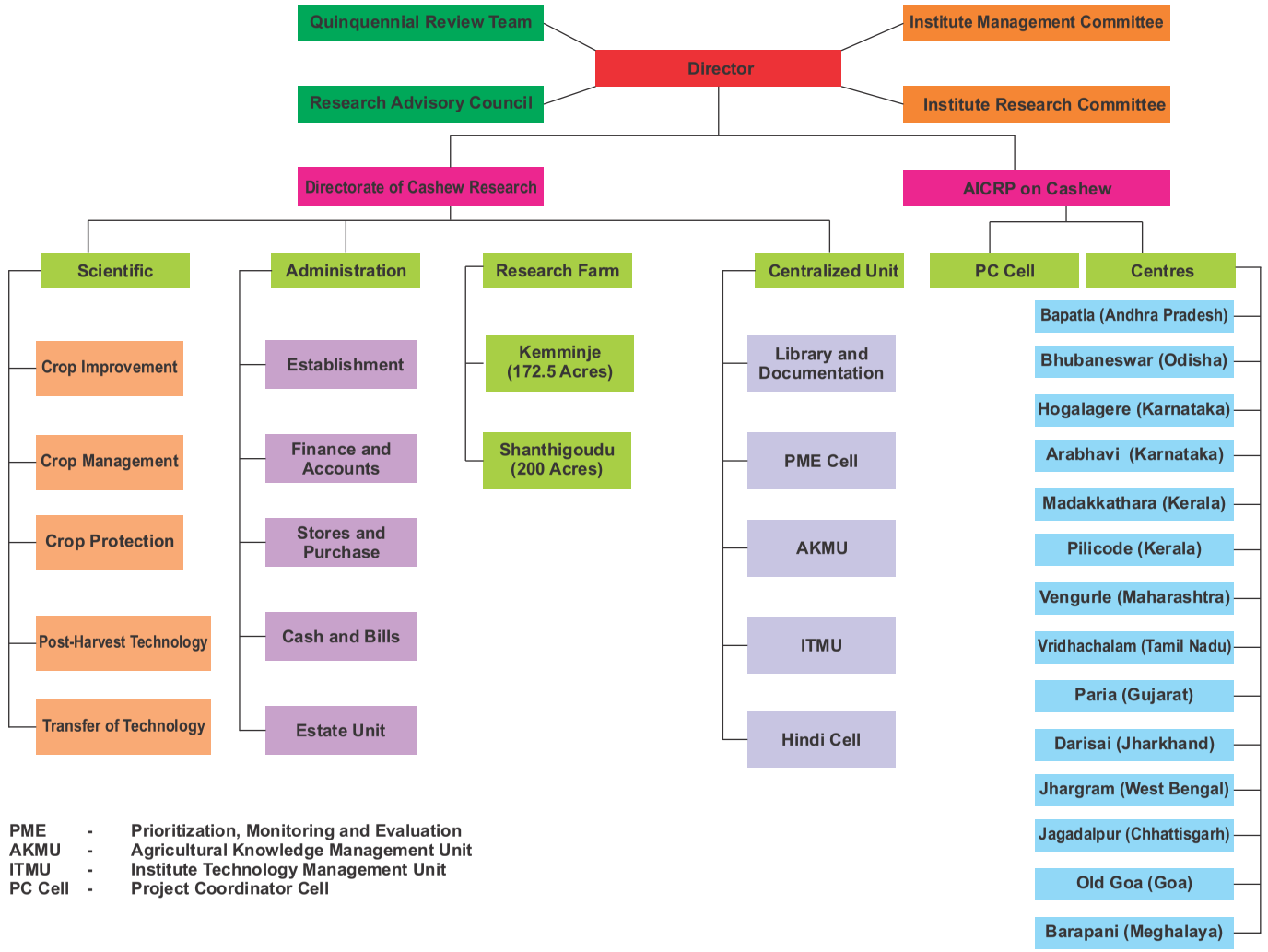
Mission

- To promote overall growth through 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 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 transfer of technology and consultancy services to stakeholders.

Organogram of ICAR-Directorate of Cashew Research



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

कार्यकारी सारांश

आईसीएआर-काजू अनुसंधान निदेशालय देश में काजू उत्पादन और उत्पादकता में सुधार के लिए अनुसंधान और विस्तार गतिविधियों का आयोजन करता है। वर्ष 2017-18 के दौरान, जर्मप्लाज्म संग्रह, मूल्यांकन और संरक्षण, काजू के आनुवंशिक सुधार, एकीकृत जल और पोषक प्रबंधन, फिनोलॉजी, एकीकृत कीट और रोग प्रबंधन, कटाई उपरांत भंडारण और प्रसंस्करण और ज्ञान प्रबंधन पर संस्थान परियोजनाएं प्रगति में है । काजू के महत्वपूर्ण कीटों और दो बाह्य वित्त पोषित परियोजनाओं पर एक प्रमुख कार्यक्रम भी वर्ष के दौरान प्रगति में है ।

पश्चिम बंगाल और झारखंड राज्य में किए गए जर्मप्लाज्म सर्वेक्षण के परिणामस्वरूप एक विपुल जीनोटाइप और सेमीकार्पस एनाकार्डियम का प्रवेश हुआ है। पहले एकत्र किए गए ग्यारह अभिगम मूल्यांकन ब्लॉक में लगाए गए हैं। काजू वर्णनकर्ताओं के अनुसार मूल्यांकन और विशेषता के तीन अभिगम संरक्षण ब्लॉक में शामिल किए गए हैं। इसके अलावा, काजू में पहली बार, 478 अभिगम से 61 अभिगमों का मूल संग्रह अनुमानी दृष्टिकोण के साथ अग्रिम अधिकतमता रणनीति के बाद पहुंचा था और इस संग्रह को क्षेत्र में स्थापित किया गया है। इसके अलावा, 61 जर्मप्लाज्म अभिगमों की सीएनएसएल का अनुमान लगाया गया है। काजू सेब का उपज और गुणों के लिए काजू जर्मप्लाज्म के मूल्यांकन पर परियोजना में चौदह अभिगमों का मूल्यांकन किया गया है।

एक जंबो नट संकर, जिसमें प्रजनन के लिए सकारात्मक प्रतिक्रिया के साथ फूलों में उच्च उपज और सटीकता होती है, की पहचान की गई है तथा किसानों के क्षेत्र में आगे के मूल्यांकन के लिए जारी किया गया। हाइब्रिड, छंटाई केलिए अच्छी प्रतिक्रिया के कारण अल्ट्रा घनत्व रोपण के लिए बेहद उपयुक्त है। शेलिंग प्रतिशत डब्ल्यू -130 से डब्ल्यू -150 के कर्नेल ग्रेड के साथ काफी अधिक (29.9%) है जो जारी जत्युपयोगी किस्मों में एक अनूठी विशेषता है। लक्षणों से जुड़े आण्विक मार्करों की पहचान पर परियोजना में, काजू, बादाम, पिस्ता और मैंगो से जुडे 138 एसएसआर प्राइमरों को पोषकों में और उल्लाल -3 x एनआरसी -492 की एफ-1 आबादी में देखा गया था और इनमें से 39 बहुरूपी पाये गए हैं। फेनोटाइपिंग के हिस्से के रूप में 84 प्रजनन पर 12 वनस्पति और प्रजनन पात्रों के लिए आकारिकीय अवलोकन दर्ज किए गए हैं। नए आण्विक मार्करों को विकसित करने के लिए, 60 आम ईएसटी आधारित एसएसआर संश्लेषित किए गए हैं और इनका मूल्यांकन उनके हस्तांतरण और आनुवंशिक विश्लेषण के लिए किया जाएगा। बौने और उच्च पैदावार वाली किस्मों के विकास के लिए, 15 बौने x लंबा क्रॉस से 27 आशाजनक अभिगम पाय गए थे। ब्याक क्रॉस प्रजनन प्रयासों में, 471 संतानों में से तेरह आशाजनक अभिगम की पहचान की गई है। क्लस्टर असर जीनोटाइप में काजू के आकार में सुधार के लिए नए क्रॉस (15) किए गए हैं। चाय मच्छर बग (टीएमबी) सहिष्णुता के साथ संभावित सामग्री विकसित करने के लिए व्यापक संकरकरण और जीनोटाइप पैदा करने के संतान से जुड़े पूर्ववर्ती प्रयास किए गए हैं। टीएमबी सहिष्णु जीनोटाइप के विकास के लिए उत्परिवर्तन प्रजनन परियोजना में, दो लोकप्रिय किस्मों के बीज और सयान स्टिक, भास्कर और उल्लाल-3 को गामा किरणों के संपर्क में लाया गया था और मूल्यांकन के लिए मुख्य क्षेत्र में स्थापित किए गए हैं। डस परियोजना के हिस्से के रूप में, डस परीक्षण के उद्देश्य के लिए तीस 'रेफरेन्स वेरैटी' स्थापित की गई हैं।

काजू में अल्ट्रा घनत्व रोपण तकनिक, वीआरआई -3, एनआरसीसी -2, के -22-01 और एच -130 जैसे पूर्ववर्ती काजू किस्मों का उपयोग करके विकसित किया गया और किसानों के क्षेत्र में प्रदर्शित किया गया है। जिसके साथ 3-4 साल में 3 टन / हेक्टेयर की रिकॉर्ड उपज हो सकती है। इस तकनीक ने, प्रारंभिक वर्षों में कच्चे काजू के उत्पादन में सुधार के लिए जबरदस्त क्षमता दिखाई है। बीबीसीएच पैमाने का उपयोग करते हुए उल्लाल -3 और भास्कर में फेनोलॉजिकल अध्ययन किए गए। अध्ययन आठ प्रमुख विकास चरणों में समाप्त हुआ और इन चरणों में से प्रत्येक के भीतर, विभिन्न माध्यमिक चरणों की पहचान की गई और छवियों के साथ दस्तावेज किया गया। काजू में पोषक नैदानिक मानदंड स्थापित करने के लिए, विभिन्न काजू उगाने वाले क्षेत्रों की मिट्टी पोषक तत्व की स्थिति का आकलन किया गया था। तदनुसार, यह पाया गया कि तमिलनाडु के विरदाचलम में मिट्टी के काजू बढ़ते क्षेत्रों में जैविक कार्बन, नाइट्रोजन और पोटेशियम की कमी थी। Zn औरCu की स्पोरैडिक कमी के साथ Fe और Mn जैसे सूक्ष्म पोषक तत्व पर्याप्त पाया गया । वर्ष के दौरान, उपज और गुणवत्ता में वृद्धी के लिए बागवानी फसलों में सूक्ष्म पोषक प्रबंधन पर आईसीएआर नेटवर्क परियोजना का निष्कर्ष निकाला गया।

सी.एस.आर.बी कीडों का मरणशीलता पर एंटेमोपेतोजनिक फंगस मेटारैज़म एनिसोपिले के उग्रता मूल्यांकन करने से यह मालूम पडा कि इसे स्थानिय स्तर पर लगाने से 15 दिन में शत प्रतिशत मरणशीलता और छाल द्वारा स्पोर्स लगाने से 21 दिन में शत प्रतिशत मरणशीलता प्राप्त होता है। टी.एम.बी. प्रंबंधन में सेमियो केमिकल का प्रभाव का अध्ययन में यह देखने में आया कि 4-5 दिने के वर्जिन टी.एम.बी. फीमेल कीडों ने जब उन्हें डेल्टा स्टिकि ट्राप में जीवित चारा के रूपमें उपयोग किया गया, सबसे ज्यादा प्रतिक्रिया दिखाया ।

डेल्टा स्टिकि ट्राप को सिलिंड्रिकल रूप देने से उनका दक्षता बढ़ाया गया। टी.एम.बी. के रासायनिक प्रबंधन संबंध में यह देखा गया कि तयोमिथोक्साम, पहले से सिफारिष की गई लाम्बडा सैलोत्रिन के बराबर काम करती है। सी.एस.आर.बी के संदर्भ में यह देखा गया है कि इमिडाक्लोरोपिड, पहले से सिफारिश की गई क्लोरफारीफास के बराबर काम करती है। काजू के दो मुख्य पोल्लिनेटिंग मधुमक्कियों, सेरोटिना हीरोग्लाय्फिका और बौनासपीस पिकिटारसस् के अध्ययन किया गया। अपिस सेश्ना मधुमक्किकयों का भी काजू बागानों में कार्य निष्पादन अध्ययन किया गया और उनका मधु का गुण्वत्ता उत्कृष्ट पाया गया। कृतक 'बी नेस्ट' बनाया गया और उनमें जंगली मधुमक्की भी अच्छे तरह से रहना देखा गया। काजू के इनफ्लोरेसेन्स पेस्ट का अध्ययन किया गया और इस वर्ष 7-9% इनफेस्टेशन लेवेल दर्ज किया गया।

इस निदेशालय में विकासित छे कटाई उपरांत प्रौध्योगिकियों को नान् एक्सक्लूसिव लैसेन्सिंग के आधार पर यंत्रोंका उत्पादक कंपनि मे॥ प्रो बी प्राडक्ट्स, बेंगलोर के साथ एम.ओ.यु करते हुए वाणिज्यकरण के लिए दिया गया है। संस्थान के लोगो को 'ट्रेड मार्क' के रुप में दर्ज कराने की कोशिश किया गया। कच्चा काजू के लिए गुणवत्ता मानदंड, प्राजेक्ट में यह देखा गया कि 'वेंगुर्ला-7' किस्म के 91 बीज एक किलो तोलता है और 'अनघा' किस्म के 250 बीज एक किलो तोलता है। वैसे ही, औट्टर्न के मामले में वी.आर.आई-cw (62%) सबसे ज्यादा और 'राघव' (45.4%) सबसे कम पाया गया। काजू के कच्चा बीजों का गुणवत्ता प्रतिनिधित्व करने वाले एक एंपेरिकल रिलेश्नशिप को विकास किया गया। काजू फल का यांत्रीकृत स्लैसर विकास करने का एक प्राजेक्ट में, काजू फल को स्लैज करने केलिए 'स्ट्रिंग और स्टागर्ड डिस्क टाइप स्लैसर' का उपयोग करने का कोशिश किया गया। भारत में काजू प्रोसेसिंग का तुलनात्मक निष्पादन, अध्ययन में यह पाया गया कि प्रासेसिंग का खर्चा, मानव श्रम से किया गया प्रासेसिंग में रु 1200/- से रु 1400/- और यांत्रीकृत प्रसेसिंग में रु 1700/- से रु 2000/- प्रति ब्याग (80 किलो कच्चा बीज) रहा।

इस वर्ष काजू फलों से बनाया नवीन मूल्यवर्धित उत्पादों जैसे पल्प, ज्याम, जेल्ली, केश लैम और सैडर का पोषकांश घटकों के बारे में और उनके सुरक्षित संचयन समय के बारे में अध्ययन किया गया। काजू फलों के रस के उपयोग करते समय आने वाली सबसे बडी समस्या है उनमें स्थित “एस्ट्रिंजेन्सी”, जो रस में अधिकांश में स्थित 'टेनिन' के कारण है। रस में स्थित टेनिन कम करने की प्रयोग में यह देखा गया कि डिफेटेड सोयाबीन मील (2%), सूखा आलू पाउडर (28.6% कम करता है) और बाज़ा पाउडर (24.0% कम करता है) के तुलना में सबसे ज्यादा बेहतर (34.3% कम करता है) पाया गया।

प्रौध्योगिकि हस्तांतरण के अंतर्गत, ट्रैबल सब प्लान से संबंधित कृषकों के खेतियों का भेंट किया गया और उन्हें प्रोत्साह देने के लिए 71 कृषकों को आर्थिक सहायता दिया गया। नर्सरी प्रबंधन और काजू उत्पादन तकनीकी के बारे में प्रशिक्षण वर्ग चलाया गया। उन कृषकों के लिए एक शैक्षणिक परिभ्रमण भी केरला केलिए आयोजन किया गया था। जागतिक परिसर दिवस, जागतिक मृदा दिवस, कृषि शैक्षणिक दिवस, डी सी आर स्थापना दिवस मनाया गया। डी सी आर ने अनेक प्रदर्शनी जैसे 'वर्ड फुड इंडिया - 2017', नई दिल्ली, सी पी सी आर आई कासरगोड में आयोजित 'मेगा किसान मेला और कृषि उध्यम मेला - 2018', आई.आई.एच.आर, बेंगलूरू द्वारा आयोजित “मेगा हार्टिकल्चर फेर - 2018”, में भाग लिया। “मेरा गाँव - मेरा गौरव” कार्यक्रम इर्दे-बेट्टंपाडी और अलेट्टी ग्रामों में आयोजन किया गया। खेती दिवस और मृदा स्वास्थ्य प्रबंधन के बारे में जागरुकता कार्यक्रम पुत्तूर तालूक के अनेक ग्रामों में आयोजन किया गया। इस वर्ष ए.आई.सी.आर.पी - काजू के कार्यशाला भी इस निदेशालय में आयोजन किया गया। 4.25 लाख काजू कलमें किसानों को बेचा गया। डी.सी.आर के वेब साइट को फेस बुक और ट्विटर अकौंट के साथ साथ निरंतर अप्डेट किया गया।

EXECUTIVE SUMMARY

ICAR- Directorate of Cashew Research, Puttur conducts research and extension activities for improving cashew production and productivity in the country. During the year 2017-18, institute projects on germplasm collection, evaluation and conservation, genetic improvement of cashew, integrated water and nutrient management, phenology, integrated pest and disease management, post harvest storage and processing and knowledge management and under progress. One flagship program on important pests of cashew and two externally funded projects are also in progress during the year.

The germplasm survey conducted in West Bengal and Jharkhand state has resulted in collection of one profuse bearing genotype and an accession of *Semicarpus anacardium*. Eleven accessions collected earlier have been planted in the evaluation block. Three accessions which are evaluated and characterized as per cashew descriptors were included in the conservation block. Further, for the first time in cashew, a core collection of 61 accessions from 478 accessions was arrived following advance maximization strategy with heuristic approach and this collection has been established in the field. Further, CNSL content of 61 germplasm accessions has been estimated. Fourteen accessions have been evaluated in the project on evaluation of cashew germplasm for apple yield and quality traits.

A jumbo nut hybrid H-130 having high yield and precocity in flowering with positive response for pruning has been identified and released for further evaluation in farmers' field. The hybrid is highly suitable for ultra density planting due to its good response to pruning. The shelling percentage is quite high (29.9%) with kernel grade of W-130 which is a unique feature among the released varieties. In the project on identification of molecular markers linked to economic traits, 138 SSR primers from Cashew, Almond, Pistachio and Mango were screened in parents and the F_1 population of Ullal-3 x NRC-492, and out of these, 39 were found to be polymorphic. The morphological observations were recorded for 12 vegetative and reproductive characters on 84 progenies as part of phenotyping. In order to develop new molecular markers, 60 mango EST based SSRs have been synthesized and these will be evaluated for their transferability and genetic analysis in cashew. Towards development of dwarf and high yielding varieties, 27 promising accessions were selected from 15 dwarf x tall crosses. In back cross breeding efforts, 13 promising accessions are identified out of 471 progenies. New crosses (15) have been made for improving nut size in cluster bearing genotypes. Prebreeding efforts involving the progeny of wide hybridization and cultivated genotypes were carried out to develop potential material with Tea Mosquito Bug (TMB) tolerance. In mutation breeding project for developing TMB tolerant genotypes, the seeds and scion sticks of two popular varieties i.e. Bhaskara and Ullal-3 were exposed to gamma rays and the seedlings are established in the main field for evaluation. As part of the DUS project, 30 reference varieties for the purpose of DUS testing have been established.

Ultra density planting in cashew using precocious cashew varieties such as VRI-3, NRCC Sel-2, K-22-01 and H-130 was developed and demonstrated in farmers field with which a record yield of more than 3 tonnes/ha could be achieved in 3-4 years. The technique has shown tremendous potential for improvement of raw cashewnut production in the early years. Phenological studies were carried out in cashew cultivars Ullal-3 and Bhaskara using BBCH scale. The study culminated in eight principal growth stages and within each of these stages, different secondary stages were identified and documented with images. In order to establish nutrient diagnostic norms in cashew, the soil nutrient status of different cashew growing regions was assessed. Accordingly, it was found that the soils of cashew growing areas in Vridhachalam, Tamil Nadu were deficient in organic carbon, nitrogen and potassium. The micronutrients such as Fe and Mn were sufficient,

with sporadic deficiency of Zn and Cu. During the year, the ICAR network project on micronutrient management in horticultural crops for enhancing yield and quality was concluded.

Evaluation of entomopathogenic fungus, *Metarhizium anisopliae* for its virulence in causing mortality of CSRB grubs revealed that it could cause 100% mortality within 15 days after treatment of topical application and 21 days of application of spores through bark as feed. In the investigations on semio-chemicals for management of TMB, it was found that virgin TMB females aged 4 and 5 days after emergence elicited maximum response when they were used as live bait in Delta sticky traps. The efficiency of sticky trap was increased by modifying the trap into cylinder form with the total sticky outer surface. As chemical management of TMB is concerned, thiamethoxam was on par with the recommended insecticide lambda cyhalothrin. In case of CSRB, imidacloprid was on par with the recommended insecticide chlorpyriphos. The nesting behaviour and life cycle of two important pollinating wild bees of cashew *viz., Ceratina hieroglyphica* and *Braunsapis picitarsus* were studied. Performance of *Apis cerana* bees in cashew ecosystem was also studied and its honey quality was found superior. Artificial bee nests were designed and found to be successfully occupied by wild bees. The inflorescence pests of cashew were documented and it was observed that about 7-9 % infestation levels this year.

Six post harvest technologies developed at this Directorate were commercialized with a MoU with the M/s Pro B Products, Bengaluru on the basis of non-exclusive licensing. Further, efforts were taken to register institute logo as trademark. In the project on developing quality standards for raw cashewnuts, it was observed that among the varieties tested, 'Vengurla-7' recorded 91 nuts per kg (minimum) and 'Anagha' registered maximum of 250 nuts per kg (maximum). As far as outturn is concerned, 'VRI-Cw' (62%) observed to be the highest and 'Raghav' (45.4%) found to the lowest. An empirical relationship was developed to represent the quality of raw cashewnuts. In the project on design and development of mechanized slicer for cashew apple, an attempt was made to slice cashew apple using string and staggered disc type cashew apple slicer. The studies on comparative performance of cashewnut processing systems in India revealed that that cost of processing ranged between Rs. 1200-1400 for labour oriented processing and in the range of Rs. 1700-2000 per bag of 80 kg raw cashew nuts depending upon the level of mechanization in the processing line.

During the year, the new value added products of cashew apple such as pulp, jam, jelly, cashlime and cider were assessed for their nutrient composition and storage life. The major problem in cashew apple utilization is its high astringency due to presence of tannins in juice. In the experiment to reduce tannin content of juice with low cost food grade materials, it was found that defatted soybean meal (2%) is more effective in reducing tannin (34.3% reduction) compared to dried potato powder (28.6%) and Bajra flour (24.0%).

Under transfer of technology programs, visits were made to fields of Tribal Sub Plan (TSP) beneficiaries and financial assistance was given to 71 farmers for encouraging and adopting the technologies in cashew cultivation. Training programs on nursery management and cashew production technology were conducted. An educational tour of tribal farmers to Kerala was also organised. World Environment Day, World Soil Day, DCR Foundation Day and Agricultural Education Day were celebrated. The DCR participated in several exhibitions *viz.,* World Food India-2017 at New Delhi, Mega Kisan mela and Agri-business expo-2018 at CPCRI, Kasargod, Mega National Horticulture fair-2018 at IIHR, Bengaluru. Mera Gaon Mera Gaurav program was conducted in Irde-Bettampady and Aletti villages. A field day and awareness program on soil health management was conducted in different villages of Puttur taluk in Dakshina Kannada. AICRP cashew workshop was also conducted at the Directorate during the year. Further, 4.25 lakhs of cashew grafts were sold to farmers. The website of DCR was continuously updated along with facebook and twitter accounts for online dissemination of information.

RESEARCH ACHIEVEMENTS

1. CROP IMPROVEMENT

1.1 Genetic Resources of Cashew

1.1.1 Germplasm survey and collection

During the year 2017-18, germplasm survey was conducted in different villages of West Bengal and Jharkhand states. A total of two germplasm accessions - one accession of *Anacardium occidentale* with profuse bearing from germplasm block in Jhargram i.e. JGM-282 (Fig. 1.2) and another accession of *Semicarpus anacardium* in a village near Darisai were identified (Fig. 1.3) and collected during the survey.

Fig. 1.1: Glimpses of germplasm survey in West Bengal and Jharkhand

Fig. 1.2: JGM-282 germplasm accession collected during survey

Fig. 1.3: An accession of *Semicarpus anacardium* collected during survey

1.1.2 Germplasm conservation

The planting material of new collections was prepared in order to include in evaluation block of National Cashew Field Gene Bank (NCFGB). The 63 plants comprising of 11 genotypes were planted in National Active Germplasm site for evaluation, conservation and characterization. Genotypes included are RFRS-171, RFRS-172, Indira Kaju, Bali-2, G-1, G-2, CARS-25, Vengurla-9 etc.

1.1.3 Germplasm evaluation

Three accessions planted during 2006-07 were evaluated, characterized and grouped as per IPGRI descriptors during the season (Table 1.1). All the accessions evaluated have upright and open canopy with extensive branching behavior and are mid season flowering types with red colour new flushes. Two accessions have tight attachment of nut to apple and one has loose attachment. One accession has high nut weight (>7 g) and remaining accessions have intermediate nut weight (5-7 g), but all three accessions have intermediate shell thickness (2.5-4.0 mm) and medium apple to nut ratio (6-12). Shelling percentage is intermediate (18-28%) in two accessions and high (>28%) in one accession. All accessions have intermediate kernel weight (1.2-2.5 g) and medium flowering duration (60-90 days). Two accessions have recorded low cumulative yield (<9.0 kg), while one has medium cumulative yield (9-18 kg) in 6 annual harvests.

Table 1.1: Details of accessions characterized during the fruiting season in the year 2017

Data Field	Descriptor	Descriptor State		No. of Accessions
7	Tree habit	3	Upright and compact	0
		5	Upright and open	3
		7	Spreading	0
9	Leaf shape	1	Oblong	0
		2	Obovate (Club-shaped)	3
		3	Oval	0
16	Branching pattern	1	Extensive	3
		2	Intensive	0
19	Colour of young leaves	1	Red	3
		2	Yellow red	0
		3	Green red	0
		4	Purple	0
28	Season of flowering	3	Early (Nov-Dec)	0
		5	Mid (Dec-Jan)	3
		7	Late (Jan-Feb)	0
31	Mature cashew apple colour	1	Yellow	1
		2	Red	1
		3	Yellow red	1
		4	Red purple	0
32	Shape of cashew apple	1	Cylindrical	2
		2	Conical-obovate	1
		3	Round	0
		4	Pyriform	0
50	Attachment of nut to cashew apple	3	Loose	1
		5	Intermediate	2
		7	Tight	0
35	Nut weight	3	Low (<5 g)	0
		5	Intermediate (5-7 g)	2
		7	High (>7 g)	1
43	Weight of cashew apple	3	Low (<27 g)	0
		5	Medium (27-52 g)	2
		7	High (>52 g)	1
60	Flowering duration	3	Short (<60 days)	0

Data Field	Descriptor	Descriptor State	No. of Accessions
		5 Medium (60-90 days)	3
		7 Long (>90 days)	0
62	Apple to nut ratio	3 Low (<6)	0
		5 Medium (6-12)	3
		7 High (>12)	0
63	Shelling percentage	3 Low (<18 %)	0
		5 Intermediate (18-28 %)	2
		7 High (>28%)	1
64	Kernel weight	3 Low (<1.2 g)	0
		5 Intermediate (1.2-2.5 g)	3
		7 High (>2.5 g)	0
57	Shell thickness	3 Thin (<2.5 mm)	0
		5 Intermediate (2.5-4.0 mm)	3
		7 Thick (>4.0 mm)	0
65	Attachment of peel to kernel	3 Loose	3
		7 Tight	0
68	Cumulative yield per plant (6 annual harvests)	3 Low (<9 kg)	2
		5 Medium (9-18 kg)	1
		7 High (>18 kg)	0

1.1.4 Germplasm database enrichment

A total of 1884 images comprising of tree, bark, leaf, flower, inflorescence, fruit and nut belonging to 164 cashew germplasm accessions were uploaded onto the cashew germplasm database during the year.

Fig. 1.4: View of core collection block

1.1.5 Field Establishment of Core collections

For the first time, the core collection consisting of 61 cashew germplasm accessions was arrived deploying advance maximisation strategy with heuristic approach. The accessions were field planted (@4 plants per accession) during November 2017 at a spacing of 4m x 4m (Fig. 1.4). The list of accessions is given as under.

Core accessions

NRC 01	NRC 11	NRC 18	NRC 20	NRC 38	NRC 40	NRC 41	NRC 43	NRC 63
NRC 96	NRC 101	NRC 111	NRC 121	NRC 126	NRC 138	NRC 140	NRC 143	NRC 145
NRC 152	NRC 153	NRC 160	NRC 185	NRC 194	NRC 211	NRC 251	NRC 265	NRC 269
NRC 238	NRC 270	NRC 273	NRC 275	NRC 276	NRC 278	NRC 281	NRC 283	NRC 286
NRC 300	NRC 301	NRC 306	NRC 308	NRC 318	NRC 319	NRC 333	NRC 335	NRC 342
NRC 346	NRC 349	NRC 366	NRC 383	NRC 385	NRC 388	NRC 401	NRC 402	NRC 406
NRC 410	NRC 416	NRC 458	NRC 463	NRC 469	NRC 470	NRC 478		

H-130 : A new jumbo nut hybrid

A new jumbo nut hybrid H-130 which was superior in yield (3kg/tree in 3 years of planting) with cluster bearing (10-20 nuts/panicle) and bold size (12-13g nut weight) and big apple (>100g) was evaluated and released for cultivation and performance evaluation in farmers field. The hybrid is highly precocious, early flowering with long fruiting duration. Plant is vigorous but sparse canopy and having large leaves and big inflorescence with strong 8-10 rachis. Has high number of bisexual flowers and fruit set is as high as more than 70 nuts per panicle in the initial stage and subsequently 10-20 nut retention per panicle. The hybrid responds well to pruning and is suitable both for ultra-density planting and normal spaced plantations. Hybrid has high shelling (29.9%) with big kernels – 3.5 – 5 g a rare type among released varieties and falls under W-130-150 category kernel grade. The kernel protein is 21% and fat is 46%.

Effect of planting density on yield of different cashew varieties

Spacing/Varieties		Yield (kg/plant)			Yield (kg/ha)		
		2nd year	3rd year	4th year	2nd year	3rd year	4th year
2.5 x 2.5 m	H-130	0.78	1.40	1.52	1248.00	2234.67	2432.00
	NRCC Sel. 2	0.15	0.39	0.46	245.33	624.00	736.00
	Bhaskara	0.01	0.04	0.10	21.33	64.00	154.67
5 x 5 m	H-130	2.12	2.67	3.03	849.33	1069.33	1212.00
	NRCC Sel. 2	1.05	1.50	1.81	418.67	600.00	724.00
	Bhaskara	1.38	1.84	2.05	552.00	734.67	820.00
7.5 x 7.5 m	H-130	2.82	3.75	4.09	498.57	663.17	723.93
	NRCC Sel. 2	2.73	3.22	3.51	483.23	570.53	620.67
	Bhaskara	2.82	3.58	3.84	499.73	633.07	679.67
CV (%)		6.13	4.88	5.15	4.96	13.54	8.80
CD @ 5%		0.2	0.2	0.2	46.0	187.4	137.3

Performance of different varieties of cashew for yield

Varieties	Yield (kg/plant)			Yield (kg/ha)		
	2nd year	3rd year	4th year	2nd year	3rd year	4th year
H-130	1.90	2.60	2.88	865.3	1322.38	1455.97
NRCC Sel. 2	1.31	1.70	1.92	382.41	598.17	693.55
Bhaskara	1.40	1.81	1.99	357.68	477.24	551.44
CD @ 5%	0.09	0.10	0.12	26.57	108.22	79.25

Three year old H-130 plant with profuse flowering and fruiting

High initial fruit set

Nut development

Mature apple and nut

Kernels

1.2 Genetic improvement of cashew for yield and quality traits

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

The cashew hybrids were evaluated for different growth parameters such as stem girth (cm), plant height (m) and canopy spread (m) for the year 2017-18. The results showed that plant height, plant girth and canopy spread were highest in cross combination of NRC 103 x NRC 269, while those parameters were found to be lowest in cross combination of NRC 99 x NRC 185 (Table 1.2).

Table 1.2: Growth characters of cashew hybrids from closely planted block

Crosses	Plant height (m)	Stem girth (cm)	Canopy spread (m)	
			EW	NS
NRC 99 x NRC 185	4.39	49.40	5.41	5.23
NRC 100 x NRC 185	5.27	62.46	6.89	6.82
NRC 240 x NRC 194	5.83	70.69	7.71	7.42
NRC 222 x NRC 68	6.05	66.93	7.20	6.35
NRC 239 x VTH-711/4	6.00	73.38	7.22	6.33
NRC 103 x NRC 269	6.75	94.46	9.44	8.50
NRC 239 x NRC276	5.75	71.81	7.93	6.89
NRC 100 x NRC 276 (B)	5.23	57.40	5.85	5.85
NRCC Selection-2 x NRC 276 (B)	5.14	62.79	7.03	7.44
NRCC Selection-1 x Bhuthnath 2	5.15	63.50	6.80	6.70
NRCC Selection-2 x NRC 271	6.00	76.58	8.78	7.65
NRCC Selection-2 x NRC 276 (A)	5.57	67.49	6.89	7.36
NRC 100 x NRC 276 (A)	4.90	57.66	7.33	6.26
Bhaskara	5.83	70.00	7.22	6.94
NRCC Selection-2	5.20	52.76	5.98	5.32

1.2.2 Evaluation of cashew hybrids obtained from crosses involving wild species and popular cultivars

The cashew interspecific hybrids were evaluated for different growth parameters such as plant girth (cm), plant height (m) and canopy spread (m) for the year 2017-18. The results showed that plant girth and canopy spread were highest in cross Ullal-3 x *A. microcarpum* and lowest in cross *A. microcarpum* x Bhaskara. The maximum plant height was recorded in cross Vengurla-4 x *A. microcarpum* and minimum in *A. microcarpum* x Bhaskara (Table 1.3). The yield ranged from 1.1 kg (Ullal-3 x *A. microcarpum*) to 4.1 kg (Bhaskara x *A. microcarpum*).

Table 1.3: Growth characters of cashew hybrids obtained from crosses involving wild species and popular cultivars

Crosses	Stem girth (cm)	Plant height (m)	Canopy spread (m)	
			EW	NS
Vengurla-4	57.50	6.00	6.83	8.67
Ullal-1 x *A. microcarpum*	75.30	8.62	8.44	8.80
Ullal-3 x *A. microcarpum*	77.46	8.20	8.49	8.84
Vengurla-4 x *A. microcarpum*	77.13	8.66	8.09	8.27
A. microcarpum x Ullal-3	76.10	8.05	6.63	6.90
Bhaskara x *A. microcarpum*	70.48	7.14	6.93	6.84
Ullal-1 x *A. othonianum*	73.86	7.36	6.71	7.29
A. microcarpum x Vengurla-4	70.00	6.50	6.00	7.00
A. microcarpum x Bhaskara	56.50	5.00	3.75	4.25

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

A total of 138 SSR primers were screened in parents Ullal-3 and NRC 492 and 39 primers were found to be polymorphic (Table 1.4). These polymorphic primers were used for genotyping of 89 individuals obtained from Ullal-3 x NRC 492. Further, phenotyping of this population was done for 12 vegetative and reproductive characters (Table 1.5). The data will be used for association analysis to identify marker linked to economic traits.

Table 1.4: Details of SSR primers screened in Ullal-3 x NRC-492 population

Species	Number of SSR primers screened	Number of polymorphic SSR primers
Cashew	21	6
Pistachio	28	6
Almond	24	11
Mango	65	16
Total	**138**	**39**

Table 1.5: Descriptive statistics of F_1 progenies (N=84)

Character	Minimum	Maximum	Mean	SD	Kurtosis	Skewness
Internodal length (cm)	2.00	13.80	6.01	2.52	0.31	0.77
Tree height (m)	3.10	9.80	5.78	1.23	0.85	0.48
Mean Tree Spread (m)	3.33	9.70	6.53	1.30	0.18	0.11
Stem girth (cm)	40.00	128.00	72.69	16.28	0.82	0.70
Weight of apple (g)	12.50	76.00	39.98	16.17	-0.90	0.22
Nut weight (g)	2.37	8.49	5.14	1.59	-0.93	0.30
Shell thickness (mm)	1.73	3.77	2.83	0.48	-0.75	-0.06
Shelling (%)	28.22	44.20	35.48	4.08	-0.71	0.33
Kernal weight with testa (g)	0.99	2.78	1.78	0.43	-0.86	0.13
Kernal weight without testa (g)	0.88	1.98	1.86	2.03	76.38	8.54
Apple to nut ratio	2.81	18.63	7.86	2.52	3.13	0.89

1.4 Development of microsatellite markers and population structure studies in cashew (*Anacardium occidentale* L.) core accessions.

In order to develop new molecular markers for cashew, NCBI sequence database was searched for Expressed Sequence Tag sequences (ESTs) and DNA sequences of *Anacardiaceae* family species such as mango, pistachio and other related species and downloaded (Table 1.6). A total of 5014 microsatellite/Simple Sequence Repeats (SSRs) motifs were identified in the EST/ DNA sequences mined from the NCBI database and primer pairs have been designed for these SSRs. For the characterization markers for utility in cashew, a total of 60 mango EST based SSRs (MiEST-SSRs) have been synthesized and these newly designed markers are to be evaluated for the transferability and genetic analyses of cashew. Likewise, primers would also be synthesized for other designed SSRs and characterized for utility in cashew genetic studies. To carryout transcriptome sequencing, panicles were tagged, flowers were pollinated and developing nuts [15 & 30 days after pollination), (Fig. 1.5)] were collected from the two targeted cashew genotypes.

Table 1.6: List of microsatellite/SSR motifs identified in the EST and genomic DNA sequences from *Anacardiaceae* species and primer pairs synthesized.

Anacardiaceae plant species (Type of nucleotide sequence)	Microsatellite/SSR motifs identified	Primer pairs synthesized
Mangifera indica (EST)	1657	60
Pistachio vera(EST)	2091	0
Pistachio vera (DNA)	1179	0
A. occidentale and *Semecarpus* sp. (DNA)	39	0
Rhus sp. (DNA)	48	0
Total	**5014**	**60**

Fig 1.5: Cashew nut development stages identified for the transcriptome sequencing: (A) 15 Days After Pollination (DAP) and (B) 30 DAP

1.5 Development and evaluation of back cross progenies of promising hybrids for dwarf stature with high yield

During the year, out of 471 back cross progenies planted during 2014, 13 promising accessions were identified for further evaluation based on vegetative and reproductive characters. The benchmark variety was Bhaskara for selecting these progenies. Observations on plant height, girth, canopy spread, and yield of these progenies have been compiled (Table 1.7). It is observed that plant number BDB-372-60 and BDB-372-84 appears to be promising with the cumulative yield of 4.94 and 4.43 kg, respectively in the fourth year i.e. second year of harvesting. However, the height of BDB-372-60 is 2.75 meters which seems to be semi-dwarf in nature. These identified plants will be evaluated further in the ensuing years for their height and yield along with other progenies.

Table 1.7: Promising progenies identified in back cross population

Plant No.	Height (m)	Girth (cm)	Canopy spread EW (m)	Canopy spread NS (m)	Yield (kg/plant)	Cumulative yieid (2 years) (kg/plant)
BDB-372 -4	3.50	40.0	3.5	4.5	2.0	2.28
BDB-372 -23	4.50	50.0	5.0	4.0	2.0	2.60
BDB-372 -36	2.50	36.0	2.8	2.5	2.4	2.41
BDB-372 -37	5.00	49.5	4.5	5.3	3.3	3.41
BDB-372 -46	4.50	41.0	4.5	3.5	2.7	2.89
BDB-372 -60	2.75	32.0	4.0	3.8	4.4	4.94
BDB-372 -61	5.15	43.5	5.3	4.8	3.6	3.75
BDB-372 -84	5.25	51.5	5.2	5.1	4.1	4.43
BDB-372 -90	5.10	45.0	4.6	4.3	3.2	3.29
BDB-626 -49	5.20	46.0	3.5	4.5	2.4	2.45
BDB-626 -97	2.75	37.5	3.1	3.3	3.5	3.50
BDB-626 -113	5.75	32.0	4.3	4.5	2.3	2.35
BDB-626 -114	3.00	41.0	3.5	4.0	1.5	1.60
BDB-626 -122	3.50	38.0	4.5	3.0	2.8	2.95
UDU-577 -85	5.00	34.5	3.3	3.0	2.4	2.46

1.6 Identification and evaluation of cashew genotypes for Cashew Nut Shell Liquid (CNSL) content

The objective of this project is to identify promising accessions with very high and low CNSL content. The CNSL extraction with hexane solvent was done for 131 accessions during 2015-17. During 2017-18, the CNSL content of 61 accessions has been estimated (Table 1.8). The evaluation of remaining germplasm accessions is being carried out.

Table 1.8. CNSL content of different cashew germplasm accessions

Sl. No.	Accession Number	CNSL Content (%)
1	NRC 5	23.00
2	NRC 6	18.53
3	NRC 7	20.93
4	NRC 8	13.95
5	NRC 15	13.44
6	NRC 16	13.55
7	NRC 17	16.54
8	NRC 20	24.27
9	NRC 22	17.78
10	NRC 25	21.33
11	NRC 31	19.09
12	NRC 32	18.52
13	NRC 34	18.27
14	NRC 36	16.68
15	NRC 42	13.66
16	NRC 45	13.85
17	NRC 51	24.60
18	NRC 63	18.52
19	NRC 73	10.06
20	NRC 74	17.15
21	NRC 76	17.16
22	NRC 91	21.27
23	NRC 92	22.98
24	NRC 97	18.91
25	NRC 100	21.02
26	NRC 105	19.93
27	NRC 107	12.50
28	NRC 113	14.36
29	NRC 118	0.00
30	NRC 142	17.54
31	NRC 150	34.50
32	NRC 189	21.63
33	NRC 194	22.03
34	NRC 196	14.07
35	NRC 210	14.05
36	NRC 211	12.96
37	NRC 232	27.00
38	NRC 235	19.37
39	NRC 245	23.25
40	NRC 246	10.03
41	NRC 247	18.33
42	NRC 263	23.13
43	NRC 271	21.21
44	NRC 302	18.65
45	NRC 305	11.81
46	NRC 306	10.34
47	NRC 320	22.78
48	NRC 340	23.95
49	NRC 341	29.27
50	NRC 342	14.29
51	NRC 352	18.15
52	NRC 361	9.70
53	NRC 364	12.28
54	NRC 365	19.44
55	NRC 366	16.23
56	NRC 375	23.82
57	NRC 385	11.60
58	NRC 399	13.15
59	NRC 400	12.93
60	NRC 401	15.01
61	NRC 403	18.62

1.6.1 Industrial CNSL extraction and its application

During the year, a CNSL plant located in Karnataka was visited to discuss about industrial applications in India. CNSL is used in electrical motor coil winding, printed circuit board (base) due to its dielectric property and also used as varnish and phenolkamine coat for ships which avoid calcium accumulation leading to longer life of ship. Viscosity, pH, volatile loss and matter soluble in toluene are certain tests to be conducted to assess its quality. While processing cashew, Anacardic acid, the major constituent of CNSL, is converted in to Cardanol / Cardol due to heat treatment. Quality of the CNSL is utmost important rather than quantity extracted.

1.7 Mutation breeding in cashew for Tea Mosquito Bug (TMB) tolerance with high yield

In existing cultivated cashew varieties and germplasm accessions, there is no tolerance/resistance to TMB, a pest which causes considerable yield losses. Currently, this pest is managed with chemical sprays at flushing, flowering and fruiting stages. However, there is an urgent need to develop tolerant/ resistant varieties to this pest. Hence, mutation breeding approach was deployed.

The seeds and scion sticks of two popular varieties i.e. Bhaskara and Ullal-3 were exposed to g rays. These seedlings and grafts were raised in the nursery (Fig. 1.6). It was observed that the germination percentage of seeds and the survival percentage of grafted plants decreased with the increase in dosage of the mutagen. However, increased branching was seen in higher dosages. The seedlings will be field planted in the ensuing season. Along with these, the next generation seedlings (M_2) from these plants will be evaluated for TMB

Fig. 1.6: Mutagen treated seedlings raised in the nursery

1.8 Development of dwarf and compact cashew hybrids for high density planting

Selection was exercised during the current fruiting season as the hybrid seedlings attained the age of five years. Overall, 27 trees were selected based on cumulative nut yield per tree from 714 trees of 15 cross combinations and the selected trees belong to eight crosses (Table 1.9; Figs. 1.7 & 1.8). Observations such as stem girth, tree height, canopy spread and yield per tree were recorded in all the selected trees. The Tree no. 5 belonging to the cross Vengurla-4 x NRC 492 recorded the nut yield of 4.35 kg during the current year. It has the highest cumulative nut yield of 6.40 kg over three years.

Fig. 1.7: Selection in Vengurla-4 x NRC 492

Fig. 1.8: Selection in Madakkathara-2 x Taliparamba-1

Table 1.9: Promising selections with their growth parameters and nut yield

Sl. No.	Cross	Row No.	Tree No.	Girth (cm)	Height (m)	Canopy Spread (m)	Yield (2018) (kg/tree)	Cumulative yield (3 years) (kg/tree)
1	Vengurla-4 x NRC 492	3	2	54.0	3.5	5.25	2.75	4.01
2		5	5	51.0	5.5	5.25	4.35	6.40
3		5	6	52.0	3.0	5.25	2.10	2.42
4		6	2	47.0	6.0	4.00	3.00	4.06
5		7	7	37.0	2.5	4.00	2.28	3.21
6		9	1	49.0	4.5	5.23	4.28	5.55
7		10	10	53.0	2.5	5.25	3.58	4.89
8		10	12	54.5	5.5	5.00	2.70	3.77
9		11	6	38.0	3.0	3.75	2.45	3.45
10		12	5	33.0	3.5	4.00	2.00	2.59
11		13	8	41.0	3.7	4.13	2.28	2.66
12	NRC 492 x Vengurla-4	17	4	46.0	2.5	4.00	3.15	3.18
13	Vengurla-4 x Taliparamba 1	23	2	57.0	5.0	5.75	4.39	5.34
14	Priyanka x NRC 492	24	2	63.0	6.5	5.25	3.90	4.90
15	Dhana x NRC 492	29	15	48.0	5.0	4.50	4.06	4.95
16		29	16	51.0	5.0	4.75	3.87	4.80
17	Madakkathara -2 x NRC 492	44	1	52.0	4.5	5.03	2.07	2.83
18		44	7	56.0	6.7	5.00	2.78	3.41
19		46	2	54.0	5.3	4.40	3.27	4.47
20	NRC 492 x Madakkathara-2	49	1	53.0	4.5	4.75	3.73	4.69
21	Madakkathara-2 x Taliparamba1	51	1	64.5	7.0	4.88	2.36	2.60
22		51	4	58.5	6.8	5.03	2.02	2.26
23		51	5	52.5	4.7	4.88	2.02	2.48
24		52	11	58.0	5.2	7.13	2.27	2.62
25		53	2	62.0	5.5	4.25	2.97	3.31
26		53	6	51.0	6.7	4.63	2.30	2.70
27		53	8	67.0	7.0	5.75	2.28	2.75

1.8.1 Breeding for improvement of nut size in cluster bearing genotypes

New crosses between jumbo/bold nut and cluster bearing genotypes were attempted to improve nut size in the latter. The list of genotypes used includes H-130, NRC 493 (Jumbo nut types), NRCC Selection-2, Priyanka (bold nut types) and Bhaskara, Ullal-2, Ullal-3, Ullal-4, Vengurla-4, Vengurla-7, VRI-3, Madakathara-2 (cluster bearing types). The cross combinations made and nuts obtained is given Table 1.10.

1.8.2 Development of pre-breeding lines for TMB tolerance

A progeny of the cross Ullal-3 x *A. microcarpum* (named TMBT) was observed consistantly as relatively tolerant to incidence of TMB under field conditions. Hence, this was used as a male parent and crossed with two popular early bearing varieties *i.e.* Ullal-3 and Vengurla-4 to develop pre-breeding lines for TMB tolerance

Table 1.10: Crosses made to improve nut size in cluster bearing genotypes and to develop pre-breeding lines for TMB tolerance.

Sl.No.	Cross	No.of flowers pollinated	No. of nuts obtained	% success
a) Breeding for improvement of nut size in cluster bearing genotypes				
1	H -130 x Ullal-2	209	49	13.11
2	Ullal-2 x H-130	228	52	23.44
3	H-130 x Ullal 4	270	52	22.81
4	NRC 493 x Ullal-2	267	47	19.26
5	Ullal-2 x NRC 493	100	22	17.60
6	H-130 x NRC 493	262	41	15.65
7	NRC 493 x H-130	206	27	15.65
8	NRCC Sel-2 x Bhaskara	171	54	31.58
9	Bhaskara x NRC 493	162	8	04.94
10	Ullal-3 x H-130	171	35	20.47
11	VRI-3 x H-130	168	37	22.02
12	Vengurla- 4 x H-130	172	53	30.81
13	Vengurla-7 x H-130	164	34	20.73
14	Madakkathara-2 x H-130	194	44	22.68
15	Priyanka x NRC 493	166	25	15.06
	Total	**2910**	**580**	
b) Development of pre-breeding lines for TMB tolerance				
1	Vengurla- 4 x TMBT	202	87	43.07
2	Ullal-3 x TMBT	199	8	4.02

1.9 Evaluation of cashew germplasm for cashew apple yield and quality traits

1.9.1 Cashew apple morphology and yield, nut yield

Among the 14 cashew apple accessions along with check (cv. Vengurla-8) evaluated. NRC 301 weighed highest (179.62 g/apple) (Table 1.11). Cashew apple yield was highest in NRC-175 (50.43 kg/tree) followed by NRC 140 (31.45 kg/tree). Similarly, NRC 175 recorded the highest nut yield (4.54 kg/tree).

Table 1.11: Cashew apple morphology, apple yield and nut yield for 2016-17

Accession Number	Apple characters			Yield		Nut weight (g)
	Weight (g)	Length (cm)	Breadth (cm)	Apple yield (kg/ tree)	Nut yield (kg/ tree)	
NRC 75	85.61	6.53	4.58	3.54	0.39	7.01
NRC 111	115.07	8.31	4.94	14.51	1.44	13.91
NRC 112	122.11	7.99	5.21	20.11	1.93	13.90
NRC 120	106.26	6.30	5.15	23.06	1.94	10.57
NRC 140	112.67	8.18	4.76	31.45	2.21	9.62
NRC 144	85.38	6.32	4.65	8.51	0.82	9.23
NRC 175	73.45	5.66	4.51	50.43	4.54	7.60
NRC 176	101.36	10.27	7.97	20.96	1.87	7.33
NRC 183	121.54	8.26	4.96	3.84	0.46	14.45
NRC 189	75.99	4.97	4.60	12.32	1.42	12.76
NRC 270	98.24	6.35	4.96	11.28	1.45	10.92
NRC 301	179.62	9.39	6.41	14.44	0.99	12.10
NRC 389	82.38	7.62	4.36	16.82	1.69	8.78
NRC 493	97.82	8.58	4.35	18.24	2.02	12.53
Vengurla-8	68.09	6.16	4.25	9.77	1.05	9.49
Mean	101.71	7.39	5.04	17.28	1.61	10.68
SEd	8.70	0.46	0.17	8.05	0.76	1.81
CV%	15.65	14.48	15.62	17.48	19.56	16.95
CD (0.05)	17.82	0.96	0.35	16.49	1.56	3.71

1.9.2 Plant height, girth and canopy spread

Among the 14 cashew apple accessions evaluated along with check (Vengurla-8), the maximum mean height was observed in NRC 493 (4.67 m) followed by NRC 112 (4.56 m), while minimum height was recorded in Vengurla-8 (3.03 m) (Table 1.12). But, the difference among accessions was not significant. The mean plant girth among the accessions were found to be the highest in NRC 112 (66.14 cm) followed by NRC 389 (62.78 cm) and NRC 75 (62.14 cm). The check variety Vengurla-8 recorded least plant girth (35.67 cm). The canopy spread ranged from 4.39 m to 6.47 m. Maximum canopy spread was recorded in NRC 112 and minimum in Vengurla-8.

Table 1.12: Morphometric parameters of different cashew accessions during 2017-18

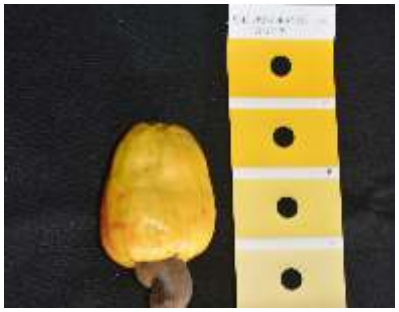
Accession Number	Growth parameters		
	Height (m)	Girth (cm)	Canopy spread (m)
NRC 301	4.13	55.39	6.07
NRC 189	4.29	50.50	5.08
NRC 176	4.22	50.67	4.99
NRC 270	3.65	52.25	4.95
NRC 112	4.56	66.14	6.47
NRC 389	4.49	62.78	6.18
NRC 175	3.81	49.08	5.45
NRC 183	3.64	45.47	4.91
NRC 75	4.43	62.14	5.74
NRC 140	3.77	57.42	5.88
NRC 120	3.74	52.64	5.29
NRC 493	4.67	57.25	5.55
NRC 111	4.33	59.08	5.21
NRC 144	3.79	53.83	5.06
Vengurla-8	3.03	35.67	4.39
Mean	4.04	54.02	5.41
SEm	0.35	0.53	0.55
CV%	14.68	17.01	17.45
CD (0.05)	NS	1.54	NS

1.9.3 Classification of apple surface colour using RHS colour chart

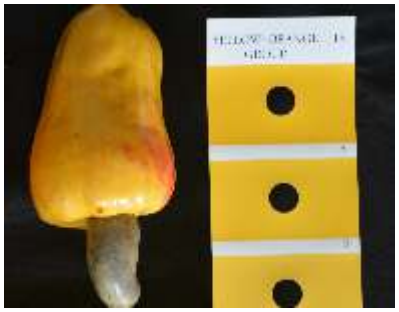
The cashew apple fruit colour surface was recorded using Royal Horticultural Society (RHS) colour chart. The surface colour of cashew apple of 15 accessions fall under Fan – 1 category (Yellow, Yellow-Orange, Orange, Orange-Red and Red groups). The results are furnished in Table 1.13.

Table 1.13: Scoring of cashew apple surface spectrum using RHS colour chart

Accession Number	Colour scale according to RHS colour chart
NRC 301	Orange Red group – 32 A
NRC 189	Yellow Orange group – 22 A
NRC 176	Red group – 40 D
NRC 270	Orange Red group – 29 A
NRC 112	Yellow Orange group – 15 A
NRC 389	Yellow group - 3A
NRC 175	Yellow green 153 B
NRC 183	Green Yellow group - 1B
NRC 75	Yellow Orange group – 14 C
NRC 140	Orange group – 29 A
NRC 120	Orange Red group 44 A
NRC 493	Orange Red group – 33 B
NRC 111	Yellow Orange group – 21B
NRC 144	Yellow Orange group – 15 C
Vengurla-8	Orange Red group – 31 C

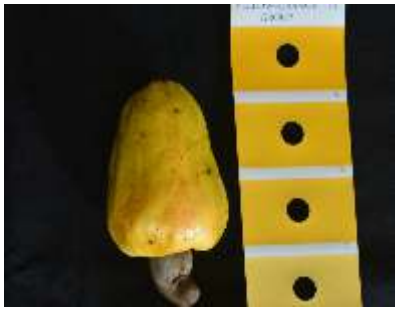

NRC 75

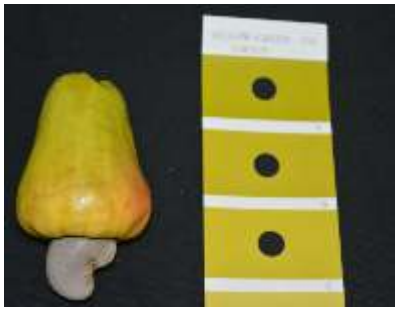

NRC 111


NRC 112


NRC 120


NRC 140


NRC 144

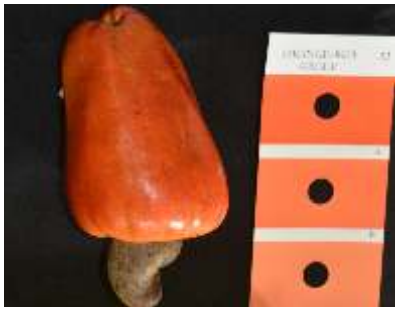

NRC 175


NRC 176


NRC 183

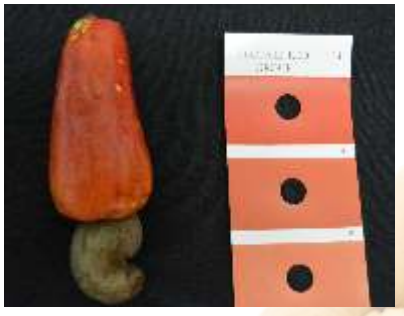

NRC 189


NRC 270


NRC 301


NRC 389

Fig. 1.9: Cashew apple surface spectrum using RHS colour chart


NRC 493

1.9.4 Incidence of insect pests on cashew accessions

Among the different pests observed, infestation levels of Tea Mosquito Bug (TMB) was more during flushing stage and it was negligible during flowering stage. Among the accessions, highest TMB infestation was recorded in NRC 175 and NRC 493 during October-November 2017, while it was low in NRC 75 and NRC 301. During flowering and fruiting stages, thrips and Apple and Nut Borer (ANB) infestation was recorded among the accessions. Infestation of thrips was high in NRC 301 (20.48 %) and NRC 140 (18.15 %), whereas, ANB incidence was more in NRC 389 (8.29 %) and NRC 176 (7.32 %) (Table 1.14). Apart from these pests, incidence of leaf folder was also noticed during September-October, 2017 with infestation levels of 10-15 % on shoots of NRC 120, NRC 175 and NRC 189, but the incidence reduced drastically towards the end of October.

Table 1.14: Infestation levels of different pests in germplasm accessions

Accession Number	Thrips infestation (%)	ANB infestation (%)	TMB damage grade (0-4)	
			Flushing stage	Flowering stage
NRC 111	09.45	5.51	0.61	0.01
NRC 112	10.97	3.74	0.62	0.08
NRC 120	06.51	6.16	1.00	0.01
NRC 140	18.15	1.93	0.84	0.14
NRC 144	07.29	6.15	0.65	0.02
NRC 175	08.83	1.86	1.23	0.01
NRC 176	09.76	7.32	0.89	0.09
NRC 183	04.55	0.01	0.97	0.07
NRC 189	04.86	1.39	0.86	0.01
NRC 270	06.05	2.54	0.71	0.02
NRC 301	20.48	3.33	0.26	0.04
NRC 389	12.95	8.29	0.99	0.01
NRC 493	04.36	5.37	1.20	0.02
NRC 75	--	--	0.25	0.01
Vengurla-8	00.94	5.66	0.42	0.01
CD (0.05%)	1.57	0.59	0.14	NS

* Thrips and ANB infestation were recorded in randomly selected matured nuts

1.10 Externally Funded Project

1.10.1 Development of morphological descriptors and DUS test guidelines for cashew

In order to develop DUS test guidelines for cashew, a project was funded by Protection of Plant Varieties and Farmers Rights Authority, New Delhi. Accordingly, the DUS test guidelines for cashew was finalized and published during 2017. Thirty reference varieties for the purpose of DUS testing have been established at ICAR-DCR, Puttur with a spacing of 6 m x 6 m and four plants/ variety.

List of reference varieties

NRC 116	NRC 140	NRC 183	NRC 190
NRC 406	NRC 492	NRCC Sel-1	NRCC Sel-2
Bhaskara	Ullal-1	Ullal-2	Ullal-3
Vengurla-1	Vengula-2	Vengurla-3	Vengurla-4
Vengurla-7	Madakkathara-1	Madakkathara-2	VRI-1
VRI-2	VRI-3	BPP-4	Priyanka
Taliparamba-1	K-22-1	VTH 30/4	VTH 174
VTH 30/2	Purple mutant		

2. CROP MANAGEMENT

Ultra Density Planting (UDP) in cashew: Novel technology to boost production in cashew

Ultra density planting consisting of 1100-1600 plants/ha or more, was pruned to maintain productive canopy was developed and standardized and demonstrated in farmers field (>100 ha) for the first time in cashew for obtaining early benefits and higher yield. This technology was developed during the period from 1999-2018. The UDP technique has shown to improve yield by 3-4 times per unit area over traditional type of planting. When demonstrated in the farmers' field on large area, up to 3 tonnes of nut yield per ha could be harvested in third year of planting at 3m x 3m spacing. The investment on orchard establishment could be realized just in three years. The complete allotted space was covered by canopy in just three years and the full potential yield of the unit land area was achieved through intensive management in the third year of planting. The precocious type of varieties such as VRI-3, NRCC Sel-2, Ullal-1, K-22-1 and H-130 are most suitable for this technique of planting. With this technique cashew yield can be increased in a short span of time and the dependency for rawnut imported from abroad can be reduced and self sufficiency attained.

Yield harvested under ultra density planting at DCR

(N=21, Var: K-22-1 @ 1600 plants per hectare)

Year of planting	kg/plant				
	2004	2005	2006	2007	2008
2003	0.1	1.7	2.3	2.0	1.7

Yield performance of ultra high density planting in farmers field (@ 3m x 3m)

Name & Address of the farmers	Year of planting	Varieties	Yield (kg/plant)						
			2011	2012	2013	2014	2015	2016	2017
Shri.P. Derana Rai Papanadka, Puttur, D.K. District	2010	NRCC Sel-2 VRI-3 Ullal-3 V-4	*	1.10	**	2.00	2.50	2.00	***
Sm.t Satyabhama Machi, Bantwala Taluk, D.K. District	2010	NRCC Sel-2 Ullal-4	*	1.20	2.50	3.20	2.70	2.80	3.10
M. r. Kadamajalu Subhash Rai Puttur taluk	2014	NRCC Sel-2 VRI-3	--	--	--	--	0.20	2.40	3.00
Mr. Somappa Rai Govindamoole Darbethadka, Puttur	2015	VRI-3	--	--	--	--	--	1.20	2.90
Mr. Karunakara Rai Derla, Madavu Vill. & Post., Puttur taluk	2015	VRI-3 NRCC Sel-2 Ullal-1 Ullal-3	--	--	--	--	--	1.00	2.44

* Deblossoming was done in the 1st year

** Due to faulty pruning and severe tea mosquito bug attack, yield could not be realized.

*** Resorted for thinning out the plants

View of ultra density orchards

Land preparation

Planting and aftercare

Pruning and canopy management

Development of frame work of primary branches

Vegetative flushes Precocious bearing

View of ultra density orchard

2.1 Studies on pruning and phenology in cashew

The phenological studies were carried out in cashew cultivars, Ullal-3 and Bhaskara using Biologische Bundesantalt Bundessortenamt und Chemische Industrie (BBCH) scale. Hundred shoots were tagged in each cultivar during the month of August, 2017 for recording observations. The observations were recorded weekly twice. The study showed that there are eight important principal growth stages in cashew namely vegetative bud development, leaf development, shoot development, inflorescence development, flowering, nut and apple development, nut and apple maturity and senescence stages. Within each principal growth stages, different secondary stages were identified according to BBCH scale. After identifying the stages, each of the phenological stages were photographed, described and assigned codes according to BBCH scale (Table 2.1 & Fig. 2.1). In addition, the observations were also recorded for pest incidence.

Table 2.1: Different phenological stages identified in cashew according to BBCH scale

Stage code	Principal stages	Code	Description
0	Vegetative bud development	010	**Dormant stage**: buds covered with brown or brownish green scales
		011	**Beginning of bud swelling**: swollen bud, brownish scales are intact
		013	**End of bud swelling**: scales completely separated, light green bud visible
		017	**Beginning of bud break**: bud completely visible
		019	**End of bud break**: leaf tip visible above the bud scales
1	Leaf Development	110	**Separation of leaf scales**: leaves start emerging
		111	**First pair of leaves separated**: Leaf petiole visible
		115	**More leaves separated**: more number of leaves separated
		117	**More leaves unfolded**: slightly expanded, appearance of coppery shades on leaves
		119	**All leaves unfolded**: Leaves unfolded and expanded
3	Shoot Development	311	**Beginning of shoot growth**: 10% of final shoot maturity, axis of developing shoots visible, coppery brown leaves
		312	**Shoots at 20% maturity**: shoots about 20% of final maturity, light green colour, smooth texture, flexible shoots, leaves are dark copper green
		314	**Shoots at 40% maturity**: shoots about 40% of final maturity, upper leaves are copper green and smooth, lower leaves are green
		317	**Shoots at 70% maturity**: shoots about 70% of final maturity, brownish green and smooth shoots, leaves are dark green and leathery
		319	**Shoots at 90% maturity**: shoots completely matured, leaves are fully developed, dark green colour, leathery
5	Inflorescence development	511	**Beginning of reproductive bud swelling**: Inflorescence bud visible
		514	**Elongation of panicle**: panicle expands, separation of laterals begins, keel leaf clearly visible
		515	**More laterals separated**: lateral elongation continues
		516	**Separation of sub laterals**: sub laterals start separating from main laterals,keel leaf green in colour and intact
		517	**More sub laterals separated**: about 80% of sub laterals separated and elongated, keel leaf dried and withered
		519	**End of panicle development**: laterals fully developed, sub laterals elongation continues, swollen flower buds
6	Flowering stages	610	**First flower opened**: First flower opened
		611	**Beginning of flowering**: Up to 10% of flowers opened, newly opened flowers are white and older flowers are pink in colour
		613	**Early flowering**: About 30% flowers opened
		615	**50% flowering**: About 50% flowers opened
		617	**70% flowering**: About 70% flower opened and early opened flowers dry
		619	**End of flowering**: First nut set
		620	**Barren panicles**: Panicles without nut set
7	Nut and Apple development	701	**Nut at 10% of final developmental stage**: nut at about 10% of the final **developmental** size, soft and spongy, style is attached, 90% of the nut cavity is filled, mostly filled by whitish testa Apple: About 2.5% of final cultivar apple size
		703	**Nut at 30% of final developmental stage**: about 30% of the final developmental stage size, soft and spongy, about 50% of the nut cavity is filled, visible kernel, nut shell grows rapidly compared to kernel and testa Apple: about 5% of final cultivar apple size
		705	**Nut at 50% of final developmental stage**: about 50% of the final developmental stage size, soft and spongy, about 50% of the nut cavity is filled, kernel about 10% of final size Apple: About 7.5% of final cultivar apple size

		707	**Nut at 70% of final developmental stage**: about 70% of the final developmental stage size, about 90% of the nut cavity is filled, whitish testa thickness attains maximum size , kernel about 80% of final size, nut surface colour is green Apple: About 10% of final cultivar apple size
		709	**Nut at 90% of final developmental stage**: about 90% of the final developmental stage size, about 100% of the nut cavity is filled, kernel about 90% of final size, testa thickness is drastically reduced and inside colour turns brownish, nut surface colour is green, inner shell colour turns olive green Apple: About 15% of final cultivar apple size
8	Nut and apple maturity	811	**Physiological nut maturity**: nut size reduced, physiologically mature, shell colour turns dark green, appearance of grey at suture region, inside shell colour turns brown, testa inner colour is brown, Kernel- slightly hard and ivory colour Apple: About 20% of final cultivar size, surface colour is green, pulp is white in colour
		813	**Beginning of nut maturity**: whole nut colour turns to greenish grey, inside shell colour turns to dark brown, hardening of nut Apple: About 30% of final cultivar size, surface colour is green, pulp is white in colour
		815	**Advanced nut maturity**: Nut colour turns to whitish grey Apple- about 50% of final cultivar size, surface colour is yellowish, pulp is white in colour
		817	**Post advanced nut maturity**: Nut colour turns to ash, Apple- about 70% of final cultivar size, shades of yellow or orange colour appear, pulp is slightly yellowish in colour
		819	**Horticultural maturity**: nuts and apple are fully mature Apple- attains about final cultivar size, surface colour is cultivar dependent (yellow/red/orange), pulp is yellowish in colour

Fig. 2.1: Phenological stages in cashew

010 **011** **013** **017** **019**

Principal growth stage 0: Vegetative bud development stages

110 **111** **115** **117** **119**

Principal growth stage 1: Leaf development stages


311


312


314


317


319

Principal growth stage 3: Shoot development stages


511


514


515


516


517

Principal growth stage 5: Inflorescence development stages


610


611


613


615


617


619

Principal growth stage 6: Flowering stages


701


703


705


707


709

Principal growth stage 7: Fruit and Nut development stages


811


813


815


817


819

Principal growth stage 8: Fruit and Nut maturity stages

2.2 Establishment of nutrient diagnostic norms in cashew

2.2.1 Soil nutrient status in cashew plantations of Vridhachalam, Tamil Nadu

A regional survey was conducted to characterize soil nutrient status of cashew growing areas of Vridhachalam, Tamil Nadu. Seventy soil samples (0 to 30 cm depth) were collected from different plantations of the region and were analyzed for selective chemical characteristics. Soil pH and EC of the samples varied from 4.06 to 7.19 and 0.02 to 0.05 dSm^{-1}, respectively. Organic carbon content of the samples ranged from 0.18 to 0.77%. The available N and K content of the soils varied from 100.11 to 350.11 kg ha^{-1} and 50.23 to 300.22 kg ha^{-1}, respectively. The soils were neutral to acidic and non saline. The nutrient index values were rated as low for available nitrogen (1.07) and potassium (1.21) with 92.85% samples under low category for nitrogen and 81.43% samples under low category for potassium. In case of organic carbon, 74.29% samples were rated as low and 25.71% is high.

The status of DTPA extractable Fe, Mn, Zn and Cu is given in Table 2.2. Available Fe status in soils of cashew plantation in Vridachalam region varied from 5.76 to 47.12 mg kg^{-1}. The Mn content varied from 5.56 to 25.81 mg kg^{-1}. Considering critical limits of Fe and Mn in soil as 4.5 mg kg^{-1} and 2.0 mg kg^{-1}, respectively, these soils are found to be sufficient in Fe and Mn. Available Zn content varied from 0.44 to 3.84 mg kg^{-1}. According to critical limits Zn of (0.6 mg kg^{-1}), only 5.71% samples were deficient in available Zn. The Cu content in these soils varied from 0.20 to 1.54 mg kg^{-1}. Considering 0.2 mg kg^{-1} as critical limit for Cu, only 2.85% samples were deficient.

Table 2.2: Available micronutrient content in soils of different cashew plantations of Vridhachalam, Tamil Nadu

Available micronutrient	Range (mg kg^{-1})	Mean (mg kg^{-1})	% samples deficient	% samples sufficient
DTPA-Fe	5.76 – 47.12	31.69	0	100
DTPA-Mn	5.56 – 25.81	22.30	0	100
DTPA-Zn	0.44 – 3.84	1.37	5.71	94.29
DTPA-Cu	0.20 – 1.54	0.64	2.85	97.15

3. CROP PROTECTION

3.1 Cashew Stem and Root Borer (CSRB)

3.1.1 Evaluation of indigenously occurring natural enemies for their efficacy against Cashew Stem and Root Borer (CSRB)

A locally encountered strain of entomopathogenic fungus, *Metarhizium anisopliae* was evaluated under laboratory conditions for its virulence in causing mortality of CSRB grubs. Aqueous spore suspension of the isolated local strain of *M. anisopliae* was applied topically 10^4 spores /ml (1 ml /grub) and through feed to CSRB grubs aged between 15 to 30 days @1 ml/ 5 x 5 cm^2 of cashew bark. All the treated CSRB grubs got infected, became moribund five days after treatment and showed 100 per cent mortality within 15 days after treatment in topical application and within 21 days in case of application of spores through bark as feed (Table 3.1). However, under field conditions, the application of spawn suspension onto infested tree trunks would be a feasible approach.

Table 3.1: Mortality of CSRB grubs induced by local strain of *M.anisopliae*

Days After Treatment (DAT)	Mortality of *M. anisopliae* treated CSRB grubs (%)	
	Topical application	Suspension provided through feed
3	0.00	0.00
5	57.14	42.85
7	60.00	53.33
10	76.92	53.84
15	100.00	71.42
21	100.00	100.00

3.1.2 Investigations on semio-chemicals for management of TMB and CSRB: Flagship Programme

Adult TMB emerging from lab culture were collected daily in the morning and evening, sexed and kept separately in different cages. The age of the virgin females was recorded and the different age groups of the TMB adult females were used for the investigations. The 'Delta' sticky traps having a horizontal sticky liner were utilized for the field observations on TMB pheromone studies. The live bait (a virgin female TMB) was placed in cotton mesh cage and hung on the upper angle of the cage; along with a tender cashew shoot placed in a glass vial having water to provide the food source. The observations revealed that the virgin TMB females aged 4 DAE (Days After Emergence) and 5 DAE elicited the maximum response (with a cumulative catches of 338 and 250 males/trap, respectively) as indicated by the number of male TMB catches/trap. No trap catches of TMB males was observed when either the lesser aged TMB females or the TMB females aged 6 days were used as live baits (Table 3.2).

Table 3.2: Trap catches of TMB males when different age groups of virgin TMB females were used as 'live bait'.

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

During the field observations, it was observed that the many TMB males initially attracted to the virgin TMB females which were used as live bait; landed on the non-sticky outer surface of the trap and after frantic searching for the female, in many cases escaped away without getting trapped. It was noticed that 30.77 to 46.29 per cent of the attracted TMB males escaped without getting caught in 'Delta' traps. Hence, the trap design was modified to form a sparsely perforated cylinder with the total outer surface being the sticky layer and the live bait *viz.,* a virgin TMB female was placed in the centre of the cylinder. This ensured that only up to 5.41 per cent of attracted males which alighted on the trap escaped; due to landing on the sticky liner edges or on wire frame (Table 3.3 & Fig. 3.1). The remaining TMB males were invariably trapped and had no chance of escape thereby giving a more accurate count of the trapped TMB males.

Table 3.3: Trap catches of male TMB in Delta and modified Cylinder traps

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

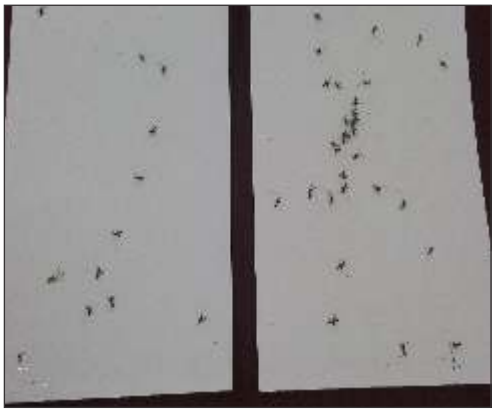
The virgin TMB females aged 4-5 days, reared in the laboratory were first placed in the net cages in cashew orchards from 9.00 AM to 10.00 AM to activate their "calling instinct" and were later stunned by placing them in deep freezer for 15 mins and immediately mascerated in Di-Chloro Methane (DCM), to a crude suspension to obtain Whole Body Extract (WBE). The WBE was stored in a freezer and subsequently evaluated for their retention of attraction capacity in comparison to the live TMB females used as baits [after 10, 15 and 30 Days After extraction (DAe)]. The maximum cumulative number of TMB male catches/trap was 94 when the TMB virgin females were used as live-bait and it was 100 when WBE was used as the bait at 30 DAe (Table 3.4).

Table 3.4: Comparative catches of TMB males in Whole Body Extract (WBE) and live female baited traps

Location	Bait source / No. of TMB males attracted					
	WBE (10 DAe)	TMB female	WBE (15 DAe)	TMB female	WBE (30 DAe)	TMB female
National Cashew Gene Bank (NCGB-1)	11	13	14	14	19	16
Scion Bank-1	14	12	12	15	21	18
NCGB-2	9	8	17	11	14	13
Entomology plot	9	11	13	11	10	12
Micronutrient plot	7	5	8	10	13	14
NCGB-3	8	12	9	13	13	11
Scion Bank-2	9	11	14	11	10	10
Total	**67**	**72**	**87**	**85**	**100**	**94**

Female bait cage inside cylinder trap

TMB catches on cylinder trap



TMB catches on 4th and 5th DAe

Fig. 3.1: Trap catches of male TMB in modified cylinder trap

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

The following parameters *viz.*, a) mortality induction b)feeding deterrence and c) oviposition repellence are being recorded using the test insecticides- thiamethaxam (0.1g/l & 0.2g/l), acetamiprid (0.5g/l), carbosulfan (2.0 ml/l) and buprofezin (2.0 ml/l) against TMB and fipronil (2.0ml/l), imidacloprid (2.0ml/l) and chlorpyriphos (10ml/l) against CSRB. It was noticed that thiamethoxam was on par with the recommended insecticide - cyhalothrin in managing TMB; but buprofezin could not induce mortality of TMB nymphs or adults even on 1 day after treatment (DAT). In case of CSRB, imidacloprid was on par with the recommended insecticide chlorpyriphos; but had lesser mortality of nascent hatched larvae (Figs. 3.2 & 3.3). The trials are in progress to finalize the most effective insecticide for managing these pests.

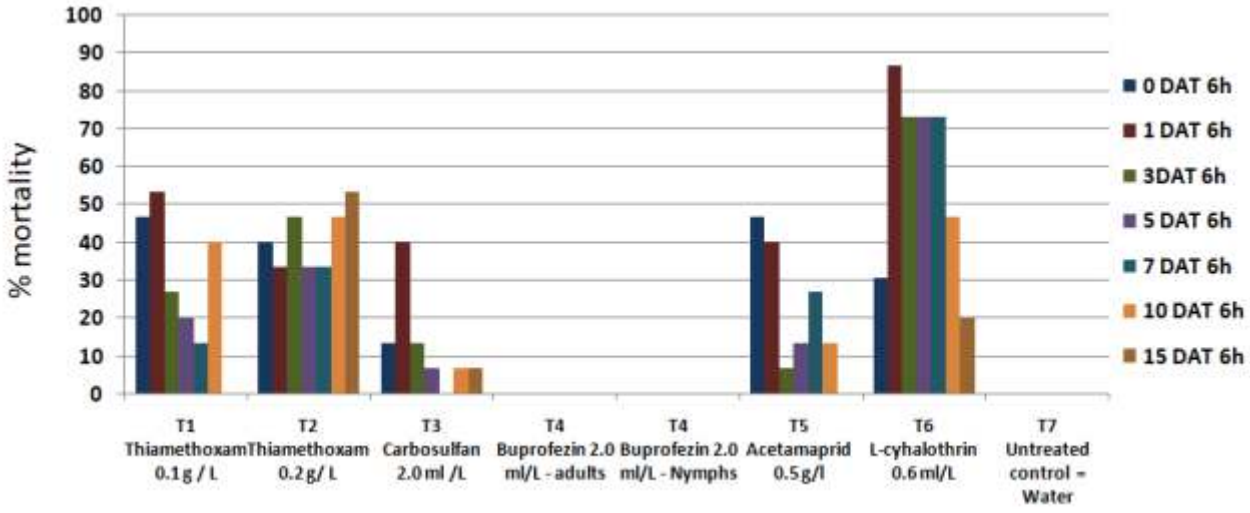


Fig. 3.2: TMB mortality level (%) at 6 h after release

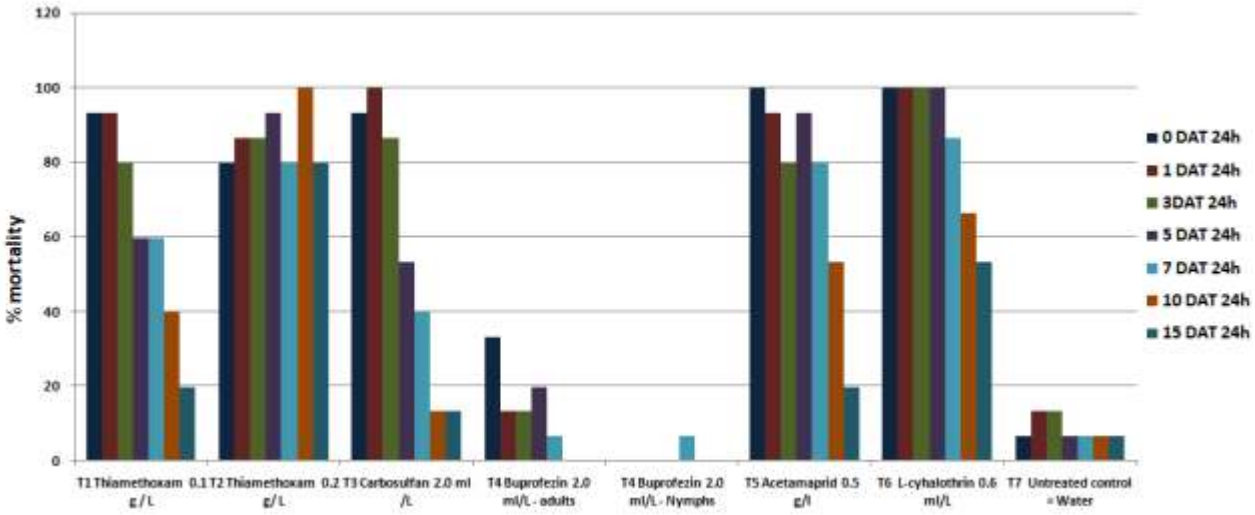


Fig. 3.3: TMB mortality level (%) at 24 h after release

3.3. Diversity, bioecology of pollinators of cashew and their role

3.3.1. Nesting behaviour and life cycle of *Ceratina hieroglyphica* and *Braunsapis picitarsus*

Dried thin shoots/panicles of the cashew trees having neat circular entrance hole at their tips indicated the presence of nests of *C. hieroglyphica* and *B. picitarsus*. Bees either made fresh nests by excavating the soft pith region of the sticks or sometimes occupied old or abandoned nests. A total of 66 nests of *C. hieroglyphica* were collected during 2017, in which, 12 were empty. Cells with older stages were at the deeper end of nests. Adults were found maximum (52.7 %) followed by pupal stages (20.9 %) (Fig. 3.4). Nest entrance of *B. picitarsus* was just 1 - 2 mm, and rarely up to 3 mm. The nests had no partition and all the stages were found together (Table 3.5). A total of 138 nests of *B. picitarsus* were collected during 2017, in which active life stages were recorded in 91 nests. Among them, 37 had all the stages *viz.,* eggs, grubs, pupa and adult. Unlike *C. hieroglyphica*, grubs of *B. picitarsus* were fed by the adult bees i.e., progressive provisioning.

Table 3.5: Duration of different stages of *C. hieroglyphica* and *B. Picitarsus*

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

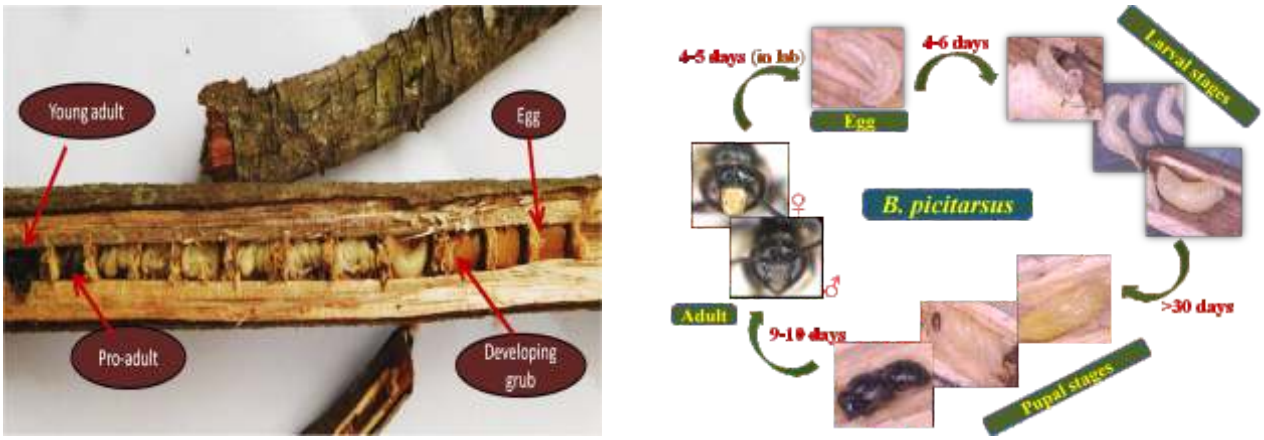


Fig. 3.4: Life stages of *C. hieroglyphica* and *B. picitarsus*

3.3.2. Behaviour

B. picitarsus bees exhibited excellent bee guarding behaviour. As a defensive behaviour, the female bee sitting at the entrance facing outside turns immediately upon noticing its enemies or disturbance and blocks the entrance hole with its abdominal tergum and pumps its abdomen so as to ward off its enemies. If the disturbance continues, the bee pushes its offsprings towards interior end away from entrance. In case of *C. hieroglyphica,* blocking the entrance hole with its metasomal tergum was commonly noticed.

3.3.1. Natural enemies of bees

Bee colonies of *Apis cerana* kept at Shantigodu station were attacked by wasps *viz., Vespa* sp. (?), greater wax moth larvae (*Galleria mellonella*) and also by unidentified beetles. The grubs of *B. picitarsus* were found to be parasitized by Neochalcis group of parasitoids (Chalcididae). The grubs of *C. hieroglyphica* were found to be parasitized to the extent of 2 - 5% (Fig. 3.5). Mites (undetermined) were also seen moving over the grubs and pupae of *C. hieroglyphica,* which might be phoretic in nature. During rainy season, mummified adults of *C. hieroglyphica* were also noticed to the extent of 3-4%.

Fig. 3.5: Parasitized brood of *C. hieroglyphica*

3.3.4. Performance of *Apis cerana* colonies and quality of honey

Apis cerana colonies were established at Shantigodu station to understand its potential of establishment and sustenance in cashew ecosystem. The colonies shifted during December -January could establish successfully and yielded up to 4 kg honey/hive within 3-4 months period with a super chamber. The quality of extracted unprocessed honey was analyzed for its physico-chemical properties in an AGMARK laboratory and found to be of superior quality (Table 3.6).

Table 3.6: Physico-chemical quality of *A. cerana* honey (unprocessed) harvested in cashew ecosystem

Parameters	Values (%)	Parameters	Values
Specific gravity	1.39 - 1.40	Acidity	0.05- 0.09 (%)
Moisture content	22	Sucrose	4 %
Total reducing sugars	65- 67	HMF (Hyrdroxy Methyl Furfural)	30-39 mg/kg
Fructose/Glucose ratio	1.10 – 1.22	Optical density at 660 nm	0.2
Total ash	0.20	Fiehe's test and Aniline chloride test	Negative

3.3.5. Bee flora

The common bee flora in and around cashew plantations were also documented. The weed species in the cashew plantations visited by different wild bees include *Spermacoce hispida*, *Alternanthera* spp., *Mimosa pudica*, *Tridox procumbens*, *Lantana camara*, *Thevetia* sp., *Ixora* spp., *Leucas aspera*, *Vedalia trilobata*, *Melastoma malabathricum*, *Blumea* sp., *Passiflora foetida* etc. Besdies, flowers of perennials found nearby cashew plantations like *Terminalia* spp., *Caesalpinia* sp., *Antigonon leptopus*, *Semicarpus pranuii*, *Peltophorum pterocarpum, Delonix regia, Cassia* spp. attracted plenty of bee species (Fig. 3.6). Flowers of *L. aspera* and *V. trilobata* were visited by three honey bee species *viz., A. cerana, A. dorsara* and *A. florea* besides wild bees like *Ceratina* spp. *Braunsapis* sp., *Xylocopa* sp. Among the bee flora, flowers of coral creeper, *A. leptopus* (Polygonaceae) was found to attract a lot of *Braunsapis* sp., *Certaina* sp., *Apis florea* and few other wild bees.

C. hieroglyphica on *T. procumbens*

C. hieroglyphica on *V. trilobata*

Bees foraging on *A. leptopus*

Fig. 3.6: Bee flora

3.3.6. Single bee visits

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

3.3.7. Artificial bee nests

Attempts have been made to design artificial bee nests for wild bees. Wooden blocks made with neat circular holes (1.5 to 5 mm diameter and 7-9 cm length) and thin sticks of bamboo, *Lantana camara*, *Cenchrus* sp., and cashew were arranged (Fig. 3.7). Bigger holes in wooden blocks were occupied by Megachilids, *Ceratina* sp. and *Tetragonula* sp. Only 5-7 % of tiny holes were occupied by *Braunsapis* bees, whereas, 60 % of medium sized holes were occupied (Fig. 3.7). The tiny sticks especially of bamboo were also well occupied by *Braunsapis* sp. Hence, such artificial bee nests could help in conserving the wild bees.

Fig. 3.7: Artificial bee nest

3.4. Investigations on inflorescence pests of cashew and their management

3.4.1. Documentation of inflorescence pests

Besides Tea Mosquito Bug (TMB), inflorescence of cashew is infested by several pests starting from its emergence till fruiting (Table 3.7 & Fig. 3.8). Shoot tip caterpillars damaged the flower buds to an extent of 3-5 % from January to March. Infestation by caterpillars was more during December - January (7-9 %.) Up to three caterpillars especially flower webbers were recorded per inflorescence. Lepidopteran pests documented during 2017 include, *Nanaguna* sp. (Nolidae), *Autoba* sp. (Erebidae), *Dudua aprobola* M. (Tortricidae), *Thylacoptila paurosema* M. (Pyralidae), *Hyposidra* sp. (Geometridae), *Euproctis* sp. (Erebidae) and also Gelechiids.

Besides, three species of thrips *viz., Scirtothrips dorsalis*, *Thrips florum* and *Thrips hawaiiensis* (Thripidae: Thysanoptera) also damage cashew flowers. Among, *S. dorsalis* was abundant (97.25 %) and up to 16 thrips was recorded in an inflorescence. Thrips damage resulted in drying of flowers, appearance of corky patches in developing nuts as well as apples, fruit cracking in matured apples and malformation of nuts. Other pests include mealy bugs *viz., Ferrisia virgata*, *Planococcus* sp. (Pseudococcidae: Hemiptera), aphids *Toxoptera odinae* (Aphididae: Hemiptera)), mirids, tiny beetles (*Oryzaephilus* sp. (?)), Cetonid beetles, undetermined mites etc.

Table 3.7: Level of infestation of inflorescence pests on cashew (N= 360)

Pest	Mean / panicle	Range
Thrips	1.86	0-16
TMB	0.07	0-2
Flower beetles	1.04	0-9
Mirids	0.38	0-4
Caterpillars including apple and nut borer	0.18	0-2
Aphids	0.25	0-6
Mealy bugs	0.15	0-3
Mites	0.21	0-4
Others	0.15	0-3

Thrips damage on cashew apples

Ferrisia virgata

Hyposidra sp. damaging a flower bud

Fig. 3.8: Inflorescence pests of cashew

3.4.1. Natural enemies

Natural enemies recorded on cashew inflorescences include predators like coccinellids, lace wing bugs, anthocorid bugs, geocorid bugs, syrphids, ants and spiders. The number of such predators varied from 1-5/inflorescence. In addition, several parasitoids also attacked caterpillars, which are yet to be documented. Parasitism and predation was noticed to a higher extent (30-40%) on flower webbers during February-March which suppressed their population build up subsequently.

4. POST-HARVEST TECHNOLOGY

4.1 Developing quality standards for raw cashewnuts

4.1.1 Dimension analysis of indigenous raw cashewnuts

Spatial dimension and nut quality in terms of nut count and outturn for 40 samples collected from AICRP centres are presented in Table 4.1. Raw nut dimension in major, minor and intermediate axes are found to be in the range of 25.8-39.5, 19.3-28.8 and 14.2-21.3mm respectively. Average values of sphericity and equivalent diameter of these nuts ranged from 18.87 to 27.69 and 0.82 to 0.88 units respectively. There was no strong correlation observed between nut and kernel characters except weight (0.76). Among the varieties, nut count found to be minimum for 'Vengurla-7' (91), whereas 'Anagha' registered maximum of 250 nuts per kg. As far as outturn is concerned, 'VRI-Cw' (62%) recorded the highest and 'Raghav' (45.4%) found to the lowest. It was observed that nut size has strong correlation with weight. Proportion of medium size nuts found to be the highest among the graded nuts. After processing kernal size turn out to be 'W320' grade and hence, this grade is considered as bench mark for price computation. The outturn was maximum in VRI-Cw (62%) and minimum in Rabhav (45.4%). Besides, pest infested nuts yielded good kernels to the tune of 18-83% and there was no definite correlation among the observed parameters. Poor correlation observed between the season of harvesting and kernel quality. This was evident from the proportion of good kernels from the nuts obtained from Kemminje (71-84%) and Shantigodu farm (49-92%).

Table 4.1: Spatial dimension of raw cashewnuts obtained from AICRP centers (N=25)

Sl. No	Variety	Rawnut				Kernel				Shelling %	Nut count	Outturn (lbs)
		Length (mm)	Width(mm)	Thickness (mm)	Weight (g)	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)			
1	BPP-1	29	22.7	17	5.6	22.3	15.3	12.2	1.6	29.4	180	51.8
2	BPP-2	28.1	21.1	16.8	5.1	22.1	14.2	11.9	1.6	30.3	218	53.4
3	BPP-3	29	23.4	18.1	6.5	25	17.5	12.6	2.1	32.3	134	56.9
4	BPP-4	30.8	22.5	16.9	5.6	24	16	12.3	1.8	32.5	177	57.3
5	BPP-5	29.9	22.3	17.8	5.9	24.2	16.3	12.8	1.9	31.4	171	55.3
6	BPP-6	32.3	23.1	16.4	6.1	25.1	16	10.7	1.9	30.6	174	54
7	BPP-8	33.4	26.1	19.1	7.8	26.7	19.1	12.9	2.4	30.1	138	53.1
8	BPP-9	34.2	26.8	18.7	8.5	26.9	18.1	13.2	2.4	28.4	126	50.1
9	Vengurla - 1	31.7	23.4	18.2	6.5	26.4	16.7	11.9	2.1	32.9	169	58.1
10	Vengurla - 2	30	22.6	14.2	5.1	24	16.8	9.6	1.8	34.7	208	61.1
11	Vengurla - 3	34.2	27	19.8	8.6	27.2	17.5	13.2	2.5	29.2	120	51.4
12	Vengurla - 4	37.3	26.7	18.4	9.6	30.1	18.9	12.2	2.7	28.7	118	50.6
13	Vengurla - 5	26.4	20.1	14.8	4.4	21.2	14.2	10.1	1.5	33.5	223	59.1
14	Vengurla - 6	35.6	27.4	20.3	9.9	28.9	19.3	14	2.8	28.3	103	49.9
15	Vengurla - 7	39.5	28	21.3	11.4	30.6	18.6	14.4	3.4	30.1	91	53.1
16	Vengurla - 8	36.7	28.8	19.7	10.2	29.1	20.2	14.6	2.9	28.5	105	50.3
17	Vengurla - 9	35.5	27.3	19.8	9.7	27.4	19	13.3	2.9	29.8	107	52.5
18	Indira caju	35.2	27.4	20.8	8.8	27	19.4	14.8	2.8	31.6	103	55.6
19	Jagannatha (BH6)	30.2	24.4	17	6.1	24.4	16.9	12.4	2.2	35	168	61.7
20	Bhuvaneshwar - 1	29.1	22	15.4	5	24	15.7	10.8	1.6	30.1	218	53
21	Balabhadra (BH85)	34.3	25	16.1	6.6	28.5	18.5	11.3	2.3	33.9	157	59.7

22	Anagha	25.8	19.3	14.8	3.8	20.6	13.7	9.4	1.2	30.7	250	54
23	K 22- 1	31.5	24.6	17.3	7.2	25.3	17.7	12.8	2.2	30.6	176	53.9
24	Dhana	32.1	24.4	19	7.7	26.2	16.6	13.2	2.1	26.6	151	46.9
25	Priyanka	31.2	24.2	18.1	6.7	25.3	16.9	13	2.1	30.7	159	54.1
26	Poornima	32.6	23.6	19.2	6.6	26.9	16.8	13.2	2.1	31.6	164	55.8
27	Maddakkathara -1	29.4	22.5	15.9	5.5	24.4	15.9	11.8	1.8	33.3	200	58.6
28	Maddakkathara -2	30.2	23.2	18.4	6.5	23.9	16.2	13.2	2	30.8	159	54.3
29	Raghav	35.3	26	17.3	8.2	27.4	17.9	11.7	2.1	25.7	147	45.4
30	Damador	30.7	23.1	18.4	6.4	24.3	16.1	13.1	2	30.7	186	54.1
31	Amrutha	29.3	22	18.8	6	24	14.9	13.3	1.8	30	170	52.9
32	Dharasree	32.9	24	19.5	7.6	26.5	17	12.6	2.3	29.9	156	52.7
33	Jhargram -1	28.8	22.5	14.7	5	23.1	16.3	10.8	1.6	33	218	58.1
34	Jhargram -2	35.7	26.9	18.6	8.3	26	18	12.5	2.3	27.4	128	48.3
35	VRI -2	29	22.6	18.8	6.1	23.9	15.3	13.6	1.9	31.3	164	55.1
36	VRI -3	32.5	25.1	17.3	7.1	27.1	18.4	12.2	2.3	32.1	146	56.5
37	VRI -4	29.5	22.3	16.5	5.6	24.8	15.6	11.4	1.8	31.8	170	56
38	VRI -Cw	32.2	25	17.7	6.9	27.1	15.9	12.9	2.2	35.2	142	62
39	Bhaskara	32.1	24	17.1	6.6	26.1	116.2	12.1	2	29.5	157	51.9
40	Mixed	31	22.9	18.8	6.8	24.7	15.1	13.5	2.2	32	156	56.3

4.1.2 Empirical relationship representing quality

To represent quality, an empirical relationship was developed by taking the proportion of graded raw cashewnuts, prevailing market price for cashew kernels, count based nut weight and yield of good kernels and other fractions. This quality index suggests the value between 0.08 and 1.0 wherein the lowest value represents completely spoiled kernels as final yield and highest value indicating 100% good kernels. This product value method has not incorporated moisture content, which has strong bearing on the quality of raw cashewnuts as far as its shelf life is concerned. It needs to be modified once instantaneous and non-destructive mode of moisture determination is devised.

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

Where, **Y** is the quality index (1.0<Y<0.1); **A** is the grade of cashew kernel; **X** is the assigned value for the grade

4.2 Design and development of mechanized slicer for cashew apple

4.2.1 Performance evaluation of cashew apple slicer

Test results of 'Multi blade mechanical slicer' developed at this Directorate, after replacing with stainless steel disc blades indicated that initial shearing force is essential to pierce the waxy layer of apple to penetrate and slice. Strength of the blade and manner in which it is fitted to shaft, prevents distortion during slicing operation and ensures uniform thickness of slices. A mechanism should be provided at the rear side of the multi blades to

avoid slices carried along its rotation and guide the slices to the outlet, preventing slices thrown away by the centrifugal force. Inlet chute need to be designed in an angular manner to regulate the cashew apples by gravity. Slicing mechanism need to be given drive force through high torque motor to have control on centrifugal force generated for slicing and check loss of juice by compression.

4.2.2 Design and development of mechanical slicer for cashew apple

Trials were conducted to slice cashew apples using multi string approach, wherein cashew apple was pressed against strings tied in parallel direction. Due to presence of waxy coat having thickness up to 0.2 mm surrounding the fruit and blunt edges of the string, shearing had not taken place to slice cashew apple. Alternatively, staggered disc blades slicer designed along with belt conveyor to feed cashew apples automatically for slicing (Fig. 4.1). This design facilitated to cut cashew apple in to two halves in the first instant, followed by slicing the cut apples by the staggered disc blades provided on either side and so on. Positioning the halves of the cashew apples after first slicing and preventing the distortion of cut apples are the prime issues encountered in this prototype.

Fig. 4.1: Staggered disc blade cashew apple slicer

4.3 Design and development of moisture meter for raw cashewnuts

4.3.1 Moisture dynamics in raw cashewnuts

Distribution of moisture content in different layers *viz.,* whole nut, shell and kernel revealed that similar trend observed for all the three different layers irrespective of varieties. In general, moisture content declined from peanut to fully matured stage for the varieties investigated indicating hardening of the nuts (Fig. 4.2) The moisture content found to be the lowest for kernel in the beginning and increased towards full maturity. Moisture content of whole nut lies between kernel and shell irrespective of growth phase and this could be used to develop moisture meter.

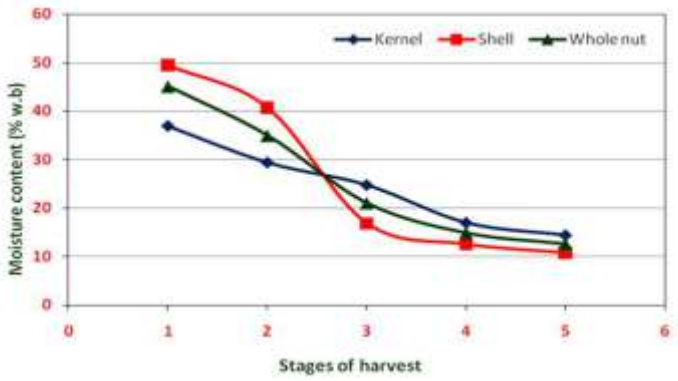


Fig. 4.2: Stage-wise moisture distribution in maturity stages of raw cashewnut

4.3.2 Developing moisture meter for raw cashewnuts (RCN)

Trials were conducted with freshly harvested RCN using 'OSAH' moisture meter available at Punjab Horticulture Post harvest Technology Centre, Punjab Agricultural University, Ludhiana to calibrate for RCN. Owing to larger size and irregular shape of the nut, the sample container could not accommodate the sample. Moreover, the pressure plate crushed RCN making CNSL to ooze out which led to inaccurate value of moisture. To augment this problem a linkage was developed with Council for Scientific Instruments Organization (CSIR-CSIO), Chandigarh for developing moisture meter.

4.4 Studying comparative performance of cashewnut processing systems in India

4.4.1 Diagnostic study on cashewnut processing units in Karnataka and Kerala

Industry oriented technical problems were identified based on the diagnostic study conducted with two units representing labour oriented and semi-mechanized mode of processing. Optimization of processing parameters influencing the quality of end product found to be the prime issue of the industry. Efficient utilization of human, thermal and electrical energy is the secondary issue to be tackled to minimize the cost. Moisture control has become the utmost important factor at all stages and non-destructive moisture meter is essential. Imparting better skill improvement training at shelling, peeling and grading stages bring balance between quality output and cost incurred. Cost of processing ranged between Rs. 1200-1400 for labour oriented processing and in the range of Rs. 1700-2000 per bag of 80 kg RCN depending upon the level of mechanization and quantum of conditioned nuts per day.

M/s. Chandra Cashews located in Kerala categorized under labour oriented unit was visited to investigate its performance. In spite of air pollution, drum roasting process is predominant in this region. Inadequate supply of raw cashewnuts at reasonable price is the major problem faced by the industry. Discolouration and lower kernel recovery are secondary level problems to be tackled. Major issue related to cashew industry in Kerala are i) Increase in the wages imposed by Government of Kerala, up to 44% including perks; ii) Reduction in the incentive for exporters from 5 to 2%; iii) Imposition of import duty on RCN; iv) Import of cashew kernels into India and v) Unethical trade practices by multinational traders.

4.5 Screening of cashew varieties to specify use of cashew apple in value added products

All the five new products (technologies) *viz.*, pulp, jam, jelly, cashlime and cider developed were studied for their nutrient composition and storage life. The parameters studied were, TSS, Vitamin C, tannin, total phenol and antioxidants activity by CUPRAC and FRAP assay.

4.5.1 Cashew apple pulp

The effect of storage time (months) on biochemical composition of fresh cashew apple pulp was studied. Effect of pulp blanching on its storage behavior was studied in comparison with unblanched sample. Heating of pulp at about 100°C for 1-2 minutes resulted in depletion in few heat labile nutrients like Vitamin C (343 mg/100 ml) over unblanched sample (368 mg/100 ml), but inactivation of enzymes due to blanching resulted in retention of maximum nutrients (TSS-9°Brix, Vit-C 273mg/100 ml, Tannins-148 mg/100 ml, Total

Phenol Content (TPC)-236 mg/100 ml, CUPRAC Assay-863 mg/100 ml and FRAP Assay-463 mg/100 ml) during the storage over unblanched samples (TSS-8.8°Brix, Vit-C251mg/100 ml, Tannins-140 mg/100 ml, TPC-230 mg/100 ml, CUPRAC Assay-803 mg/100 ml and FRAP Assay- 426 mg/100 ml) and color of the blanched pulp at the end of twelve months frozen storage was better than unblanched samples (Table 4.2).

Table No. 4.2: Storage study of unblanched & blanched cashew apple pulp

Particulars	TSS (°Brix)							Vit-C (mg/100 ml)						
Months after storage	0	2	4	6	8	10	12	0	2	4	6	8	10	12
Unblanched pulp	9	9	9	8.8	9	9	8.8	368	355	311	292	282	264	251
Blanched pulp	9.5	9.5	9.5	9.6	9.5	9.2	9	343	333	326	303	296	283	273
Mean	9.25	9.25	9.25	9.2	9.25	9.1	8.9	355.5	344	318.5	297.5	289	273.5	262
SD	0.2	0.2	0.14	0.25	0.22	0.1	0.08	1.24	1.36	4.25	2.39	0.69	1.78	1.51

Particulars	Tannin (mg/100 ml)							TPC (mg/100 ml)						
Months after storage	0	2	4	6	8	10	12	0	2	4	6	8	10	12
Unblanched pulp	172	172	170	162	158	148	140	252	250	248	250	239	232	230
Blanched pulp	186	179	166	160	156	152	148	248	251	248	243	239	238	236
Mean	179	175.5	168	161	157	150	144	250	250.5	248	246.5	239	235	233
SD	3.81	2.17	1.3	0.96	0.96	1.71	2.38	1.5	1.31	1.93	1.97	1.3	1.89	1.58

Particulars	CUPRAC Assay (mg/100 ml)							FRAP Assay (mg/100 ml)						
Months after storage	0	2	4	6	8	10	12	0	2	4	6	8	10	12
Unblanched pulp	917	910	903	902	890	860	803	511	508	510	508	492	470	426
Blanched pulp	916	903	897	891	887	871	863	497	492	486	479	474	467	463
Mean	916.5	906.5	900	896.5	888.5	865.5	833	504	500	498	493.5	483	468.5	444.5
SD	0.63	1.89	3.33	2.87	2.191	3.07	1.74	3.76	3.99	1	0.79	1.19	1.11	1.07

4.5.2 Cashew apple jam

Cashew apple jam was also studied for its nutrient value and storage life at room temperature. Jam being a self-stable processed product due to its high sugar content (68°Bx) could retain maximum of its nutrients (TSS-67°Brix, Vit-C 83mg/100 ml, Tannins-103 mg/100 ml, TPC-119 mg/100 ml, CUPRAC Assay-372 mg/100 ml and FRAP Assay 169 mg/100 ml) even after five months of storage at room temperature (Table 4.3) compared to fresh preparation (TSS-68°Brix, Vit-C 121mg/100 ml, Tannins-112 mg/100 ml, TPC-134 mg/100 ml, CUPRAC Assay-403 mg/100 ml and FRAP Assay-200 mg/100 ml).

Table 4.3: Storage study of jam

Storage time (Months)	TSS (°Brix)	Acidity (%)	Ascorbic acid (mg/100ml)	Tannins (mg/100ml)	TPC (mg/100ml)	CUPRAC (mg/100ml)	FRAP (mg/100ml)
Fresh Preparation	68	0.54	121	112	134	403	200
1	68	0.54	116	119	139	390	203
2	67	0.54	110	112	129	396	189
3	67	0.56	94	109	128	382	182
4	68	0.57	90	108	126	371	167
5	67	0.57	83	103	119	372	169
6	67	0.56	NA	NA	NA	NA	NA

4.5.3 Cashew apple jelly

The trend of nutrient retention of jelly was found similar to the jam. Jelly was also stored at room temperature and was observed for change in its nutrient content during storage. Jelly also being a self-stable processed product like jam due to its high sugar content (65.5^{0}Bx) could retain maximum of its nutrients (TSS-65^{0}Brix, Vit-C 91mg/100ml, Tannins-90 mg/100 ml, TPC-107 mg/100 ml, CUPRAC Assay-282 mg/100 ml and FRAP Assay- 122 mg/100 ml) even after five months of storage at room temperature (Table 4.4) compared to fresh preparation (TSS-65.5^{0}Brix, Vit-C 142 mg/100 ml, Tannins-93 mg/100 ml, TPC-117 mg/100 ml, CUPRAC Assay-316 mg/100 ml and FRAP Assay-152 mg/100 ml).

Table 4.4: Storage study of Jelly

Storage time (Months)	TSS (°Brix)	Acidity (%)	Ascorbic acid (mg/100ml)	Tannins (mg/100ml)	TPC (mg/100ml)	CUPRAC (mg/100ml)	FRAP (mg/100ml)
Fresh Preparation	65.5	0.50	142	93	117	316	152
1	65.5	0.50	134	94	116	321	154
2	65.5	0.50	121	91	108	318	153
3	66.0	0.52	107	93	104	309	138
4	66.0	0.52	98	92	111	289	129
5	65.0	0.53	91	90	107	282	122
6	65.0	0.52	NA	NA	NA	NA	NA

4.5.4 "Cashlime" - A Cashew apple and lemon juice blended RTS/Nectar:

Like other products, cashlime was also analyzed for its nutrient content and storage life. The product was stored at refrigeration temperature and room temperature. Based on biochemical behavior of the products at both the storage conditions, it was observed that the product stored at refrigeration temperature could retain maximum of its nutrients till completion of fifth month (TSS-10.5^{0}Brix, Vit-C 72 mg/100 ml, Tannins-76 mg/100 ml, TPC-58 mg/100 ml, CUPRAC Assay-186 mg/100 ml and FRAP Assay- 123 mg/100 ml) compared to fresh one (TSS- 12^{0}Brix, Vit-C 86 mg/100 ml, Tannins-76 mg/100 ml, TPC-72 mg/100 ml, CUPRAC Assay-242 mg/100 ml and FRAP Assay-169 mg/100 ml) whereas, the samples stored at room temperature began to lose its quality after two months of storage (Table 4.5).

Table 4.5: Storage study of blended RTS at refrigeration and room temperature

Particulars	TSS (°Brix)						Acidity (%)					
MAS*	0	1	2	3	4	5	0	1	2	3	4	5
4°C	12	12	12	12	11.5	10.5	0.38	0.38	0.36	0.35	0.46	0.49
Room temp.	12	11.5	10	8.5	-	-	0.38	0.51	0.55	0.49	-	-
Mean	12	11.75	11	10.75	-	-	0.38	0.45	0.44	0.42	-	-
SD	0.1	0.14	0.42	0.82	-	--	0.01	0.3	0.4	0.03	-	-

Particulars	Vit-C (mg/100 ml)						TPC (mg/100 ml)					
MAS*	0	1	2	3	4	5	0	1	2	3	4	5
4°C	86	86	83	77	74	72	72	71	69	68	61	58
Room temp.	86	77	72	54	-	-	72	62	51	36	-	-
Mean	86	81.5	76.5	66.5	-	-	72	66	59.5	47	-	-
SD	0.01	2.91	3.11	6.22	-		0.01	0.75	1.45	2.9	-	-

Particulars	CUPRAC Assay (mg/100 ml)						FRAP Assay (mg/100 ml)					
MAS*	0	1	2	3	4	5	0	2	4	6	8	10
4°C	242	238	230	225	203	186	169	164	158	151	142	123
Room temp.	242	220	178	134	-	-	169	148	110	76	-	-
Mean	242	229	204	129.5	-	-	169	155	134	113.5	-	-
SD	0.01	0.37	0.78	1.25	-	-	0.01	0.23	0.38	1.2	-	-

*MAS : Months After Storage

4.5.5 Cashew apple cider (3-6% Alcohol):

Cashew apple cider was analyzed for its functional nutrient value and shelf life. The product was stored at refrigeration and room temperature. Based on biochemical behavior of the products at both the storage conditions it was observed that the product stored at refrigeration temperature could retain maximum of its nutrients till completion of 24 months (Vit-C 109 mg/100 ml, TPC-137 mg/100 ml, CUPRAC Assay-84 mg/100 ml and FRAP Assay-246 mg/100 ml) compared to fresh one (Vit-C 220 mg/100 ml, TPC-205 mg/100 ml, CUPRAC Assay-98 mg/100 ml and FRAP Assay-452 mg/100 ml) whereas the samples stored at room temperature were found stable with maximum nutrient retention up to 12 months of storage without any detrimental change in sensory quality of the product (Table 4.6).

Table 4.6: Biochemical changes during the storage of Cider at different temperatures

Vit-C (mg/100 ml)										
MAS*	0	3	6	9	12	15	18	21	24	27
Room temp.	220	182	142	109	92	81	62	34	26	9
4°C	220	209	206	190	165	142	128	114	109	94
Mean	220	195.5	174	149.5	128.5	111.5	95	74	67.5	51.5
SD	0.05	0.56	0.77	0.89	0.88	0.98	0.94	0.56	0.51	0.87

TPC (mg/100 ml)										
MAS*	0	3	6	9	12	15	18	21	24	27
Room temp.	205	196	178	168	146	128	110	102	93	84
4°C	205	203	198	197	187	160	145	140	137	134
Mean	205	199.5	188	182.5	166.5	144	127.5	121	115	109
SD	0.01	0.75	0.14	0.58	0.85	0.38	0.58	0.53	0.96	0.92

CUPRAC Assay (mg/100 ml)										
MAS*	0	3	6	9	12	15	18	21	24	27
Room temp.	98	89	80	73	70	65	62	60	54	50
4°C	98	96	96	92	88	86	85	85	84	84
Mean	98	92.5	88	82.5	79	75.5	73.5	72.5	69	67
SD	0.01	0.55	0.47	0.91	0.72	0.39	0.17	0.33	0.54	0.76

FRAP Assay (mg/100 ml)										
MAS*	0	3	6	9	12	15	18	21	24	27
Room temp.	452	442	365	307	261	235	203	168	113	98
4°C	452	450	436	407	393	381	340	298	246	209
Mean	452	446	400.5	357	327	308	271.5	233	179.5	153.5
SD	0.78	1.13	0.21	0.65	0.3	0.8	0.74	0.13	0.72	0.87

*MAS : Months After Storage

5. TRANSFER OF TECHNOLOGY

5.1 Tribal Sub Plan (TSP) programme

5.1.1 TSP demonstration plot visits

Visits were made to the different demonstration plots of TSP beneficiaries located in villages of Puttur and Sullia taluks *viz.,* Irde, Bettampady, Shanthigodu, Sampya, Sarve, Thingalady, Mandekolu. The TSP plots located at Chembu and Karike villages of Madikeri districts were also visited. The farmers were advised to follow the recommended package of practices for cashew cultivation. Financial assistance was given to 71 TSP beneficiaries for adopting improved cultivation practices in different parts of Dakshina Kannada, Madikeri and Kasaragod districts.

5.1.2 Training programme on cashew production technology

Technical advise was offered on cashew cultivation to tribal farmers of Chembu village, Madikeri Taluk on 27th February 2018 at Sri Vishnumurthy temple, Kudrepaya. The chief guest of the programme was Mr. Madhava K.K President, Gram panchayath, Chembu. Lecture on various aspects of cashew production technology like varieties, site selection, planting, maintenance of plants with proper pruning and training, fertilizer application, soil and water conservation, pest management, harvesting and value addition was delivered. Later, the trainees were taken to the field where the aspects of managing cashew plants, identification of pests like CSRB and TMB followed by their management were explained.

5.1.3 Farmers' education tour to Kerala

Eight TSP farmers were taken on agricultural education tour to Kerala during 12-14th March 2018. The farmers visited Indian Institute of Spices Research, Calicut and came to know about different pepper propagation techniques, nutmeg and turmeric varieties. They were exposed to different cashew varieties, cultivation practices and value addition aspects of cashew apple at Cashew Research Station, Madakkathara, Kerala. A visit was made to Agricultural Research Station, Munnuthi where the concept of Food Security Army was explained and different machineries for paddy cultivation were shown. They also visited a farmer's cashew plantation to learn about the practice of eco-friendly ways of controlling TMB. Further, the farmers visited Regional Research Station, Pilicode to know about different value addition possibilities in coconut and cashew.

5.2 Programmes organized

5.2.1 Programme on Nursery management and production technology in Cashew

ICAR-Directorate of Cashew Research, Puttur, in association with *Sevabharathi Savayava Krishi Parivar*, Puttur and *Samrudhi gida-gelaethana Sanga*, Puttur organised one day programme on nursery management and production technology in cashew on 11th September, 2017. The programme was sponsored by Directorate of Cashew and Cocoa Development Board (DCCD), Cochin. More than 100 cashew growers attended the programme. The chief guests were Dr. Venkatesh N. Hubballi, Director, DCCD, Cochin, and R.K. Bhaskar, president, *Samrudhi Gida-Gelaethana Sanga*, Puttur. The soft wood grafting technique and nursery management in cashew was explained and the grafting technique was demonstrated.

The chief guest Dr. Venkatesh N. Hubballi addressed the gathering and stated the achievements of DCCD in cashew area expansion in 13 different states. He also highlighted about conversion of rubber and mango plantations in Kerala and Maharastra into cashew plantations due to attractive price of raw cashewnut apart from ease of cultivation. Mr. R.K. Bhaskar expressed the cordial relationship between the farmers and ICAR-DCR, Puttur in dissemination of technologies for the last 25 years. He requested ICAR-DCR to continue the support in future.

5.2.2 Field day and awareness programme on soil health management

Two field day cum awareness programmes on soil health management were undertaken on 10th and 21st November, 2017. Different villages in Puttur taluk of Dakshina Kannada district namely, Balegudi, Madaka, Irde, Perlathadka, Uppalige, Bettampady, Mundur, Chavadi Mane, Balayer Mane, Thingaladi, Kedambadi Chavadi Mane, Keyyur and Kavu were covered. The importance of soil testing was explained and proper methods of soil sampling were demonstrated in farmer's field. Farmers were encouraged to take soil samples from their fields. A total of 54 soil samples were collected during the programme.

5.2.3 World Soil Day

World Soil Day was celebrated on 5th December, 2017 at the Directorate. The programme was attended by 130 participants including farmers from various villages in the Dakshina Kannada district of Karnataka and students of agricultural universities. The Chief Guest was Mrs. Shakunthala T. Shetty, Member of Karnataka Legislative Assembly, Mr. Nalin Kumar Kateel, Member of Parliament from Dakshina Kannada, Haji B.H. Khader Bantwal, Chairman, Karnataka Cashew Development Corporation (KCDC), Sri. Prakash S. Netalkar, Managing Director, KCDC were present as dignitaries. They spoke about the imporatance of soil health. Soil health cards were distributed to farmers by the dignitaries.

5.2.4 World Environment Day - 2017

The World Environment Day programme was organized at ICAR-DCR Puttur on 5th June, 2017. The programme included a talk on "Importance of preserving environment for the present and for the future" by Shri Jayaram Poojari, Sr. Health Inspector, Department of Health, Dakshina Kannada district, Mangalore. The Directorate with the help of Health Department, Government of Karnataka initiated a blood sampling programme amongst the construction labourers working at the construction site of Silver Jubilee Building and also for the staff and family of the Directorate to prevent the outbreak of monsoon related contagious diseases like malaria, dengue etc. On this occasion, the Directorate had also initiated fogging, clearing of water stagnation etc in the office premises, construction site, and residential complex to control the mosquito menace.

5.2.5 Foundation day and farmers meet – 2017

ICAR-Directorate of Cashew Research, Puttur celebrated its 31st Foundation Day on 17th June, 2017. On this occasion, 'Farmers Meet – 2017' was also organized in which more than 150 progressive cashew farmers participated besides nursery men, representatives of ICAR Institutes, KVKs, development departments, NGOs and scientists. Dr. D.C. Chowta, a progressive farmer from Kasaragod, was the chief guest of this function and guests of honour were Shri B.K. Ramesh, General Body member, Indian Council of Agricultural Research, New Delhi and Dr. Venkatesh N. Hubballi, Director of Directorate of Cashew nut and Cocoa Development , Cochin.

During the program, the renovated website of the institute (http://cashew.icar.gov.in) and two technical folders on 'High density planting in cashew' and 'Post harvest technologies for commercialization in cashew" were also released. Further, two selected cashew farmers were felicitated. Mr. Sheenappa Gowda, a progressive farmer from Perabe, Puttur was felicitated for achieving good productivity in cashew in a span of three years. Another farmer felicitated was Shri Dhooma Malekudiya, who took cashew cultivation under tribal sub plan of the institute.

In the inaugural address, Dr. Chowta opined that farmers of this region should grow income generating crops along with many other fruit crops. Further, he opined that farmers should be able to fix the price for their produce instead of others. He felt that farming should be taken up as a happy enterprise by all farmers. Dr. Venkatesh Hubballi, said that this is a golden period for cashew as the price is high and farmers are getting lot of encouragement.

5.2.6 Agricultural Education Day - 2017

ICAR- Directorate of Cashew Research, Puttur organized Agricultural Education Day on 4th December, 2017 (designated on 3rd December) to commemorate the birth anniversary of first President of Independent India and Union Minister of Agriculture, Dr. Rajendra Prasad. The programme was attended by nearly 200 members representing pre university students and teachers from various colleges in Puttur as well as ICAR-DCR. Capt. Ganesh Karnic, MLC, Karnataka was the chief guest. He motivated the young minds to choose agriculture which has a spectrum of job opportunities for securing the future of both individual as well as nation. The guests of honour were Shri. B. K. Ramesh, General Body member, ICAR and Shri. N. Achutha Moodethaya, a progressive farmer. A lecture on "Scope of Agricultural Education" delivered by Shri. Eradasappa, Scientist, DCR, Puttur highlighted different disciplines of agricultural sciences, agricultural universities in Karnataka and India, career opportunities in agriculture and national schemes and scholarships available to promote agricultural education.

5.2.7 Annual Cashew Day – 2018

The Annual Cashew Day was celebrated on 21st March, 2018 at the Directorate. Dr. Narayanaswamy, Vice Chancellor was the chief guest and Shri. Gurunath Odugoudar, a progressive farmer of Gadag district, Former Board Member of University of Agricultural Sciences, Dharwad and Shri B.K. Ramesh, General Body Member, ICAR and Dr. Ananda K.S., Head, Regional Station, ICAR- CPCRI, Vittal were the guests of honour. On the occasion, the first cashew hybrid of ICAR-DCR, H-130 was released for evaluation in the farmers' fields. This hybrid has precocious flowering behavior and suitable for high density planting. It has bold nuts weighing around 12-13 grams and yield levels are also high. In the program, the Memorandum of Understanding for licensing of six cashew nut processing machinery technologies of DCR was also exchanged with the private company M/s. Pro B products, Bengaluru.

An exhibition on cashew production technologies, different cashew varieties and cashew apple products was also organized. In addition, various publications on cashew production and processing technologies were displayed. Farmers were taken to the fields to show the various cashew research plots. More than 200 cashew farmers participated besides nursery men, representatives of KVK, development departments and scientists.

5.3 Exhibitions

5.3.1 World Food India- 2017, New Delhi

ICAR-DCR, Puttur participated in World Food India (WFI), a global event organized by the Ministry of Food Processing Industries, Government of India during 3-5th November, 2017 to facilitate partnerships between Indian and international businesses and investors. WFI was a gateway to the Indian food economy and an opportunity to showcase, connect and collaborate. WFI was the largest gathering of investors, manufacturers, producers, food processors, policy makers, and organizations from the global food ecosystem. The Directorate exhibited technologies in the form of cashew apple based value added products namely, Cashlime (cashew apple lemon blend RTS), Cider, Jam and jelly along with posters.

5.3.2 Mega Kisan Mela and Agri-Business Expo - 2018

ICAR-DCR, Puttur participated in the Mega Kisan Mela and Agri-Business Expo at ICAR- Central Plantation Crops Research Institute, Kasaragod from 5-10th January, 2018. The Directorate put up an exhibition stall showcasing the technologies developed by the Directorate and AICRP Centres on cashew. The technologies on scientific cultivation practices, nursery management, varietal information, pest and disease management, post harvest handling and value addition were exhibited. The stall was visited by many farmers, students, extension functionaries, researchers and public from different parts of Kerala, Karnataka and other regions of the country including Tamil Nadu and Gujarat.

5.3.3 Mega National Horticulture Fair-2018

ICAR- DCR, Puttur participated in Mega National Horticulture Fair-2018 held at ICAR-Indian Institute of Horticulture Research, Hesarghatta, Bengaluru from 15-17th March, 2018. During the event, ICAR-DCR exhibited the different technologies like commercial varieties of cashew, high density planting and ultra high density planting systems, water and soil management in cashew, TMB and CSRB management and processing of cashew apple. More than five thousand participants from Karnataka, Tamil Nadu, Telangana, Andhra Pradesh and Maharashtra had visited the stall.

5.4 Mera Gaon Mera Gaurav (MGMG) program

5.4.1 Programme at Irde- Bettampady

A MGMG programme was organized by Scientists of ICAR-DCR, Puttur, at Irde-Bettampady village, D.K on 28th March, 2018. More than 20 people including farmers, gram panchayat members, students and scientists attended the programme. In the interaction session, farmers were given information about management of cashew and other plantation crops.

5.4.2. Program at Aletti

On 23rd February, 2018, a program under MGMG was conducted in Aletti village, Dakshina Kannada district. Nearly 25 farmers were participated and cashew cultivation and processing related issues were discussed in detail. The farmers were distributed with cashew production technology pamphlet and cashew graft application.

5.5 Development of an exclusive android application for cashew cultivation

A state of the art android app giving comprehensive information on cultivation, processing, marketing, agencies involved in cashew development etc. will be developed in 10 languages with the inputs from AICRP centres on cashew. During the year, a detailed story board involving all elements of the app was written and the development of app is under progress.

ADDITIONAL INFORMATION

6. CONCLUDED PROJECTS

6.1 Network project on micronutrient management in horticultural crops for enhancing yield and quality

Project Leader	:	Dr. T.R. Rupa (Apr. 2014 - Feb. 2016) Mrs. Prabha Susan Philip (Feb. 2016 - Jul. 2017) Dr. Shamsudheen, M. (From Jul. 2017 - Jan. 2018)
Project Associate	:	Dr. Babli Mog (From Apr. 2014)
Project Number	:	Network Project
Project Duration	:	April 2014 to March 2017

6.1.1 Introduction

A network project was in operation on micronutrient management in cashew at ICAR-Directorate of Cashew Research from 2014-15 to 2017-18 with ICAR- Indian Institute of Horticultural Research, Bengaluru as the lead centre. The project was implemented with the following objectives.

6.1.2 Objectives

- To delineate micronutrient deficient areas of cashew using district boundary maps and secondary data.
- To document micronutrient deficiency symptoms in cashew seedlings and establishment of micronutrient guidelines.
- To exploit soil-microbial and micro-nutrient interactions for efficient mobilization of micronutrients.
- To develop management methods for production of micronutrient dense fruits / nuts
- To develop region specific soil and foliar nutrient formulations for cashew.

6.1.3 Results

6.1.3.1 Micronutrient status in cashew growing soils of Dakshina Kannada district, Karnataka

To characterize the available micronutrient status of cashew growing soils of Dakshina Kannada district of Karnataka, 33 farmers' fields were selected. Soil sampling was carried out by taking samples to represent the entire village, by collecting 10 to 12 samples to make one composite sample. The analysis revealed that available Fe and Mn were sufficient in all the soils while; the available Zn was deficient in 75.8% of the soil samples. The available Cu was deficient in 6.06% samples and available B was deficient in majority of the soils (87.9 per cent of soil samples). The available micronutrients content of these soils were in the order of Fe > Mn > Cu > Zn > B. The available Fe, Mn, Zn, Cu and B status maps of cashew orchards of Dakshina Kannada district in Karnataka are shown in Figs. 6.1 to 6.5.

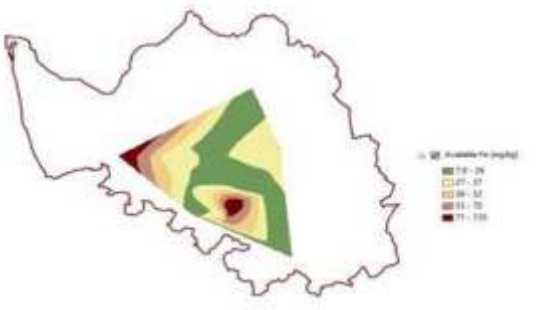


Fig. 6.1: Available Fe status map

Fig. 6.2: Available Mn status map

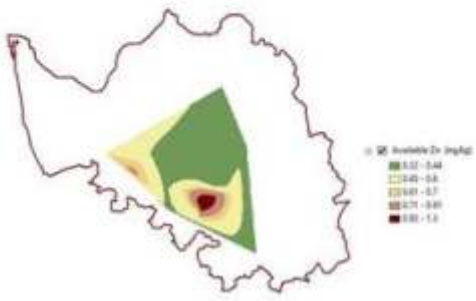


Fig. 6.3: Available Zn status map

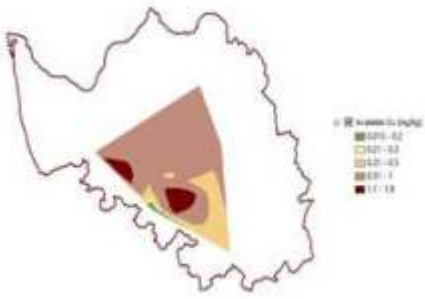


Fig. 6.4: Available Cu status map

Fig. 6.5: Available B status map

Fig. 6.1-6.5 : Micronutrient status Map of Dakshina Kannada district of Karnataka

6.1.3.2 Micronutrient status in cashew growing soils of Ratnagiri district, Maharashtra

The maps showing the spatial distribution of available micronutrients in cashew growing soils of Ratnagiri District, Maharashtra is presented in Figures 6.6 to 6.9. Available micronutrient status of cashew orchard soils of Ratnagiri district measured in terms of nutrient index (NI) indicated that the values for DTPA-Fe, Mn, Zn and Cu were 3.0, 3.0,

2.18 and 2.71, respectively. Nutrient index value of <1.5 is taken as low, values between 1.5 and 2.5 indicates medium and >2.5 as higher fertility status of a given area. Based on the nutrient index value, cashew orchard soils of Ratnagiri district were high in DTPA-Fe, DTPA-Mn and DTPA-Cu contents while, majority of soils were medium in DTPA-Zn content.

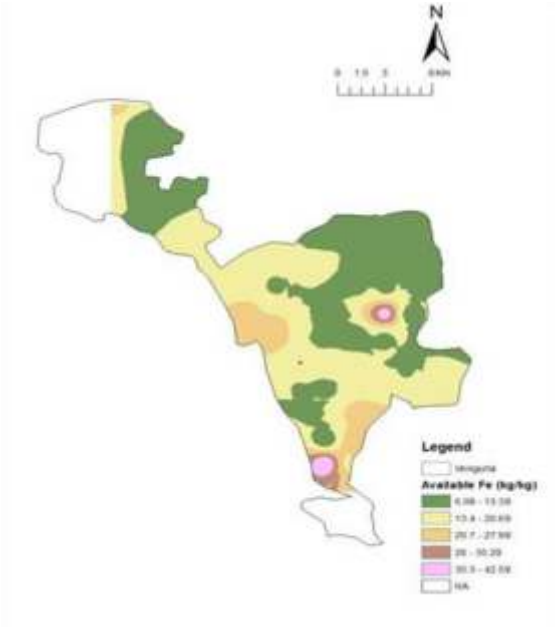


Fig. 6.6: Available Fe status map

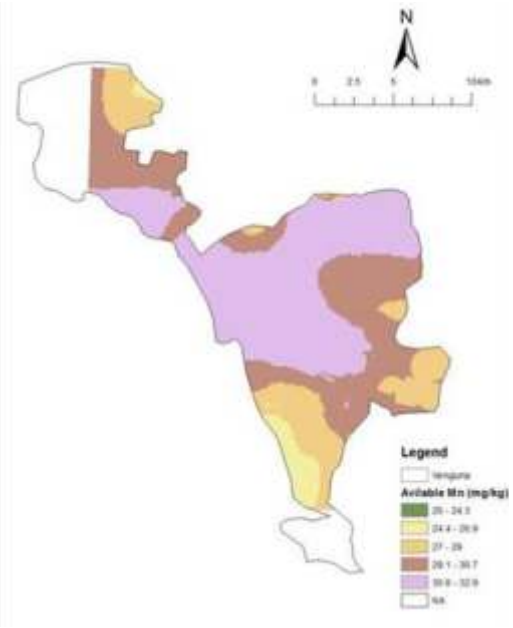


Fig. 6.7: Available Mn status map

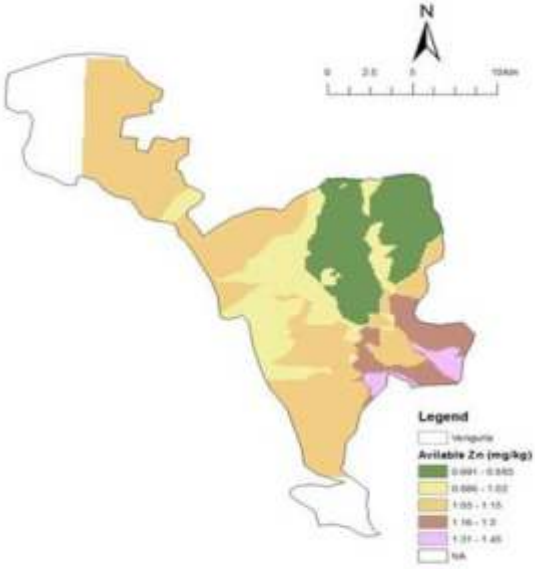


Fig. 6.8: Available Zn status map

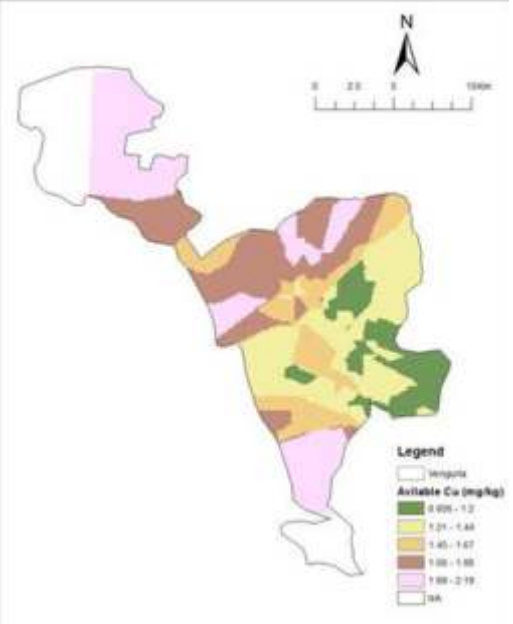


Fig. 6.9: Available Cu status map

Fig. 6.6-6.9 : Micronutrient status Map of Rathnagiri district of Maharashtra

6.1.3.3 Micronutrient deficiency symptoms in cashew seedlings

To determine the effects of nutrient deficiencies on the growth and vigour of cashew seedlings and to identify and document deficiency symptoms, sand culture nutrient deficiency studies with young cashew seedlings variety Bhaskara were initiated in the polyhouse. Two months old cashew seedlings of uniform height and stem diameter raised in coir

pith medium, were transferred to plastic pots containing acid treated sand. Treatments included -N, -P, -K, -Ca, -Mg, -S, -Fe, -Mn, -Zn, -Cu, -B and -Mo, complete nutrient solution and control. The untreated sand and acid washed sand were tested for their nutrient contents before pot preparation. The pH, organic carbon and available N contents of acid washed sand were 6.8, 0.20% and 36 mg kg^{-1}, respectively while available K, Ca and Mg contents were negligible. The acid washed sand had pH of 6.7 whereas, the organic carbon content, available N, P, Ca and Mg contents were negligible and suitable for treatment applications.

Nutrient deficiency symptoms of cashew seedlings were identified (Fig. 6.10). Nitrogen (N), Phosphorus (P), Potassium (K) and Magnesium (Mg) being mobile elements inside the plant system, deficiency symptoms appeared in older/lower leaves of the potted plants. Iron (Fe), Sulphur (S) deficiency symptoms developed on the younger leaves. Calcium (Ca) and Boron (B) deficiency symptoms developed on the terminal buds/ leaves. Zinc (Zn), Copper (Cu), Molybdenum (Mo) and Manganese (Mn) deficiency symptoms appeared on middle and upper leaves. Plants deficient in nitrogen exhibited stunted growth with reduced plant height, girth and number of leaves. Lower/older leaves were initially dark green and later, the color changed to light green and finally to yellow; petiole also changed from green to reddish colour. Symptoms appeared 4-7 weeks after treatment imposition. Phosphorus deficient plants showed the symptoms very late. Leaves were dark green during initial 3-4 months, later stages lower leaves developed greenish yellow and then turned yellow starting from midrib to leaf margin between the veins. The symptoms of potassium deficiency appeared after three months of treatment imposition. The lowest leaves turned yellow, starting from the apex and along the leaf margins.

The youngest/terminal leaves of Calcium deficient plants were chlorotic. Curling of top leaves occurs in cases giving them an undulated appearance. Magnesium deficiency symptoms were interveinal yellowing of the lower leaves. Sulphur deficiency symptoms were quite similar to that of Nitrogen but, deficiency appeared on terminal leaves. Terminal leaves became chlorotic and colour of leaves gradually changed from green to yellow and premature leaf drop also noticed in such terminal leaves. Iron deficiency appeared eight weeks after treatment imposition. Severe chlorosis of young leaves occurred, and later the whole leaf turned chlorotic except the midrib and the main veins. Boron deficiency was visible on terminal buds/ emerging shoots characterized by dieback of twigs along with gummosis. This condition in turn lead to development of more number of lateral shoots. In case of Molybdenum deficiency, lower leaves turned chlorotic then to greenish yellow with red to brown colored mottled spots on both sides of the leaves.

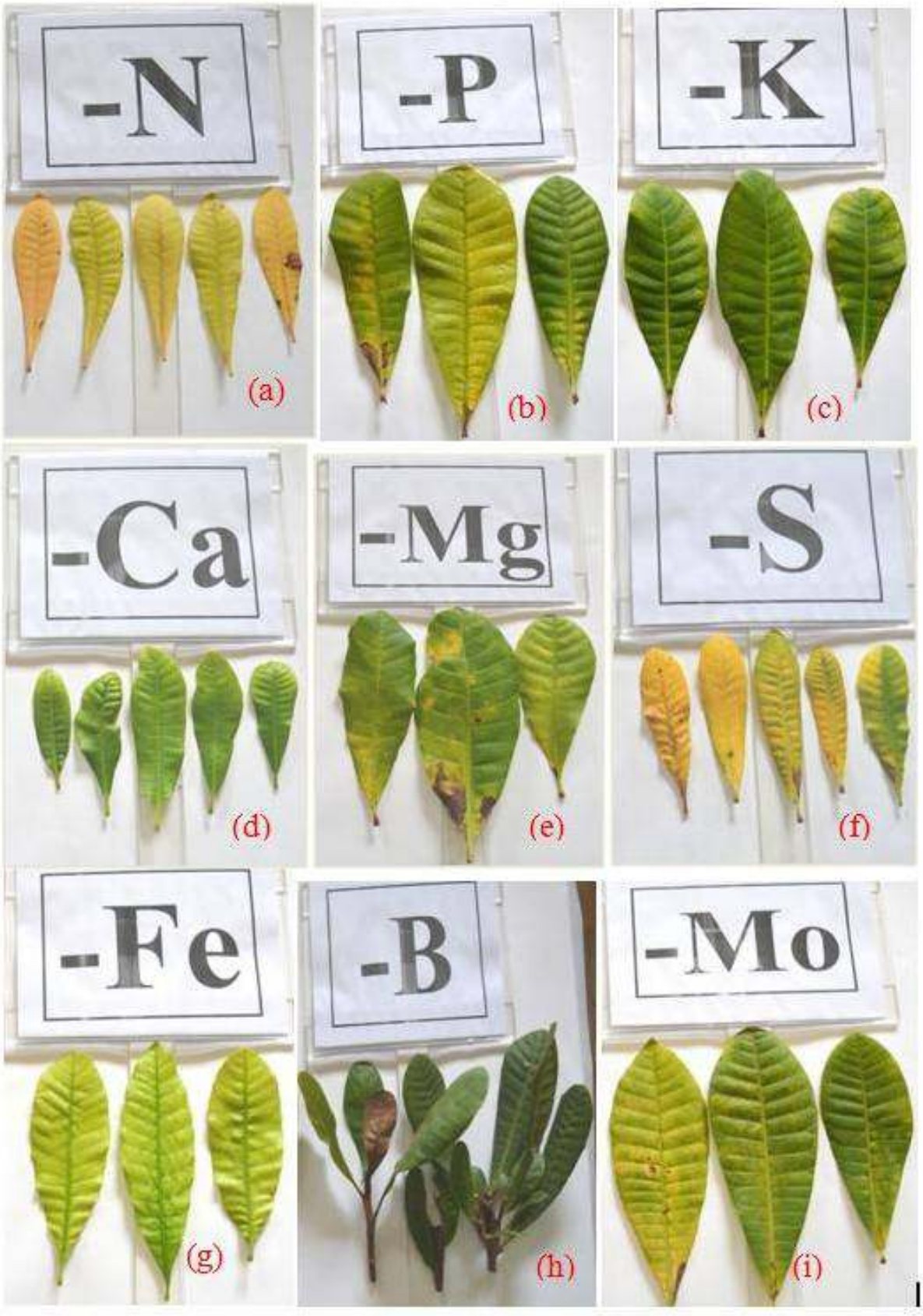


Fig. 6.10: Symptoms of mineral nutrient deficiencies in cashew seedlings

6.1.3.5 Microbial population in the rhizosphere and non rhizosphere soils under cashew orchards

The rhizosphere and non-rhizosphere soil samples from healthy and unhealthy cashew plants (Ten sub-samples for each site) were collected. Soil samples for microbiological analysis were stored at 4^0C in a refrigerator until processed for analysis. For enumeration of microbial population, 10 g of moist soil was drawn from each sample and analysed for general microbial community, *viz.,* bacteria, actinomycetes and fungi and function-specific microbial community, *viz.,* free-living N-fixers, phosphate solubilizers and Fluorescent *Pseudomonas*. Enumeration was done by serial dilution and pour plate method. Nutrient agar medium for bacteria, Martin's Rose Bengal agar medium for fungi, Ken Knight and Munaier's agar medium for actinomycetes, Jensen's agar medium for free-living N-fixers, Pikovskaya agar medium for phosphate solubilizing bacteria and King's-B medium for Fluorescent *Pseudomonas* were used in this study and microbial population was expressed in terms of CFU per g of dry soil.

The population of bacteria, fungi, actinomycetes, N-fixers, P-solubilizers and Fluorescent *Pseudomonas* was more in the rhizosphere soil than in the non-rhizosphere soil. The microbial population was considerably higher in the rhizosphere soil of healthy plants than the rhizosphere soil of unhealthy plants except fungal population. The bacterial population was higher in the rhizosphere soil of healthy cashew plants followed by actinomycetes, P-solubilizers, N-fixers, fungal and Fluorescent *Pseudomonas* population. Similar trend was observed in case of rhizosphere soil of unhealthy cashew plants except fungal whose population was higher than the N-fixers population. On an average, 2.83, 2.04, 2.24, 2.86 and 11.25 fold greater in the population of bacteria, actinomycetes, N-fixers, P-solubilizers and Fluorescent *Pseudomonas*, respectively was recorded in the rhizosphere soil of healthy cashew plants as compared to rhizosphere soil of unhealthy cashew plants. While, 24.1, 10.65, 6.28, 9.7, 8.82 and 5.42 fold greater in the population of bacteria, actinomycetes, fungi, N-fixers, P-solubilizers and Fluorescent *Pseudomonas*, respectively in the rhizosphere soil of healthy cashew plants was observed as compared to non-rhizosphere soil of cashew plants (Table 6.1).

Dehydrogenase activity, which is used as an indicator of microbial activity of soil was appreciably higher in rhizosphere soil than in the non-rhizosphere soil. On an average the dehydrogenase activity in rhizosphere soil of healthy plants was 1.6 and 6.52 fold higher as compared to rhizosphere soil of unhealthy cashew plants and non-rhizosphere soils, respectively. The organic carbon content of rhizosphere soil of healthy plants was 1.38 and 1.68 fold higher than the rhizosphere soil of unhealthy cashew plants and non-rhizosphere soils, respectively (Table 6.2).

Table 6.1: Microbial population in the rhizosphere and non-rhizosphere soil of cashew plants

Microbial Population	Rhizosphere soil		Non-rhizosphere soil
	Healthy plant	Unhealthy plant	
Bacteria (×10^6 CFU/g dry soil)	105.63	37.35	4.38
Actinomycetes (×10^6 CFU/g dry soil)	33.34	16.27	3.13
Fungi (×10^4 CFU/g dry soil)	35.34	66.27	5.63
Free N-fixers (×10^4 CFU/g dry soil)	60.64	27.11	6.25
P-solubilizers (×10^5 CFU/g dry soil)	82.73	28.92	9.38
Fluorescent *Pseudomonas* (× 10^3 CFU/g dry soil)	27.11	2.41	5.00

Table 6.2: Dehydrogenase activity and organic carbon in the rhizosphere and non-rhizosphere soil of cashew plants

Microbial Population	Rhizosphere soil		Non-rhizosphere soil
	Healthy plant	Unhealthy plant	
Soil Dehydrogenase Activity (µg TPF/g dry soil/24 h)	36.14	22.56	5.54
Soil organic carbon (g/kg)	17.3	11.7	8.2

6.1.3.6 Enumeration of microbial population in the rhizosphere soil of cashew orchards from different regions

The rhizosphere soil samples from cashew plantations (Ten sub-samples from each site) representing Bhubaneswar (Odisha), Bapatla (Andhra Pradesh) and Dakshina Kannada district (Karnataka) were collected for enumeration of microbial population. A considerable difference in microbial population in the rhizosphere soil sample of cashew orchards collected from different regions was noted. The microbial population was higher in cashew orchards of Dakshina Kannada district as compared to Bhubaneswar and Bapatla regions. On an average, in cashew orchards of Dakshina Kannada district, the population of bacteria (78.8×10^6 CFU/g dry soil), actinomycetes (29.47×10^6 CFU/g dry soil), fungi (58.19×10^4 CFU/g dry soil), free N-fixers (59.56×10^4 CFU/g dry soil), P-solubilizers (49.22×10^5 CFU/g dry soil) and Fluorescent *Pseudomonas* (13.97×10^3 CFU/g dry soil) were recorded, which were 2.81 and 3.64; 1.96 and 2.91; 4.71 and 4.66; 17.8 and 14.0; 5.22 and 3.06; and 1.77 and 2.36 fold higher than Bhubaneswar and Bapatla regions, respectively.

Dehydrogenase activity was highest in cashew orchards of Dakshina Kannada district (31.81 µg TPF/g dry soil/24 h/30°C) which was 9.94 and 10.13 fold greater than Bhubaneswar and Bapatla regions, respectively. While the acid phosphatase activity (4.91 µg PNP/g dry soil/h/37°C) of cashew orchard soils of Dakshina Kannada district was 3.45 and 2.99 fold greater than Bhubaneswar and Bapatla regions, respectively.

6.1.3.7 Effect of foliar application of sub-optimal levels of micronutrients

In order to examine the effect of foliar spray of need based micronutrients on cashew, a field experiment has been initiated in 2015. The treatments were sole and different combinations of micronutrient fertilizers containing B, Zn, and Mo. The experimental plants were 6 years old plants (During first year of study) of Bhaskara variety spaced at 5 m x 5 m.

The treatments were as follows:

T1 : Boron 50 ppm
T2 : Zinc 200 ppm
T3 : Molybdenum 10 ppm
T4 : Boron 50 ppm + Zinc 200 ppm
T5: Boron 50 ppm + Molybdenum 10 ppm
T6 : Zinc 200 ppm + Molybdenum 10 ppm
T7 : Boron 50 ppm + Zinc 200 ppm + Molybdenum 10 ppm
T8 : Control.

Treatment difference was not observed with respect to growth and yield by applying sub-optimal levels of micronutrients to cashew trees of age 5-7 years (Table 6.3).

Table 6.3. Effect of foliar application of micronutrients on plant height, lateral spread and nut yield during 2017

Treatment	Plant height (m)	Spread - EW(m)	Spread - NS (m)	Nut yield (kg tree^{-1})
1	6.75	5.87	5.45	1.36
2	7.29	6.08	5.91	1.27
3	6.87	5.54	5.66	1.08
4	7.77	6.26	6.66	1.50
5	7.33	6.37	6.25	0.86
6	6.79	5.95	5.75	0.86
7	6.95	6.04	5.95	0.91
8	6.83	5.33	5.62	0.81
Mean	7.07	5.93	5.91	1.08
CD	NS	NS	NS	NS
CV(%)	11.47	10.29	12.57	33.43

6.2 Irrigation requirement for cashew under high density planting system

Project Leader : Dr. R. Rejani (2011-12)
Dr. D. Kalaivanan (2012-13)
Dr. Ramkesh Meena (2014-15)
Mrs. Prabha Susan Philip (2015-17)
Dr. Shamsudheen, M. (2017-18)

Project Associate : Dr. J.D. Adiga (From June 2011 to October 2015) and from 1st March 2017 to January 2018)
Dr. T.R. Rupa (2011-16)
Dr. D. Kalaivanan (2012-15)
Dr. Ramkesh Meena (2013 to 2014)

Project Number : 2.19

Project Duration : 2011-18

6.2.1 Introduction

Cashew is generally grown as a rainfed crop on neglected lands unsuitable for any other crop. In India, cashew experiences severe moisture stress from January to May, that adversely affects its flowering and fruit set. There is a possibility of increasing the productivity of cashew by adopting high density planting system coupled with proper water and nutrient management. A project was undertaken to standardize the irrigation requirement for cashew under different densities at ICAR-Directorate of Cashew Research during 2011-12 to 2017-18.

6.2.2 Objectives

- To determine the optimal irrigation required for cashew grown under different plant densities.
- Comparison of irrigation and soil & water conservation treatments in increasing the net profit from cashew plantation.

6.2.3 Results

To achieve the project objectives a field experiment was set up at Shantigodu Experimental Station of the Directorate. The soil at the experimental site was acidic (pH 4.8 to 5.3) and non saline (electrical conductivity 0.03 dSm^{-1} to 0.012 dSm^{-1}). The available nitrogen content of the soil was low (203 to 247 kg ha^{-1} at 0-30 cm) and the available P_2O_5 content was also low which ranged from 7.0 to 7.3 kg ha^{-1} at 0-30 cm. The available K_2O content ranged from 112 to 198.0 kg ha^{-1}. The soil moisture content during February was 11.0 to 12.7% on dry basis whereas in March, it was 10.2 to 11.2%, i.e., below the available soil moisture range.

The treatments consisted of three plant densities in main plot and six irrigation levels in subplots in a split plot design. The plant densities were M_1: 5x4 m (accommodating 500 plants ha^{-1}), M_2: 6x4 m (416 plants ha^{-1}) and M_3:10x5 m (200 plants ha^{-1}). The irrigation treatments were T_1: irrigation at 60% Cumulative Pan Evaporation (CPE), T_2: irrigation at 40% CPE, T_3: irrigation at 20% CPE, T_4: Critical irrigation once in 15 days, T_5: Soil and water conservation technique and T_6: control; without irrigation and soil water conservation techniques. The soil and water conservation technique followed in T_5 treatments was modified crescent bund.

6.2.3.1 Effect of plant density and irrigation on growth characteristics of cashew

The growth characteristics of cashew as influenced by planting density and irrigation during the years 2015-16 and 2016-17 are presented in Table 6.4. During the year 2016-17, the stem girth was significantly influenced by planting density (P<0.05). The highest stem girth (56.21 cm) was recorded with M_3 planted at 10 x 5 m spacing accommodating 200 plants per ha. The stem girth was at par with other two plant densities, M_1 (50.38 cm) and M_2 (51.15 cm). Various irrigation treatments significantly affected canopy spread in east-west direction (P<0.05) during 2016-17. The highest canopy spread (5.35 m) was recorded by T_2 receiving irrigation at 40% CPE and was on par with T_1 receiving irrigation at 60% CPE (5.35 m), T_3 receiving 20% CPE (5.29 m) and T_4 receiving critical irrigation once in 15 days. The lowest canopy spread was recorded with (T_5), where soil and water conservation practice was

followed which in turn was on par with control (T_6). The increased canopy spread was observed in treatments receiving irrigation at 60, 40 and 20% CPE (T_1 to T_3) which were on par with each other. The canopy spread was lowest in control (T_6) (5.19 m) and treatment which received soil and water conservation (T_5) (5.06 m).

Table 6.4: Effects of irrigation regime and plant density on growth characteristics of cashew in 2015-16 and 2016-17

Plant density	Irrigation levels	Plant height (m)		Stem girth (cm)		Canopy spread – EW (m)		Canopy spread - NS (m)	
		2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
M_1	T_1	4.80	5.24	39.36	50.75	4.23	5.31	4.11	5.24
	T_2	4.70	5.04	40.17	50.92	3.74	5.19	4.45	5.22
	T_3	5.13	5.33	43.21	50.17	4.13	5.35	4.40	5.51
	T_4	4.70	5.55	39.88	53.42	3.78	5.17	4.02	5.23
	T_5	4.67	5.67	39.17	51.58	3.95	5.22	4.37	5.34
	T_6	4.67	4.78	34.03	45.42	3.93	5.13	4.37	5.16
M_2	T_1	4.51	5.09	39.61	52.33	4.23	5.13	3.76	5.52
	T_2	4.82	5.30	39.42	55.25	3.74	5.44	3.96	5.41
	T_3	4.35	5.33	36.92	51.08	4.13	5.36	3.98	5.32
	T_4	4.47	5.20	37.71	51.44	3.78	5.25	3.76	5.06
	T_5	4.24	4.84	38.74	47.42	3.95	4.76	4.20	4.95
	T_6	4.45	4.38	37.36	49.17	3.93	5.26	3.92	5.29
M_3	T_1	4.96	5.09	42.86	57.42	4.46	5.60	4.71	5.46
	T_2	4.60	5.11	41.25	58.08	3.97	5.42	3.92	5.70
	T_3	4.48	5.20	39.54	52.17	3.72	5.16	3.97	5.54
	T_4	4.36	5.30	40.88	56.83	4.41	5.47	4.22	5.58
	T_5	4.67	4.65	40.71	54.75	4.42	4.79	4.41	4.90
	T_6	4.88	5.34	42.42	58.00	4.26	5.15	4.24	5.11
F ratio and (SE_d)	M	2.54 (13.7)^{ns}	0.44 (26.8)^{ns}	0.83 (2.36)^{ns}	14.8 (1.17)*	0.40 (31.9)^{ns}	0.07 (17.3)^{ns}	1.0 (27.6)^{ns}	0.31 (16.5)ns
	T	0.43 (21.1)^{ns}	1.16 (24.1)^{ns}	0.39 (2.12)^{ns}	0.94 (2.45)^{ns}	0.85 (24.9)^{ns}	2.56 (14.4)*	0.60 (19.7)^{ns}	4.10 (10.9)**
	MxT	0.70 (36.0)^{ns}	1.15 (46.6)^{ns}	0.66 (4.10)^{ns}	0.63 (4.05)^{ns}	0.46 (50.7)^{ns}	1.16 (28.6)^{ns}	0.92 (41.6)^{ns}	2.24 (23.9)*

** - Significant at 1%, * - Significant at 5%, ns- Non Significant

In M_1, the average canopy spread was 4.13 m and 5.26 m in 2015-16 and 2016-17, respectively (Fig. 6.11). In M_2, it was 3.95 m and 5.23 m respectively. It means that by the year 2016-17, the canopy had spread to such an extent to touch the neighbouring plants, especially in closely spaced treatments (M_1: 5 x 4 m spacing and M_2: 6 x 4 m spacing). Cashew produces flowers and fruits on current season new flushes and hence, the overlapping canopies will have adverse effect on yield. There is a need for proper canopy management by pruning to realise increased yield form cashew under high density and irrigation. Pruning will improve light interception and nutrient allocation, if carried out at most appropriate time. However, this may also decrease the leaf area available for synthesizing adequate photosynthates to support the growth of trees. The successful canopy management through pruning and training also depends on the behaviour of variety to pruning.

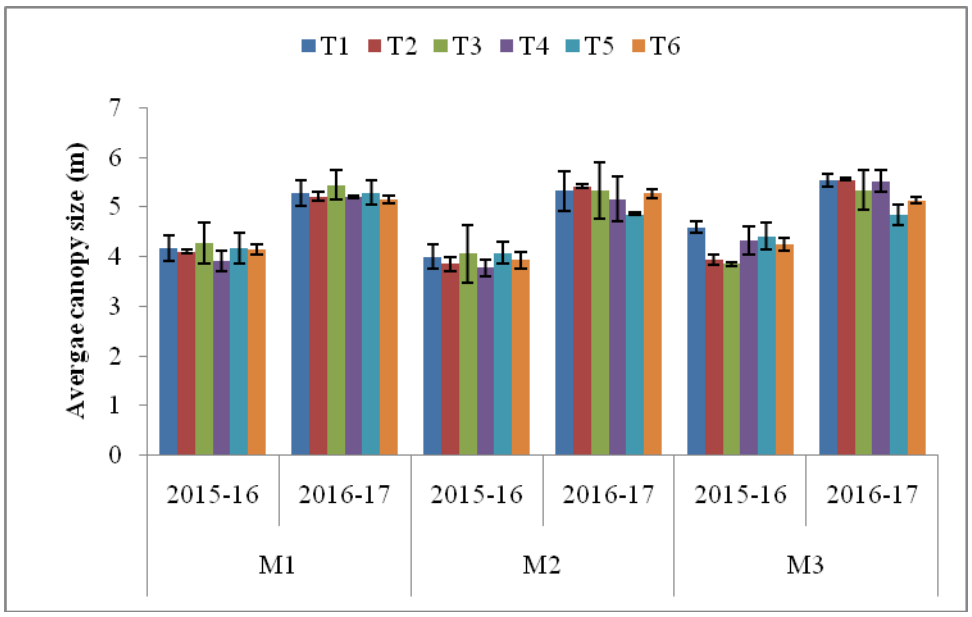


Fig. 6.11: Average canopy spread during 2015-16 and 2016-17 as influenced by plant density and irrigation levels in cashew

6.2.3.2 Effect of plant density and irrigation on nut yield of cashew

Both planting density and irrigation significantly influenced the raw cashew nut yield during the year 2015-16 and 2016-17 (P<0.01, Fig. 6.12). Among three planting densities, the highest yield of 1776.7 kg ha^{-1} was recorded by M_1 which was on par with M_2 (1657.5 kg ha^{-1}) and the lowest yield was recorded by M_3 (806.2 kg ha^{-1}) during the year 2015-16. Similar effect was observed during the year 2016-17. Among different irrigation treatments, the highest raw cashewnut yield of 1706.5 kg ha^{-1} was recorded by T_4, followed by T_3 (1587.1 kg ha^{-1}) and T_2 (1442.9 kg ha^{-1}) which were on par with each other. The lowest yield was recorded in control (1178.9 kg ha^{-1}) and T_5 (1197.9 kg ha^{-1}) during the year 2015-16. The irrigation treatments T_3 and T_4 recorded the highest, while T_6 recorded the lowest raw cashew nut yield during 2016-17. However, the interaction of plant density with irrigation was not significant during both the years.

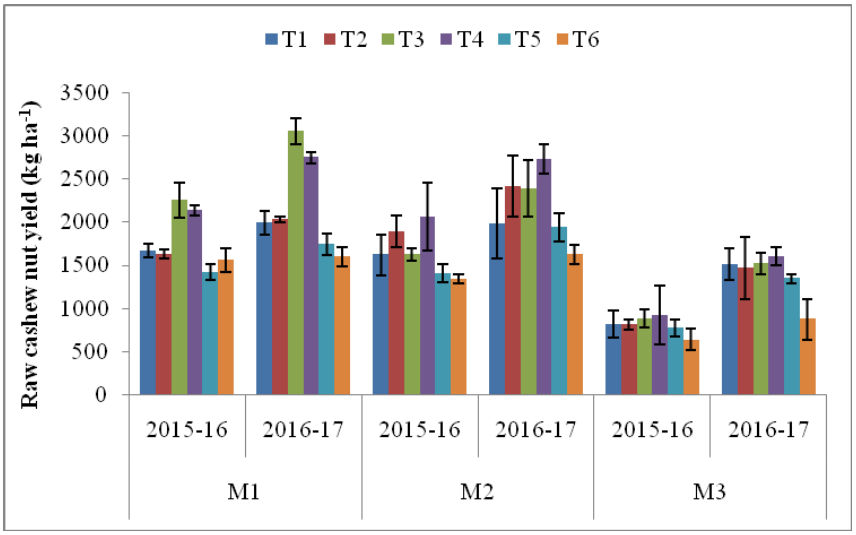


Fig. 6. 12: Raw cashewnut yield (kg ha^{-1}) during 2015-16 and 2016-17 as affected by planting density and irrigation

6.2.3.3 Effect of plant density and irrigation on water productivity and economics

The total water productivity of cashew during 2015-16 and 2016-17 are presented in Fig. 6.13. The average total water productivity was significantly influenced by density, irrigation and their interaction (P<0.01). The average water productivity over two years were highest for M_2 (0.056 kg m^{-3}) which was on par with M_1 (0.052 kg m^{-3}) and it was lowest for M_3 (0.038 kg m^{-3}). Among irrigation treatments, the highest average water productivity (0.071 kg m^{-3}) was recorded for T_4 which was on par with T_3 (0.067 kg m^{-3}), followed by T_2 (0.059 kg m^{-3}) and T_1 (0.056 kg m^{-3}) which in turn was on par with each other. The lowest water productivity (0.045 kg m^{-3}) was recorded for T_6 (control).

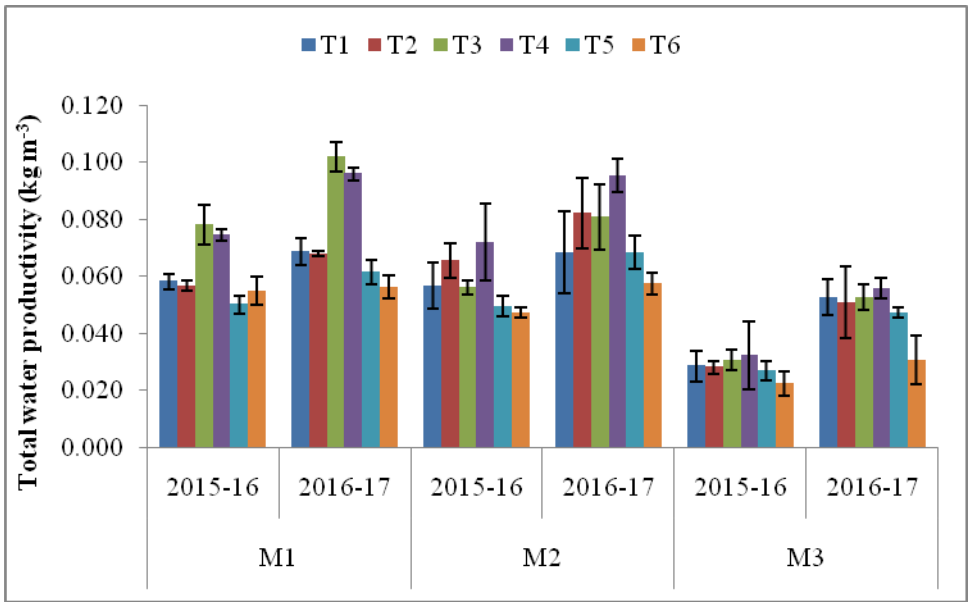


Fig. 6.13. Total water productivity (kg m^{-3}) during 2015-16 and 2016-17 as affected by planting density and irrigation

The net income was highest for M_1 and M_2 compared to M_3. Under different irrigation regimes, the average net income was highest for T_4. (Table 6.5) This was followed by T_3 and T_2. The highest benefit- cost ratio (BCR) was associated with M_2 on par with M_1 while the lowest BCR was associated with M_3. The average BCR was highest and on par with T_4, T_5 and T_6. The treatment M_2T_4 recorded the highest BCR (4.11). In areas where water resources are not available for irrigation, the adoption of soil and water conservation techniques can increase the farm income.

Table 6.5. Effects of irrigation regime and plant density on economics of cashew nut production

Plant density	Irrigation levels	Gross income (lakhs) $ha^{-1} yr^{-1}$	Cost of production (lakhs) $ha^{-1} yr^{-1}$	Net income (lakhs) $ha^{-1} yr^{-1}$	BC Ratio
M_1	T_1	2.30	0.88	1.19	2.59
	T_2	2.30	0.88	1.19	2.59
	T_3	3.36	0.96	1.94	3.44
	T_4	3.08	0.78	1.87	3.85
	T_5	1.99	0.58	1.22	3.41
	T_6	1.97	0.54	1.40	3.59
M_2	T_1	2.27	0.77	1.27	2.91
	T_2	2.72	0.81	1.64	3.34
	T_3	2.55	0.79	1.32	3.15
	T_4	3.03	0.72	1.89	4.11
	T_5	2.12	0.53	1.25	3.89
	T_6	1.87	0.47	1.21	3.9
M_3	T_1	1.49	0.53	0.81	2.74
	T_2	1.46	0.53	0.79	2.7
	T_3	1.53	0.53	0.85	2.82
	T_4	1.61	0.57	0.88	2.76
	T_5	135663	43405	78994	3.05
	T_6	95648	36365	57175	2.56
LSD and (SEd)	M	63.8 (10883)**	621.0 (813)**	334.3 (2996)**	12.7 (0.16)**
	T	21.6 (11485)**	443.7 (872)**	26.0 (5431)**	11.6 (0.14)**
	MxT	3.7 (21170)**	31.7 (1601)**	10.7 (9095)**	3.9 (0.24)**

6.3 Organic farming in cashew

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Project Number : 2.20

Project Duration : 2011-2018

6.3.1 Introduction

Most of the productive land area in the country is used for growing field crops and cashew is considered to be a crop to be grown in wastelands and on least fertile soil, and yield of cashewnuts per tree is quite low due to less care and management of orchards. Cashew tree demands large amounts of nutrients for its optimum productivity. It has been estimated that a cashew tree yielding 10 kg of nuts removes 641 g of N, 205 g of P_2O_5 and 247 g of K_2O per annum. To maintain the productivity of the soil, the nutrients removed have to be

returned back to the soil. In the west coast, cashew is mainly grown as a rainfed crop along the steep slopes of barren hillocks where the fertile top soil is eroded completely leading to exposure of sub-soil. Hence the nutrient content of soil in cashew plantations is low which adversely affects the growth and yield of cashew.

Increasing realization of the ill effects of long sustained, exclusive use of chemical fertilizers, and consistent growing demand from the consumers for organic cashew, coupled with unsustainable productivity of cashew, have fostered experimentation with some alternative cultural practices. Use of organic materials such as farmyard manure, cakes of plant origin, vermicompost, microbial bio-fertilizers on one hand, and exploiting the synergism between cashew-vesicular arbuscular mycorrhizal fungus on the other hand, are important components of the bio-organic concept of cashew cultivation. A research project on organic farming in cashew was carried out at ICAR-Directorate of Cashew Research during 2011-12 to 2017-18.

6.3.2 Objectives

- To examine the influence of organic sources on growth, yield and quality of cashew.
- To quantify the changes in soil physical, chemical and biological properties resulting from organic farming practices.

6.3.3 Treatment details

A field experiment was established by planting cashew grafts in pits of size 1 m^3 at a spacing of 7.5 m x 7.5 m. The experiment consists of 11 treatments in 3 replications in RBD and the treatment details are given below.

1. FYM to supply 500 g N/tree
2. FYM to supply 500 g N/tree+ biofertilizer consortia*
3. FYM to supply 500 g N/tree + Rock phosphate to supply 125 g P_2O_5/ tree and woodash to supply 125 g K_2O/tree.
4. Poultry manure to supply 500 g N/tree
5. *In situ* composting using recyclable cashew biomass and weeds
6. *In situ* composting using recyclable cashew biomass and weeds + green manuring (Growing glyricidia between two rows of cashew)
7. Vermicomposting of recyclable cashew biomass
8. FYM + Organic cakes + Recyclable cashew biomass + biofertilizer consortia
9. Recommended NPK fertilizer**
10. Recommended NPK fertilizer + 10 kg FYM/tree
11. Control.

*Azospirillum, PSB and AMF at a rate of 50 g each/tree/year.

**Fertilizer dose: 1st year of planting: 1/3rd of recommended N, P and K per tree per year, 2nd year: 2/3rd of recommended N, P and K per tree per year and 3rd year onwards full dose i.e. 500 g N, 125 g each of P_2O_5 and K_2O/tree/year.

6.3.4 Results

6.3.4.1 Initial nutrient status of soil

Initial soil samples at three different depths (0-30 cm, 31-60 cm and 61-90 cm) were collected and characterised. The soils were acidic in reaction, free of soluble salts, high in organic carbon. The soils were low in available nitrogen, medium to high in available phosphorus and medium to high in available potassium. Surface soils were found to contain more amounts of available N, P and K than subsurface soils. Available Fe, Mn, Zn and Cu varied from 15.29 to 21.31 mg/kg, 3.41 to 6.45 mg/kg, 0.90 to 1.39 mg/kg and 0.61 to 0.90 mg/kg at different soil depths. The soils were found to be sufficient in available Fe, Mn, Zn and Cu.

6.3.4.2 Effect of different organic and inorganic sources of nutrients on growth of cashew

During the year 2013-14 significant effect was observed on plant height. The plant height ranged from 212 to 277 cm with T10 recording the highest and T1, the lowest (Table 6.6). During the year 2014-15, there was significant effect of treatments on plant height and canopy spread. The plant height and stem girth varied from 2.5-3.4 m and 22.4 to 26.0 cm, respectively. The canopy spread in N-S direction ranged from 2.17 to 2.92 m and in E-W direction from 2.18 to 3.08 m. During 2015-16, stem girth and canopy spread (E-W) was found to be significantly affected by treatments. The plant height and stem girth varied from 3.66 to 4.58 m and 30.78 to 37.83 cm, respectively. The canopy spread in N-S direction ranged from 3.0 to 4.08 m and in E-W direction from 3.04 to 4.20 m.

Table 6.6: Effect of different organic and inorganic sources of nutrients on plant height and stem girth of cashew

Treatment	Plant height (m)					Stem girth (cm)				
	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016
T1	1.28	2.12	2.81	4.29	5.71	8.92	16.5	25.00	33.83	42.92
T2	1.35	2.58	3.00	4.54	5.94	8.83	16.3	23.57	34.58	43.92
T3	1.43	2.46	3.04	4.29	5.79	9.33	17.3	24.92	36.33	43.67
T4	1.33	2.47	3.04	4.38	5.96	8.83	16.2	25.75	35.25	42.08
T5	1.50	2.45	2.83	3.71	5.42	9.08	16.3	23.50	31.42	37.08
T6	1.64	2.5	3.00	4.17	5.81	10.2	18.7	24.58	33.58	39.50
T7	1.28	2.48	2.79	3.75	5.71	8.83	16.8	24.17	31.67	39.50
T8	1.39	2.18	2.58	3.92	5.58	8.67	17.2	22.65	31.00	41.83
T9	1.34	2.5	2.88	4.25	6.35	8.75	16.5	23.50	33.92	40.75
T10	1.51	2.77	3.42	4.58	6.46	10.0	17.8	25.83	37.83	45.83
T11	1.50	2.26	2.89	3.67	5.56	9.00	16.7	22.39	30.78	35.00
LSD ($p<0.05$)	NS	0.038	NS	NS	NS	NS	NS	NS	4.31	NS

6.3.4.3 Effect of different organic and inorganic sources of nutrients on soil nutrient status

During the year 2012-13, the soil pH ranged from 5.16 to 5.97, electrical conductivity from 0.014 to 0.089 dSm^{-1}. Significant effect of treatments on pH, N, P and K was found compared to control. The highest pH (5.97) was observed with T10, followed by T9 (5.84) and lowest in T2 (5.16) and T11 (5.24). The highest content of available nitrogen was recorded with T10 (382.2 kg/ha), followed by T9 (368.6 kg/ha), and T8 (344.7 kg/ha), whereas lowest was recorded with T11 (304.6 kg/ha) (Table 6.7).

During the year 2013-14, significant effect of treatments on P and K was observed. The treatment recording highest P content was T10 (27.59 kg/ha) and T9 (26.85 kg/ha) and lowest were T11 (21.87 kg/ha) and T5 (22.91 kg/ha). With respect to K the highest content was recorded by T10 (147.9 kg/ha), followed by T9 (139.6 kg/ha) and lowest was by T11 (92.8 kg/ha) and T6 (97 kg/ha). The micronutrient content of Fe ranged from 15.2 to 21.2 ppm, Mn from 6.0 to 9.0 ppm, Zn from 0.74 to 0.92 ppm and Cu from 1.00 to 1.98 ppm.

Table 6.7: Effect of different organic and inorganic sources on soil nutrients during 2012-13

Treatment	pH	EC (dSm^{-1})	OC (%)	Available N ($kg\ ha^{-1}$)	Available P ($kg\ ha^{-1}$)	Available K ($kg\ ha^{-1}$)	Exch.Ca cmol (p^{+}) kg^{-1}	Exch.Mg cmol (p^{+}) kg^{-1}
T1	5.37	0.042	1.80	324.6	23.02	184.8	1.06	0.73
T2	5.16	0.026	1.81	322.3	23.45	182.7	1.04	0.68
T3	5.33	0.030	1.68	334.7	25.96	204.5	1.68	1.18
T4	5.75	0.051	1.79	319.6	25.55	188.6	1.05	0.76
T5	5.39	0.021	1.60	322.2	23.64	181.4	1.08	0.68
T6	5.41	0.014	1.69	338.6	24.10	186.0	1.01	0.65
T7	5.44	0.059	1.70	332.0	24.68	190.8	1.36	0.77
T8	5.64	0.022	1.66	344.7	23.22	185.7	1.06	0.75
T9	5.84	0.089	1.82	368.6	25.72	208.6	2.10	1.45
T10	5.97	0.084	1.87	382.2	26.80	220.5	1.84	1.16
T11	5.24	0.038	1.57	304.6	22.40	177.0	0.90	0.67
SEm	0.064	0.004	0.08	8.63	0.62	7.08	0.05	0.04
LSD (p<0.05)	0.20	0.012	NS	27.2	1.97	22.3	0.16	0.14

6.3.4.4 Effect of different organic and inorganic sources of nutrients on leaf nutrient status of cashew

Leaf nutrient status under different treatments was not significantly different during the year 2012-13. The leaf nitrogen content ranged from 1.25–1.37, phosphorus from 0.5–0.8%, potassium from 0.39-0.44%, calcium from 0.31-0.35% and Mg from 0.19-0.22%. During 2014 -15 also, there was no significant effect on NPK content of leaf with respect to treatments. The N, P and K content in leaf varied from 1.18 to 1.27%, 0.15 to 0.19% and 0.35 to 0.40%, respectively (Table 6.8).

Table 6.8: Effect of different organic and inorganic sources on leaf nutrient status during 2014-15

Treatment	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)
T1	1.21	0.17	0.35	0.52	0.20	51.3	79.5	18.6	12.8
T2	1.23	0.18	0.37	0.56	0.22	48.9	74.0	17.5	12.5
T3	1.26	0.18	0.39	0.57	0.23	52.6	65.6	18.4	13.6
T4	1.21	0.17	0.35	0.57	0.25	55.6	70.5	18.1	14.2
T5	1.16	0.16	0.35	0.50	0.18	50.2	69.7	18.9	13.5
T6	1.24	0.15	0.37	0.52	0.17	47.8	65.6	16.8	14.0
T7	1.22	0.18	0.36	0.51	0.18	51.4	72.2	17.1	12.9
T8	1.19	0.17	0.36	0.50	0.16	50.5	70.5	17.1	13.0
T9	1.24	0.18	0.38	0.60	0.23	46.8	66.0	16.8	12.5
T10	1.27	0.19	0.40	0.60	0.25	52.9	68.2	17.0	13.5
T11	1.18	0.15	0.35	0.45	0.15	47.5	66.9	16.8	12.2

6.3.4.5 Effect of organic and inorganic sources of nutrients on soil quality characteristics

The bulk density and particle density of the surface soils under different treatments varied from 1.16 to 1.28 g/cc and 1.70 to 2.04 g/cc respectively. The pore space of the soils ranged from 31.5 to 38.5%. The soil Microbial Biomass Carbon (MBC) varied significantly with different treatments. Various organic sources of nutrients significantly improved soil quality attributes such as MBC, organic carbon and soil enzymes. Soil MBC significantly varied with nutrient management regimes (Fig. 6.14, P <0.01). Application of FYM, organic cakes, recyclable cashew biomass and biofertilisers increased the MBC by 37.7% compared to control. The treatment T3 (FYM, rock phosphate and wood ash) increased MBC by 33.8% compared to control. Microbial Biomass Nitrogen (MBN) followed the same trend as of MBC and was significantly different among treatments. MBN ranged from 20.7 to 39.1 mg kg^{-1} and with respect to control different treatments had 7.7 to 88.6% increase in MBC. Soil enzymes such as dehydrogenase, acid phosphatase and β-glucosidase differed significantly with different treatments (P <0.001). Soil dehydrogenase activity varied from 0.46 to 0.85 µg TPF g^{-1} h^{-1}. Acid phosphatase activity increased by 79.1% by application of FYM, organic cakes, recyclable cashew biomass and biofertilisers (T8), while application of FYM, rock phosphate and wood ash increased it by 70.1%. Application of organic and inorganic sources of nutrients increased β-glucosidase activity from 0.5 to 132% compared to non application of nutrients.

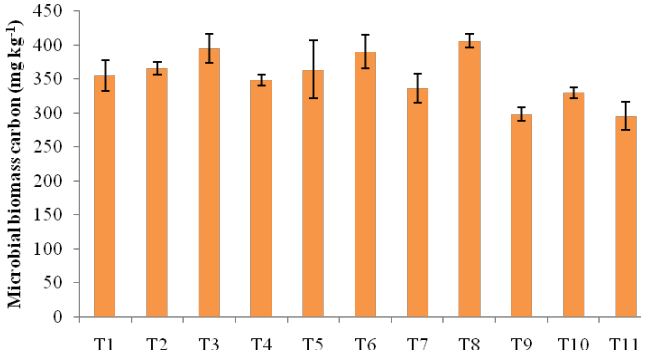

Fig. 6.14: Microbial biomass carbon under different nutrient management regimes

6.3.4.6 Effect of organic pest management practices

During 2014-15, three rounds of spray with both liquid formulation and wettable powder formulation of *Beauveria bassiana* was not found to be effective in controlling of TMB in the field (Table 6.9). No difference in TMB damage score was obtained between treated and untreated plants. During 2015-16, two rounds of entomopathogenic fungus ($2x10^7$ spores/ml) were sprayed in the form of liquid formulation and wettable powder for management of tea mosquito bug (TMB) infestation. The TMB damage score recorded at three different intervals showed that there was no significant difference in TMB damage score between treated and control. On an average, the TMB damage score was 0.87, 1.34 and 1.25 in liquid formulation, wettable powder and control, respectively. During 2016-17, sprays with biopesticide nimbicidine (3ml/l) and *B. bassiana* (5 ml/l and 10 ml/l) were taken up. However, this was also not effective. Release of reduvids, *Sycanus* sp. in the field was also found to be less effective on TMB.

Table 6.9. Effect of organic pest management practices during 2014-15

Date of observation	TMB damage grade		
	Liquid formulation of *Beauveria bassiana*	Wettable powder formulation of *Beauveria bassiana*	Control
12.2.2015	1.20	1.90	1.46
21.2.2015	1.07	1.72	1.44
6.3.2015	0.34	0.40	0.42

6.3.4.7 Effect of cashew kernel quality as influenced by organic and inorganic sources of nutrients

The protein content in cashew kernel under different organic and inorganic sources of nutrients did not show any significant differences.

6.3.4.8 Effect of organic and inorganic sources of nutrients on yield of cashew

The cashewnut yield under different treatments ranged from 0.5 to 1.22 kg/tree (Fig. 6.15) during the year 2016. The effect of different treatments did not show any significant variation.

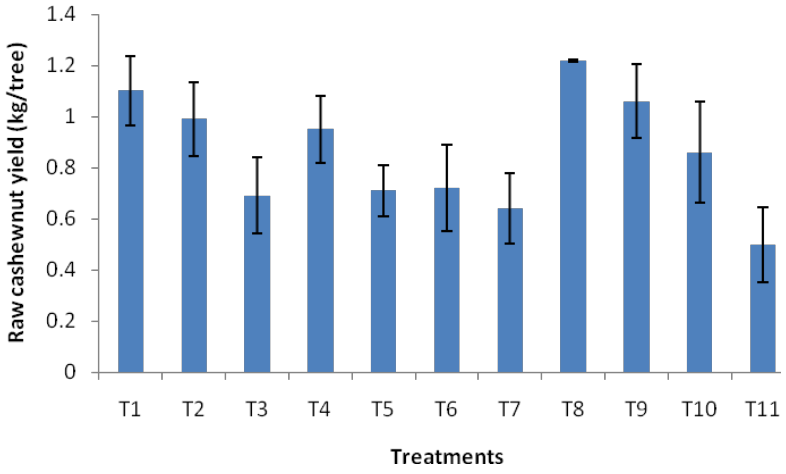

Fig. 6.15 : Effect of different organic and inorganic sources on yield of cashew during 2016

6.4 Biodiversity of arthropod fauna in cashew ecosystems

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Project Associate	:	Dr. T.N. Raviprasad (2010-16) Dr. K. Vanitha (2011-15)
Project Number	:	3.17
Project Duration	:	2010 – 2016 (6 Years)

6.4.1 Introduction

Cashew is reported to be damaged by more than 180 pests feeding on various plant parts during different periods. Apart from two major pests, TMB and CSRB, there are a few pests causing considerable damage to the crop. While in the changing scenario, proper determination of pest status for the pests on a particular crop variety is important to evolve suitable control measures. Hence this project was initiated during 2009 with the main objective of documenting the arthropod fauna in cashew ecosystems so as to understand the current pest status and to find out any emerging pest of cashew. Besides, determining the role of documented arthropods will help in understanding the purpose of every insect in cashew ecosystem. Similarly, knowledge on insect pests and natural enemies and the extent of predation/ parasitism helps to decide upon scheduling of management measures, if required.

6.4.2 Objectives

- To record the insect fauna associated with cashew in different cashew growing regions of the country.
- To document the seasonality of insect pests of cashew and record the nature and extent of damage by different pests of cashew.
- To determine the role of different arthropods infesting cashew.

6.4.3 Materials and methods

The documentation of arthropods was initiated during 2009 and continued till 2016 by conducting random field surveys at fortnight intervals in the cashew plantations of Puttur and Shantigodu regions. The arthropods comprising insects, mites and spiders occurred on cashew were collected and preserved. The arthropods got identified by contacting experts of the field. The percent of infestation by different insect pests, extent of damage, season of occurrence, plant part infested, natural enemies were also documented. The insect stages were brought to laboratory to observe for its natural enemies and their extent of pest control. Attempts have been made to record the biology of few species. Incidence of pests was also recorded in other cashew growing areas of the country.

6.4.4 Results

6.4.4.1 Documentation of insect pests

Random surveys were taken up at weekly intervals for various cashew pests and their natural enemies in the cashew plots of Directorate of Cashew Research, Puttur. The documented insects were got identified time to time by consulting experts of field. A total of 191 insect pest species and 123 natural enemies were documented in the past five years. The insects were taxonomically grouped and the diversity indices were worked out. Family wise, the abundant insect order was Hemiptera with 19 families followed by Lepidoptera with 17 families. There were a total of 57 species documented in Lepidoptera followed by Coleoptera (53) and Hemiptera (41). A total of 17,282 insects were observed under this study upon random surveys (Table 6.10). The major insect pests of cashew causing economic damage are tea mosquito bug (TMB), cashew stem and root borers (CSRB) followed by thrips and apple and nut borers. Apart from these insect pests, two species of mites and 120 species of spiders have also been documented in cashew.

Table 6.10 : Diversity indices of cashew pests

Sl. No.	Index	Value
1	Species richness	191
2	Simpson index	0.105
3	Dominance index	0.895
4	Shannon index	4.355
5	Berger-parker Dominance index	0.245
	Total no. of organisms	17,282

Fig. 6.16 : Cashew pests - a) Thrips b) Leaf miner c) Tasar silkworm d) Mealy bugs

6.4.4.2 Relative abundance of TMB species and sex ratio

Continuous laboratory rearing of TMB, *H. antonii* was done using cashew shoots to record the life cycle and sex ratio of adults emerged every month. It was found that male was more in most part of the year and there was no much variation in the life cycle of *H. antonii* during different months (Table 6.11).

Table 6.11: Sex ratio of TMB upon laboratory rearing

Month	Sex ratio (M:F)	Month	Sex ratio (M:F)
Apr	0.69	Oct	1.28
May	1.35	Nov	1.22
Jun	1.23	Dec	1.10
Jul	1.21	Jan	1.25
Aug	1.13	Feb	1.03
Sep	1.10	Mar	0.88

Co-existence of four species of tea mosquito bug *viz., Helopeltis antonii, H. bradyi, H. theivora* and *Pachypeltis maesarum* was observed in cashew plantations during October to February. Among these, *H. antonii* is the dominant species followed by *H. bradyi*. Among the four species, *H. antonii* was dominant in all the months of a year. Incidence of *H. bradyi* was noticed from October and prevailed up to January. Incidence of *H. theivora* started from September-October, reaching the peak during December and prevailed up to March. The other species, *P. maesarum* was present between July-March, but in very less numbers. On an average, *H. antonii* was 70-77%, followed by *H. bradyi* (14-18 %), *H. theivora* (7-10%) and *P. maesarum* (2-14%).

6.4.4.3 New reports of insect pests and their occurrence

Sudden incidence of a pentatomid bug *Catacanthus incarnatus* Dru. was reported. It caused pronounced damage on cashew tender apples as well as ripened cashew apples during fruiting season. On an average, 6-9 adult bugs were observed feeding on a single panicle with fruits and around 300 bugs were found on tree. Occurrence and damage pattern of a chrysomelid leaf beetle namely, *Monolepta longitarsus* was also reported. Four colour morphs were seen in the beetle. Though it is a regular pest of cashew during the early monsoon season, its damage intensity varied year by year. Similarly, occurrence of tasar silk worm, *Antheraea mylitta* Drury Ecorace K2 on cashew was reported and its biology, indoor rearing feasibility on cashew and the commercial silk properties were studied in detail.

6.4.4.4 Pests of weed species

Insect pests on certain common weed species of the cashew plantations have also been documented under this project. Shoots of *Terminalia paniculata* were found to be damaged by chrysomelid beetles namely, *Cryptocephalus bisexsignatus* and *C. sexsignatus* and by a leaf twisting weevil, *Paramecolabus discolour*. It is important to note that most of the insect pests attacking *T. paniculata* are also pests of cashew *viz*., *Helopeltis antonii*, *Amblyrhinus poricollis*, *Eurybrachis* sp., *Oenospila flavifusata*, membracid bugs, lymantrid hairy caterpillar, *Hyposidra talaca* and *Orthaga exvinacea*. During July-October, development of leaf galls and shoot drying were noticed on *Getonia* (= *Calycopteris*) *floribunda* every year. Besides leaf thrips namely *Scirtothrips dorsalis* and *Thrips hawaiiensis*, gall forming thrips like *Liothrips* sp., *Mesothrips* sp., and two wasps, *Megastigmus viggianii* and *Systole calycopterae* were seen.

TMB was found to infest 14 weed species belonging to ten different families during flushing period of cashew (September-October 2013-14). Weeds observed to support TMB are *Terminalia paniculata, Getonia floribunda, Macaranga peltata, Chromolaena odorata, Melastoma malabathricum, Meremmia vitifolia, Solanum torvum, Cissus repanda, Strychnos nuxvomica, Ixora* sp., *Lantana camera* and *Leea* sp. Besides, ornamental plants *viz., Acalypha hispida* and *Acalypha wilkesiana* were also seen as hosts for TMB species. Maximum TMB infestation was seen during October on *C. odorata* (more than 30 % of weed population), *M. peltata* and *G. floribunda*.

6.4.4.5 Abundance of insects

The season wise most abundant insect species were grouped. *Monolepta longitarsus*, *Acrocercops syngramma* and *Neculla* (?) *pollinaria* were dominant during Jun-Aug, while, *A. syngramma*, *Toxopetra odinae* and *Helopeltis antonii* were abundant during September to November. During flowering period between Dec-May, thrips especially *Scirtothrips dorsalis* was most abundant followed by mealy bugs and aphids. Some species like slug caterpillars, tasar silk worm were seen only during rainy season (July-Nov). Similarly, *Drosophila* sp. and *Carpophilus* species were abundant during March-May.

6.4.4.6 Pest status of leaf miner

Studies were conducted in a cashew plantation at Puttur, Karnataka, India between 2011 and 2015 on 11 common cashew varieties during post monsoon flushing period to determine the pest status of leaf miner by adopting Jacob (1993). Maximum number of larvae in a single leaf ranged between 15 and 45 among the varieties. Least larval density was recorded on NRCC-Sel-2 followed by Vengurla-4, while, highest was recorded on Ullal-4, Vengurla-7 and Madakkathara-2. A maximum of 45 larvae/leaf was recorded on Ullal-4 followed by Vengurla-7 (44 larvae), VRI-3 (41) and Madakkathara-2 (40). Within a single blotch, even up to five larvae were seen. In most of the varieties, there was no significant correlation between the leaf area and the number of leaf miner larvae. Average leaf area damage (*i.e.,* a blotch) caused by individual leaf miner larva upon full development varied from 2.71 (Vengurla-1, Vengurla-4) to 3.16 cm^2 (Ullal-1). Considering the average leaf area of infested leaves and the average leaf area damage, the number of larvae required for a complete leaf was calculated between 17.4 and 29.1, which was highest for Bhaskara and lowest for Vengurla-1. The pest status of leaf miner remained as low to medium in all 11 cashew varieties.

6.4.4.7 Influence of plant density on pest diversity

Influence of pest diversity *vis-a-vis* plant density was also studied for two consecutive years and found that there were non-significant differences in pest population especially leaf miner, apple and nut borer, flower thrips and flower beetles among four different plant densities *i.e.,* spacing, but significant differences were noticed among varieties.

6.4.4.8 Natural enemies in cashew ecosystems

The general predatory fauna observed in cashew plantations are an array of spiders, ants, reduviids, wasps, praying mantises, coccinellids, syrphids, green lace wing, anthocoreid bugs, geocorid bugs, mantis flies, mirid bugs, odonates, pentatomid bugs etc. Among the natural enemies, dominant insect order was Hymenoptera followed by Hemiptera with 62 and 21 species, respectively. A list of spiders (120 sp.), reduviids (18 sp.), praying mantises (16 sp.), ants (41 sp.) and other predators was made.

The parasitoid species occurring on cashew pests were documented and new reports on some parasitoids were also made. There are three species of egg parasitoids on TMB eggs, among *Telenomus* sp is the dominant. A new egg parasitoid *Telenomus cuspis* sp. nov. (Hymenoptera: Platygasteridae) of tea

mosquito bug *Helopeltis antonii* on cashew from India has been described. Occurrence of three species of larval parasitoids namely, *Chrysocharis* sp., *Closterocerus* sp. and *Aprostocetus* sp. all belonging to Eulophidae were recorded on cashew leaf miner larvae for the first time. Among these three parasitoids, *Chrysocharis* sp. was the dominant (99%) in all four years of observation. While, *Closterocerus* sp. and *Aprostocetus* sp. were recorded only during 2011 at 0.5 % level. Up to 58 % parasitism of leaf miner larvae has been recorded in field conditions. Hence, except in nursery and very young cashew plants, there is no need of insecticidal spray unless required. Similarly, first report on egg parasitism in tasar silk worm was made. A total of five parasitoids identified as *Anastatus leithi* have emerged from a number of 42 field collected eggs, in which two emerged during August 2014 and the other three during August to September 2015. All the parasitoids emerged were males.

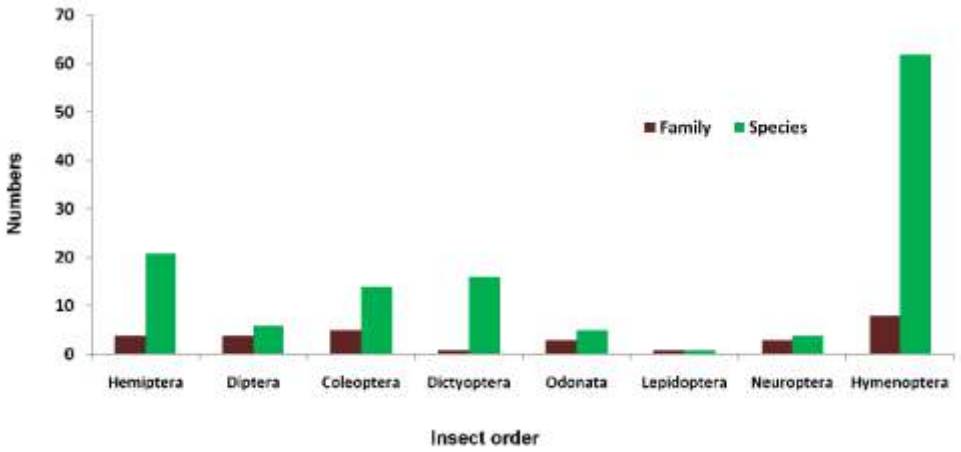

Fig. 6.17 : Natural enemies recorded in cashew ecosystems

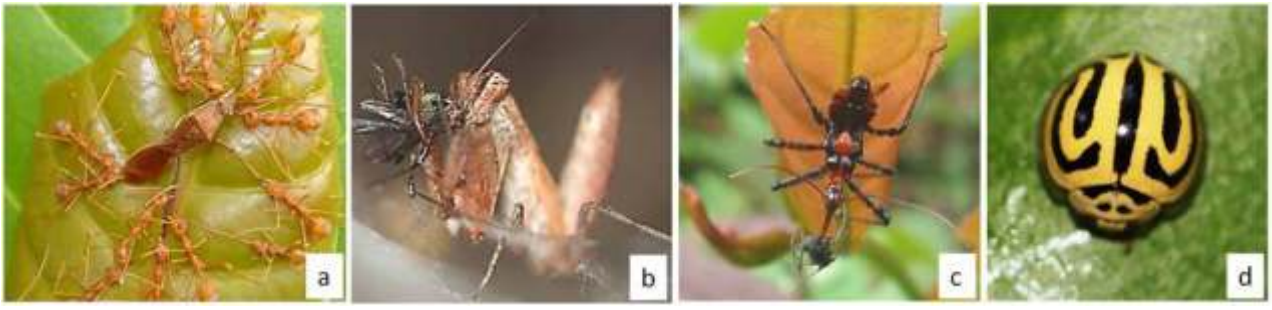

Fig. 6.18: Common natural enemies in cashew plantations - a) Red ants (*Oecophylla smaragdina*) b) Praying mantis (*Ephestiasula pictipes*) c) Reduviids (*Panthos bimaculatus*) d) Coccinellids

6.4.5 Conclusion

The different arthropods occurred on cashew during 2010-16 were documented showing high pest diversity in cashew ecosystems. It is understood that still TMB and CSRB are the major pests of cashew requiring timely management measures to prevent yield loss. Apart from these two pests, thrips, apple and nut borers and inflorescence caterpillars are some emerging pests and are able to cause economic loss requiring research focus. Though few Orthopterans, Thysanopterans and Isopterans were documented, some more species need identification, besides soil dwelling insects. The knowledge on beneficial insects including natural enemies of different cashew pests and pollinators, and their influence helps to decide on management measures. Knowledge on commercial insects like silkworm rearing in cashew can be transferred to interested farmers. But continuous monitoring is required to understand the changing pest scenario.

6.5 Reduction of tannins in cashew apple juice by low cost food grade materials

Project Leader	:	Mr. Rajkumar Arjun Dagadkhair
Project Associate	:	Dr. Babli Mog (2015-16) Dr. P. Janani (2016-18)
Project Number	:	4.18
Project Duration	:	2015-2018

6.5.1 Introduction

Despite its high nutritive value, the cashew apple products are not available in the consumer market. Cashew apple contains 0.099% vitamin B2, 0.24% vitamin C, 0.041% calcium, 0.011% phosphorus and 0.003% iron. Indeed, the vitamin C content of cashew apple is almost ten times more than that of pineapple, a customary tropical fruit. The major culprit in cashew apple utilization is its high astringency. The phenolic compounds present in apple are mostly responsible for astringency of the juice. Tannins interfere with the assimilation of proteins in the body, resulting in nutritional deficiency. Therefore to make cashew apple juice acceptable like other fruits, tannin reduction becomes a major step.

Under this project, few methods of tannin reduction established by earlier workers included the use of gelatin, Poly Vinyl Pyrolidone (PVP), starch, sago, and rice gruel were reviewed and verified. The efficiency of tannin reduction varied depending on the change in the agent/method used. Use of PVP is limited despite its efficiency because of its inaccessibility and higher cost. Gelatin powder is also efficient but there is no consensus regarding the quanitity required (India-5%, Brazil-10%, Benin-10% solution) and also to some extent use of animal originated gelatin is not preferred because of ethical issues. Enzymes like tannase are difficult to use because of difficulty in sourcing and affordability. Microfiltration is also in practice but requires tedious pre-treatments like use of clarifying agents prior to filtration and is expensive as well. Cassava starch is readily available, cheap but requires refrigeration of the juice and takes more time (8 h) lead to fermentation of juice. Rice gruel is also an effective clarifying agent and takes less time (20 to 40 min) to process but the quantity of gruel to be added is always more than 100 ml which leads to dilution of fruit juice and taste alteration.

In view of these, a reliable cost and time effective technique is required for reduction of tannin in cashew apple juice without disturbing its nutritional and organoleptic characteristics. Three low cost food grade materials *viz.,* defatted soya meal, dried potato starch and bajra (pearl millet) starch. were identified and the method was modified and standardized and the drawback of earlier methods mentioned were addressed to a greater extent. The newly identified agents are readily available with a meager expenditure and a cohesive and an integrated detannification strategy is developed for reducing the astringency and antinutritional effects of tannins in cashew apple juice.

6.5.2 Objectives

- To identify and use low cost food grade material for tannin reduction in cashew apple juice.
- To improve the processability of cashew Apple.

6.5.3 Results

6.5.3.1 Review and verification of earlier methods of tannin reduction

The methods of tannin reduction developed by earlier workers were reviewed and the results were in line with the earlier reports (Table 6.12). The cassava starch 2% (Sago) was found more effective (39.8% tannin reduction) over PVP 4% (34.3% tannin reduction), gelatin 3% (33.5% tannin reduction) and activated charcoal 2.5% (15.0% tannin reduction). However, the use of 2.5% charcoal brought out the highest clarity (96.3% juice clarity) in juice after treatment compared to PVP 4% (91.6% juice clarity), gelatin 3% (82.9% juice clarity) and sago 2% (91.2% juice clarity) concentrations.

Table 6.12: Earlier methods tested for tannin reduction in cashew apple juice

Treatments	Juice recovery (%)	Absorbance	Transmittance (%)	Tannin reduction (%)
Control	70.5	0.15	88.04	07.25
Sago 1%	88.5	0.19	92.95	23.33
Sago 2%	86.5	0.12	91.28	39.80
Sago 3%	80.0	0.16	87.80	28.91
Sago 4%	78.0	0.21	81.15	24.39
PVP 1%	91.0	0.16	88.50	31.60
PVP 2%	87.0	0.20	83.50	27.28
PVP 3%	82.5	0.19	87.72	30.17
PVP 4%	80.0	0.14	91.68	34.36
Gelatin 1%	87.5	0.50	58.78	26.39
Gelatin 2%	81.5	0.85	42.63	24.70
Gelatin 3%	82.5	0.19	82.90	33.54
Gelatin 4%	80.5	0.13	53.65	25.58
Charcoal 2.5%	87.5	0.04	96.33	15.08
Charcoal 5.0%	79.5	0.11	87.66	13.24
Charcoal 7.5%	80.5	0.21	77.48	07.88
Charcoal 10.0%	79.5	0.19	80.47	09.47
Mean	82.5	0.22	80.73	23.70
SEm	0.59	0.23	0.83	0.27
SD	0.83	0.33	1.18	0.37
CD (0.05)	1.78	0.70	2.54	0.80

6.5.3.2 Use of pectinase for cashew apple juice tannin reduction:

Pectinase could not bring out significant results compared to other non-enzyme treatments (Table 6.13).

Table 6.13: Use of pectinase for cashew apple juice tannin reduction

	Absorbance	% Tannin reduction
Control	0.194	4.75
Pectinase 0.05%	0.185	7.70
Pectinase 0.1%	0.182	8.30
Mean	0.187	6.98
SEm±	0.001	0.09
SD	0.001	0.12
CD (0.05)	0.005	0.53

6.5.4 Synergistic effect of detanning agent and filtration on tannin reduction of cashew apple juice:

Through series of trials, it was found that fresh cashew apple juice tend to clarify its own through sedimentation of dissolved and undissolved solids when kept undisturbed for some time. The tannins either free (fresh juice) or in precipitate form (treated juice) still remained in the clear juice to a major extent. If the fresh and treated juice were subjected to filtration (Whatman filter paper No. 1 and at 4°C) after the specified treatment time tannins got reduced two fold less than the unfiltered sample (Table 6.14).

Table 6.14: Synergistic effect of detanning agent and filtration on tannin reduction of cashew apple juice

Treatment	% Tannin reduction
Without Treatment/ filtered	13.65
Without Treatment/ unfiltered	07.30
Sago 2%/filtered	28.80
Sago 2%/unfiltered	15.25
PVP 2%/filtered	26.65
PVP 2%/unfiltered	12.50
Defatted Soybean meal 2%/filtered	29.05
Defatted Soybean meal 2%/unfiltered	14.35
Mean	18.44
SEm	0.17
SD	0.24
CD (0.05)	0.58

6.5.5 Tannin reduction efficiency of newly identified low cost food grade material

The new detanning agents were identified based on the chemical nature of tannins. Tannins form soluble and insoluble and sometimes irreversible complexes with protein, starch and iron (Jansman 1993). Accordingly, new low cost food grade materials were identified *viz.* defatted soya meal (rich in proteins), dried potato starch and bajra (pearl millet) starch (rich in starch and iron). All the three newly identified detannying agents were tested for their efficiency in tannin reduction. Defatted soybean meal (2%) found to be more

effective (34.3%) over dried potato powder (28.6%) and bajra flour (24.0%) (Table 6.15).The treatment given was similar to earlier methods except the treatment time at 4^{0}C was just four hours instead of 8-10 hours followed in case of sago. This in turn prevented the early spoilage of detanned juice during subsequent storage. In case of bajra flour, the only drawback was that it imparted dull color to the juice treated but addition of 0.5% activated charcoal along with bajra flour and other detanning agents solved this color problem.

Table 6.15: Efficiency of newly identified low cost food grade materials for tannin reduction

Food grade material	Juice recovery (%)	Absorbance	Transmittance (%)	Tannin reduction (%)
Defatted soymeal 1%	84.50	0.074	88.82	28.67
Defatted soymeal 2%	89.50	0.110	92.13	34.33
Defatted soymeal 3%	79.50	0.161	78.94	24.03
Defatted soymeal 4%	77.75	0.206	75.93	22.31
Dried potato powder 1%	82.50	0.096	86.19	26.03
Dried potato powder 2%	84.50	0.132	89.51	28.62
Dried potato powder 3%	75.50	0.159	79.58	23.92
Dried potato powder 4%	72.50	0.207	82.43	22.30
Bajra Flour 1%	82.00	0.098	81.91	21.14
Bajra Flour 2%	80.50	0.234	78.12	24.06
Bajra Flour 3%	75.50	0.361	74.43	19.17
Bajra Flour 4%	72.50	0.412	70.03	17.39
Control	70.50	0.146	88.04	7.25
Mean	79.02	0.184	82.00	23.02
SEm	0.45	0.001	0.11	0.08
SEd	0.64	0.001	0.16	0.11
CD (0.05)	1.38	0.003	0.34	0.24

7. LINKAGES / COLLABORATION

Organization	Area of collaboration
ICAR-National Bureau of Agriculturally Important Insects (NBAII), Bengaluru	Identification of kairomones/ pheromones of major pests of cashew.
ICAR-Indian Institute of Horticultural Research (IIHR), Bengaluru	Biosystematics of tea mosquito bug and natural enemies. Biotechnology Department for SSR marker analysis in cashew
University of Agricultural Sciences (UAS), GKVK, Bengaluru	Identification of arthropod fauna associated with cashew.
ICAR-Indian Agricultural Research Institute (IARI), New Delhi	
Directorate of Cashewnut and Cocoa Development (DCCD), Kochi	Training programmes for farmers and frontline demonstrations.
ICAR-Central Institute of Agricultural Engineering, Bhopal	Development of post harvest technology machinery
Department of Horticulture, Karnataka. Horticultural Research Station, Ullal, Mangalore. Zonal Agricultural Research Station, Brahmavar, Udupi district, Karnataka.	Training programmes for farmers and Krishi Melas.
KVK, Mangalore Achal Industries, Mangalore UAHS, Shimoga CPCRI, Kasaragod KCMA, Mangalore	Transfer of technology
AICRP-Cashew Centres located in SAUs / ICAR institutes	Multilocational testing, exchange of research findings/germplasm/planting material.
ICAR-Central Plantation Crops Research Institute, Kasaragod, Kerala	Evaluation of EPN species in cashew ecosystem
ICAR-Directorate of Medicinal and Aromatic Plant Research, Anand, Gujarat	Identification and synthesis of organic components in the whole body extracts (WBE) of virgin females of TMB.
Malabar Christian College, Calicut, Kerala	Identification of insect parasitoids.
Council for Scientific and Instruments Organization (CSIR-CSIO), Chandigarh (Ministry of Industry and Commerce, GOI)	Development of moisture meter for raw cashewnuts.

8. TRAINING AND CAPACITY BUILDING

	Training Programme	Duration
Scientists		
Dr. Preethi Dr. Siddanna Savadi Sri. Muralidhara, B.M.	Writing and publishing skills for scientists at ICAR- Central Plantation Crops Research Institute, Kasargod	07 – 09 March 2018
Dr. Shamsudheen Mangalassery	National Conference on Application of geospatial technologies and ICTs in smart agriculture (SMARTAGRI-2018) at University of Agricultural Sciences, Dharwad by Indian Society of Agricultural Information Technology	23-24 January 2018
Dr. Shamsudheen Mangalassery	Standing committee meeting for organizing 23rd PLACROSYM at Indian Society for Plantation Crops at CPCRI, Kasaragod	21 February 2018
Dr. Shamsudheen Mangalassery	State Level Project Screening Committee meeting under RKVY at Vikas Soudha, Bengaluru	28 February 2018
Dr. T.N. Raviprasad	Competency Enhancement Programme for Effective Implementation of Training Functions from by HRD Nodal Officers of ICAR	15-17 February, 2018
Dr. T.N. Raviprasad	Priority Setting, Monitoring and Evaluation (PME) of Agricultural Research Projectsat NAARM, Hyderabad	6-11 October, 2017
Technical		
Sri. R. Arulmony	GFR 2017 at ISTM, New Delhi	21-25 August 2017
Sri. R. Arulmony	PFMS at UAS, Hebbal Campus, Bangalore	18 September 2017
Sri. R. Arulmony	One day awareness workshop on CERA held at CMFRI, Cochin	15 December 2017
Sri. R. Muthuraju	ERP training programme for technical personnel of ICAR, IASRI, New Delhi	20-25 March, 2017
Sri. Raghuram Kukkude	ERP training programme for technical personnel of ICAR, IASRI, New Delhi	20-25 March, 2017
Administrative Staff		
Sri. Jayamara Naik, K.M.	Administration and Finance Management Training at ICAR-NAARM, Hydrabad	17-23 August, 2017

Status of Budget (2017-18) for training and capacity building

Allocation	:	Rs. 3.00 lakhs
Utilization	:	Rs. 1.37 lakhs
Budget (Approx.) proposed for training (2018-19)	:	Rs. 4.00 lakhs

9. PUBLICATIONS

9.1 Research Publications

9.1.1 International

Adiga, J.D., Mohana, G.S., Eradasappa, E., Meena, R.K. and Saroj, P.L. 2017. Development of jumbo nut hybrid and character association studies in cashew (*Anacardium occidentale* L.), *Vegetos* 30: 336-339.

Babli Mog, Adiga, J.D., Nayak, M.G. and G.S. Mohana. 2017. Variation in seed mass as key factor in germination and seedling vigor in cashew (*Anacardium occidentale* L.). *Bioscan* 12:657-665.

Lakshmipathi, Adiga, J.D., Kalaivanan, D., Muralidhara, B.M. and Preethi, P. 2018. Effect of Zinc and Boron application on leaf area, photosynthetic pigments, stomatal number and yield of cashew. *International journal of current microbiology and applied sciences*. 7(1):1786-1795.

Mohana, G.S., and Nayak, M.G. 2018. Development of the core collection through advanced maximization strategy with heuristic approach in cashew (*Anacardium occidentale* L.). *Plant Genetic Resources: Characterization and Utilization,* 1-11. https://doi:10.1017/S147926218000035

Savadi, S. 2017. Molecular regulation of seed development and strategies for engineering seed size in crop plants. *Plant Growth Regulation*. 84,401-422.

Veena, G.L., Muralidhara, B.M., Rajan, S. and Bhattacharjee, A.K. 2017. Breeding for nutraceuticals in sub tropical fruit crops - A Review. *International Journal of Pure & Applied Biosciences.* 5(5):302-310.

9.1.2 National

Babli Mog, Adiga, J.D., Nayak, M.G and Mohana, G.S. 2017. Germination and seedling establishment in Cashew : An interaction between seed size, relative growth rate and seedling biomass. *Journal of Plantation Crops.* 45(2):110-120.

Lakshmipathi, Adiga, J. D., Kalaivanan, D. and Halesh, G.K. 2017. Effect of plant growth regulators on leaf area, chlorophyll content, carotenoids, stomatal count and yield of cashew (*Anacardium occidentale* L.) var. Bhaskara. *Journal of Current Microbiology*. 7:1786-1795.

Mohana, G.S., Nayak, M.G. and E. Eradasappa. 2017. Genetic architecture of cashew germplasm accessions. *Journal of Plantation Crops.* 45(1):57-65.

Vanitha, K. and Adiga, J.D. 2017. Insect pests on common weeds under cashew plantations in Puttur region of Karnataka. *The Indian Forester.* 143 (12): 1330-1335.

Vanitha, K. and Bhat, P.S. 2017. Life cycle and behaviour of *Hestiasula brunneriana* and *Euantissa pulchra* (Acromantinae: Hymenopodidae, Mantodea) - predators in cashew plantations. *Journal of Applied Zoological Researches.* 28(2):147-156.

9.2 Papers presented in Symposia/Workshops/Seminars/Abstracts

Balasubramanian, D. 2017. Post harvest technology of cashew and utilization of its by-products. In: 26th Indian Convention of Food Scientists and Technologies (ICFoST). Food and Nutrition Challenges: Role of Food Science and technology, conducted by CSIR-Indian Institute of Chemical Technology, Hyderabad, 7-9 December, 2017.

Mangalassery, S. and Nayak, M.G. 2018. Geospatial technologies for assessing seasonal variability in crop coefficient for efficient irrigation scheduling in cashew. The National Conference on Application of Geo-spatial technologies and ICTs in smart agriculture (SMARTAGRI-2018) (Eds. Patil, P.L., Dasog, G.S., Biradar, D.P., Partil, V.C. and Aladakatti, Y.R), University of Agricultural Sciences, Dharwad and Indian Society of Agricultural Information Technology, 23-24 January 2018.

Mohana, G.S. and Nayak, M.G. 2017. Development of a dynamic database for effective use and dissemination of genetic resources: a case study of cashew germplasm. National Seminar on "Bioresource Conservation and Utilization" 13-14 May, 2017, College of Forestry, Sirsi.

Mohana, G.S. and Nayak, M.G. 2017, Unique DSS for cashew germplasm management: Harnessing latest IT tools. International Symposium on Horticulture: Priorities and emerging trends. 5-8th September, 2017, IIHR, Bangalore.

Rajkumar, A.D. 2017. Current practices and future techniques of for safe ripening of fruit at National level seminar held during 7-8th April, 2017 at Department of Agricultural Engineering, MIT, Aurangabad, Maharashtra.

Vanitha, K. 2017. Foraging activity and nesting behavior of *Braunsapis picitarsus* (Apidae: Hymenoptera), a key pollinator of cashew. International Symposium on Horticulture: Priorities and emerging trends, 5-8 September 2017, Bengaluru, India. A 646. P. 114.

Vanitha, K., Raviprasad, T.N. and Shwetha, V. 2018. Life cycle of *Eocanthecona furcellata* Wolff. (Hemiptera: Pentatomidae) upon laboratory rearing on greater wax moth larvae. XVI AZRA International Conference on Applied Zoological Research for sustainable Agriculture and Food Security, 9-11 February, 2018.

Vanitha, K. 2018. Foraging, nesting behaviour and life cycle of *Ceratina hieroglyphica*, a common wild bee pollinator of cashew. XVI AZRA International Conference on Applied Zoological Research for sustainable Agriculture and Food Security, 9-11 February, 2018.

9.3 Book Chapters/ Lecture Notes

Adiga, J.D. and Kalaivanan, D. 2017, Cashew based cropping systems. In: Cashew Improvement, Production and Processing (Edited by Saroj, P.L.). Daya Publishing House, A Division of Astral International Pvt. Ltd. New Delhi – 110 002. pp 277-294.

Adiga, J.D. and Kalaivanan, D. 2017, Rootstocks. In: Cashew Improvement, Production and Processing (Edited by Saroj, P.L.). Daya Publishing House, A Division of Astral International Pvt. Ltd. New Delhi – 110 002. pp 207-216.

Balasubramanian, D. and Saroj, P.L. 2017. Post Harvest Management of Cashew. In: The Cashew. Eds. Saroj, P.L. and Swamy, K.R.M. Published by DKMA, Indian Council of Agricultural Research, Pusa, New Delhi. pp: 239-255.

Bhat, M.G., Adiga, J.D., Saroj, P.L., Mohana, G.S. and Eradasappa, E. 2017. Crop Improvement in Cashew In: The Cashew. Eds. Saroj, P.L. and Swamy, K.R.M. Published by DKMA, Indian Council of Agricultural Research, Pusa, New Delhi.pp.62-86.

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Mohana, G.S., Eradasappa, E. and Saroj, P.L. 2017. Botany, taxonomy and genetic In: The Cashew. Eds. Saroj, P.L. and Swamy, K.R.M. Published by DKMA, Indian Council of Agricultural Research, Pusa, New Delhi. pp.41-61.

Nayak M.G. Muralidhara, B.M. and Shamsudeen M. 2018. Innovative production technologies to enhance production and processing of cashew. National conference of Cashew (Souvenir). pp. 28-37.

Saroj, P.L. and Dagadkhair R.A. 2017. Nutritional and Nutracutical Properties of Cashew, In: The Cashew. Eds. Saroj, P.L. and Swamy, K.R.M. Published by DKMA, Indian Council of Agricultural Research, Pusa, New Delhi. pp. 268-280.

Thimmappaiah and Mohana, G.S. 2017. Biotechnology of cashew In: The Cashew. Eds. Saroj, P.L. and Swamy, K.R.M. Published by DKMA, Indian Council of Agricultural Research, Pusa, New Delhi. pp.87-106

Vanitha, K. and Bhat, P.S. 2017. Insect - Pest management. In: The Cashew. Eds. Saroj, P.L. and Swamy, K.R.M. Published by DKMA, Indian Council of Agricultural Research, Pusa, New Delhi. pp: 183-220.

9.4 Technical Reports / Compendia

Annual Report, 2016-17. ICAR-Directorate of Cashew Research, Puttur, p. 122 (Ed: Balasubramanian, D.).

Annual Report, 2016-17. All India Co-ordinated Research Project on Cashew. ICAR-Directorate of Cashew Research, Puttur, p. 232 (Ed: Mohana, G.S.).

Cashew News, 2017. ICAR-Directorate of Cashew Research, Puttur, Vol. 22 (1), p. 12 (Ed: D. Balasubramanian, J.D. Adiga and K. Vanitha).

Cashew News, 2017. ICAR-Directorate of Cashew Research, Puttur, Vol. 22 (2), p. 12 (Ed: Vanitha, K., Shamsudheen, M. and Mohana, G.S.).

DUS test guidelines for cashew published in Plant Variety Journal of May 2017 (Nayak, M.G. and Mohana, G.S. as members of the Task Force constituted by PPV-FRA, New Delhi).

Sobana, A., Mohana, G.S. and Nayak, M.G. 2017. Report on varietal screening of cashew apple for preparation of RTS and Jam. ICAR-DCR, Puttur. pp. 1-47.

9.5 Extension Bulletins / Pamphlets

Nayak, M.G. 2017. Ultra density planting in cashew – Technical Pamphlet (both in Kannada and English).

Nayak, M.G., and Sajeev, M.V. 2018. Improved Cashew Production Technology. Technical pamphlet in Kannada.

9.6 Technical / Popular Articles

Balasubramanian, D. 2017. Make shift Solar Dryer – A farmer friendly technology to transform perishable cashew apple in to stable food powder. Cashew News. 22(1):2-4.

Mohana, G.S. and Nayak, M.G., 2017. Development of core collection through advanced maximisation strategy with heuristic approach. Cashew News. 22(2):2-3.

Mohana, G.S. and Nayak, M.G. 2017. Unique decision support system for cashew germplasm management. Cashew News. 22(2):4.

Nayak M.G., Muralidhara, B.M. and Preethi, P. 2017. Nursery techniques for quality planting material production in cashew. Nursery Today. Nov-Dec issue. pp. 36-39.

Vanitha, K. 2018. Wild bees play vital role in pollination of plants and to be conserved for sustained production. *Kerala Karshakan*, e-journal, 5 (7):40-45.

9.7 Teaching/Training/Guiding of Students

Four M.Sc. (Biotechnology) students from S.D.M. PG College, Ujire were trained under Dr. Mohana, G.S., Sr. Scientist (Genetics & Cytogenetics) and the projects are as follows:

1. Chandana Kumari, V.B. and Athira Manohar- Project on SSR Marker Studies for Assessing Genetic Relationship among some Popular Varieties of Cashew (*Anacardium occidentale* L.).
2. Anitha, P. and Srivatsa Prabhu - Project on Development of Core Collection in Cashew using Morphological and Molecular Data

9.8 Website

Muthuraju, R. and G.S. Mohana, 2017. Renovated website of Directorate of Cashew Research https://cashew.icar.gov.in/ released on 17-06-2017.

10. RAJBASHA

राजभाषा कार्यान्वयन एवं प्रगति

राजभाषा कार्यान्वयन समिति

1.	डा. एम.जी. नायक	अध्यक्ष
2.	डा. संशुद्धिन एम	सदस्य
3.	श्री के.एम. जयराम नायक	सदस्य
4.	श्री राजकुमार अर्जुन दागडखैर	सदस्य
5.	श्री विजय सिंह	सदस्य
6.	श्री सीताराम के.	सदस्य
7.	श्रीमती लीला एम.	सदस्य
8.	श्री रघुराम कुकडे	सदस्य
9.	श्री प्रकाश जी. भट्	सदस्य सचिव

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

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

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

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

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

राजभाषा के प्रति जागरुकता पैदा कराने हेतु राजभाषा विभाग की ओर से जारी किए गए वार्षिक कार्यक्रम के अनुसार इस निदेशालय में 14 सितंबर से हिंदी सप्ताह समारोह आयोजन किया गया। इस अवसर पर कर्मचारियों के लिए विभिन्न प्रतियोगिताओं जैसे हिंदी निबंध लेखन, प्रारुप, टिप्पण एवं मसौदा लेखन प्रतियोगिता, क्विझ प्रतियोगिता आदी आयोजित की गई है। प्रतियोगिताओं के विजेताओं को पखवाडा के समापन

समारोह में पुरस्कार भी वितरण किया गया है। इसके अतिरिक्त सरकारी काम काज में हिंदी का अधिकाधिक प्रयोग करनेवाले अधिकारियों एवं कर्मचारियों को इस अवसर पर मुख्य अतिथि द्वारा प्रोत्साहन योजना के अधीन नकद पुरस्कार वितरण किया गया है।

इस वर्ष हिन्दी सप्ताह समापन समारोह के अवसर पर श्रीमती प्रफुल्ला, हिन्दी अध्यापिका, इंद्रप्रस्थ विद्यालय, उप्पिनंगडि, मुख्य अतिथि थी। डा आनंद, प्रधान, सी.पी.सी.आर.आई., प्रादेशिक केन्द्र, विट्ल विशेष अतिथि थे।

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

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

वेबसाइट का प्रदर्शन :

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

हिंदी कार्यशाला

सरकारी काम काज में हिंदी का प्रयोग बढ़ाने एवं हिंदी कार्य का उपयोगी ज्ञान प्राप्त कराने हेतु निदेशालय में कुल चार कार्यशालाओं को आयोजन किया जा रहा है। इस वर्ष भी अनुभवी मर्गदर्शकों की मार्गदर्शन में मसौदा लेखन, टिप्पण, अनुवाद एवं राजभाषा नियम, अधिनियम पर 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 आस पास के केन्द्र सरकारी कार्यलयों में राजभाषा हिन्दी का कार्यान्वयन सुनिश्चित करने की दृष्टी से पुत्तूर और विट्ल में स्थित केंद्रीय सरकार के कार्यालय, उपक्रम, बैंक सहित 22 सदस्य कार्यालय सम्मिलित नगर राजभाषा कार्यान्वयन समिति (नराकास) का घटन किया गया है। पुत्तूर नराकास की 32वीं और 33वीं अर्धवार्षिक बैठक दिनांक 25.07.2017 को और दिनांक 28.01.2018 को निदेशक महोदय की अध्यक्षता में आयोजित की गई।

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

निदेशालय में निम्नलिखित रिपोर्ट हिंदी में प्रकाशित किया गया :

1. निदेशालय का वार्षिक प्रतिवेदन (वर्ष 2016-17) पूर्ण रूप से हिंदी में।

2. अखिल भारतीय समन्वित काजू अनुसंधान परियोजना की वार्षिक प्रतिवेदन सारांश (वर्ष 2016-17)

3. काजू समाचार में हिंदी समिती की गतिविधियों के बारे में प्रतिवेदन।

4. दैनंदिन प्रयोग में आने वाले प्रपत्रों का हिंदी रूपान्तरण।

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

11. AWARDS / RECOGNITIONS

Individual/Team

Awards

Muralidhara, B.M. - Certificate of Excellence as reviewer from the Journal of Experimental Agriculture International for the year 2017.

Muralidhara, B.M. - Certificate of Excellence as reviewer from the International journal of plant and soil science for the year 2017.

Preethi, P. - Best poster award in “International symposium on Horticulture- Priorities and Emerging trends” organized by ISHS, Belgium and IIHR, Bengaluru 05-08th, September, 2017.

Preethi, P. - EET CRS Top list, 2018 Scientist award by Education Expo TV team, Greater Noida, India. 18th March, 2018, Hyderabad.

Siddanna Savadi - Jawaharlal Nehru Award for PG outstanding doctoral thesis 2017.

Siddanna Savadi - Young Achiever Award 2017. Society for Advancement of Human and Nature (SADHNA), Nauni, Himachal Pradesh.

J.D. Adiga. - Environmentalist award-2017 during the International Conference of SCICON series on current trends in Bioscience, organized by SCIRE Science held at Kochi, India during 21st -23rd August 2017.

Vanitha, K. - SCIRE Young Scientist Award-2017 during the International Conference of SCICON series on current trends in Bioscience, organized by SCIRE Science held at Kochi, India during 21st -23rd August 2017.

Vanitha, K. - Dr. Jagadiswari Rao Women Scientist Award - 2017 by the Applied Zoologists Research Association, Bhubaneswar conferred during XVI AZRA International Conference on "Applied Zoological Research for Sustainable Agriculture and Food Security," 9-11th February, 2018 at Banaras Hindu University, Varanasi.

Recognitions

Trademark is registered for the 'Institute's logo' (3217680) on 01.02.2018.

Muralidhara, B.M. - Nominated as member of Expert committee on Access and Benefit Sharing (ABS) of Karnataka Biodiversity Board for implementation of the biological Diversity Act, 2002. (F.No.IIHR/PMEC/1.4 (KBB)/2017/39019)

Muralidhara, B.M. - Nominated as Expert for selection of field assistant under project "Participatory Demostration plots on arecanut Based Multi Spices Cropping System" at CPCRI-Regional Station Vittal. (F.No.204-16/2016-Esst).

M.G. Nayak. - Invited as Key Speaker (Panel Expert) in 'Caju India' - Global Cashew Meet organized by CEPCI, Kollam during 17-19th September, 2017 at Panaji, Goa.

M.G. Nayak. - Invited as key Speaker by DCCD Kochi to deliver lecture on Innovative Production Technologies for Production and Processing of Cashew in the National Seminar on Cashew at Bhubaneswar during 11-12th February, 2018. Also chaired a technical session on the occasion.

Rajkumar Arjun Dagadkhair - Chaired a technical session at national level seminar on "Advanced Trends in Agricultural engineering and Food Engineering" held during 7-8th April 2017 at Department of Agricultural Engineering, MIT, Aurangabad, Maharashtra.

Vanitha, K. - Nominated as Expert for selection of field assistant under project "Participatory Demostration plots on arecanut Based Multi Spices Cropping System" at CPCRI-Regional Station Vittal. (F.No.204-16/2016-Esst) during 18th May, 2017.

Preethi, P. - Recognized as post graduate teacher at University of Agricultural and Horticultural Sciences (UAHS), Shivamogga w.e.f. 12.03.2018.

Preethi, P. Recognized as post graduate teacher at University of Horitcultural Sciences, Bagalkot w.e.f. 21.03.2018.

Siddanna Savadi - Recognized as the PG teacher of UAHS, Shivamogga w.e.f. 19.03.2018.

Mohana, G.S. - Task Force Committee member, DUS test Guidelines for cashew, PPV- FRA, New Delhi

Mohana, G.S. - Nominated as an outside expert for the selection of senior research fellow under the revolving fund project 'Seed production in agricultural crops and fisheries' at CPCRI- Vittal on 31.07.2017.

M.G. Nayak. - i) Member in National Steering Committee on Cashew (Govt. of India). ii) Member in Doubling Farmers Income : Karnataka State Committee (ICAR). iii) Member in Committee of Verification of GM Crops Applications (Govt of Karnataka). iv) Member – Board of Coastal Cashew Technology Development Institute, Kumta (Govt. of Karnataka). v) Task Force Committee member, DUS test Guidelines for cashew, PPV- FRA, New Delhi.

12. RAC / IMC / IRC / IJSC MEETINGS

12.1 Research Advisory Committee (RAC)

Dr. R.R. Hanchinal, Former Chairperson, Protection of Plant Varieties and Farmers' Rights Authority, 52, A –Block, NASC Complex DPS Marg, Pusa, New Delhi	Chairman
Dr. K.R.M. Swamy, Former Head (VS), IIHR, 630, 3rd cross, CBI Road, HMT Layout, Ganganagar, RT Nagar, Bengaluru-560032	Member
Dr. C.A. Viraktamath, Professor (Retd.), Department of Entomology, University of Agricultural Sciences, GKVK, Bengaluru	Member
Dr. R.T. Patil, Former Director, CIPHET, Ludhiana, Technocrat Institute of Technology, Anand Nagar, Bhopal- 462021	Member
Dr. M.R. Hegde, Principal Scientist (Retd.), Indian Institute of Horticultural Research, Hesaraghatta Lake, Bangalore	Member
Dr. M.G. Nayak, Director (Acting), DCR, Puttur	Member
Dr. W.S. Dhillon, ADG (H-I), ICAR, KAB-II, Pusa, New Delhi-110012	Member
Shri. Vishnu Vasanth Bhandarakara, Post- Karki, Honnavara Taluk, Uttara Kannada district	Non Official Member
Smt. Sharada R. Rai, Shreya, Mogarodi Post, Kaniyooru, Belthangadi Taluk, Dakshina Kannada district	Non Official Member
Dr .G.S. Mohana, Sr. Scientist (Genetics and Cytogenetics), Directorate of Cashew Research, Puttur	Member Secretary

The third meeting of 7th RAC was held during 26-27th September 2017. The meeting was started with the introductory remarks of Dr. R.R. Hanchinal, the Chairman of RAC. Following this, Action Taken Report of previous RAC recommendations was presented by Dr. Mohana, G.S, Senior Scientist & Member Secretary (RAC). Thereafter, presentations on progress of research in Crop Improvement, Crop Management, Crop Protection and Post Harvest Technology were made by scientists of DCR. For each section, many useful suggestions were given by RAC members. Specifically, it was recommended that the registration of new cashew varieties may be taken up with PPV-FRA, New Delhi. It was suggested to take help from CGIAR institute like Bioversity International to facilitate visits of institute scientists to biodiversity rich countries. The committee also suggested taking up institute technologies for result demonstrations in the farmers' fields.

12.2 Institute Management Committee

Name and Address	Status
Dr. M. Gangadhara Nayak, Director (Acting), ICAR-DCR, Puttur - 574 202, Karnataka.	Chairman
Dr. Ranveer Singh, Principal Scientist, (HS) Division, Indian Council of Agricultural Research, Krishi Anusandhan Bhavan-II, Pusa, New Delhi-110 012	Member
The Joint Director of Horticulture, Directorate of Horticulture, Govt. Of Karnataka, Lalbagh, Bengaluru 560 004	Member
Dr. Mahabaleshwar Hegde, Professor of Horticulture, College of Agriculture, Hassan, Hassan District, Karnataka	Member
Dr. K.V. Bhat, Head, DNA Fingerprinting, ICAR-NBPGR, Pusa Campus, New Delhi 110 012	Member
The Special Officer (Cashew), Aravind Chambers, Mundakkal West, Near DCC Office, Kollam - 691 001, Kerala State	Member
Dr. D.V.S. Reddy, Principal Scientist, ICAR-Agricultural Technology Application Research Institute, Zone VIII, MRS, H.A. Farm, P.O. Hebbal, Bangalore – 560 024	Member
Dr. K. Bhanu Prakash, Principal Scientist, ICAR- Indian Institute of Horticultural Research, Hesaraghatta Lake post, Bangalore 560 089	Member
Dr. N. Vijaya Kumari, Principal Scientist, ICAR-Central Citrus Research Institute, Shankar Nagar P.O. , Post Box No. 464, Nagpur – 440 010	Member
Dr.Ravi Bhatt, Head, Crop Production, ICAR-CPCRI,Kasargod, Kerala 671124	Member
Smt. Sharda R. Rai, Shreya, Mogarodi, Kaniyooru Post, Belthangadi Taluk, D.K. District, Karnataka	Non-Official Member
Shri Vishnu Vasanth Bhandarakar, Post Karki, Taluk Honnavara District Uttara Kannada, Karnataka	Non-Official Member
The Finance and Accounts Officer, ICAR-CPCRI, Kasaragod - 671 124, Kerala	Member
The Administrative Officer, ICAR-DCR, Puttur- 574 202, Karnataka	Member Secretary

The 46th IMC meeting of this Directorate was held on 25th September, 2017. During the meeting, nine members were replaced by the Council and the term of the new members is upto 2016 to August 2019. The proceedings of the 46th IMC was forwarded to council for approval and all the recommendations of the IMC were approved.

12.3 Institute Research Committee

The 30th annual meeting of Institute Research Committee (IRC) of ICAR- DCR, Puttur was held on 28th and 29th September, 2017 under the Chairmanship of Dr. M.G. Nayak, Director (Acting). Dr. M.G. Nayak made introductory remarks. There were five technical sessions chaired by experts of the field. Dr. S. Ramesh, Professor (Plant Breeding and Genetics), GKVK, UAS, Bengaluru was the resource person for the technical session on 'Crop Improvement'. Dr. Lingaiah, H.B., Director of Education, UHS, Bagalkot was the resource person for 'Crop Management'. For 'Crop Protection and Post Harvest Technology' sessions, Dr. S.U. Patil, Associate Director of Research, ZAHRS, Brahmavar (Shivamoga) and Dr. Doreyappa Gowda, Principal Scientist and Head, CHES, Chettali were the resource persons, respectively.

In each session, the results of various ongoing projects were presented along with new project proposals by the scientists of DCR. Accordingly, the technical programme of the projects for the year 2017-18 was also finalized.

12.4. Institute Joint Staff Council

Sl.No.	Name	Status
1.	Dr. M.G. Nayak	Chairman, IJSC
2.	Sri. Jayarama Naik KM	Member (Official side)
3.	Sri. R. Arulmony	Member (Official side)
4.	Dr. Shamsudheen M	Member (Official side)
5.	Sri. Rajkumar A.D.	Secretary (Official side)
6.	Smt. Leela M.	Member (Official side)
7.	Smt. Reshma K.	Secretary (Staff side)
8.	Sri. Babu Poojari	Member (Staff side, CJSC)
9.	Sri. Ravishankar Prasad	Member (Staff side)
10.	Sri. Padmanabha T.	Member (Staff side)
11.	Sri. Gopalkrishna K.	Member (Staff side)

IJSC meetings were held at quarterly intervals during the year at this Directorate to discuss on issues for the welfare of the staff.

12.5 Institute Technology Management Unit (ITMU)

Six post harvest technologies developed at this Directorate *viz.,* Radial arm type cashew kernel extracting machine, Rotating type roasting machine for raw cashewnuts, Dual mode dryer for raw cashewnuts, Hydraulic juice extractor for cashew apples, Concentric drum type rotary sieve grader for raw cashewnuts and Cashew shell cake based updraft gasifier have been commercialized to private machinery manufacturer on the basis of non-exclusive licensing. In this regard, a MoU was signed between ICAR-DCR, Puttur and M/s Pro B Products, Bengaluru on 21.03.2018.

Concerted efforts we taken to register institute logo as 'Trade mark'. Institute Technology Management Committee (ITMC) Meetings were conducted twice on 15.09.2017 and 19.03.2018 to discuss about IPR issues primarily on commercialization of developed technologies, collaborative research projects, trade mark registration, technology disclosing, pricing and valuation of technologies, inducting research associate and pertinent administrative activities. Technical consultancy was provided by Dr. D. Balasubramanian, Principal Scientist (AS & PE) on payment basis to *M/s. Dry Fruit factory LLP*, Ahmedabad, Gujarat and *M/s Plantation Corporation of Kerala* (PCK), Kasaragod, Kerala.

Major ongoing research programmes

A. Institute projects

- Collection, conservation, characterization, evaluation and documentation of cashew germplasm.
- Improvement of cashew through conventional and innovative approaches.
- Integrated water and nutrient management and physiological intervention for improving productivity of cashew.
- Horticultural intervention / approaches for enhancing productivity of cashew.
- Integrated pest and disease management in cashew.
- Development and refinement of post harvest handling, storage and processing techniques.
- Knowledge management and impact assessment in cashew for improving cashew production

B. Flagship Programme

- Management of Tea Mosquito Bug (TMB) and Cashew Stem and Root Borer (CSRB) using semiochemicals.

C. Externally Funded Projects

- Development of Morphological Descriptors and DUS Test Guidelines for Cashew (*Anacardium occidentale* L.) – PPV&FRA, New Delhi
- Development of an exclusive android application for cashew cultivation-DCCD, Cochin

ANNEXURES

Annexure - I

Ongoing Research Projects/Experiments

Sl. No.	Project	PI	Co-PI
Crop Improvement			
1	1.1: Collection, conservation, evaluation and documentation of cashew germplasm [1986 – Long term]	Nayak, M.G.	Mohana G.S., K. Vanitha and Muralidhara, B.M. (since Sep 2017)
2	1.2: Genetic improvement of cashew for yield and quality traits. [1986 – Long term]	J.D. Adiga (since September 2017) Mohana, G.S. (till August 2017)	Mohana, G.S., M.G. Nayak, Rajkumar, A.D, Siddanna Savadi Muralidhara, B.M. (since September 2017) and E. Eradasappa (Since November 2017).
3	1.2.1: Development of dwarf and compact cashew hybrids suitable for high density planting [2013 – 2023]	Eradasappa (since November 2017) Mohana, G.S. (till November 2017)	Mohana, G.S. (Since Nov 2017) Janani (till Sep 2017)
4	1.8: Genetic analysis of mapping population through molecular markers for important traits in cashew. [2012 – 2018]	Mohana, G.S.	Siddanna Savadi Eradasappa E. (Since November 2017) J.D. Adiga (Since September 2017) Nayak M.G. (till September 2017)
5	1.9: Development and evaluation of back cross progenies of promising hybrids for dwarf stature and high yield . [2013-2025]	Mohana, G.S.	Nayak, M.G. (till September 2017) E. Eradasappa (since November 2017)
6	1.10 Evaluation of cashew apple germplasm for cashew apple yield and quality traits. [2013-2020]	Preethi, P. (since July 2017)	M.G. Nayak, K. Vanitha, Rajkumar A., Janani, P. E. Eradasappa (since November 2017)
7	1.11: Identification and evaluation of cashew genotypes for Cashew Nut Shell Liquid content. [2016-2024]	Mohana, G.S.	Nayak, M.G. Balasubramanian, D.
8	Development of morphological descriptors and DUS test guidelines for cashew (PPV & FRA, New Delhi). [2015-2019]	Nayak, M.G.	Mohana, G.S.
9	Mutation breeding in Cashew for TMB and CSRB resistance along with higher yield, medium nut size, cluster bearing and semi-compact plant type [2017-2029]	Mohana, G.S.	Eradasappa, E (since November 2017) Vanitha K.

10	Development of microsatellite markers and population structure studies in cashew (*Anacardium occidentale*) core accessions	Siddanna Savadi	Mohana, G.S. and J.D. Adiga
Crop Management			
1	2.19: Irrigation requirement for cashew under high density planting system. [2011 – 2015]	M. Shamshudeen (since August 2017) Prabha Susan Philip (Till July 2017)	Babli Mog J.D. Adiga
2	2.20: Organic farming in cashew [2011 – 2016]	M. Shamshudeen (since August 2017) Prabha Susan Philip (Till July 2017)	Raviprasad, T.N.
3	2.21: Establishment of nutrient diagnostic norms in cashew. [2013-2018]	M. Shamshudeen (since August 2017) Prabha Susan Philip (Till July 2017)	Nayak, M.G.
4	2.22: Characterization of physiological responses of cashew to salt and drought stresses. [2015-2017]	Babli Mog	Prabha Susan Philip (till July 2017)
5	Net work project: Micronutrient Management in Horticultural Crops for Enhancing Yield and Quality – Cashew. [2014-2017]	M. Shamshudeen (since August 2017) Prabha Susan Philip (Till July 2017)	Babli Mog
6	2.23: Development of cashew based cropping system under rain fed condition of Karnataka. [2016- 2019]	Janani, P.	Prabha Susan Philip (Till July 2017)
7	Studies on pruning and phenology in cashew [2018-202]	J.D. Adiga	Preethi, P. and Muralidhara, B.M
Crop Protection			
1	3.21: Diversity and bio-ecology of insect pollinators and their efficiency in increasing yield of cashew. [2014-2019]	K. Vanitha	Raviprasad, T.N.
2	3.6: Survey and surveillance of important diseases of cashew – kept in abeyance. [2015-2020]	Loganathan, M. (till March 2017)	Raviprasad, T.N.
3	3.22: Flagship project Investigations on semio-chemicals for management of TMB and CSRB. [2014-2019]	Raviprasad, T.N.	Vanitha, K. and Bhaktavatsalam, N. (NBAIR, Bengaluru)
4	3.23: Evaluation of newer molecules for their efficacy against Tea Mosquito Bug (TMB) and Cashew Stem and Root Borers (CSRB)	Raviprasad, T.N.	K. Vanitha

5	3.23: Investigations on inflorescence pests of cashew and their management	K. Vanitha	Raviprasad, T.N.
6	Standardization of pest management practices involving EPN and *Metarhizium anisopliae* for management of CSRB	T.N. Raviprasad	Rajkumar, CPCRI, Kasaragod
Post Harvest Technology			
1	4.16: Developing quality standards for raw cashew nuts. [2014-17]	D. Balasubramanian	K. Vanitha
2	4.17: Design and development of mechanical slicer for cashew apple [2014-17]	D. Balasubramanian	Dr. Ravindra Naik, ICAR-CIAE (since December 2017)
3	4.21: Design and development of moisture meter for raw cashewnuts. [2017-2020]	D. Balasubramanian	--
4	4.22: Studying comparative performance of cashewnut processing systems in India. [2017-2018]	D. Balasubramanian	--
5	4.19: Screening of cashew vareiteis to specify use of cashew apple in value added products [2014-2017]	Rajkumar Arjun D.	Preethi, P. Sajeev, M.V. (till February 2017)
Transfer of Technology			
1	5.1: Transfer of Technology programmes in Cashew. [1986 – Long term]	Adiga, J.D. (Since March 2017)	Nayak, M.G. and Balasubramanian, D. (till September 2017)
2	5.2: Impact of cashew production technologies on area, production and productivity of cashew – Kept in abeyance [2011 – 2015]	Sajeev, M.V. (till March 2017)	Mohana, G.S.
3	Development of an exclusive android application for cashew cultivation (Directorate of Cashew and Cocoa Development, Cochin) [2017-2019]	Mohana, G.S.	Nayak, M.G.

Annexure - II

Participation in Symposia / Conferences / Seminars / Meetings / Review Meetings

M.G. Nayak	Presented a lecture on 'Improved Cashew Production Technology' in the farmers seminar organized by Farmers Association at Moodabidri of Dakshina Kannada Dist.	1st April, 2017
M.G. Nayak	Attended the Parliamentary Committee on Agriculture meeting organized at CMFRI Regional Centre, Mangalore.	28-29th April, 2017
M.G. Nayak	Attended the National Steering Committee on Cashew by DCCD, Kochi	17th May, 2017
M.G. Nayak	Participated in the National Seminar on Semi -Arid Tropics organized by CHES, Chettali	20th May, 2017
Muralidhara, B.M.	Participated in National Conference on Horticultural Crops of Humid Tropics-Diversification for Sustainability held at CHES-Chettalli.	20-21st May, 2017
M.G. Nayak	Participated in the National level training programme on cashew organized by DCCD, Kochi in association with ZARS Bharmavara, UAHS Shimoga, and delivered a lecture on Cashew Research Scenario and high density concept in cashew.	15th June, 2017
Eradasappa, E	Participated in International conference on Recent Trends in Agriculture, Biotechnology and Food Processing, College of Agriculture, Hassan, UAS, Bengaluru	5-7th July, 2017
M.G. Nayak	Attended the ICAR Directors Conference and Award Ceremony on ICAR Foundation Day held at New Delhi	15-16th July, 2017
J.D. Adiga	Participation in International conference on "Current trends in Biosciences", Cochin, Kerala	21st -23rd August, 2017
M.G. Nayak	Attended the ICAR Vigilance Officers Meet at NIANP, Bangalore	24th August 2017
M.G. Nayak	Participated in the cashew seminar organized by Horticulture College, Mysore and delivered a lecture on High density planting in Cashew.	01st September, 2017
Mohana, G.S. Preethi, P. Muralidhara, B.M. K. Vanitha	Participated in International symposium on Horticulture-Priorities and Emerging trends organized by ISHS, Belgium and IIHR, Bengaluru.	04-08th September, 2017
M.G. Nayak	Participated in 'Caju India 2017' – The Global Cashew summit at Panjim, Goa,organized by CEPCI– Kollam and presented paper on 'New trends in Cashew Cultivation'.	17-19th September 2017
Preethi, P.	Participated in "National conference on Nanotechnology for ever green agriculture" organized by IDRC, Canada and TNAU, Coimbatore	05-06th October, 2017
M.G. Nayak	Participated in Krishi mela at ZAHRS, Brahmavar and delivered lecture on profitable cultivation of cashew.	14th October, 2017
M.G. Nayak	Participated and delivered lecture on cashew varieties and high density orchards in the seminar organized by Samrudhi Balaga at Balila of Sullia Taluk, DK Dist. Karnataka	29th October, 2017
Mohana, G.S.	Participated as resource person and delivered a talk on	29th October, 2017

	'Agricultural related websites useful to farmers' at Silver Jubilee celebration of Samrudhi Gida Gelethana Sangha Puttur at Kotemundugaru, Sulya Taluk, Dakshina Kannada district.	
Rajkumar Arjun Dagadkhair	Participated in an International Event and conference "World Food India 2017" and exhibited the cashew apple based value added products/ Technologies, held at New Delhi, organized by Ministry of Food Processing Industry, India.	3rd – 5th November, 2017
Siddanna Savadi	Participated in VI NGGIBCI conference on the topic "Crop Genomics: Present & Future", ICRISAT, Hyderabad,	6-8th December, 2017
Balasubramanian, D.	Particpated in 26th Indian Convention of Food Scientists and Technologies. Food and Nutrition Challenges: Role of Food Science and technology, conducted by Indian Institute of Chemical technology, Hyderabad.	7-9th December, 2017
M.G. Nayak	Participated as Guest of Honour in Cashew Seminar at Mandya organized by Mandya District Agriculture Graduate Association and delivered a lecture on Cashew Varieties and High Density Planting.	19th December, 2017
Mohana, G.S. Raviprasad, T.N. Muralidhara, B.M. Preethi, P. Siddanna Savadi Eradasappa, E. K. Vanitha	Participated in Annual Group Meeting of Scientists of AICRP on cashew held at ICAR-DCR, Puttur.	21st -23rd December, 2017
M.G. Nayak	Participated in Cashew seminar organized by Govt. of Meghalaya at Tura and delivered a talk on 'Cashew Cultivation Practices'.	9-10th January, 2018
M.G. Nayak	Participated in the Cashew Day Programme of HRS, Ullal, UAHS, Shimoga and delivered a lecture on High Density Planting in Cashew	6th February, 2018
M.G. Nayak	Participated in the Agricultural Seminar on Plantation crops organized by Farmers Association, Mandekolu of Sullia Taluk, Dakshina Kannada District and delivered a talk on Improved Cashew Cultivation.	3rd February, 2018
M.G. Nayak	Participated in National Conference on Cashew organized by DCCD, Kochi at Bhubaneswar and presented paper on 'Innovative Production Technologies to enhance Production and Processing in Cashew and chaired a Technical Session No. IV.	11-12th February 2018
M.G. Nayak	Participated in Cashew Day Programme of ZARS Brahmavar and delivered lecture on Cashew Varieties and High Density Planting.	3rd March, 2018
M.G. Nayak	Attended the Cashew Cluster Meeting organized by Department of Industries and Commerce, Govt. of Karnataka at Syndicate Rural Development Institute, Kumta	8th August, 2017
M.G. Nayak	Participated as Chief Guest for National Conference on Recent Trends in Food Processing Industries organized by Department of Food Processing and Engineering & DDU	5th March, 2018

	Kushal Kendra held at St. Aloysius College, Mangalore	
M.G. Nayak	Participated in the ICAR Directors Conference at NASC, New Delhi.	8-9th March, 2018
M.G. Nayak	Participated in the meeting on GM Crops at UAS, Bangalore	27th March, 2018

Farmers' Day/Krishi Mela/Exhibitions/Campaigns

Name of scientist	Programme	Date
J.D. Adiga	Coordinated the conduct of Foundation Day & Farmers Meet 2017, Programme on Nursery management, Agricultural Education Day-2017, Programme on Cashew production Technology for TSP farmers, Cashew Day 2018	17th June, 2017 11th September, 2017 4th December, 2017 27th February, 2018 21st March, 2018
J.D. Adiga Rajkumar, A.D.	Coordinated the conduct of exhibitions at New Delhi, CPCRI, Kasaragod	03-05 November, 2017 10, January, 2018
M. Shamsudheen B.M. Muralidhara	The Field day on "Soil health management" was organized at Farmers field Irde, Bettampadi	10th November, 2017
M. Shamsudheen B.M. Muralidhara	The Field day on "Soil health management" was organized at Farmers field Thingaladi	21st November, 2017
T.N. Raviprasad	Training imparted on management of cashew stem and root borers (CSRB) and tea mosquito bug (TMB) in Telugu ; to farmers from Vishakapattanam district of Andhra Pradesh at this Directorate. Method demonstration of CSRB grub removal and PET treatment was also done to acquaint the farmers about the technique.	7th August, 2017 14th December, 2017
M. Shamsudheen E. Eradasappa B.M. Muralidhara P. Preethi	Organization of World Soil Day -2017	5th December, 2017
M.G. Nayak G.S. Mohana	Organized Annual Group Meeting of Cashew Research Workers (Workshop) of AICRP on Cashew at DCR Puttur	21st- 23rd December, 2017
M.G. Nayak	Organized an Interface meeting on Scientists, Farmers, Processors, Exporters and officials of line departments at DCR Puttur.	23rd December, 2017
G.S. Mohana	Resource person for a one day interactive and hands on training programme on basics of MS-Office and usage of ERP and DCR website organized in the new Audio Visual Lab of the Directorate	28th August, 2017
E.Eradasappa	Delivered a lecture on Scope of Agriculture Education at DCR, Puttur	4th December, 2017
G.S. Mohana	Resource person in the Interactive Session on Cashew cultivation in Ulavi village of Soraba Taluk, Shimoga district	8th February, 2018

G.S. Mohana	Coordinator, Exposure visit of 8 TSP farmers to IISR Calicut and CRS,Madakkathara	12-14th March, 2018
B.M. Muralidhara	Participated and exhibited DCR technologies in National Horticulture Fair held at Indian Institute of Horticulture Research, Bengluru.	15 – 17th March, 2018
J.D. Adiga G.S. Mohana E.Eradasappa P. Preethi Rajkumar, A.D. B.M. Muralidhara	Organized and demonstrated DCR technologies on Cashew Day-2018 held at ICAR-DCR Puttur	21st March, 2018

Annexure - III

Radio Talk / TV Programme

M.G. Nayak	Delivered a lecture on Ultra density planting – recorded by AIR Mangalore and broadcast on 22nd February 2018.	15th February, 2018
Muralidhara, B.M.	Delivered radio talk on "Future fruit crops of Coorg region" in the series of radio programmes organized by Department of Horticulture, Madikeri (ZP)	12th January, 2018
M.G. Nayak	A lecture on Ultra density planting in cashew was recorded and the same was telecast by DD-1 (Chandana) on 13.9.2017.	1st September, 2017
M.G. Nayak	Three lectures on 'Softwood Grafting and Nursery Management' Cashew varieties suitable for Karnataka' and Ultra density planting in cashew' were recorded and telecast by Suddi TV.	14th August, 2017

Annexure - IV

Services offered to farmers

Sale of cashew grafts: ICAR-DCR has a cashew nursery accredited by National Horticulture Board (NHB) to cater the need of planting materials. Softwood grafts of varieties like Bhaskara, NRC Selection-2, Ullal-3, Ullal-1, VRI-3, Vengurla-7, Vengurla-4, Dhana etc. are available for sale in the nursery between June to August every year. During the year 4.25 lakhs cashew grafts were supplied to farmers

Soil testing: Soil analysis is done on charge basis for various parameters such as pH, EC, organic carbon, available N, P, K, Exch. Ca, Exch. Mg and available micronutrients such as Fe, Mn, Zn and Cu.

Soil Health Card: Soil health cards for different cashew growing regions are being prepared and distributed to farmers.

Advisory service: Advisory service on all aspects of cashew cultivation and processing is given to growers and stakeholders through pamphlets, brouchers, media and other publications.

Consultancy service: Consultancy service on all aspects of cashew is also provided.

Annexure - V

Distinguished Visitors list

Name	Address	Date of visit
Shri. Prem Prakash Maurya	Undersecretary (Parliament &IC) DARE, New Delhi	01-05-2017
Shri. Rajeev Kumar Sharma	Section officer (Parliament), ICAR/DARE, New Delhi	01-05-2017
Mr. Chhabilendra Roul	Additional Secretary (DARE) & Secretary (ICAR), New Delhi	06-07-2017
Mr. Nagaraja, IFS	Managing Director, Karnataka Cashew Development Corporation, Mangalore	27-07-2017
Mr. Harihar Nath Giri	Representative, Caju Business Conclave	27-07-2017
Mr. Prakash S. Netalkar, IFS	Managing Director, Karnataka Cashew Development Corporation, Mangalore	04-08-2017 & 05-12-2017
Dr. Ranveer Singh	Principal Scientist, (HS) Division, ICAR, Krishi Anusandhan Bhavan-II, Pusa, New Delhi - 110 012	25-09-2017
Dr. D.V.S. Reddy	Principal Scientist, ICAR-Agricultural Technology Application Research Institute, Zone VIII, MRS, H.A. Farm, P.O. Hebbal, Bangalore – 560 024	25-09-2017
Dr. N. Vijaya Kumari	Principal Scientist, ICAR-Central Citrus Research Institute, Nagpur	25-09-2017
Dr.Ravi Bhatt,	Head, Crop Production, ICAR-CPCRI, Kasargod, Kerala 671124	25-09-2017
Mr. Shirish K.	The Special officer (Cashew), Aravind Chambers Mundakkal West, Near DCC Office, Kollam 691 001, Kerala	25-09-2017
Dr. R.R. Hanchinal	Former Chairperson, Protection of Plant Varieties and Farmers' Rights Authority, New Delhi	26 & 27-09-2017
Dr. K.R.M. Swamy	Former Head, Indian Institute of Horticultural Research, Bengaluru	26 & 27-09-2017
Dr. R.T. Patil	Former Director, CIPHET, Ludhiana	26 & 27-09-2017
Dr. W.S. Dhillon	Additional Director General, ICAR, New Delhi	26 & 27-09-2017
Mrs. Sharada R. Rai,	Non-official member (RAC), Shreya, Mogarodi, Kaniyooru post, Belthangadi Taluk, Dakshina Kannada	26 & 27-09-2017
Dr. S. Ramesh	Professor, Genetics and Plant Breeding, GKVK, Bengaluru	28-09-2017
Dr. Lingaiah, H.B	Director of Education, UHS, Bagalkot	28-09-2017
Dr. S.U. Patil	Associate Director of Research, Zonal Agricultural Research Station, UAHS, Shimoga	29-09-2017
Dr. Doreyappa Gowda	Head, IIHR-CHES, Chettalli	29-09-2017
Mr. Sanjay Mohan	Additional PCCF (Research), KFD, Bengaluru	13-10-2017
Mr. C. K. Basavaraj	Principal Senior Civil Judge and ACJM, Puttur	03-11-2017
Capt. Ganesh Karnik	MLC and Opposition Chief Whip, Govt. of Karnataka	04-12-2017
Mr. B.K. Ramesh	Member, ICAR General Body, Puttur	04-12-2017
Mr. Nalin Kumar Kateel	Member of Parliament, Dakshina Kannada	05-12-2017
Mrs. Shakunthala T. Shetty	Member of Karnataka Legislative Assembly, Puttur	05-12-2017

Haji B.H. Khader Bantwal	Chairman, Karnataka Cashew Development Corporation, Mangalore	05-12-2017
Dr. K.V. Peter	Former Vice Chancellor, Kerala Agricultural University	21-12-2017
Dr. M.G. Bhat	Former Director, ICAR-Directorate of Cashew Research, Puttur	21-12-2017
Dr. P. Chowdappa	Director, ICAR-Central Plantation Crops Research Institute, Kasargod	21-12-2017
Dr. H.P. Maheswarappa	Project Coordinator (Palms), ICAR-CPCRI, Kasargod	21-12-2017
Dr. K.S. Anand	Head, ICAR-CPCRI, Research Station, Vittal	21-12-2017
Dr. Abraham Varghese	Former Director, National Bureau of Agricultural Insects Resources, Bengaluru	23-12-2017

Annexure - VI

Personnel

Staff Position as on 31.3.2018

Category	Sanctioned	Filled	Vacant
Director (RMP)	1	-	1
Scientific	17	14	3
Technical	19	14	5
Administrative	15	9	6
Canteen staff	1	1	-
Skilled support staff	38	20	18
Total	**91**	**58**	**33**

Research Management Position		
1.	Dr. M. Gangadhara Nayak	Director (Acting)
Scientific		
1.	Dr. T.N. Raviprasad	Principal Scientist(Agricultural Entomology)
2.	Dr. D. Balasubramanian	Principal Scientist (Agricultural Structures and Processing Engineering)
3.	Dr. J. Dinakara Adiga	Principal Scientist (Horticulture)
4.	Dr. Mohana G.S.	Senior Scientist (Genetics & Cytogentics)
5.	Sri Eradasappa E	Scientist (Plant Breeding)
6.	Dr. (Mrs.) K. Vanitha	Scientist(Agricultural Entomology)
7.	Sri. Rajkumar Arjun Dagadkhair	Scientist (Food Technology)
8	Dr. Babli Mog	Scientist (Plant Physiology)
9.	Dr. (Mrs.) Janani P	Scientist (Spices, Plantation, Medicinal and Aromatic Plants)
10.	Mrs. Prabha Susan Philip	Scientist (Soil Science) till 10th July 2017
11.	Dr. Shamsudheen M.	Scientist (Soil Science)
12	Dr. Preethi P.	Scientist (Fruit Science)
13	Sri Muralidhara B.M.	Scientist (Fruit Science)
14	Dr. Siddanna Savadi	Scientist (Agricultural Biotechnology

Technical		
1	Sri. K. Muralikrishna	Chief Technical Officer
2	Sri. P. Abdulla	Chief Technical Officer
3	Sri. R. Arulmony	Assistant Chief Technical Officer
4	Sri. Prakash G Bhat	Assistant Chief Technical Officer
5	Sri. A. Padmanabha Hebbar	Asst. Chief Technical Officer (Superannuated on 30.4.2016)
6	Sri. N. Manikandan	Sr. Technical Officer
7	Sri. Raghurama Kukude	Sr. Technical Officer
8	Sri. K.V. Ramesh Babu	Sr. Technical Officer
9	Sri. R. Muthuraju	Sr. Technical Officer
10	Sri. K. Seetharama	Technical Officer
11	Sri. M. Bhojappa Gowda	Technical Officer
12	Sri. Vijay Singh	Sr. Technical Assistant
13	Sri. Ravishankar Prasad	Sr. Technical Assistant
14	Sri. K. Babu Poojari	Sr. Technical Assistant
15	Sri. Honnappa Naik P	Sr. Technician
Administration		
1	Sri. V. Raghuraman	Administrative Officer (till 03-08-2017)
2	Shri Jayarama Naik K.M,	Administrative Officer (from 04-08-2017)
3	Smt. M. Rathna Ranjini	Asst. Administrative Officer
4	Sri. O.G. Varghese	Private Secretary
5	Smt. Reshma K	Personal Assistant
6	Ms. Winnie Lobo	Assistant
7	Smt. M. Leela	Assistant
8	Sri. Umashankar	Upper Division Clerk
9	Smt. K. Padminikutty	Upper Division Clerk
10	Sri. K. Balappa Gowda	Gestetner Operator

Promotions (Technical)

- Sri R. Arulmony Asst. Chief Technical Officer has been promoted to the next grade of Chief Technical Officer w.e.f. 01.01.2016.

Retirement

- Sri Krishnappa, Skilled Support Staff retired on superannuation on 30.4.2017
- Sri B. Chennappa Poojary, Skilled Support Staff retired on superannuation on 30.6.2017
- Sri P. Vasantha Kumar, Skilled Support Staff retired on superannuation on 31.10.2017
- Sri H. Veerappa Gowda, Skilled Support Staff retired on superannuation on 31.12.2017

Annexure - VII

BUDGET 2017-18

Budget:

	Allocation (lakhs)	Utilization (lakhs)
GIA capital	1.00	0.00
GIA salary	527.19	527.19
Pension	116.00	111.95
GIA general	324.00	183.56
TSP	6.00	3.60
NEH	2.00	1.68
Total	976.19	827.98

Revenue generation (2017-18)

Particulars	Revenue generation (Rupees in lakhs)
DCR	208.88

Annexure - VIII

Meteorological Data (2017-18)

Month	Temperature (°C)		Humidity (%)		Rainy days	Rainfall (mm)	Mean wind velocity (km/h)	Sunshine hours (h)	Pan evaporation (mm)
	Max	Min	FN	AN					
April	35.2	27.4	77.1	50.1	1	1.0	1.0	247.1	4.7
May	33.4	23.4	85.1	65.7	11	253.7	253.7	158.5	3.1
June	30.9	23.5	97.4	83.0	30	801.6	801.6	54.9	2.0
July	29.6	23.2	90.4	80.1	31	726.5	726.5	55.9	2.2
August	29.5	22.8	90.1	81.4	27	617.4	617.4	55.1	2.4
September	32.2	23.3	90.0	75.9	11	274.2	274.2	135.1	2.7
October	32.1	22.2	83.6	71.6	9	92.7	92.7	142.2	2.5
November	33.0	22.7	80.2	53.6	1	28.2	28.2	195.1	3.1
December	33.6	20.3	74.9	49.1	2	62.3	62.3	224.3	3.1
January	33.7	18.8	75.1	46.1	0	0.0	0.0	225.5	3.6
February	35.3	21.2	72.1	33.9	0	0.0	0.0	240.1	4.3
March	35.2	35.2	72.5	34.4	3	27.3	27.3	223.4	4.6
Total					**126**	**2884.9**	**2884.9**	**1902.3**	**38.2**

Rainfall is monthly total; other parameters are monthly mean values

Annexure - IX

Publications for Sale

Sl. No.	Publication	Price (Rs)
1	Cashew production technology (Revised)	60.00
2	Softwood grafting and nursery management in cashew (Revised)	45.00
3	Annotated bibliography on cashew (1985-1994)	75.00
4	Catalogue of minimum descriptors of cashew	
	Germplasm accessions - I	165.00
	Germplasm accessions - II	125.00
	Germplasm accessions - III	128.00
	Germplasm accessions - IV	--
	Germplasm accessions - V	--
5	Database on cashewnut processing in India (2003)	100.00
6	Directory of cashewnut processing industries in India (2003)	100.00
7	Process catalogue on development of economically viable on-farm cashewnut processing	45.00
8	Annotated bibliography on cashew (1995-2007)	205.00
9	Soil and water management in cashew plantations	30.00
10	Biochemical characterization of released varieties of cashew	85.00
11	Pruning and canopy architecturing in cashew	40.00
12	Development of dual mode dryer for raw cashewnuts	90.00
13	Alternate energy utilization of cashew shell cake for thermal application	90.00
14	Cashew cultivation practices (Pamphlet)	*
15	Status of cashew germplasm collection in India (Booklet)	*
16	Compendium of concluded research projects (1986 -2001)	*
17	Cashew nutritive value (Revised) (Brochure)	*
18	Insect pests of cashew and their management	*

Price indicated above does not include postage.

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

* Free of cost

Ultra high density planting at ICAR-Directorate of Cashew Research, Puttur

भाकृअनुप
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