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2015-16

भाकृअनुप–काजू अनुसंधान निदेशालय
पुत्तूर – 574 202, कर्नाटक

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Puttur - 574 202, Karnataka

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भाकृअनुप–काजू अनुसंधान निदेशालय

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प्रस्तावना

भाकृअनुप – काजू अनुसंधान निदेशालय, पुत्तर (कर्नाटक) का वार्षिक प्रतिवेदन 2015–16 प्रस्तुत करना मेरे लिए खुशी कि बात है। अनुमोदित तकनीकी कार्यक्रम के अनुसार फसल सुधार, फसल प्रबंधन, फसल संरक्षण, कटाई उपरांत प्रौद्योगिकी और प्रौद्योगिकी हस्तांतरण के क्षेत्रों में विभिन्न परियोजनाओं पर कार्य चल रहा है जिसके बारे में प्रगति रिपोर्ट प्रोषित है। यह उल्लेख करना प्रासंगिक है कि दौरान, इस निदेशालय को आईएसओ 9001:2008 से प्रमाणित किया गया है और साथ में संस्थान को 30–03–2016 पर फसल प्रौद्योगिकी के क्षेत्र में ''रेडियल बाह प्रकार की काजू गुठली निकालने की मशीन'' के विकास के लिए एक पेटेंट से भी सम्मानित किया गया है (भारत पेटेंट संख्या 272, 371)।

आनुवंशिक संसाधन प्रबंधन के राष्ट्रीय काजू फील्ड जीन बैंक में लगाए गए 539 में से 499 एकसेशन्स को आईपीजीआरआई वर्षनकर्ता के अनुसार मुल्यांकित किया गया है। जर्मप्लाज्म सूची V 115 काजू जर्मप्लाज्म एकसेशन्स की न्यूतनम डिस्क्रिप्टर्स को प्रकाशित किया गया है। इस प्रकाशन में, 1998–2003 के दौरन NCFGB पर लगाए गए जर्माप्लाज्म एकसेशन्स के लक्षण वर्णन के बाद शामिल किया गया है। एक संकर एच – 126 बोल्ड (11–12 ग्राम) नट और उच्च उपज (6 फसल तुड़ाई में 17.4 किलो/पेड़ का संचयी उपज) के साथ जारी करने के लिए पहचान की गई है। बौना सह सघन संकर, बौना सह अधिक उपज देने वाली संतती तथा बड़े आकार के फल के साथ अधिक उपज देने वाली किस्मों की पहचान और लक्षण वर्णन के विकास में अच्छी प्रगति की गई है। उच्च घनत्व रोपण के माध्यम से प्रति इकाई क्षेत्र में काजू उपज में वृद्धि पाई गई है। 500 पौधों / हेक्टेयर के धनत्व रोपण पर 7.64 टन उपज दर्ज की गई (सात फसल तुड़ाई में) जो सामान्य धनत्व में प्राप्त (200 पेड़/हेक्टेयर) उपज (3.54 टन/हेक्टेयर) की तुलना में 2.16 गुना अधिक है। महाराष्ट्र के रत्नागिरी जिले के काजू बागानों के लिए मिट्टी के सूक्ष्म पोषक तत्वों के नक्शे तैयार किए गए है। पोषक तत्व सूचकांक के मामले में सूक्ष्म पोषक तत्वों के विश्लेषण में दर्शाया गया कि Fe, Mn और Cu उच्च श्रेणी (>2.5) में थे जबकि Zn मध्यम रेंज (1.5–2.5) में था। भुवनेश्वर क्षेत्र के काजू बागानों के लिए बनाए गए पोषक तत्वों के मानदंडों से पता चला कि अधिकांश मिट्टी के नमूने जैविक कार्बन, उपलब्ध नाइट्रोजन, उपलब्ध पोटेशियम में कम थे तथा पीएच अम्लीय से उदासीन (3.72–6.02) था। प्राकृतिक दुश्मन और परागण के दस्तावेज के अलाव ''काजू स्टेम और जड़ छिद्रक'' और ''चाय मच्छर बग'' के जैविक नियंत्रण पर काम भी प्रगति पर हैं। काजू बागान में काले धब्बे टेहनी का डाय बेक / गमोसीस और फूल सुखने / डाय बैक जैसे रोगों कि पहचान की गई है जो बड़ी क्षति पैदा कर रहे है। कटाई उपरांत प्रौटयोगिकी में ''कच्चे काजू और सेब के लिए सौर सूरंग ड्रायर'' ''काजू सेब के लिए यांत्रिक स्लाइसर'' के डिजाईन और विकास में कई संरचनात्मक परिवर्तन तथा उनकी प्रभावकारित में सुधार करने का प्रयास किया गया है। काजू सेब पाउडर की गुणवत्ता विश्लेषण से पता चला है कि सेब फाँके सोडियम क्लोराइड घोल के साथ में एस्कॉर्बिक एसिड को बनाए रखता है और टैनिन को पीबीपी और जिलेटिन की तुलना में ज्यादा कम कर देता है। मूल्य वर्धित उत्पादों में, काजू सेब साइडर और काजू सेब जेली के उत्पादों के मानकीककरण पर कार्य चल रहा है। प्रौद्योगिकी हस्तांतरण के तहत कर्नाटक के दक्षिण कन्नड़ जिले में काजू किसानों की काजू में FLD के प्रभाव और आईसीटी के उपयोग के पैटर्न का अध्ययन किया गया है। डीसीआर प्रौद्योगिकियों को दो किसान बैठक, तीन प्रशिक्षण कार्यक्रमों और पांच प्रदर्शनियों के माध्यम से प्रचारित किया गया है। इसके अलावा, नागालैंड में जागरुकता अभियान और दक्षिण कन्नड़, कर्नाटक और कासरगोड़, केरल में टीएसपी के तहत प्रक्षेत्र प्रदर्शन पर कार्य चल रहा है।

सभी वैज्ञानिकों को अपने अनुसंधान के योगदान के लिए और संपादकीय समिति के सदस्यों को वार्षिक रिपोर्ट 2015–16 के संपादन के लिए मैं धन्यवाद देता हूँ।

स्थान : पुत्तूर, कर्नाटक
दिनांक : 15 जून 2016

(पी. एल. सरोज)

ICAR-DIRECTORATE OF CASHEW RESEARCH

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PREFACE

It is my pleasure to present the Annual Report 2015-16 of ICAR-Directorate of Cashew Research (DCR), Puttur (Karnataka). As per the approved technical programme, projects in the areas of Crop Improvement, Crop Management, Crop Protection, Post-Harvest Technology and Transfer of Technology have been taken up and the progress made during the period under report has been presented. It is pertinent to mention that during 2015-16, DCR has been certified as ISO 9001:2008 institute and awarded with a patent (India patent No. 272371 awarded on 30-03-2016) for development of "Radial arm type cashew kernel extracting machine" in post harvest technology.

In genetic resource management, 499 accessions out of 539 planted in National Cashew Field Gene Bank (NCFGB), have been evaluated as per IPGRI descriptors. A Germplasm Catalogue-V: Minimum Descriptors of Cashew Germplasm Accessions containing 115 accessions has been published. In this catalogue, the germplasm accessions planted during 1998-2003 at NCFGB have been included after characterization. A hybrid H-126 with bold nut (11-12 g nut weight) and high yield (cumulative yield of 17.4 kg/plant in 6 harvests under replicated trial) has been identified for release. A good progress has been made in development of dwarf cum compact hybrids and dwarf cum high yielding progenies, and identification and characterization of large size cum high yielding apple varieties/germplasm lines. Increased cashew yield per unit area through high density planting at a planting density of 500 plants/ha recorded the nut yield (in seven harvests) of 7.64 t/ha which is 2.16 times higher than yield (3.54 t/ha) obtained in normal density (200 plants/ha). Soil micronutrients maps for cashew orchards in Ratnagiri district, Maharastra have been prepared. Analyses of micronutrients in terms of nutrient index indicated that Fe, Mn and Cu were in high range (>2.5) while Zn was in medium range (1.5-2.5). Establishment of nutrient diagnostic norms for cashew orchards in Bhubaneshwar regions indicated that most of the soils were low in organic carbon, available nitrogen and available K, and had acidic to near neutral pH (3.72 to 6.02). The works on biological control of "Cashew Stem and Root Borer" and "Tea Mosquito Bug" are also under progress apart from documentation of natural enemies and pollinators. Diseases such as black spot, die back of shoot/twig/gummosis and inflorescence drying/die back have been identified in cashew plantations causing major damage. Under post harvest technology, in design and development of "Solar tunnel dryer for raw cashew nut and apple" and "Mechanical slicer for cashew apple" several structural changes have been attempted to improve their efficacy. Quality analysis of cashew apple powder revealed that slices treated with NaCl retained the ascorbic acid and reduced the tannin content than PVP and gelatin. In value added products, the input requirements for Cashew apple cider and Cashew apple jelly have been standardized. Under transfer of technology, impact of FLD in cashew and ICT usage pattern of cashew farmers in Dakshina Kannada District of Karnataka have been studied. DCR technologies have been disseminated through two farmers' meets, three training programmes and five exhibitions. Also, awareness campaign in Nagaland and FLDs in Dakshina Kannada, Karnataka and Kasaragod, Kerala have been taken up under TSP.

I thank all the scientists for their research contributions and members of Editorial Committee for editing of the Annual Report 2015-16.

Place : ICAR-DCR, Puttur
Date : 15th June, 2016

(P. L. Saroj)

CONTENTS

INTRODUCTION

Research on cashew was first initiated in the early 1950s. Indian Council of Agricultural Research (ICAR), sanctioned adhoc schemes for Research Centres located at Kottarakkara (Kerala), Ullal (Karnataka), Bapatla (Andhra Pradesh), Daregaon (Assam) and Vengurla (Maharashtra). In 1971, ICAR also sanctioned All India Coordinated Spices and Cashew Improvement Project (AICS and CIP) with its Headquarters located at CPCRI, Kasaragod. The CPCRI Regional Station, Vittal (Karnataka) was given the mandate to carry out research work on cashew while four Centres under Universities (Bapatla, Vridhachalam, Anakkayam and Vengurla) were assigned the research component on cashew under AICS and CIP. During the V and VI plan periods three more Centres (Bhubaneswar, Jhargram and Chintamani) came under the fold of AICS and CIP and with shifting of work of Anakkayam Centre to Madakkathara. The recommendations made by the Quinquennial Review Team (QRT) constituted by ICAR in 1982, working group on Agricultural Research and Education constituted by the Planning Commission for VII Plan Proposals and the Task Force on Horticulture constituted by ICAR resulted in the establishment of National Research Centre for Cashew at Puttur on 18 June, 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 Kemminje (12.45° N latitude, 75.15° E longitude and 90 m above MSL). The main campus has an area of 68 ha with field experiments and Laboratory-cum-Administrative Block. Experimental Station at Shantigodu, which also forms part of the Directorate is 13 km away from the main campus and has an area of 80 ha. At main campus, the laboratories like Horticulture, Soil Science, Plant Breeding, Plant Physiology, Biotechnology, Plant Protection, Post Harvest Management and Audio-Visual Laboratory have been established. Besides, Project Coordination Cell of AICRP on Cashew, PME Cell, AKMU 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 data base, are also available. The library is equipped with automation software and bar coding facility. The library has 1853 books and 1950 back volumes of various journals. The library subscribes 35 National and 20 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.

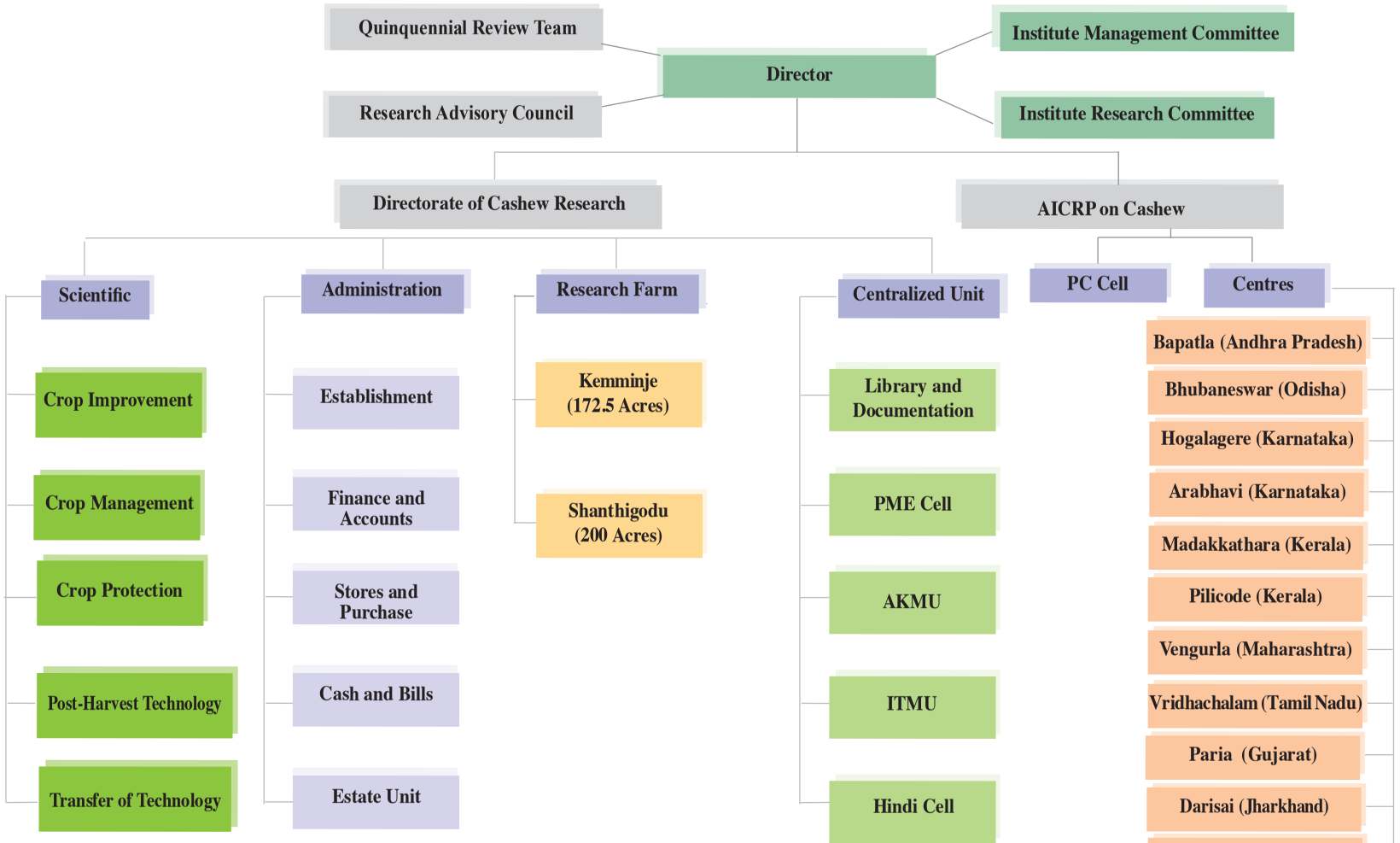
Mission

- 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.

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

Organizational Structure

कार्यकारी सारांश

वर्ष 2015-16 के दौरान निदेशालय को आईएसओ 9001: 2008 का प्रमाण पत्र प्रदान किया गया। इसके अलावा संस्थान को 30-3-2016 पर फसल प्रौद्योगिकी के क्षेत्र में ''रेडियल बाह प्रकार की काजू गुठली निकालने की मशीन' के विकास के लिए एक पेटेंट से भी सम्मानित किया गया है (भारत पेटेंट संख्या 272371)। इस वर्ष, 15 अनुसंधान प्रकाशनों को 3 अंतरराष्ट्रीय और 12 राष्ट्रीय पत्रिकाओं में प्रकाशित किया गया है। चार पुरस्कारों के अलावा, 2 विस्तार बुलेटिनों, 15 पुस्तक अध्याय और 6 लोकप्रिय लेख भी प्रकाशीत किए गए है।

वर्ष 2015-16 के दौरान आईसीएआर - डीसीआर मे कुल चौदह परियोजनाऐं कार्यान्वीत थी, जिनमे सात संस्थागत, एक फ्लैगसिप, चार नेटवर्क / भागीदारी और दो बाह्य वित्त पोषित परयोजनाऐ शामिल है। दो नयी किस्मे, वेंगुर्ला-9 और गोवा-2, अखिल भारतीय समन्वित काजू अनुसंधान परियोजना के क्रमश: वेंगुर्ला और केंद्रीय तटीय कृषि अनुसंधान संस्थान, गोवा न जारी किये, जिनको राष्ट्रीय काजू फील्ड जीन बैंक (एन.सी.एफ.जीबी.) में जोड़ दिया गया है और इसी के साथ कुल संग्रह बढ़कर 541 हो गया है। वर्ष 2004-05 के दौरान लगाए गए पांच जर्मप्लाज्मों का मूल्यांकन करके आई.पी.जी.आर.आई के वर्णनाकर्ता के अनुसार लक्षण वर्णन किया गया है। एक अन्य परिक्षण में मूल्यांकित किऐ गए संकरों में से H-125 में काफी उपज 2.49 किलो/पेड़ और H-126 में 2.37 किलो/पेड़ दर्ज की गई। जबकि 6 संचयी फसल की उपज H-126 मे उच्च (17.40 किलो/पेड़) और H-125 मे थोड़ी कम (16.21 किलो/पेड़) पाई गई। मार्कर सहायता चयन में 15 में से 6 आम और 24 में से 11 बादाम के प्रायमरों को पैतृक जाँच में बहुरूपी पाया गया (उल्लाल-3 और एनआरसी-492)। बौना और सघन संकर विकसित करने के लिए, कई संयोजनों की कोशिश की गई है। उनमे से प्रियंका x एनआरसी-492, प्रियंका x तालीपरंबा-1, तालीपरंबा-1 x प्रियंका और मडकत्तरा-2 x तालीपरंबा-1 की संततियां, पौधे के ऊंचाई के लिए अत्याधिक नकारात्मक टेढ़ी थी। हालांकि प्रियंका x तालीपरंबा-1 की संततियां पौधे के ऊंचाई के लिए अत्याधिक नकारात्मक टेढ़ी थी। हालांकि प्रियांका x तालीपरंबा-1 की संततियों की दोनों, पौधों की ऊंचाई और चंदवा प्रसार अत्यधिक नकारात्मक पाई गयी, जो बौना और सघन पौधा प्राप्त करने की संभावना दर्शाती है। बौना और उच्च उपज के लिए बेक क्रॉस किए गऐ संततियों के मुल्यांकन के तहत, भास्कर बेक क्रॉस संततियो की दूसरे साल की उपज 0.0 से 0.30 किलो/पेड़ थी, जबकी उल्लाल-3 बैक क्रॉस संततियों की उपज 0.0 से 0.24 किलो/पेड़ दर्ज की गई। इसके अलावा भास्कर की 50 और उल्लाल-3 की 49 बैक क्रॉस संततीयों में असामयिक कुसुमितता दिखाई दी। DUS परीक्षण की दिशा-निदेशों को विकसित करने के लिए 42 विमोचित काजू किस्मों के 68 विशेषताओं पर पी.पी.वि.एफ.आर.ए. (PPVFRA) के तहत आँकड़ों को संकलित किया गया है। पंद्रह एकसेशनों में क्षेत्र की स्थिति के तहत मोर्फोमेट्रीक पैरामीटरों का अध्ययन किया गया है। इनके बीच एनआरसी-301 के पौधे की ऊंचाई 3.35 मी और तना परिधि 38.17 सेमी अधिकतम पायी गई। जबकि चांदवा क्षेत्र और पेड़ आयतन के आँकड़े एनआरसी-140 (28.64मी^{2} और 18.23मी^{3}) और एनआरसी-189 (27.9मी^{2} और 17.22मी^{3}) मे कमश: अधिक थे।

विभिन्न पादप घनत्व का उपज पर प्रभाव का मूल्यांकन किया गया है। उच्चतम संचयी नट उत्पादन (7.67 ट्न/हेक्टेयर, सात फसलों में) 500 पेड़/हेक्टेयर घनता वाले क्षेत्र में पाया गया जो 200 पेड़ /हेक्टेयर की उपज (3.54 टन/हेक्टेयर) की तुलना में 2.16 गुना अधिक था। इन किस्मो के बीच भास्कर की संचयी नट उपज सबसे अधिक (6.25 ट्न/हेक्टेयर) तथा उल्लाल-3 (5.94 ट्न/हेक्टेयर) और वी-4 (5.59 ट्न/हेक्टेयर) थोड़ी कम दर्ज की गयी। काजू के उपज पर मूलवृंत और कलम संयोजन के प्रभाव का अकलन किया गया है। विभिन्न स्टिओनीक संयोजनो के बीच बीआरआई-3 का एनआरसी-492 के मूलवृंत पर सर्वाधिक (3.30 किलो/पेड़) काजू उपज दर्ज की गई तथा उल्लाल-3/तलिपरंबा-1 के में थोडी कम (3 किलो/पेड़) उपज दर्ज की गई। वीआरआई-3/एनआरसी-492 का स्टिओनीक संयोजन 4 फसलों के उच्चतम संचयी काजू उपज में 12.08 किलो/पेड़ प्राप्त हुआ।

महाराष्ट्र के रत्नागिरी जिले के मिट्टी के सुक्ष्म पोषक तत्वो के नक्शे तैयार किए गए है। रत्नगिरी जिले के काजू बागानों की मिट्टी में उपलब्ध सूक्ष्म पोषक तत्वों के पोषक तत्व सूचकांक में यह पाया गया की काजू बागानों (72.5%) की मिट्टी में DTPA-Fe, DTPA-Mn और DTPA-CU की मात्रा अति अधिक है जबकी ज्यादातर मृदाओं मिट्टीयों में DTPA-Zn की मात्रा मध्यम है। विभिन्न क्षेत्रों के काजू बगीचे के रायझोस्पियर मिट्टी के सूक्ष्म जीवाणु संख्या गणन ने संकेत दिया है कि, बैक्टीरिया, एक्टीनोमायसेट्स, कवक, फॉसफौरस को घुलानेवाले और फ्लोरोसेंट स्यूडोमोनास जैसे सूक्ष्मजिवों का प्रमाण दक्षिण कन्नड जिले (कर्नाटक) में भुवनेश्वर (ओडिसा) और बापटला (आंध्र प्रदेश) से 1.77 से 5.22 गुना अधिक है, जबकी मुक्त नाइट्रोजन निर्धारकों की तादात दक्षिण कन्नड़ जिले में अति अधिक (14.0-17.8 गुना) दर्ज की गई। इसी तरह डिहाइड्रोजनेज और एसिड़ फारफेरेज एंजाइमों की गतिविधियाँ, जो सूक्ष्म जिवों की गतिविधियों निरूपित करती है, वह भी दक्षिण कन्नड़ जिले के काजू बागानों की मिट्टी में अधिक पाई गई।

काजू के पोषक तत्व मानदंडों की स्थापना करने के लिए, भुवनेश्वर क्षेत्र के 70 काजू बागानों के मिट्टी के नमूने भौतिक-रासायनिक विशेषताओं के लिए विश्लेषीत किए गए। प्रतिक्रिया में ज्यादातर मिट्टियाँ आम्लीय से (pH=3.72 से 6.02) थे, जैविक कार्बन की मात्रा 58 बागों में कम और 12 बागों में मध्यम स्वरूप की थी। उपलब्ध नाइट्रोजन 66 बागों में कम और 4 बागो में मध्यम पाया गया। उपलब्ध पोटेशियम 41 बागों में कम जबकी 25 बागों में मध्यम पाया गया। पुत्तूर (कर्नाटक), वेंगुर्ले (महाराष्ट्र) और भुवनेश्वर (ओडिशा) क्षेत्रों की मिट्टी की उर्वरता सूचकांक से यह पता चला है कि, जैविक कार्बन की मात्रा पुत्तूर और वेंगुर्ला में मध्यम स्वरूप का है। उपलब्ध पोटेशियम पुत्तूर और वेंगुर्ला में मध्यम और भूवनेश्वर में कम पाया गया।

काजू के पत्तोंका कृत्रिम परिवेशयि परिस्थिती में नमक तनाव अनुक्रिया का मुल्यांकन किया गया है। विभिन्न किस्मों के बीच 200mM नमक सांद्रन में कुल क्लोरोफिल मात्रा भास्कर में सबसे अधिक (2.30 मीग्रॉ/ग्रॉ) थी जबकी वेंगुर्ला-4 मे कम (1.29 मीग्रॉ/ग्रॉ) पायी गई। भास्कर किस्म ने अपेक्षाकृत क्लोरोफिल स्थिरता सूचकांक भी अधिक (81.8%) बनाए रखा जबकी वेंगुर्ला-4 किस्म में यह क्रम (45.79%) पाया गया।

फसल सुरक्षा के क्षेत्र में, काजू तना और जड़ छिद्रक के प्राकृतिक भक्षी के सर्वेक्षण से यह पता चला है कि, केवल मेटारायझीयम ऑनिसोप्ली ही सीएसआरबी के खादयात्र पर प्रकोप की गंभीर अवस्था में पाई गई। एन्टेमोपॅथोजनिक निमाटोड़ की उपस्थिती जांचने के लिए कर्नाटक काजू विकास निगम के बागानों का व्यापक मिट्टी परिक्षण करने पर यह पता चला है की 30.81% मिट्टी नमूनों में रॅब्डीटी समूह उपस्थित है, हालाकी स्टेनरनिमॅटीड और डेटरोरॅब्डीटीड समुह का अस्तित्व नही था। काजू की छाल के क्रीटमल सामग्री में मौजूद वाष्पशील का उपयोग करके सीएसआरबी को पकड़ने के लिए, कीटमल का जीसी-एमएस विश्लेषण किया गया। चार मुख्य वाष्पशील घटकों की पहचान की गई, जिसमें किटोन, अल्डीहाईड्स, जेरानिओल और ब्युटरेटस पाए गए। इन घट्कों के विभिन्न मिश्रणों का सीएसआरबी को आकर्षित करने के लिए विपचिपा फलक जाल तैयार कर क्षेत्र परिक्षण किया गया लेकिन काजू तना और जड़ छिद्रक (सीएसआरबी) को आकर्षित नहीं कर सके। टिएमबी के जैविक नियंत्रण के तहत, प्रयोगशाला में पाले गए वर्जान मादा कीड़े (एच एन्टोनी) को डेल्टा चिपचिपे जाल में रखकर सबसे अधिक (52 नर/दिवस/जाल) नर कीडों को आकर्षित कर पाए। आकर्षण का प्रतिदिन लय सुबह 8.30 से 11.00 बजे तक और दोपेहर 3.30 से 5.00 बजे तक पाया गया। जादातर नर (12-35 नर/जाल) सुबह के दौरान पाए गए, जबकी तुलना में शाम के दौरान कम (3-7 नर/जाल) पाए गए। रेडूविड परभक्षी के जीवविज्ञान के तहत, सायकेनस गल्बेनस, जो काजू मे टीएमबी का भक्षण करता है, उसका अध्ययन किया गया है। प्रयोगशाला परिस्थितियों में यह जीव 68.92 ± 1.27 दिन जीता है जिसमें थोड़ा पक्षपाती नर लिंग अनूपान (10:0:93) चक्र पाया गया। इसकी परभक्षण क्षमता 4.60 टीएमबी वयस्क/निम्फस प्रति दिन है जो दुसरे रेडूबिड्स की तुलना में अधिक है। इस प्रजाति में अन्य रेडूबिड्स के विपरीत नरभक्षण होता नही है, जो बड़े पैगाने पर गुणन के लिए वांछनीय विशेषता है।

प्रभावी आईपीएम रणनीति विकसित करने के लिए पिछले कुछ वर्षो में संधीपाद पशुवर्ग की जैव विविधता दर्ज की जा रही है। वर्ष 2015-16 के दौरान टीएमबी से हुए नुकसान पिछले

साल की तुलना में मध्यम स्वरूप का थी, लेकिन इसी वर्ष कीटों और एपल और नट छिद्रक (40%) का प्रकोप विकास के दौरान (20%) अधिक था। इसके अतिरिक्त, कली कीड़े और फूल खानेवाली सूँडी/इल्ली को जनवरी मे देखा गया (2-10% पुष्पक्रम) लेकिन बाद में परजीवी भक्षक की वजह से यह समस्या कम पाई गयी। काजू की 11 किस्मों में पत्ता खाने वाले कीट एवं निष्पत्रण कीट की स्थिती का आकलन किया गया, जो की कम से मध्यम स्वरूप का पाया गया। टसर रेशम कीड़े के अंडों पर पहली बार एक परजीवी भक्षी दर्ज किया गया यह औथेराका मिलीट्टा है, जो काजू का निष्पत्रण करनेवाला किट है। काजू रोपन के सामान्य खर-पतवार का भी प्रलेखन किया गया है।

काजू कीटों के प्राकृतिक शत्रुओं के प्रलेख ने यह दर्शाया है की, सात परिवारों और दस उप परिवारों के कुल सोलह (16) प्रजातीयाँ दक्षिण कन्नड़ के पुत्तूर और शांतीगोडू के काजू बागानों में पायी गयी है। इन परिवारों के बीच, है मनोपोटेरा और मैंटीडी प्रमुख थे, जो पांच प्रजातियों का प्रतिनिधित्व करती है, जबकी ट्रीडोप्टेरीजीडी, लिटूरगुसायडी, टाराकोडीडी, इंपुसायडी और टेक्सोडेरायडी केवल एक प्रजाती का प्रतिनिधित्व करती है। ओथेसी और वयस्क मैटीड्स का मौसम, उपयुक्त स्थान और आकार भी दर्ज किया गया है। काजू के परागण कीटों और उनके खोजने के तरीका को भी प्रलिखीत किया गया है। मधुमक्खियों के बीच स्युडापीस, ब्राउनसापीस, ऐपीस सेरेना इंडिका, सेलेडोनीया, सेरेटीना प्रजाचीयोंको काजू फलों पर परागण और मधुरस को पाने के लिए लगातार आते देखा गया है। ऐपीस सेरेना इंडिका और ए फ्लोरीया की तुलना में स्युडापीस, ब्राउनसापीस, सेलेडोनाया और सेरेटीना प्रजातियों के कीटों में पराग की मात्रा अधिक पाई गयी है। मधुमक्खियों की फोरेजींग गतिविधि धूप के आधार पर 9.00 - 9.30 पर शुरु होती देकी गई है, लेकिन शिखर गतिविधि सुबह 10.00 से दोपहर 12.00 बजे अवलोकित की गई है। आम मधुमक्खियों के घोसलों की जगहों को भी स्थित किया गया है।

काजू के रोगों पर अवलोकन करने पर यह पता कि, फसल के विभिन्न विकास अवधियों के दौरान सात रोग अर्थात, सुख जाना / सड़ाध, पत्ती पर काले दाग, सूटी मोल्ड, लाल जंग, टहनी सड़ांध / गमोसीस, फूल सुखना / फूल डाय बेक और नट सड़ांध दर्ज किए गऐ है। इन रोगोंमें से पत्तों पर काले दाग, टहनी का डाय बैक / टहनी सड़ांध / गमोसीस और फूलों का सूखना इत्यादि रोग ज्यादातर किस्मो में गंभीर पाये गए हैं, जबकि नट सड़ाध रोग विशिष्ट संकरों पर ही पाये गया है।

कटाई उपरांत प्रौद्योगिकी में, काजू नट और एपल को सुखाने का लिए तैयार किए गए सौर सुरंग ड्रायर के डिजाइन के विकास में कुछ संरचनात्मक बदलाव किए गए है, अर्थात्, हवा निकास, पार्श्व हवा के झरोखे और पार्श्वसतह को शामिल किया गया है जिससे ड्रायर की कार्यक्षमता में सुधार आएगा। बाष्प दषाव अंतर बढ़ाकर फाँकों से नमी प्रसार बढ़ाने के लिए सेंसर आधारित पर्यावरण नियंत्रण प्रणाली को डिजाइन किया गया है। काजू सेब पावडर की गुणवता विश्लेषण से यह पाया गया है की फाँकें नमक के सलूशन में कुछ देर रखने से एस्कॉर्बिक एसिड़ की मात्रा को बनाए रखकर टैनिन को भी जिलेटीन और पीवीपी की तुलना में अधिक मात्रा में कम कर देता है। काजू सेब पावडर से कुकीज तयार किए जा सकते है। काजू के गुणवत्ता मानको के विकास से नमी का मात्रा, आइटर्न और नट संख्या को काजू की गुणवत्ता को प्रभावित करने वाले महत्वपूर्ण पैरामीटर माना जाता है। काजू सेब के यांत्रिक स्लाइसर के विकास और डिझाइन के तहत, विभिन्न किस्मो के काजू सेब को अलग अलग 6 विकास चरणों से, अर्थात मूंगफली अवस्था से पूरी तरह से पके अवस्था तक तोड़कर सेब की दृडता को जैव-उपज बिंदु के अनुसार गठन पार्श्वचित्र विश्लेषक की मदत से निर्धारित किया गया। खाद्य प्रसंस्करण में इस्तेमाल किए जाने वाले चक्रीय तश्तरी और ऊर्ध्वाधिर धूमने वाले दाँतेदार ब्लेड की तुलना करके एक बहु तश्तरी काजू सेब स्लाइसर विकासित कर मूल्यांकन किया गया। बहु तरतरी काजू सेब स्लाइसर की कमियों को पूरा करने के लिए एक वैचारिक और वैकल्पिक डिजाइन भी तैयार किया गया है।

काजू सेब साईडर और काजू सेब जेली जैसे मूल्य वर्धित उत्पादों को विकासित करने का प्रयास किया गया है। काजू सेब साइडर के प्रभावी किण्वन के लिए 1.5 - 2.0 ग्र/लि. सक्रिय सूखी खमीर का इनाकुलम उपयुक्त है। इसी मात्रा के साथ साइडर का रंग और स्वाद भी बेहतर पाया गया है। उत्पाद के संवेदी मुल्यांकन से यह पता चला कि, विभिन्न किस्मों के मिश्रित रस से तैयार की गयी सायडर अधिक बेहतर है। काजू सेब साइडर में 3.5 - 5.5% v/v अल्कोहल की मात्रा थी, जबकि प्रारम्भ में काजू सेब रस में 8.5 से 10.5% शक्कर थी जो किन्वन के बाद 0.5 से 2% रह गई। काजू सेब जेली तैयार करने के लिए 1.0% से ज्यादा खाद्य पेक्टीन की आवश्यकता है।

पौद्योगिकी हस्तांतरण में काजू के सीमावर्ती प्रदशनों से यह दर्शाया गया की, दक्षिण कर्नाटक में लोकप्रिय 10 किस्मों / संकरों के बीच भास्कर सबसे अधिक उपज देने वाली किस्म है। भास्कर किस्म में प्रौद्योगिकी अंतर सबसे कम देखा गया, जहां यह अंतर वेंगुर्ला–7 (15.89 किलो/पेड) और वेंगुर्ला–4 (14.77 किलो/पेड़) पाया गया, जबकी उल्लाल–3 किस्म (1.16 किलो/पेड़) में विस्तार का अंतर सबसे अधिक था। दक्षिण कर्नाटक में उगाई सभी प्रमुख काजू किस्मों की पैदावार के संबंध में बहुत ही उच्च प्रौद्योगिकी अंतर अवलोकित किया गया। प्रदर्शन के किसानों में प्रौद्योगिकी के उपयोग का दर्जा वित्तीय सहायता अवधि के बाद गिरता पाया गया और इन किसानों के बीच प्रमुख काजू उत्पादन तकनीक को अपनाने का सुचकांक चेक किसानों की तुलना में अधिक दर्ज किया गया। कर्नाटक के काजू किसानों की आईसीटी उपयोग के पैटर्न का विश्लेशण करने के लिए एक अध्ययन आयोजित किया गया था, साथ ही आईसीटी उपयोग का संबंद्ध और निर्धारकों की पहचान करने का प्रयास भी किया जा रहा है।

उत्तरी केरल में काजू खाती के सामाजिक – आर्थिक प्रभाव के विश्लेशण में, दस प्रमुख सामाजिक और आर्थिक प्रभाव संकेतकों का अध्ययन उत्तरदाताओं के बीच काजू खेती के सामाजिक – आर्थिक प्रभावों को जानने के लिए किया गया। काजू किसानों का सामाजिक और आर्थिक लाभ के आधार पर उपर्जित वर्गीकरण यह दर्शाता है की, लगभग आधे (47%) काजू किसान उच्च सामाजिक प्रभाग वर्ग के है, जबकि आर्थिक प्रभाव बहुसंख्यों (47%) के मामले में कम लाभ श्रेणी के पाए गए। कुल मिलाकर आधे (46%) किसान सामाजिक – आर्थिक प्रभाव के निम्न स्तर पर दर्ज किए गए। आईसीएआर के कृषि पोर्टल पर प्रस्तुत करने के लिए, डाटाबेस के तीन सेट जिनमें पहला दक्षिण कन्नड़ जिले के 5 तालुकों के काजू किसानोंका प्रतिनिधित्व करने वाला डेटाबेस, दुसरा केरल के कन्नूर और कासरगोड जिले के काजू किसानों का प्रतिनिधित्व करने वाला और तीसरा दक्षिण कन्नड़ जिले के सीमावर्ती प्रदर्शन किसानों के पांच तालुकों का प्रतिनिधित्व करने वाले आँकड़ों को संकलित कर आईसीआर के कृषि पोरट्ल को सुपूर्द किया गया है।

कई किसान बैठकों के माध्यम से आशाजनक डीसीआर प्रौद्योकियों को प्रचारित किया गया। वर्ष 2015–16 के दौरान दो किसान बैठकों का आयोजन किया था, जिसमें डीसीआर स्थापना दिवस सहित काजू किसानों की बैठक – 2015 और काजू दिवस सह आदिवासी किसानों से चर्चा का आयोजन किया था, जिसमें 350 से अधिक किसानों ने सक्रिय रूप से भाग लिया और 3 अभिनव किसानों को सम्मानित कर उनके नवाचारों को प्रलिखित किया गया। तीन प्रशिक्षण कार्यक्रमों का भी आयोजन किया गया था, जिसमें एक ''काजू उत्पादन प्रौद्योगिकी के क्षेत्र में अभिवृद्धि'' और दो ''काजू में एकीकृत कीट प्रबंधन'' शामिल थे, जिसका करीब 100 प्रतिभागियों को लाभ मिला । विभिन्न स्थानों पर काजू उत्पादन तकनीक और विस्तार पर पांच डीसीआर प्रदर्शनियों की व्यवस्था की गई थी । कर्नाटक के दक्षिण कन्नड़ और केरल के कासरगोड़ जिले के आदिवासी किसानों के खेतों में 26 नए सीमावर्ती प्रदर्शन प्लाट टीएसपी कार्यक्रम के तहत स्थापित किए गए है। टीएसपी कार्यक्रम के तहत 26 काजू किसानों को रु. 2,93,800/– सहयोग की राशि प्रथम वर्ष किस्त के रूप में और 25 आधिवासी किसानों को रु.57,190/– की सहयोग की राशि दूसरे वर्ष के किस्त के रूप में वितरित की गई। डीसीसीडी योजना के तहत विभिन्न तालुकों में स्थापित की किसान भागीगारी काजू प्रदर्शन प्लाटों में भी 108 क्षेत्र यात्राओं के माध्यम से निगरानी की गई। विभिन्न काजू किसमों पर छंटाई का प्रभाव और अति उच्च घनत्व रोपन में किस्मों का प्रदर्शन पर नियमित निगरानी की गई।

नवीनतम काजू जानकारी और तकनीकी ज्ञान के लिए एक फेसबुक पेज का निर्मण कर ई–विस्तार को और भी मजबूत बनाया गया है। पेज को नियमित रूप से संपादित, अदयतन और प्रासंगीक सामग्री के साथ अपलोड किया जाता है। किसानों द्वारा अवसर पूछे जाने वाले प्रश्नों के लिए एक तैयार गणन–तालिका (Ready reckoner) और 1 से 5 तक के जर्मप्लाझम कैटलागों को डिजिटाईज करके www.cashewres.in पर ऑनलाईन उपलब्ध कराया गया है। इस अवधि के दौरान डीसीआर की वेबसाइट www.cashewres.in से जुड़ा एक जूमला डाटाबेस (सामग्री प्रबंधन प्रणाली) का भी नियमित रूप से अद्यतन किया गया है।

EXECUTIVE SUMMARY

During 2015-16, the institute has been awarded with ISO 9001:2008 and has come out with 14 research publications; 2 in international and 12 in national journals, 2 extension bulletins, 16 book chapters, and 9 popular articles apart from bagging 4 awards. Besides, one patent (No. 272371/30-03-2016) has been awarded in post harvest technology for development of "Radial arm type cashew kernel extracting machine".

During 2015-16, a total of fourteen projects including seven institutional, one flagship, four ICAR network/consortia and two externally funded were in operation at ICAR-Directorate of Cashew Research, Puttur, Karnataka. Two varieties, Vengurla-9 and Goa-2 released from AICRP-Vengurla centre and Central Coastal Agricultural Research Institute, Goa, respectively have been added to the National Cashew Field Gene Bank (NCFGB) raising the total collection to 541. Five germplasm collections planted during 2004-05 were evaluated and characterized as per IPGRI descriptors. Among the hybrids evaluated in replicated trial, H-125 recorded significantly highest yield (2.49 kg/plant) followed by H-126 (2.37 kg/plant). However, the cumulative yield of 6 harvests was high in H-126 (17.40 kg/plant) followed by H-125 (16.21 kg/plant). In the marker assisted selection, 6 mango and 11 almond primers out of 15 and 24 respectively were found polymorphic in parental screening (Ullal-3 and NRC-492). In order to develop dwarf and compact hybrids, several cross combinations have been tried. Among them, the progenies of Priyanka x NRC-492, Priyanka x Taliparamba-1, Taliparamba-1 x Priyanka and Madakkathara-2 x Taliparamba-1 progenies were highly negatively skewed for plant height under descriptive statistic analysis indicating a good chance of getting real dwarf plants. However, both plant height and canopy spread (NS) values were highly negatively skewed in Priyanka x Taliparamba-1 indicating the increased possibility of recovering dwarf and compact plants. Under evaluation of the back cross progenies for dwarf and high yield, Bhaskara back cross progenies in the second year yielded 0.0 to 0.30 kg/plant while it was 0.0 to 0.24 kg in Ullal-3 back cross progenies. Also, 50 Bhaskara back cross progenies and 49 Ullal-3 back cross progenies have shown precocious flowering. In order to develop DUS test guidelines, the data on 68 characteristics of 42 released cashew varieties have been compiled under PPV FRA project. Morphometric parameters were studied in fifteen accessions under field conditions. Among the cashew apple accessions, NRC-301 recorded the maximum plant height (3.35 m) and trunk girth (38.17 cm) while canopy area and tree volume were more in NRC-140 (28.64 m^2 and 18.23 m^3) and NRC-189 (27.59 m^2 and 17.22 m^3) respectively. In case of yield, NRC-175 recorded the highest apple yield (37.89 kg/tree) and nut yield (2.84 kg/tree).

Influence of different plant densities on yield was evaluated. The highest cumulative nut yield (7.67 t/ha in seven harvests) was achieved in the density of 500 plants/ha which was 2.16 times more than the yield (3.54 t/ha) obtained in 200 plants/ha. Among the varieties, Bhaskara recorded the highest cumulative nut yield (6.25 t/ha), closely followed by Ullal-3 (5.94 t/ha) and V-4 (5.59 t/ha). Effect of root stock/scion combination on nut yield was assessed. Among different stionic combinations, VRI-3 grafted on NRC-492 recorded the highest nut yield (3.30 kg/plant) closely followed by the stionic combination of Ullal-3/Taliparamba-1 (3 kg/plant). The stionic combination of VRI-3/NRC-492 was associated with highest cumulative nut yield (12.08 kg/plant) over 4 harvests. Soil micronutrient maps of Ratnagiri District, Maharashtra have been

prepared. Available micronutrient status of cashew orchard soils of Ratnagiri district measured in terms of nutrient index (NI) indicated that cashew orchard soils of the district were high (>2.5) in DTPA-Fe, DTPA-Mn and DTPA-Cu contents while majority of soils were medium (1.5-2.5) in DTPA-Zn content. Enumeration of microbial population in the rhizosphere soil of cashew orchards from different regions indicated that populations of microbes such as bacteria, actinomycetes, fungi, P-solubilizers and Fluorescent Pseudomonas in Dakshina Kannada district (Karnataka) were 1.77-5.22 fold higher than in Bhubaneswar (Odisha) and Bapatla (Andhra Pradesh) regions while very high population of free N-fixers (14.0-17.8 fold) was recorded in Dakshina Kannada district than the other two places. Similarly, activities of dehydrogenase and acid phosphatase enzymes, which denote microbial activities, were high in cashew orchards of Dakshina Kannada district.

In view of establishing nutrient diagnostic norms in cashew, 70 cashew orchard soil samples of Bhubaneswar region were analysed for physico-chemical characteristics. Soils were mostly acidic to near neutral (pH=3.72 to 6.02) in reaction, organic carbon content was low in 58 orchards and medium in 12 orchards, available N content was low in 66 orchards and medium in 4 orchards, and available K content was low in 41 orchards, medium in 25 orchards and low in 4 orchards. Soil fertility index of cashew orchards representing Puttur (Karnataka), Vengurla (Maharasta) and Bhubaneswar (Odisha) regions revealed that the organic carbon content was high in Puttur and Vengurla and low in Bhubaneswar, available nitrogen was low in both Puttur and Bhubaneswar and medium in Vengurla, and available potassium was medium in Puttur and Vengurla regions, and low in Bhubaneswar region.

In vitro response of cashew leaves to salt stress was assessed. Among different varieties, the total chlorophyll content was high in Bhaskara (2.30 mg /g fresh wt) and low in Vengurla-4 (1.29 mg/g fresh wt) at 200 mM salt concentration. Also, Bhaskara maintained relatively higher chlorophyll stability index (81.8%) while it was low in Vengurla-4 (45.79 %).

Under crop protection, surveys for natural enemies of cashew stem and root borer (CSRB) infesting cashew indicated that only *Metarhizium anisopliae* occurred on the grubs of CSRB in trees having severe stages of infestation. Extensive soil sampling from Karnataka Cashew Development Corporation plantations for presence of entomopathogenic nematodes (EPN) revealed the occurrence of Rhabditid group in 30.81% of soil samples analysed, whereas, Steinernematid and Heterorhabditid groups were not encountered. In order to trap the CSRB using volatiles present in the frass materials of cashew bark, the frass were subjected to GC-MS analysis. Four main volatile components *viz.,* ketones, aldehydes, geraniol and butyrates were identified. Various blends of these components were field-tested for attraction to CSRB using sticky vane traps, but could not induce attraction of CSRB. Under biological control of Tea Mosquito Bug, laboratory reared virgin female bugs of *Helopeltis antonii* when used as bait in DELTA sticky traps attracted the highest numbers of males (52/day/trap). The diurnal rhythm of attraction was during 8.30 am to 11.00 am and during 3.30 pm to 5.00 pm. Higher number of males were attracted during mornings (12-35 males /trap) than in the evenings (3-7 males/trap). Biology of the reduviid predator, *Sycanus galbanus* which predate on TMB in cashew was studied. It had a life cycle of 68.92 ± 1.27 days and slightly male biased sex ratio (1.0:0.93) under laboratory conditions. Its predatory potential was 4.60 TMB adults or nymphs per day, which was significantly higher than other reduviids. This species had no cannibalism unlike other reduviids, which is a desirable attribute for mass multiplication.

Biodiversity of arthropod fauna is being recorded over the years for developing effective IPM strategies. In 2015-16, TMB incidence was

low to medium compared to previous years, but incidences of thrips (20%) as well as apple and nut borer (40%) were high during nut development. Besides, bud worms and flower eating caterpillars were noticed during January (2-10% of inflorescences), but later the incidence was brought down by the action of parasitoids. Status of a common defoliating pest of cashew *i.e.,* leaf miner on 11 varieties was assessed and it ranged from low to medium. An eupelmid parasitoid was recorded for the first time on eggs of tasar silk worm, *Antheraea mylitta* which is a defoliating pest of cashew. Pests of common weeds of cashew plantations were also documented.

Documentation of natural enemies of cashew pests indicated that a total of 16 species of praying mantids, belonging to seven families and ten sub families were recorded to occur on cashew plantations of Puttur and Shantigodu regions of Dakshina Kannada. Among the families, Hymenopodidae and Mantidae were the dominant, represented by five species each while Iridopterygidae, Liturgusidae, Tarachodidae, Empusidae and Toxoderidae were represented by single species only. The seasonality, niche and size of oothecae as well as adult mantids were also recorded. The pollinators of cashew and their foraging behavior were documented. Among the bees, *Pseudapis* sp., *Braunsapis* sp., *Apis cerana indica, Ceratina* spp., *Seledonia* sp. and *Lasioglossum* sp. were recorded as frequent visitors of cashew flowers for pollen and nectar. *Pseudapis* sp, *Braunsapis* sp. *Seledonia* sp. and *Ceratina* spp. had higher pollen load per insect compared to *Apis cerana indica* and *A. florea.* Foraging activity of bees started from 9.00 - 9.30 am depending on the sunshine, but peak activity was observed between 10.00 am and 12.00 Noon. Nesting sites of common bees were also located.

Periodical observations on diseases of cashew indicated that seven disease *viz.,* wilt or rot, black leaf spot, sooty mold, red rust, die back of shoot/twig rot/gummosis, inflorescence drying/die back and nut rot were recorded in different growth period of the crop. Among the diseases, black leaf spot, die back of shoot/twig rot/gummosis and inflorescence drying/die back were severe on across the cultivars/lines while nut rot disease was observed only on certain line/hybrid.

Under post harvest technology, in design development of solar tunnel dryer for raw cashewnut and apple, structural changes *viz.,* air exhaust, lateral air vents and black ground surface have been incorporated to improve the efficiency of dryer. Sensor based environment control assembly has been designed to generate vapour pressure difference to enhance moisture diffusion from slices. Quality analysis of cashew apple powder (CAP) revealed that slices treated with NaCl retained more ascorbic acid and reduced higher tannin than PVP and Gelatin. Cookies could be prepared out of CAP. In developing quality standards for raw cashewnuts, moisture content, outturn and nut count were considered as important parameters influencing the quality of cashew. As an initial step to develop moisture meter, a private company was identified and a MoU has been prepared to design the meter. Under design and development of mechanical slicer for cashew apples, firmness of cashew apples of different varieties harvested at six different growth phase from peanut stage to fully ripened stage have been determined using texture profile analyzer in terms of bio-yield point. Comparing the rotational disc type blades and vertical reciprocating serrated blade employed in food processing, a multi disc cashew apple slicer was developed and its performance was evaluated. A conceptual alternative design was also prepared to overcome the problems encountered in the multi disc slicer.

Development of value added products such as cashew apple cider and cashew apple jelly have been attempted. In case of cashew apple cider, addition of inoculum of active dry yeast (1.5 -2.0 g/L) was suitable for effective fermentation, and to develop colour, flavour and taste of the product. Sensory evaluation of the product indicated that the cider prepared from mixed juices was found to be

superior. The prepared cider was having 3.5-5.5% v/v alcohol and 8.5 to 10.5% sugar. For preparation of cashew apple jelly, addition of more than 1.0% edible pectin was essential.

Under transfer of technology, impact analysis of Frontline Demonstrations (FLD) in cashew in South Karnataka indicated that variety Bhaskara recorded highest productivity among 10 popular varieties/hybrids. Technology gap was identified as lowest in case of variety 'Bhaskara' (4.93 kg/tree) where as it was very high in case of varieties 'Vengurla-7' (15.89 kg/tree) and 'Vengurla-4' (14.77 kg/tree), while extension gap was high in variety 'Ullal-3' (1.16 kg/tree). Very high technology gap was observed with respect to yields of all major cashew varieties grown in South Karnataka. Technology utilisation status of FLD farmers were found to decline after period of financial support and the Adoption Index of major cashew production technologies among these farmers were recorded as higher than check farmers. A study was conducted to analyse the ICT usage patterns of cashew farmers of south Karnataka while also attempting to identify the correlates and determinants of ICT usage.

Ten major social and economic impact indicators were studied to arrive at the socio-economic impact of cashew farming in North Kerala. Classification of cashew farmers based on the social and economic benefits accrued shows that nearly half of the cashew farmers (47%) belong to high social impact category while in case of economic impact majority (47%) belonged to low benefits category. Overall, nearly half of the cashew farmers (46%) recorded low levels of socio-economic impact. Three sets of databases; database of cashew farmers representing 5 taluks of Dakshina Kannada district, cashew farmers representing Kannur and Kasaragode districts of Kerala and FLD farmers representing 5 taluks of Dakshina Kannada district were compiled and maintained for submission to Krishi Portal of ICAR, New Delhi.

Promising DCR technologies were disseminated to farmers through several farmers' meets. During 2015-16, two farmers meet such as 'DCR Foundation Day cum Cashew Farmers Meeting-2015' and 'Cashew day cum Interaction meeting with tribal farmers' were organized, in which more than 350 farmers actively participated and 3 innovative farmers were felicitated and the innovations were documented. Three training programmes, one on 'Advances in Cashew Production Technology' and two on 'Integrated Pest Management in cashew' were organized, which benefitted around 100 participants. Five DCR exhibitions on cashew production technology and extension at various venues were arranged. Under TSP program, 26 new FLD plots were established in tribal farmer fields of Dakshina Kannada, Karnataka and Kasaragode district, Kerala. Financial support amounting Rs. 2,93,800/- to 26 tribal farmers as first year installment and Rs. 57,190/- as second year installment to 25 tribal farmers were disbursed under TSP programme. Farmer participatory Cashew demonstration plots in different taluks of the district established under DCCD Scheme were also monitored through 108 field visits during the period. Participatory Technology Development and Demonstration on ultra high density (3x3 m) and high density (5x5 m) plantings of cashew was carried out in selected farmer plots. Effect of pruning on different cashew varieties and varietal performance under ultra high density planting were monitored regularly.

E-extension was strengthened in cashew by developing a Facebook page for dissemination of latest cashew information and technical knowledge. The page has been regularly edited, updated and uploaded with relevant content. Ready reckoner on frequently asked questions by farmers and Cashew germplasm catalogues from I to V were digitized and made available online at www.cashew.res.in. A Joomla database (Content Management System) supporting www.cashew.res.in website of DCR, Puttur was fine tuned and updated regularly during the period.

RESEARCH ACHIEVEMENTS

1. CROP IMPROVEMENT

1.1 Genetic Resources of Cashew

1.1.1 Germplasm survey and collection

During the fruiting season the locally available cashew gardens and solitary trees were observed for their uniqueness. However, no such material could be located or collected. Two released varieties *viz.,* V-9 and Goa-1 have been collected and added to National Cashew Field Gene Bank (NCFGB) collections.

1.1.2 Germplasm conservation

Planting materials for the 16 evaluated accessions have been prepared and they are being maintained in the nursery for planting in main field. Also planting materials for gap filling in the existing germplasm conservation block have been prepared and gap filling was taken up.

1.1.3 Germplasm evaluation

Five germplasm collections planted during 2004-05 were evaluated and characterized as per IPGRI descriptors (Table 1.1). Among them all five were having upright growth habit with compact canopy and extensive branching. All were having mid season flowering and fruiting behaviour with short to medium fruiting duration. Mostly they had obovate to oval leaf shape and yellow red colour young leaves. Majority had conical to obovate shaped, big size cashew apple. The nut attachment to cashew apple was intermediate type with medium nut to apple ratio. Most of them were medium to bold nut types. About 80% of them had intermediate to low shell thickness with loose testa attachment having high shelling percentage (<28%) and medium kernel weight. More than 60% of the collections were low yielders and had less than 9 kg/tree (cumulative yield in 6 harvests).

Table 1.1: Important features of cashew germplasm accessions evaluated in 2015.

Data Field	Descriptor		Descriptor State	No. of Accessions
7	Tree habit	3	Upright and compact	0
		5	Upright and open	5
		7	Spreading	0
9	Leaf shape	1	Oblong	0
		2	Obovate (Club-shaped)	2
		3	Oval	3
16	Branching pattern	1	Extensive	5
		2	Intensive	0
19	Colour of young leaves	1	Red	1
		2	Yellow red	3
		3	Green red	1
		4	Purple	0

Data Field	Descriptor		Descriptor State	No. of Accessions
28	Season of flowering	3	Early (Nov-Dec)	0
		5	Mid (Dec-Jan)	5
		7	Late (Jan-Feb)	0
31	Mature cashew apple colour	1	Yellow	3
		2	Red	1
		3	Yellow red	1
		4	Red purple	0
32	Shape of cashew apple	1	Cylindrical	1
		2	Conical-obovate	4
		3	Round	0
		4	Pyriform	0
50	Attachment of nut to cashew apple	3	Loose	0
		5	Intermediate	5
		7	Tight	0
35	Nut weight	3	Low (<5 g)	1
		5	Intermediate (5-7 g)	2
		7	High (>7 g)	2
43	Weight of cashew apple	3	Low (<27 g)	0
		5	Medium (27-52 g)	1
		7	High (>52 g)	4
60	Flowering duration	3	Short (<60 days)	2
		5	Medium (60-90 days)	3
		7	Long (>90 days)	0
62	Apple to nut ratio	3	Low (<6)	1
		5	Medium (6-12)	4
		7	High (>12)	1
63	Shelling percentage	3	Low (<18 %)	0
		5	Intermediate (18-28 %)	1
		7	High (>28%)	4
64	Kernel weight	3	Low (<1.2 g)	0
		5	Intermediate (1.2-2.5 g)	3
		7	High (>2.5 g)	2

Data Field	Descriptor		Descriptor State	No. of Accessions
57	Shell thickness	3	Thin (<2.5 mm)	1
		5	Intermediate (2.5-4.0 mm)	4
		7	Thick (>4.0 mm)	0
65	Attachment of peel to kernel	3	Loose	5
		7	Tight	0
68	Cumulative yield per plant	3	Low (<9 kg)	3
	(6 annual harvests)	5	Medium (9-18 kg)	2
		7	High (>18 kg)	0

1.2 Genetic Improvement of cashew for yield and quality traits

The promising hybrids were evaluated for yield and other characters (Table 1.2). The highest yield was recorded in H-125 (2.49 kg/plant) followed by H-126 (2.37 kg/plant). The yield levels of these hybrids are significantly different from checks (Selection-2 and Bhaskara). The cumulative yield of 6 harvests showed that H-126 yielded the highest with 17.40 kg/plant followed by H-125 (16.21 kg/plant). Among the hybrids, a significant difference was observed in stem girth while other characters were not significant.

Table 1.2: Performance of promising hybrids.

Hybrid/ Variety	Plant Height (m)	Stem Girth (cm)	Canopy Spread (EW)	Canopy Spread (NS)	Yield (kg/plant)	Cumulative yield of 6 harvests (kg/plant)
H-43	5.6	49.92	6.34	5.8	1.01	9.04
H-66	5.76	61.58	5.89	5.95	2.05	10.18
H-68	6.42	65.58	6.32	6.87	1.2	13.61
H-125	5.18	57.92	6.45	6.48	2.49	16.21
H-126	5.66	66	6.72	6.69	2.37	17.40
H-2452	5.24	63.83	7.17	6.94	0.21	9.57
H-2473	5.67	72.11	6.99	7.21	0.93	4.2
H-1250	5.63	53.25	5.9	5.96	1.36	8.65
Selection- 2	5.82	57.53	5.81	6.18	1	8.62
Bhaskara	7.24	69.97	6.03	6.68	0.82	11.51
Mean	**5.82**	**61.77**	**6.36**	**6.47**	**1.34**	
CD (0.05)	**NS**	**4.85**	**NS**	**NS**	**0.76**	
CV(%)	**11.92**	**8.37**	**9.28**	**12.25**	**19.15**	

Further, fingerprinting of promising hybrids (H-125 and H-126) has been attempted with 12 polymorphic SSR markers and patterns were drawn. The DNA profile of cashew SSR (CS-17) is depicted in the figure (Fig.1.1)

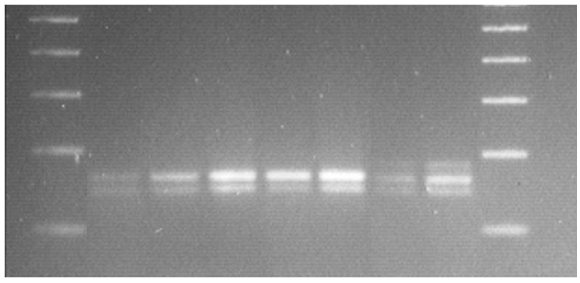


Fig.1.1: DNA profile of Cashew SSR (CS-17); Index: from left : Ullal-3, Bhaskara, Selection-2, Bhedasi, H-125, H-126

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

Parental DNA of Ullal-3 and NRC-492 were extracted. Mango (15) and almond (24) primers in parents were re-screened to confirm polymorphism. Accordingly 6 mango and 11 almond primers were found to be polymorphic. Further, two cashew SSR primers (CS-2 and CS-3) were screened in 89 F_1 progenies and banding patterns were generated. The morphological parameters such as plant height, girth and canopy spread were recorded on these progenies along with the yield (Table 1.3). The skewness values indicated the approximately symmetric distribution for all the characters.

Table 1.3: Descriptive statistics of F_1 progenies.

Character	Minimum	Maximum	Mean	SD	Kurtosis	Skewness
Plant Height (m)	2.00	12.00	6.32	1.97	0.32	0.32
Canopy Spread (EW)	1.50	12.00	7.05	2.22	-0.29	-0.22
Canopy Spread (NS)	1.00	13.00	7.02	2.44	0.05	0.10
Stem Girth (cm)	36.00	96.00	62.11	13.47	-0.46	0.34

1.4 Development of Dwarf and Compact Cashew hybrids for High Density Planting

A total of 737 trees planted during October 2013 were observed for plant height, girth and spread along with yield (Tables 1.4; 1.5; 1.6; 1.7 and 1.8). Plant height values of Priyanka x NRC-492, Priyanka x Taliparamba-1, Taliparamba-1 x Priyanka and Madakkathara-2 x Taliparamba-1 progenies were highly negatively skewed indicating chances of getting real dwarf plants. The progenies of Vengurle-4 x NRC-492, Vengurle-4 x Taliparamba-1, Dhana x NRC-492 and Madakkathara-2 x NRC-492 progenies are moderately skewed indicating the recovery of few dwarf plants. However, both plant height and canopy spread (NS) values were highly negatively skewed in Priyanka x Taliparamba-1 indicating the increased possibility of recovering dwarf and compact plants. The range of yield levels were highest in NRC-492 x Madakkathara-2 (0.0 to 0.21 kg/plant) and there was no yield recorded in the progenies of Taliparamba-1 x Vengurle-4.

Table 1.4: Descriptive statistics of direct and reciprocal crosses for plant height.

Cross	Plant Height (cm)						
	No. of plants	Min	Max	Mean	SD	Kurtosis	Skewness
Vengurle-4 x NRC-492	150	75	475	324.57	63.93	1.76	-0.79
NRC-492 x Vengurle-4	9	195	345	278.33	51.60	-0.88	-0.16
Vengurle-4 x Taliparamba-1	116	75	500	316.72	73.06	1.16	-0.52
Taliparamba-1 x Vengurle-4	6	350	450	407.50	47.30	-2.92	-0.13
Priyanka x NRC-492	65	100	450	341.54	66.99	3.19	-1.20
NRC-492 x Priyanka	12	290	425	359.17	42.36	-0.87	-0.15
Priyanka x Taliparamba-1	9	75	450	335.56	116.20	2.69	-1.54
Taliparamba-1 x Priyanka	6	375	425	410.83	19.60	2.15	-1.50
Dhana x NRC-492	56	175	450	353.84	63.92	0.23	-0.69
NRC-492 x Dhan	11	275	500	353.64	60.17	3.09	1.37
Dhana x Taliparamba-1	65	200	550	386.38	80.16	-0.44	-0.05
Taliparamba-1 x Dhana	4	350	500	406.25	65.75	2.23	1.44
Madakkathara-2 x NRC-492	135	100	510	376.85	64.52	2.03	-0.82
NRC-492 x Madakkathara-2	10	310	415	373.5	34.24	-0.46	-0.47
Madakkathara-2 x Taliparamba-1	65	30	510	410.31	84.80	5.66	-1.91

Table 1.5: Descriptive statistics of direct and reciprocal crosses for stem girth.

Cross	Stem Girth (cm)						
	No. of plants	Min	Max	Mean	SD	Kurtosis	Skewness
Vengurle-4 x NRC-492	150	11	34	24.16	4.49	-0.09	-0.03
NRC-492 x Vengurle-4	9	21	28	24.78	2.28	-0.59	-0.38
Vengurle-4 x Taliparamba-1	116	11	37	26.31	5.20	0.44	-0.37
Taliparamba-1 x Vengurle-4	6	26	34	31.17	2.86	2.05	-1.41
Priyanka x NRC-492	65	8	40	28.55	5.96	2.46	-1.01
NRC-492 x Priyanka	12	23	41	31.75	6.05	-1.10	-0.09
Priyanka x Taliparamba-1	9	10	42	31.00	9.63	2.34	-1.20
Taliparamba-1 x Priyanka	6	30	54	40.33	8.69	-0.23	0.72
Dhana x NRC-492	56	14	41	30.48	5.19	0.89	-0.32
NRC-492 x Dhana	11	16	44	29.36	6.77	2.71	0.25
Dhana x Taliparamba-1	65	18	45	30.37	6.36	-0.47	-0.02
Taliparamba-1 x Dhana	4	30	39	34.5	3.70	1.14	0.00
Madakkathara-2 x NRC-492	135	12	48	28.84	4.79	2.08	0.10
NRC-492 x Madakkathara-2	10	24	36	29.2	3.97	-0.89	0.43
Madakkathara-2 x Taliparamba-1	65	10	42	31.68	5.78	1.95	-0.90

Table 1.6: Descriptive statistics of direct and reciprocal crosses for Canopy Spread – EW.

Cross	Canopy Spread - EW (cm)						
	No. of plants	Min	Max	Mean	SD	Kurtosis	Skewness
Vengurle-4 x NRC-492	150	100	400	217.90	56.47	0.79	0.69
NRC-492 x Vengurle-4	9	210	350	261.67	47.37	-0.06	0.93
Vengurle-4 x Taliparamba-1	116	75	410	227.20	63.01	0.64	0.37
Taliparamba-1 x Vengurle-4	6	175	310	245.00	54.41	-1.83	0.00
Priyanka x NRC-492	65	75	500	265.85	77.55	1.09	-0.12
NRC-492 x Priyanka	12	250	425	325.42	56.47	-0.67	0.23
Priyanka x Taliparamba-1	9	75	400	282.22	103.53	0.83	-0.74
Taliparamba-1 x Priyanka	6	345	400	372.50	23.61	-1.81	-0.21
Dhana x NRC-492	56	100	430	281.16	64.93	0.44	0.18
NRC-492 x Dhana	11	200	400	283.64	56.97	0.36	0.76
Dhana x Taliparamba-1	65	150	450	282.62	73.27	-0.41	0.17
Taliparamba-1 x Dhana	4	250	310	267.5	28.72	3.41	1.85
Madakkathara-2 x NRC-492	135	75	350	219.63	49.76	0.10	0.17
NRC-492 x Madakkathara-2	10	215	330	285	38.73	-0.58	-0.72
Madakkathara-2 x Taliparamba-1	65	20	475	252.62	67.00	2.59	0.03

Table 1.7: Descriptive statistics of direct and reciprocal crosses for Canopy Spread – NS.

Cross	Canopy Spread - NS (cm)						
	No. of plants	Min	Max	Mean	SD	Kurtosis	Skewness
Vengurle-4 x NRC-492	150	75	425	219.33	63.01	-0.09	0.42
NRC-492 x Vengurle-4	9	190	370	255.56	57.69	0.41	1.05
Vengurle-4 x Taliparamba-1	116	50	440	215.26	58.64	1.88	0.15
Taliparamba-1 x Vengurle-4	6	225	325	298.33	38.94	3.01	-1.72
Priyanka x NRC-492	65	100	550	277.15	84.47	1.22	0.47
NRC-492 x Priyanka	12	250	400	316.67	44.59	-0.50	0.47
Priyanka x Taliparamba-1	9	50	400	297.78	115.98	1.52	-1.29
Taliparamba-1 x Priyanka	6	310	405	370.00	36.33	0.06	-0.99
Dhana x NRC-492	56	110	420	285.63	67.92	0.07	-0.04
NRC-492 x Dhana	11	225	400	300.91	53.94	-0.35	0.64
Dhana x Taliparamba-1	65	120	410	267.54	70.33	-0.27	0.29
Taliparamba-1 x Dhana	4	200	300	256.25	42.70	0.34	-0.75
Madakkathara-2 x NRC-492	135	105	405	217.78	51.87	0.51	0.50
NRC-492 x Madakkathara-2	10	210	400	291.5	60.33	-0.51	0.31
Madakkathara-2 x Taliparamba-1	65	25	430	267.69	83.10	-0.04	-0.24

Table 1.8: Yield levels in different crosses during second year.

Cross	No. of plants	Yield (kg/plant)	
		Min	Max
Vengurle-4 x NRC-492	150	0.0	0.17
NRC-492 x Vengurle-4	9	0.0	0.12
Vengurle-4 x Taliparamba-1	116	0.0	0.17
Taliparamba-1 x Vengurle-4	6	0.0	0.0
Priyanka x NRC-492	65	0.0	0.19
NRC-492 x Priyanka	12	0.0	0.20
Priyanka x Taliparamba-1	9	0.0	0.16
Taliparamba-1 x Priyanka	6	0.0	0.04
Dhana x NRC-492	56	0.0	0.17
NRC-492 x Dhana	11	0.0	0.14
Dhana x Taliparamba-1	65	0.0	0.19
Taliparamba-1 x Dhana	4	0.0	0.06
Madakkathara-2 x NRC-492	135	0.0	0.18
NRC-492 x Madakkathara-2	10	0.0	0.21
Madakkathara-2 x Taliparamba-1	65	0.0	0.06

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

A total of 542 plants involving 472 back cross progenies and 70 parent plants were planted during October 2014. The back cross progenies were generated by back crossing either Bhaskara or Ullal-3. Observations on plant height, girth, canopy spread, precocious flowering and yield have been compiled on these progenies during the current year. The summary of statistics of different characters in two back cross progenies is given in Table 1.9 and Table 1.10.

The yield obtained from Bhaskara back cross progenies was 0.0 to 0.30 kg while it was 0.0 to 0.24 kg in Ullal back cross progenies. Precocious flowering was recorded in 50 progenies of Bhaskara back cross and 49 progenies of Ullal-3 back cross. Plant height in Bhaskara back cross progenies and stem girth in Ullal-3 back cross progenies showed moderate negative skewed distribution indicating that plants with less plant height and stem girth are less likely in the respective progenies. Other characters showed approximately symmetric distribution. The progenies will be evaluated further in the ensuing years for their dwarf stature and yield.

Table 1.9: Descriptive statistics of (Bhaskara x NRC-492) x Bhaskara progenies.

Parameter	Minimum	Maximum	Mean	SD	Kurtosis	Skewness
Plant Height (cm)	50.00	300.00	195.10	50.15	0.47	-0.77
Stem Girth (cm)	3.00	27.00	15.87	4.03	0.70	-0.49
Canopy Spread (EW)	12.00	300.00	159.02	53.38	-0.28	-0.28
Canopy Spread (NS)	9.00	290.00	154.43	54.07	-0.24	-0.09
Yield (kg)	0.00	0.30				

Table 1.10: Descriptive statistics of (Ullal-3 x NRC-492) x Ullal-3 progenies.

Character	Minimum	Maximum	Mean	SD	Kurtosis	Skewness
Plant Height (cm)	25	320	196.14	44.57	1.26	-0.29
Stem Girth (cm)	2	24	15.78	3.54	1.42	-0.77
Canopy Spread (EW)	9	275	146.26	45.81	-0.07	-0.10
Canopy Spread (NS)	8	250	143.62	45.59	-0.41	-0.21
Yield (kg)	0	0.24				

1.6 Evaluation of cashew genotypes for Cashew Nut Shell Liquid content

A new project on identification and evaluation of cashew genotypes for Cashew Nut Shell Liquid (CNSL) was initiated. To identify accessions with high and very low CNSL content, extraction of CNSL using hexane solvent was standardised. Estimation of CNSL content in 21 accessions indicated that CNSL was high in NRC-109 (23.32%) while it was low in NRC-40 (10.62%) (Table 1.11).

Table 1.11: CNSL content of different cashew germplasm accessions.

Accessions	CNSL content (%)
NRC 40	10.62
NRC 88	11.98
NRC 27	13.06
NRC 98	15.26
NRC 78	15.74
NRC 190	16.19
NRC 23	17.25
NRC 351	17.68
NRC 18	18.01
NRC 85	18.56
NRC 171	19.00
NRC 291	19.50
NRC 87	19.80
NRC 19	20.27
NRC 267	20.85
NRC 83	21.59
NRC 346	21.70
NRC 359	22.16
NRC 362	22.66
NRC 300	23.30
NRC 109	23.32

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

1.7.1 Morphological characterization of different cashew accessions

Fourteen germplasm accessions along with one hybrid check (cv. Vengrule-8) were planted at a spacing of 7.5 m x 7.5 m in RBD with three replications in 2013 for evaluation of cashew apple yield and quality traits. Observations on morphometric parameters *viz.,* plant height, trunk girth, canopy spread (E-W and N-S), canopy area and tree volume were recorded for the accessions during 2015-16 (Table 1.12). Among the different accessions, NRC 301 recorded the maximum plant height (3.35 m) and trunk girth (38.17 cm) (Fig 1.2). However, the maximum canopy spread (E-W and N-S) was recorded in NRC 140 (4.42 m and 4.95 m) and NRC 189 (4.50 m and 4.64 m) respectively. Similarly, NRC 140 (28.64m^2 and 18.23m^3) and NRC 189 (27.59 m^2 and 17.22 m^3) exhibited the maximum canopy area and tree volume respectively.

Fig 1.2. Growth of NRC 301

Table 1.12: Observations on morphometric parameters of different accessions.

Accessions	Height (m)	Trunk girth (cm)	Canopy spread (m)		Canopy area (m^2)	Tree volume (m^3)
			EW	NS		
NRC 301	3.35	38.17	4.18	4.10	25.97	15.63
NRC 389	3.08	34.33	4.17	4.60	26.35	16.00
NRC 120	3.23	30.83	4.08	4.11	24.56	14.14
NRC 189	3.02	33.17	4.50	4.64	27.59	17.22
NRC 175	2.87	35.17	4.50	4.54	26.02	15.47
NRC 493	2.97	34.58	4.18	4.02	23.35	13.29
NRC176	2.96	30.25	3.75	3.97	22.24	12.36
NRC183	2.86	32.00	3.71	3.81	20.28	10.65
NRC 111	3.06	34.17	4.06	3.91	23.01	12.95
NRC 270	2.81	34.83	4.21	3.87	22.01	11.97
NRC75	2.73	35.25	4.38	4.58	25.00	14.51
NRC 144	2.58	30.17	3.68	3.85	19.08	9.81
NRC 112	3.05	36.42	4.25	4.52	26.27	15.83
NRC 140	2.97	33.58	4.42	4.95	28.64	18.23
Vengurla -8 (check)	2.25	21.50	3.83	3.79	17.92	8.90
Mean	**2.92**	**32.96**	**4.13**	**4.22**	**23.88**	**13.80**

A wide variation in colour of young and mature leaves, leaf shape, apex, length and breadth of leaves was observed among the accessions. In case of colour of young leaves, 13 accessions were in yellow red, and one each was in red (NRC 120) and green yellow (NRC 183) (Fig. 1.3 and 1.4). Whereas in colour of mature leaves, one accession was in light green (NRC 183) and rest were in green (14 accessions). In case of leaf shape and apex, the majority of the trees were oblong shape leaves and rounded leaf apex (Table 1.13). Leaf length and leaf breath were high in Vengurla 8 (16.19 cm and 9.61 cm respectively) and vice versa in NRC 175 (11.17 cm and 6.59 cm respectively). Similarly, the maximum leaf area was recorded in Vengurla 8 (111.27 cm^2).

Fig 1.3: Red colour young leaves in NRC 120

Fig 1.4: Green yellow colour young leaves in NRC 183

Table 1.13: Observations on leaf descriptors of different accessions.

Accessions	Colour of young leaf	Colour of mature leaf	Leaf shape	Leaf apex	Leaf size (cm) Length	Breath	Leaf area (cm^2)
NRC 301	Yellow red	Green	Oblong	Rounded	14.79	8.27	88.00
NRC 389	Yellow red	Green	Oblong	Rounded	14.45	7.92	82.40
NRC 120	Red	Green	Obovate	Rounded	13.84	8.54	84.20
NRC 189	Yellow red	Green	Oblong	Indented	14.09	8.04	82.01
NRC 175	Yellow red	Green	Oblong	Rounded	11.71	6.59	55.15
NRC 493	Yellow red	Green	Oblong	Rounded	13.63	7.92	77.98
NRC176	Yellow red	Green	Oblong	Rounded	13.62	7.68	74.93
NRC183	Green yellow	Light green	Oval	Rounded	14.51	8.87	92.22
NRC 111	Yellow red	Green	Oblong	Rounded	14.38	7.89	81.24
NRC 270	Yellow red	Green	Oblong	Pointed	16.35	8.92	104.59
NRC75	Yellow red	Green	Oblong	Pointed	14.45	7.57	77.88
NRC 144	Yellow red	Green	Oblong	Pointed	14.44	7.61	78.61
NRC 112	Yellow red	Green	Oblong	Rounded	14.58	8.16	85.28
NRC 140	Yellow red	Green	Oblong	Indented	14.29	7.68	78.33
Vengurla -8 (check)	Yellow red	Green	Oblong	Indented	16.19	9.61	111.27
Mean					**14.36**	**8.08**	**83.61**

Characterization of inflorescence indicated that among the 15 accessions, 10 were in pyramidal shape and 5 were in broadly pyramidal shape (Table 1.14; Fig. 1.5 and 1.6), while compactness, type and color of inflorescence were uniform in all accessions. Inflorescence length and breadth were more in NRC 183 (22.16 cm) and NRC 389 (27.83cm) respectively. Colour of boot leaf was light green in all accessions except overlapping of pink or red in different proportions present in NRC 140 and NRC 183.

Fig. 1.5: Broadly Pyramidal inflorescence in NRC 183

Fig. 1.6: Broadly pyramidal inflorescence in NRC 140

Table 1.14. Inflorescence characters of different cashew accessions.

Accessions	Inflorescence						Colour of boot leaf
	Shape	Colour	Compact	Type	Length (cm)	Breath (cm)	
NRC 301	Pyramidal	Cream	Loose	All around main axis	15.73	19.93	Light green
NRC 389	Broadly Pyramidal	Cream	Loose	All around main axis	21.85	27.83	Light green
NRC 120	Pyramidal	Cream	Loose	All around main axis	19.97	25.15	Light green
NRC 189	Broadly Pyramidal	Cream	Loose	All around main axis	17.13	27.41	Light green
NRC 175	Pyramidal	Cream	Loose	All around main axis	18.17	25.52	Light green
NRC 493	Pyramidal	Cream	Loose	All around main axis	16.99	25.37	Light green
NRC176	Pyramidal	Cream	Loose	All around main axis	16.41	21.83	Light green
NRC183	Broadly Pyramidal	Cream	Loose	All around main axis	22.16	26.23	Light green with pink tinge
NRC 111	Pyramidal	Cream	Loose	All around main axis	18.53	25.75	Light green
NRC 270	Pyramidal	Cream	Loose	All around main axis	16.44	21.96	Light green
NRC75	Pyramidal	Cream	Loose	All around main axis	17.26	22.43	Light green
NRC 144	Pyramidal	Cream	Loose	All around main axis	18.13	22.39	Light green
NRC 112	Broadly Pyramidal	Cream	Loose	All around main axis	18.88	26.91	Light green
NRC 140	Broadly Pyramidal	Cream	Loose	All around main axis	21.07	27.02	Light green with pink tinge
Vengurla -8 (check)	Pyramidal	Cream	Loose	All around main axis	17.41	21.67	Light green
Mean					**18.41**	**24.49**	

1.7.2 Screening of cashew apple accessions against diseases under field conditions

Fourteen lines were screened for resistance against black spot, shoot die back/twig rot/ gummosis and inflorescence drying/die back diseases during 2015-16. Disease was scored using 0-4 scale and per cent disease index (PDI) was calculated using standard formula. On

the basis of PDI, genotypes were categorized in six disease reaction groups: symptomless (SL, 0), resistant (R, 0.1–10), moderately resistant (MR, 10.1–25), moderately susceptible (MS, 25.1–50), susceptible (S, 50.1–75) and highly susceptible (HS, 75.1–100). Among fourteen lines, three lines *viz.,* NRC 301, NRC 176 and NRC 75 were resistant to black leaf spot disease while none of the lines were resistant to shoot die back/twig rot/gummosis and inflorescence drying/die back diseases (Table 1.15).

Table 1.15: Reaction different germplasm to black leaf spot, Shoot die back/twig rot/gummosis and Inflorescence drying/die back diseases under field conditions.

Germplasm/ cultivar	Reaction (PDI)		
	Black leaf spot	Shoot die back/twig rot/gummosis	Inflorescence drying/die back
NRC 301	R (7.00)*	MS (34.0)	MS (35.7)
NRC 493	MR (14.20)	MS (34.0)	MR (27.8)
NRC140	MR (20.90)	MR (20.4)	MS (36.1)
NRC 389	MR (11.20)	MS (31.0)	MS (28.2)
NRC 75	R (8.70)	MS (34.5)	MR (18.4)
NRC 111	MR (15.50)	MR (22.0)	MR (17.2)
NRC 120	MR (13.90)	MS (28.0)	MR (21.9)
NRC 176	R (1.30)	MS (25.5)	MS (43.2)
NRC 270	MR (15.60)	MR (23.0)	MS (32.5)
NRC 112	MR (10.90)	MS (28.1)	MR (7.0)
NRC 144	MR (17.00)	MS (35.4)	MR (15.1)
NRC 189	MS (30.60)	MS (32.0)	MS (33.2)
NRC 175	MS (34.30)	MS (26.0)	MR (17.4)
NRC 183	S (67.20)	MS (28.2)	MS (33.5)

Values in parentheses are PDI

1.7.3. Incidence of insect pests on different cashew apple accessions

During 2015-16, incidence of Tea Mosquito Bug (TMB) (*Helopeltis antonii*) was less, but thrips (*Scirtothips dorsalis*) and, Apple and Nut Borer (ANB) (*Thylacoptila paurosema*) infestations were more compared to previous years (Table 1.16).

Table 1.16: Incidence of insect pests on the accessions during 2015-16

Accession	TMB damage grade (0-4)	Thrips damaged nuts (%)	Apple and nut borer damaged nuts (%)
NRC 176	0.83	45.12	06.69
NRC 389	1.01	18.75	05.30
NRC 144	0.43	16.50	16.74
NRC 175	1.56	29.45	05.45
NRC 112	0.88	29.38	10.25
NRC 75	1.00	01.05*	02.78*
NRC 270	0.82	18.34	15.15
NRC 301	1.08	40.00	08.25
NRC 111	0.91	29.60	14.41
NRC 140	0.61	33.64	04.90
NRC 120	0.85	16.96	07.11
NRC 183	0.83	00.00*	00.00*
NRC 493	1.11	28.71	22.07
NRC 189	0.84	24.07	02.98
Vengurla 8	0.13	12.12	02.75

(Where, Resistant: 0.0-1.0, Moderately Resistant: 1.1-2, Moderately Susceptible : 2.1-3, Susceptible : 3.1-4)
*Late flowering accessions, yielding is in progress.

During flushing period, highest TMB damage was recorded in NRC 175 followed by NRC 493. In all the accessions, TMB damage was less than grade 2. But, spraying of insecticide (lambda cyhalothrin 5 EC @ 0.006 %) was taken up immediately after TMB grading. During flowering and fruiting period, TMB population was very less. But thrips and ANB incidences were more between December and April while other pests like aphids, mealy bugs, slug caterpillar and leaf miner were also recorded in a localized manner at very low level. Among the accessions, infestation of thrips was very high on NRC 176 (45.12%), followed by NRC 301 (40.0%) and NRC 140 (33.64%). Least thrips damage was recorded on check variety Vengurla-8 (12.12%), followed by NRC 144 (16.5 %) and NRC 120 (16.96%). Whereas, apple and nut borer infestation was maximum on NRC 493 (22.07%) followed by NRC 144 (16.74%) and NRC 270 (15.15%) while, V-8 (2.75%) and NRC 189 (2.98%) had minimum infestation of ANB.

1.7.4. Yield of cashew apple and nut in different accessions

Among the different accessions, NRC 175 recorded the highest apple yield (37.89 kg/tree) followed by NRC 140 (18.56 kg/tree), NRC 389 (14.96 kg/tree) while the yield was lowest (0.334 kg/tree) in NRC 183 (Fig.1.7 and Fig.1.8). Similarly, NRC 175 registered high nut yield (2.84 kg/tree) whereas it was low in NRC 183 (0.038 kg/tree).

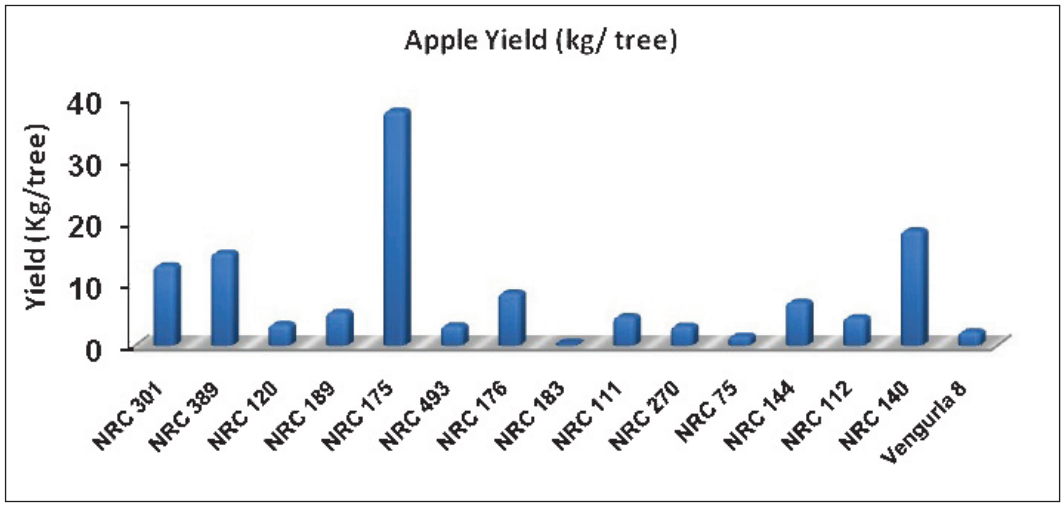


Fig.1.7. Cashew apple yield indifferent accessions

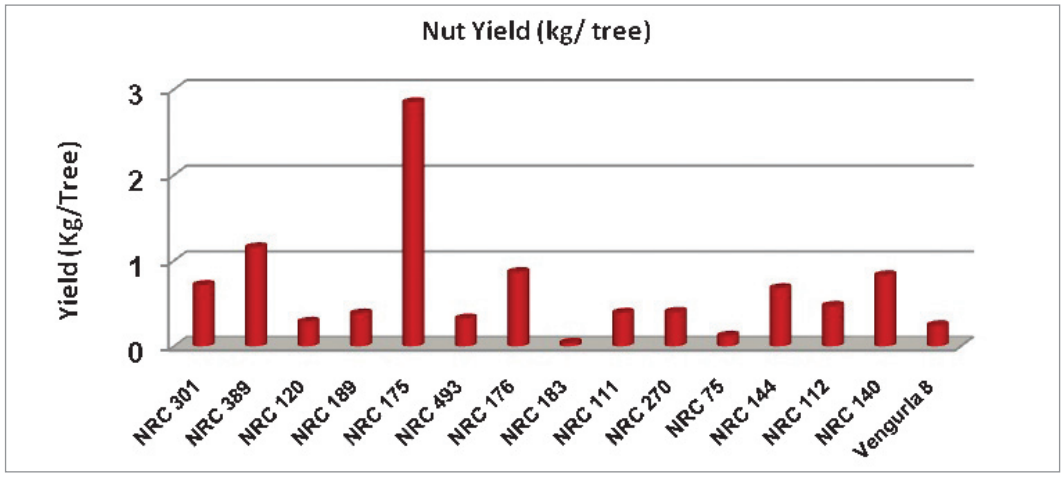


Fig.1.8. Cashewnut yield in different accesions

1.7.5. Variability in apple characters

Significant differences in fruit weight, juice content, TSS, pH, acidity, tannin, vitamin C and phenol content were recorded in various cashew apple accessions (Table 1.17). Among fifteen accessions, the highest fruit weight was recorded in NRC-301 (177 g) (Fig. 1.9) while it was lowest in NRC-176 (47 g). NRC-301 recorded the highest juice content (77.00%) and lowest juice was in NRC-176 (71.00%). Whereas, NRC-176 recorded highest content of pomace (28.3%) and lowest pomace was in NRC-183 (22.0%). The highest TSS (13.5°B) was recorded in NRC-176 and NRC-183 while lowest TSS was in NRC-112 (10°B). Maximum acidity of 0.76% was recorded in accession NRC-270 and NRC-183 while it was minimum in NRC-75 (0.31%). Accession NRC-175 had the highest tannin content (6.43 mg/ml of juice) followed by NRC-140 (6.10 mg/ml of juice) whereas NRC-183 recorded lowest tannin content (2.11 mg/ml of juice). Accession NRC-270 had the highest vitamin C content (3.9 mg/ml of juice) followed by NRC-112 (3.8 mg/ml of juice) and NRC-144 (3.6 mg/ml of juice) whereas NRC-140 recorded the lowest vitamin C content (2.2 mg/ml of juice). Among the fifteen accessions the highest phenol content was recorded in NRC-270 (0.38%) followed by NRC-176 (0.32%) and NRC-111 (0.31%) while the lowest phenol was found in NRC-175 (0.18%).

Table 1.17: Variations in apple quality in different cashew accessions.

Accession/ Variety	Apple Weight (g)	Juice yield (%)	Pomace yield (%)	TSS (°B)	pH	Acidity (%)	Tannin content (mg/ml)	Vit. C (mg/ml)	Phenols (%)
NRC 301	177	77.00	22.50	11.5	4.7	0.72	3.94	3.3	0.28
NRC 389	97	75.10	23.70	12.5	4.4	0.50	3.05	2.8	0.28
NRC 144	110	76.00	23.00	11.5	4.5	0.56	2.34	3.6	0.24
NRC 175	89	75.60	23.00	12.5	4.6	0.68	6.43	3.2	0.18
NRC 112	105	76.20	23.10	10.0	4.4	0.54	3.10	3.8	0.33
NRC 75	85	74.80	24.00	12.5	4.6	0.31	2.70	3.3	0.27
NRC 270	93	76.00	23.00	12.0	4.3	0.76	3.02	3.9	0.38
NRC 176	47	71.00	28.30	13.5	4.3	0.48	3.80	3.5	0.32
NRC 111	124	76.25	23.00	11.5	4.5	0.58	2.80	2.8	0.31
NRC 140	148	74.80	23.80	13.0	4.5	0.56	6.10	2.2	0.23
NRC 120	115	71.30	23.30	12.0	4.5	0.58	5.65	3.3	0.26
NRC 183	158	76.70	22.00	13.5	4.4	0.76	2.11	2.8	0.22
NRC 493	128	75.00	24.10	11.5	4.6	0.53	2.21	3.2	0.26
NRC 189	109	74.40	25.10	12.0	4.4	0.49	2.90	3.8	0.28
V 8	92	73.20	26.00	12.0	4.6	0.71	2.60	3.3	0.26

Fig. 1.9: Large size apple of NRC 301

1.8 Externally Funded Projects

1.8.1 Development of morphological descriptors and DUS test guidelines for cashew (Funded by PPV FRA, New Delhi)

In order to arrive at DUS test guidelines for cashew, a project funded by Protection of Plant Varieties and Farmers Rights Authority, New Delhi was initiated. During the year, the data on 68 characteristics of 42 released cashew varieties have been compiled and Image database of these varieties with respect to different plant parts are being compiled (Fig 1.10).

BHASKARA	
 Colour of young leaves	 Grooves on cashew apple
 Leaf apex shape	 Suture of nut

DHANA	
 Colour of young leaves	 Grooves on Cashew apple
 Leaf apex shape	 Suture of nut

Fig 1.10: Morphological descriptors for DUS testing

1.8.2 CRP-Agro biodiversity

A Consortia Research Platform on Agro biodiversity was initiated during the year at this Directorate with Indian Institute of Horticultural Research, Bangalore as the nodal centre. The main objective of the program is to generate evaluation data on existing germplasm collections and maintain germplasm bank. Accordingly, characterisation of 5 cashew germplasm accessions planted during 2006 and documentation of data on 16 accessions evaluated during 2014-15, were completed.

2. CROP MANAGEMENT

2.1. Organic Farming in Cashew

A field experiment has been initiated in 2012 to develop organic nutrient management modules for sustainable cashew productivity. The objectives of the project include: i) to examine the influence of organic sources on growth, yield and quality of cashew and ii) to quantify the changes in soil physical, chemical and biological properties resulting from organic farming practices.

The experiment was laid out in randomized block design with cashew variety 'Bhaskara'. The planting was done at a spacing of 7.5 m x 7.5 m. The details of the treatments are shown below:

T_1: FYM to supply 500 g N/tree

T_2: FYM to supply 500 g N/tree + biofertilizer consortia*

T_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.

T_4: Poultry manure to supply 500 g N/tree

T_5: *In situ* composting using recyclable cashew biomass and weeds

T_6: *In situ* composting using recyclable cashew biomass and weeds + Green manuring (Growing Glyricidia between two rows of cashew)

T_7: Vermicomposting of recyclable cashew biomass

T_8: FYM + Organic cakes + Recyclable cashew biomass + biofertilizer consortia

T_9: Recommended NPK fertilizer**

T_{10}: Recommended NPK fertilizer + 10 kg FYM/tree

T_{11}: Control.

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

** Fertilizer dose: 1st year of planting: 1/5th of recommended N, P and K per tree per year, 2nd year: 2/5th of recommended N, P and K per tree per year, 3rd year: 3/5th of recommended N, P and K per tree per year, 4th year: 4/5th of recommended N, P and K per tree per year and 5th year onwards full dose i.e. 500 g N, 125 g each of P_2O_5 and K_2O/tree/year.

The Influence of organic and inorganic sources of nutrients on growth of cashew showed a wide variation. Growth parameters were the greatest in 'recommended NPK fertilizer + 10 kg FYM/tree' followed by 'poultry manure to supply 500 g N/tree' with minimum under 'control'. The plant height and stem girth varied from 366.67 to 458.33 cm and 30.78 to 37.83 cm, respectively. The canopy spread in N-S direction ranged from 300 to 408.33 cm and in E-W direction varied from 304.17 to 420.83 cm, canopy height ranged from 70.50 to 98.92 cm (Table 2. 1).

Table 2.1: Influence of organic source of nutrients on growth parameters of cashew

Treatment	Plant height (cm)	Girth (cm)	Canopy spread (cm)		Canopy height (cm)
			E-W	N-S	
T_1	429.17	33.83	383.33	370.83	80.25
T_2	454.17	34.58	387.50	391.67	81.83
T_3	429.17	36.33	370.83	358.33	81.67

Treatment	Plant height (cm)	Girth (cm)	Canopy spread (cm)		Canopy height (cm)
			E-W	N-S	
T_4	437.50	35.25	350.00	337.50	98.92
T_5	370.83	31.42	325.00	308.33	92.92
T_6	416.67	33.58	304.46	341.67	84.67
T_7	375.00	31.67	304.17	300.00	70.50
T_8	391.67	31.00	341.67	366.67	87.83
T_9	425.00	33.92	325.00	333.33	83.67
T_{10}	458.33	37.83	420.83	408.33	96.42
T_{11}	366.67	30.78	316.67	308.33	97.67
CD (p=0.05)	**NS**	**4.31**	**69.78**	**NS**	**NS**

Influence of organic and inorganic sources of nutrients on soil micronutrient contents was analysed (Table 2.2). Variations in Fe (15.2 to 21.2 ppm), Mn (6.0 to 9.0 ppm), Zn (0.74 to 0.92 ppm) and Cu (1.00 to 1.98 ppm) contents were observed among the different treatments.

Table 2.2. Influence of organic and inorganic sources of nutrients on soil micronutrient content

Treatment	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)
T1	20.0	8.2	0.82	1.86
T2	19.8	8.2	0.91	1.85
T3	21.2	8.8	0.90	1.95
T4	20.0	9.0	0.86	1.98
T5	18.5	7.0	0.74	1.22
T6	17.9	7.9	0.82	1.45
T7	18.2	7.8	0.80	1.40
T8	18.0	7.0	0.78	1.30
T9	16.0	6.2	0.76	1.20
T10	21.0	8.6	0.92	1.84
T11	15.2	6.0	0.74	1.00

2.1.1 Management of Tea Mosquito Bug using Entomopathogenic fungus

Two rounds of entomopathogenic fungus (2 x 10^7 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.

2.2 Irrigation requirement of cashew under high density planting

Field experiment was laid out in split plot design with variety Bhaskara during 2011. The treatment details of the experiment are given below

Main plot treatments (Plant densities):

- M_1: 5 m x 4 m (500 plants/ha)
- M_2: 6 m x 4 m (416 plants/ha)
- M_3: 10 m x 5 m (200 plants/ha)

Sub plot treatments (Irrigation levels):

- T_1: 20% CPE
- T_2: 40% CPE
- T_3: 60% CPE
- T_4: critical irrigation (once in 15 days)
- T_5: Soil and water conservation technique
- T_6: control (without irrigation and soil & water conservation)

2.2.1 Plant densities and irrigation levels on growth of cashew

The growth parameters *viz.,* plant height, girth and canopy spread (N-S and E-W direction) of cashew plant was recorded under different densities and irrigation levels (Tables 2.3 and 2.4). No significant difference was observed in growth parameters with respect to different densities and irrigation levels. However, the height of the plant ranged from 447.89 cm to 467.25 cm under different plant densities and 444.72 cm to 476.16 cm under different irrigation levels. Girth of the plant under different densities and irrigation levels varied from 38.29 cm to 41.28 cm and 37.94 to 40.61 cm, respectively.

Table 2.3: Effect of spacing and irrigation on plant height and girth of cashew var. Bhaskara

Irrigation (T)	T_1	T_2	T_3	T_4	T_5	T_6	Mean (M)
Spacing (M)			**Plant height (cm)**				
M_1	480.14	470.83	513.75	470.83	467.50	400.42	467.25
M_2	451.67	482.08	435.42	447.92	424.86	445.42	447.89
M_3	496.67	460.83	448.75	436.67	467.08	488.33	466.39
Mean (T)	476.16	471.25	465.97	451.81	453.15	444.72	
Source	Main (M)	Sub (T)	Sub (T) x Main (M)		Main (M) x Sub (T)		
SE (d)	**27.55**	**19.73**	**34.17**		**41.62**		
LSD at 5%	**NS**	**NS**	**NS**		**NS**		
Spacing			**Trunk Girth (cm)**				
M_1	39.36	40.17	43.21	39.88	39.17	34.03	39.30
M_2	39.61	39.42	36.92	37.71	38.74	37.36	38.29
M_3	42.86	41.25	39.54	40.88	40.71	42.42	41.28
Mean (T)	40.61	40.28	39.89	39.49	39.54	37.94	
Source	Main (M)	Sub (T)	Sub (T) x Main (M)		Main (M) x Sub (T)		
SE (d)	**2.36**	**2.12**	**3.68**		**4.10**		
LSD at 5%	**NS**	**NS**	**NS**		**NS**		

Canopy spread in N-S and E-W direction of the cashew plant under different densities varied from 393.56 cm to 425.02 and 396.64 cm to 421.25 cm, respectively. Canopy spread with respect to different irrigation levels ranged from 392.08 to 433.19 cm in N-S direction and 392.73 to 417.82 cm in E-W direction.

Table 2.4: Effect of spacing and irrigation on canopy spread of cashew (cv. Bhaskara).

Irrigation (T)	T_1	T_2	T_3	T_4	T_5	T_6	Mean (M)
Spacing (M)	**Canopy Spread N-S (cm)**						
M_1	411.81	445.42	440.00	402.92	437.50	359.44	416.18
M_2	376.25	396.67	398.75	376.25	420.83	392.64	393.56
M_3	471.39	392.92	397.50	422.92	441.25	424.17	425.02
Mean (T)	419.81	411.67	412.08	400.69	433.19	392.08	
Source	Main (M)	Sub (T)	Sub (T) x Main (M)		Main (M) x Sub (T)		
SE (d)	**27.55**	**19.73**	**34.17**		**41.62**		
LSD at 5%	**NS**	**NS**	**NS**		**NS**		
Spacing	**Canopy Spread E-W (cm)**						
M_1	381.25	412.50	461.25	403.75	414.58	358.61	405.32
M_2	423.89	374.17	413.75	378.75	395.97	393.33	396.64
M_3	446.67	397.92	372.08	441.67	442.92	426.25	421.25
Mean (T)	417.27	394.86	415.69	408.06	417.82	392.73	
Source	Main (M)	Sub (T)	Sub (T) x Main (M)		Main (M) x Sub (T)		
SE (d)	**31.88**	**24.93**	**43.19**		**50.70**		
LSD at 5%	**NS**	**NS**	**NS**		**NS**		

2.2.2 Soil properties as affected by different plant densities and irrigation levels

Soil samples at three different depths (0-30, 31-60 and 61-90 cm) were collected and processed for analysis of various physical, physico-chemical and chemical properties under different densities and irrigation levels (Table 2.5). Influence of irrigation levels on soil properties under different plant densities indicated that there was no significant difference in pH, EC, organic carbon and Exch. Mg contents. However, available N, K and Exch. Ca were significantly higher in normal density (10 m x 5 m) as compared to high density planting (5 m x 4 m and 6 m x 4 m). Of the irrigation levels, 40% CPE and 60% CPE resulted in higher available nutrient contents over other treatments.

Table 2.5: Effect of plant densities and irrigation levels on soil properties

Treatment Plant density (M)	pH	EC (dS m^{-1})	OC (%)	Available N(kg ha^{-1})	Available K(kg ha^{-1})	Exch.Ca cmol (p^+) kg^{-1}	Exch. Mg cmol (p+) kg^{-1}
M_1	5.20	0.08	1.12	278.8	200.5	2.22	0.82
M_2	5.31	0.07	1.06	282.6	193.2	2.10	0.90
M_3	5.10	0.08	1.18	319.5	216.8	2.36	0.95
CD (p=0.05)	**NS**	**NS**	**NS**	**19.35**	**20.8**	**0.34**	**NS**

Irrigation (T)	pH	EC (dS m^{-1})	OC (%)	Available N(kg ha^{-1})	Available K(kg ha^{-1})	Exch.Ca cmol (p^+) kg^{-1}	Exch. Mg cmol (p+) kg^{-1}
T_1	5.19	0.07	1.15	292.7	209.3	2.21	0.88
T_2	5.16	0.09	1.19	300.5	218.1	2.32	0.97
T_3	5.18	0.06	1.18	312.5	205.8	2.29	0.90
T_4	5.21	0.08	0.99	288.5	208.4	2.20	0.93
T_5	5.17	0.07	1.08	287.4	189.5	2.16	0.85
T_6	5.29	0.09	1.14	280.2	190.0	2.18	0.81
LSD at 5%	**NS**	**NS**	**NS**	**30.1**	**22.5**	**NS**	**NS**

2.3 Establishment of Nutrient Diagnostic Norms in Cashew

2.3.1 Regional survey and collection of soil and leaf samples from selected Centres of AICRP on Cashew

A regional survey was carried out in cashew orchards of 5 to 20 years old in Puttur (Karnataka), Vengurla (Maharashtra), Bhubaneswar (Odisha) and Bapatla (Andhra Pradesh) regions in order to develop diagnostic norms and for evaluation of yield limiting nutrients in low yielding orchards. Seventy cashew orchards each in Puttur, Vengurla and Bhubaneswar and Bapatla under AICRP-Cashew were selected at random, covering the entire range of management and yield level. Soil and leaf samples were collected from different cashew orchards besides information on yield and other management practices of each orchard.

2.3.2 Spatial Variability of Available Micronutrients in Cashew Orchards of Konkan Region, Maharashtra

In order to assess the spatial variability of available micronutrients *viz.,* Fe, Mn, Zn and Cu in different cashew orchards of Ratnagiri district, Maharashtra, 70 cashew orchards of 5 to 20 years old in different villages were selected at random, covering the entire range of management and yield level. Surface soil (0-30 cm) samples collected from each orchard were utilized for the analysis. The collected soil samples were processed and analysed for DTPA extractable Fe, Mn, Zn and Cu as per standard methods (Lindsay and Norvell, 1978). The range and mean values of DTPA extractable micronutrient contents in soils showed wide variation among orchards (Table 2.6). The content of DTPA-Fe in soils varied from 5.48 to 42.63 mg kg^{-1} with an average value of 15.44 mg kg^{-1}. Considering the critical limits of 4.5 mg Fe kg^{-1} soil as suggested by Lindsay and Norvell (1978), Fe contents of cashew orchard soils of Ratnagiri district are on the high side. The Mn situation in cashew orchards was very similar to that of Fe. The DTPA-Mn content varied from 12.86 to 34.93 mg kg^{-1} with mean value of 30.10 mg kg^{-1}. As per critical limits (2.0 mg Mn kg^{-1} soil), cashew orchard soils of Vengurla were exceptionally rich in Mn. Owing to the acidic nature of soils, Fe and Mn values were typically high in Vengurla. Moreover, laterization processes in which sesquioxides accumulate to increase the Fe content since the soils under study were laterite soils.

The DTPA-Zn contents of soils vary largely from one site to another. It varied from 0.1 to

3.64 mg kg^{-1} with mean value of 0.97 mg kg^{-1}. Considering the critical limits (0.6 mg Zn kg^{-1}), 26 per cent of soil samples were deficient in available Zn. Similarly, the DTPA-Cu contents of soil vary largely, extremely very low and very high DTPA-Cu values were recorded. The DTPA-Cu contents of soils varied from 0.06 to 19.92 mg kg^{-1} with an average value of 1.67 mg kg^{-1}. Considering the critical limits (0.2 mg Cu kg^{-1} soil), 9 per cent of soil samples were deficient in available Cu. The available micronutrient contents of these soils were in the order of Mn > Fe > Cu > Zn. High spatial variability in available micronutrient content of cashew orchards of Vengurla might be due to differences in nutrient management approaches among cashew farmers.

Based on the analysis of micronutrient contents of cashew growing orchards of Vengurla region, they were classified into three ratings as shown in Table 2.7. The frequency distribution of available micronutrients showed that, in most parts of the study area, the DTPA-Fe content was greater than 10.0 mg kg^{-1}, while, in a few places, the content varied between 5 and 10 mg kg^{-1}. In whole study area, DTPA-Mn content was higher than 10 mg kg^{-1}, revealing that available Fe and Mn content of all cashew orchards under study were sufficient to meet the crop demand for longer period. Ranges of variation in DTPA-Fe were wide as compared to DTPA-Mn, though all of the Fe and Mn values were on higher side. With respect to DTPA-Zn content, only in a small part of the study area, DTPA-Zn content was < 0.5 mg kg^{-1}, while in other parts it varied from 0.5 to >1.0 mg kg^{-1}. On the basis of critical limits of available zinc, 18.6 per cent soil samples were deficient, 44.3 per cent samples were marginal and 37.1 per cent samples were sufficient in available zinc. Although the DTPA-Zn content of most cashew orchard soils (44.3% of soil samples) of Vengurla seems to be medium (>0.5-1.0 mg Zn kg^{-1} soil), which may potentially be at risk to Zn deficiency in future, if no external sources are applied. As the case for DTPA-Zn, the variation of soil DTPA-Cu was very wide. Of the 70 soil samples, 8.6 per cent of cashew orchard soils fell in deficient, 11.4 per cent occured in the marginal and 80.0 per cent of cashew orchard soils were in sufficient categories. Only in very few locations, Cu deficiencies have been noted. However, a great number of samples showed alarmingly high contents of Cu (>1.0 mg kg^{-1}). The data clearly indicates the deficiency of a single micronutrient prevails in different cashew orchards of Vengurla compared to the multiple micronutrient deficiencies. DTPA-Fe and DTPA-Mn have lower spatial variability compared to DTPA-Zn and DTPA-Cu, most likely due to no / limited application rates (Table 2.8).

Micronutrient status of cashew orchard soils was measured in terms of nutrient index (NI) values. Based on the soil test values for DTPA extractable micronutrients, soil samples were classified into three categories, low, medium and high. Using these categories, nutrient index was calculated as per the following equation.

Nutrient index = (NL x 1 + NM x 2 + NH x 3) / NT

Where, NL, NM and NH are number of samples falling in low, medium and high classes of micronutrient status, respectively and NT is total number of samples analyzed for a given area.

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

Table 2.6: Available micronutrient content in different cashew orchards (70) of Ratnagiri district

Available micronutrient	Range (mg kg^{-1})	Mean (mg kg^{-1})	% samples deficient	% samples sufficient
DTPA-Fe	5.48-42.63	15.44	0	100
DTPA-Mn	12.86-34.93	30.10	0	100
DTPA-Zn	0.1-3.64	0.97	25.71	74.29
DTPA-Cu	0.06-19.92	1.67	8.57	91.43

Table 2.7: Ratings for DTPA extractable micronutrient soil test levels

Rating	DTPA extractable			
	Fe	Mn	Zn	Cu
Low	<5	<5	<0.5	<0.2
Medium	5-10	5-10	0.5-1.0	0.2-0.4
High	>10	>10	>1.0	>0.4

Table 2.8: Frequency distribution of micronutrient availability of cashew orchards of Ratnagiri district

Category	DTPA-Fe		DTPA-Mn		DTPA-Zn		DTPA-Cu	
	No. of soil samples	% of soil samples	No. of soil samples	% of soil samples	No. of soil samples	% of soil samples	No. of soil samples	% of soil samples
Low	0	0	0	0	13	18.57	6	8.57
Medium	18	25.71	0	0	31	44.29	8	11.43
High	52	74.29	70	100	26	37.14	56	80

2.3.3 Assessing soil properties of cashew orchards in Bhubaneswar region

Seventy soil samples (0 to 30 cm depth) collected from different cashew orchards in Bhubaneswar region were analyzed for selective physico-chemical characteristics. Soil pH varied from 3.72 to 6.02 with a mean value of 4.58. The pH values of all representative soils were mostly acidic to near neutral in reaction. The organic carbon content of the samples ranged from 0.14 to 0.71 with a mean value of 0.38 per cent. Organic carbon content was low in 58 orchards, medium in 12 orchards and none of the samples recorded high status for organic carbon.

The available N content of the soils varied from 75.05 to 350.95 kg/ha with a mean value of 209.30 kg/ha. Available N content was low in 66 orchards and medium in 4 orchards. None of the soils fell under the category of high in available N content in the region. Available K content of the soils showed a wide variation ranging from 5.03 to 667.01 kg/ha with a mean value of 124.31 kg/ha, indicating 41 orchards were low, 25 were medium and 4 were high in available K content in the region.

Rating chart and nutrient index value for soil test values of organic carbon, available nitrogen and available potassium for soil samples collected from cashew orchards of Puttur, Vengurla and Bhubaneswar regions have been presented in Tables 2.9 and 2.10. High fertility index for Puttur and Vengurla and low for Bhubaneswar were recorded with respect to organic carbon content. Fertility index value for available nitrogen was low for both Puttur and Bhubaneswar and medium for Vengurla. For available potassium, medium fertility index values, were recorded for Puttur and Vengurla regions and low for Bhubaneswar region.

Table 2.9: Rating chart for soil test values for organic carbon, available N and K of cashew orchards

Soil parameter	No. of soil samples falling under the category of		
	Low	Medium	High
Soil organic carbon	2 : Puttur 14 : Vengurla 58 : Bhubaneswar	10 : Puttur 4 : Vengurla 12 : Bhubaneswar	5 : Puttur 52 : Vengurla 0 : Bhubaneswar
Available N	66 : Puttur 26 : Vengurla 66 : Bhubaneswar	4 : Puttur 44 : Vengurla 4 : Bhubaneswar	0 : Puttur 0 : Vengurla 0 : Bhubaneswar
Available K	46 : Puttur 32 : Vengurla 41 : Bhubaneswar	20 : Puttur 33 : Vengurla 25 : Bhubaneswar	4 : Puttur 5 : Vengurla 4 : Bhubaneswar

Table 2.10: Soil fertility index of cashew orchard soils

Soil parameter	% Frequency		
	Low <1.5	Medium 1.5-2.5	High >2.5
Organic carbon	1.17 : Bhubaneswar		3.57 : Puttur 2.55 : Vengurla
Available N	1.28 : Puttur	1.63 : Vengurla 1.06 : Bhubaneswar	
Available K	1.47 : Bhubaneswar	1.79 : Puttur 1.62 : Vengurla	

2.4 Rootstock studies in cashew

The different stionic combinations planted in the field were compared for growth and yield. The stionic combinations varied with respect to flowering and yield parameters (Table 2.11). Among different stionic combinations, the highest number of flowering laterals per m^2 was recorded in VRI-3/V-4 (12.90) which was on par with NRCC Selection-2/V-4 (12.60), V-4/V-4 (12.40), Ullal-3/NRC 492 (12.40), VRI-3/ Taliparamba-1 (11.70), VRI-3/ NRC 492 (11.30) and Ullal-3/V-4 (11.00). The non-flowering laterals did not exhibit significant differences among the different stionic combinations. A significant variation was

observed in nut yield per plant among different stionic combinations. The highest nut yield was associated with a combination of VRI-3/NRC 492(3.30 kg/plant), which was on par with Ullal-3/ Taliparamba-1 (3.00 kg/plant), V-4/Taliparamba-1 (2.90 kg/plant), V-4/V-4 (2.80 kg/plant), VRI-3/V-4 (2.70 kg/plant), Ullal-3/NRC 492 (2.70 kg/plant), Sel-2/NRC 492(2.60 kg/plant), V-4/ NRC 492 (2.60 kg/plant), Ullal-3/V-4(2.50 kg/ plant) and Sel-2/V-4 (2.40 kg/plant). The stionic combination of VRI-3/NRC 492 was associated with highest cumulative nut yield (12.08 kg/plant) over 4 harvests.

Table 2.11: Flowering parameters and yield in different stionic combinations in cashew (2014-15)

Stionic combination (scion/rootstock)	Flowering Laterals/m^{-2}	Non-Flowering laterals/m^{-2}	Yield (Kg/plant)	Cumulative yield (4 harvests)
Ullal-3/ V-4	11.00	8.30	2.50	6.98
VRI-3/V-4	12.90	10.50	2.70	8.65
Sel-2/V-4	12.60	11.00	2.40	6.24
V-4/V-4	12.40	8.70	2.80	9.12
Ullal-3/ NRC 492	12.40	8.30	2.70	10.04
VRI-3/ NRC 492	11.30	14.00	3.30	12.08
Sel-2/ NRC 492	9.00	12.00	2.60	8.24
V-4/ NRC 492	8.30	9.00	2.60	8.76
Ullal-3/ Taliparamba-1	7.50	10.50	3.00	8.81
VRI-3/ Taliparamba-1	11.70	10.00	1.80	6.53
Sel-2/ Taliparamba-1	7.00	9.00	2.10	4.69
V-4/ Taliparamba-1	8.00	11.50	2.90	7.61
Mean	10.34	10.23	2.62	-
CD@5%	**3.09**	**NS**	**1.08**	**-**

2.5. Performance of high yielding varieties of cashew in different planting densities.

A field experiment was laid out in 2006 with grafts of nine varieties in four different spacing to determine optimum plant density for achieving the highest yield and profits for the first ten years.

Main plot: Number of trees/ha

S1 - 200 (10 m x 5 m), S2 - 236 (6.5 m x 6.5 m), S3 - 384 (6.5 m x 4 m), S4 - 500 (5 m x 4 m)

Sub plot: Varieties

T1 – VRI-3, T2 - NRCC Sel- 2, T3 - V-7, T4 - Ullal -1, T5 - Dhana, T6 - Madakkathara-2, T7 – Ullal- 3, T8 – V-4, T9 - Bhaskara

Design: Split plot, Replication: 3

2.5.1 Growth parameters under different planting densities

Different plant density did not exhibit significant effect on plant growth *viz.,* plant height, girth and average spared of canopy. The plant height ranged from 3.96 m (VRI-3 planted at 6.5

m x 6.5 m) to 6.96 m (Madakkathara-2 planted at 5 m x 4 m spacing). The stem girth ranged from 40.17 cm (VRI-3 planted at 6.5 m x 6.5 m) to 65.25 cm (Madakkathara -2 planted at 6.5 m x 4 m). The average spread of canopy ranged from 5.21 m (VRI-3 planted at 5 m x 4 m) to 7.31 m (Ullal -3 planted at 10 m x 5 m) (Table 2.12).

Table.2.12. Effect of plant densities and varieties on morphometric characteristics of cashew

Varieties	VRI-3	Ullal-3	V4	Bhaskara	Madakka Thara-2	Sel-2	V7	Ullal-1	Dhana	Mean
Treatments-plants/ha	**Plant height (m)**									
S1-200	4.17	6.05	5.08	5.75	5.83	4.60	6.04	5.88	5.33	5.42
S2-312	3.96	5.58	5.74	5.88	6.04	4.96	4.92	5.79	5.67	5.39
S3-384	4.25	6.00	5.79	6.21	6.17	5.79	5.50	6.08	6.08	5.76
S4-500	4.08	5.88	4.83	5.75	6.96	4.38	5.50	6.58	5.96	5.55
Mean	4.12	5.88	5.36	5.90	6.25	4.93	5.49	6.08	5.76	General mean= 5.53
				CD for main plot (p=0.05)						**NS**
				CD for sub plot (p=0.05)						**0.57**
				CD for main x sub plot (p=0.05)						**NS**
	Girth of Collar region(cm)									
S1-200	46.83	61.83	52.50	60.50	63.33	47.33	62.00	58.33	61.00	57.07
S2-312	40.17	55.83	53.33	54.17	65.50	49.33	56.17	55.17	62.17	54.65
S3-384	44.83	58.50	53.67	59.17	65.17	47.33	52.33	61.33	54.17	55.17
S4-500	45.33	60.00	44.83	67.83	65.67	46.83	58.33	57.67	55.83	55.81
Mean	44.29	59.04	51.08	60.42	64.92	47.71	57.21	58.13	58.29	General mean= 55.68
				CD for main plot (p=0.05)						**NS**
				CD for sub plot (p=0.05)						**5.48**
				CD for main x sub plot (p=0.05)						**NS**
	Average spread of canopy (m)									
S1-200	5.25	7.31	6.25	6.71	5.96	6.15	7.04	7.17	6.43	6.47
S2-312	5.54	6.58	6.27	6.00	6.23	5.50	6.25	5.79	7.04	6.13
S3-384	5.52	6.63	6.58	6.75	6.38	6.04	6.33	6.46	6.83	6.39
S4-500	5.21	7.21	5.81	6.52	5.90	5.58	6.13	6.08	6.48	6.10
Mean	5.38	6.93	6.23	6.49	6.11	5.82	6.44	6.38	6.70	General mean= 6.27
				CD for main plot (p=0.05)						**NS**
				CD for sub plot (p=0.05)						**0.62**
				CD for main x sub plot (p=0.05)						**NS**

2.5.2 Effect of plant density and varieties on ground coverage

The ground coverage of different varieties planted at different densities indicated that the density of 500 plants/ha occupied highest available space (148.73%), closely followed by the density of 384 plants/ha (125.17%). The ground coverage by plant canopy was least (67.65%) under the density of 200 plants/ha. The ground coverage of canopy was influenced by different varieties. The ground coverage was highest (117.86%) with Dhana, while it was least (75.88%) with VRI-3 (Table 2.13).

Table 2.13: Effect of plant density and varieties on the ground coverage by canopy (%) (2015)

Varieties	VRI-3	Ullal-3	V4	Bhaskara	Madakkathara-2	Sel-2	V7	Ullal-1	Dhana	Mean
Treatments-plants/ha										
S1-200 1-200	43.96	84.37	61.79	73.87	55.76	62.13	78.25	82.21	66.55	67.65
S2-236	57.90	80.85	74.38	67.80	72.24	57.00	72.60	62.80	93.90	71.05
S3-384	93.29	133.31	133.28	138.28	124.62	110.99	122.77	128.30	141.73	125.17
S4-500	108.36	204.61	133.90	167.92	136.64	124.41	148.11	145.35	169.27	148.73
Mean	75.88	125.79	100.84	111.97	97.32	88.63	105.43	104.67	117.86	General Mean =103.15
CD for main plot (p=0.05)										**16.32**
CD for sub plot (p=0.05)										**21.40**
CD for main x sub plot (p=0.05)										**NS**

2.5.3 Nut yield as influenced by variety and spacing

The annual nut yield exhibited significant differences among the varieties, spacing treatments and their interactions (Table 2.14). However, among plant densities, the density of 500 plants/ha was associated with highest annual yield of 1.46 t/ha. Among the varieties, Bhaskara (1.56 t/ha) recorded the highest annual yield in the seventh harvest while VRI-3 recorded the lowest yield (1.04 t/ha).

Table 2.14. Effect of plant density and varieties on the nut yield (t/ha) (2014-15)

Varieties (Yield t/ha)	VRI-3	Ullal-3	V4	Bhaskara	Madakka Thara-2	Sel-2	V7	Ullal-1	Dhana	Mean
Treatments-plants/ha										
S1-200	0.72	1.32	1.47	1.62	1.53	0.90	1.48	1.28	1.12	1.27
S2-236	0.79	1.24	1.36	1.48	1.26	0.87	1.24	1.10	1.02	1.15
S3-384	1.25	1.41	1.50	1.57	1.41	1.25	1.44	1.54	1.54	1.43
S4-500	1.42	1.54	1.33	1.58	1.38	1.29	1.58	1.33	1.71	1.46
Mean	1.04	1.38	1.42	1.56	1.39	1.08	1.44	1.31	1.35	General mean= 1.33
CD for main plot (p=0.05)										**0.09**
CD for sub plot (p=0.05)										**0.07**
CD for main x sub plot (p=0.05)										**0.15**

Among different plant densities, density of 500 plants/ha recorded highest cumulative nut yield (7.67 t/ha), followed by density of 384 plants/ha (6.68 t/ha) (Table 2.15). The density of 200 plants/ha was associated with lowest cumulative yield of 3.54 t/ha. Increase in yield to the tune of 2.16 times under the density of 500 plants per hectare over the density of 200 plants per hectare indicates the potentiality of high density planting in cashew in the initial years of plantation. Among the varieties, Bhaskara recorded highest cumulative nut yield of 6.25 t/ha, followed by Ullal-3 (5.94 t/ha) and V-4 (5.59 t/ha).

Table 2.15. Effect of plant density and varieties on the cumulative nut yield (t/ha) (2008-15)

Varieties	VRI-3	Ullal-3	V-4	Bhaskara	Madakka thara-2	Sel-2	V-7	Ullal-1	Dhana	Mean
Treatments-plants/ha										
S1-200	2.55	3.74	3.63	4.32	3.71	3.13	3.69	3.91	3.14	3.54
S2-236	3.19	4.14	5.32	4.34	3.93	3.46	3.82	4.24	4.13	4.06
S3-384	5.78	6.73	5.54	7.36	6.50	7.77	6.49	6.57	7.32	6.68
S4-500	6.55	9.15	7.86	8.94	7.22	7.62	7.07	7.50	7.09	7.67
Mean	4.52	5.94	5.59	6.25	5.34	5.49	5.27	5.55	5.42	General mean= 1.33

2.6 Assessing relationship between Leaf Morphological/Physiological Traits and yield of cashew

Morphological and physiological parameters for 15 cashew accessions and their responses on weather parameters and yield have been studied. Average nine years data on weather and yield have been correlated with morphological and physiological traits.

2.6.1 Relationship between leaf morphological traits/growth and physiological parameters

A significant positive correlation was observed between leaf traits and growth parameters. Among leaf traits studied, leaf length, leaf width, petiole length and leaf thickness showed highly significant positive correlation with total leaf area. Leaf density showed significant positive correlation with specific leaf weight while it was significant negative correlation with specific leaf area. Leaf thickness did not show any correlation with specific leaf area (Table 2.16).

Table 2.16: Correlation between leaf traits and growth parameters

	Leaf width (cm)	Leaf size	Petiole length (cm)	Leaf thickness (µm)	Leaf density (mg/cm^3)	Leaf area	Specific leaf area	Specific leaf weight
Leaf length	0.825 **	0.271	0.984**	0.706 **	-0.145	0.669**	-0.117	0.161
Leaf width		-0.316	0.912**	0.855**	-0.080	0.739**	-0.263	0.289
Leaf size			0.097	-0.279	-0.0890	-0.156	0.236	-0.207
Petiole length				0.780**	-0.130	0.716**	-0.168	0.208

	Leaf width (cm)	Leaf size	Petiole length (cm)	Leaf thickness (µm)	Leaf density (mg/cm^3)	Leaf area	Specific leaf area	Specific leaf weight
Leaf thickness					-0.036	0.609**	-0.320	0.390
Leaf density						-0.375	-0.912**	0.904**
Leaf area							0.097	-0.083
Specific leaf area								-0.975**

* - Correlation significant at 5% **- Correlation significant at 1%

Among physiological parameters studied, chlorophyll b, total chlorophyll content and per cent water loss showed positive and negative correlation with leaf morphological and growth traits. There was no significant correlation among chlorophyll a, carotenoid content and Relative Water Content and per cent membrane leakage (Table 2.17).

Table 2.17: Correlation between leaf growth parameters and physiological parameters

	Chl b	Total chl	Carotenoid	RWC	Water loss %	% leakage	LTh	LD	LA	SLA	SLW
Chll a	-0.347	0.657**	0.428	0.167	-0.210	-0.148	0.299	0.005	0.379	-0.103	0.145
Chl b		0.477*	0.510*	-0.130	0.191	-0.195	-0.118	-0.559*	-0.082	0.580*	-0.572*
Total chl			0.812**	0.051	-0.046	-0.296	0.185	-0.444*	0.289	0.369	-0.323
Carotenoid				-0.013	0.189	-0.089	-0.149	-0.413	0.117	0.414	-0.437
R WC					-0.668**	-0.530*	0.037	-0.347	0.051	0.298	-0.301
% water loss						0.491*	-0.495*	0.311	-0.572*	-0.063	0.086
% leakage							-0.199	0.515*	-0.313	-0.398	0.393
LTh								-0.036	0.609**	-0.320	0.390
LD									-0.375	-0.912**	0.904**
LA										0.097	-0.083
SLA											-0.975**

* - Correlation significant at 5% **- Correlation significant at 1%
RWC-Relative water content; Lth- leaf thickness; LD- leaf density; La- leaf area; SLW-specific leaf weight and SLA- specific leaf area

2.6.2 Relationship between leaf traits and canopy characters

Significant correlation was observed between leaf traits and canopy characters. Among canopy characters studied, a strong positive correlation was exhibited by main shoot, lateral shoot and total leaves of lateral shoots and also flowering panicle with leaf traits. There was no relationship found between canopy spread and leaf traits (Table 2.18).

Table 2.18: Correlation between leaf growth traits and canopy characters

	MS	LS	TL	FP	LL	LW	LTh	LA	SW
CS	0.200	0.432	0.490*	0.318	0.085	0.204	0.208	0.180	0.177
MS		0.556*	0.563*	0.504*	0.476*	0.637**	0.402	0.479*	0.108
LS			0.632**	0.290	0.338	0.557*	0.446*	0.563*	0.383
TL				0.746**	0.417	0.567*	0.452*	0.493*	0.498*
FP					0.569*	0.498*	0.272	0.381	0.364
LL						0.825**	0.706**	0.669**	0.161
LW							0.855**	0.739**	0.289
LTh								0.609**	0.390
LA									-0.083

* - Correlation significant at 5% **- Correlation significant at 1%
CS- canopy spread, MS- main shoot, LS- lateral shoot, TL- total leaves
FP- flowering panicle, LL- leaf length, LW- leaf width, LTh.- leaf thickness, LA- leaf area and SW- specific leaf weight

2.6.3 Relationship between leaf morphological/growth traits and nut yield

There was significant relationship between leaf morphological/growth traits and yield. Among leaf traits studied, significant positive correlation was recorded by leaf length, leaf width, petiole length and leaf thickness but it was opposite in case of relationship between leaf size and yield. Among growth parameters studied, significant positive correlation was observed between total leaf area and yield but it was non- significant in case of SLW (Table 2.19).

Table 2.19: Correlation between leaf traits/growth parameter and yield

	Leaf length	Leaf width	Leaf size	Petiole length	Leaf thickness	Leaf density	Leaf area weight	Specific leaf
Yield	0.508*	0.715**	-0.461*	0.593**	0.645**	-0.086	0.499*	-0.282
Leaf length		0.826**	0.271	0.350	0.706**	-0.145	0.669**	0.161
Leaf width			0.305	0.448*	0.855**	-0.080	0.739**	0.290
Leaf size			-0.182	-0.072	-0.279	-0.089	-0.156	-0.207
Petiole length					0.780**	-0.130	0.716**	0.208
Leaf thickness						-0.036	0.609**	0.390
Leaf density							-0.375	0.904**
Leaf area								-0.083

* - Correlation significant at 5% **- Correlation significant at 1%

2.6.4 Relationship between physiological/ canopy characters and nut yield:

There was no significant correlation between physiological parameters and yield but it showed positive correlation with canopy characters (Table 2.20).

Table 2.20: Correlation between physiological parameters/canopy characters and yield

	Chlorophyll a	Chlorophyll b	Total chlorophyll	Relative water content	Rate of water loss	Main shoots	Lateral shoots	Total leaves of lateral shoots	Flowering panicle
Yield	0.090	-0.102	-0.002	-0.047	-0.319	0.502*	0.504*	0.496*	0.498*
Chlorophyll a		-0.347	0.657**	0.167	-0.213	0.385	0.011	0.489*	0.554*
Chlorophyll b			0.477*	-0.130	0.191	-0.339	-0.455*	-0.453*	-0.446*
Total chlorophyll				0.051	-0.043	0.088	-0.355	0.094	0.161
Relative water content					-0.668**	0.196	0.068	0.024	0.074
Rate of water loss						-0.249	-0.437	-0.369	-0.233
Main shoots							0.556*	0.563*	0.504*
Lateral shoots								0.632**	0.290
Total leaves for lateral shoots									0.746**

* - Correlation significant at 5% **- Correlation significant at 1%

2.6.5. Relationship between weather parameters and yield

There was no significant correlation between yield, and rainfall and temperature whereas it showed positive significant correlation with sunshine hours and pan evaporation (Table 2.21).

Table 2.21: Correlation between yield and environmental parameters

	Total rainfall (mm)	Average temperature (°C)	Sunshine (hours)	Pan evaporation (mm)
Yield	-0.072	-0.319	0.577*	0.566*
Total rainfall (mm)		0.027	-0.255	0.215
Average temperature (°C)			-0.300	0.442*
Sunshine (hours)				0.119

* - Correlation significant at 5% **- Correlation significant at 1%

In the present study, leaf traits, growth parameter and canopy characters showed significant relationship with yield and yield attributing characters. Therefore, it is evident that important morphological and physiological traits should be integrated together in order to study the complex mechanisms influencing biomass partitioning and yield.

2.7 Screening of cashew varieties for tolerance to salt stress:

2.7.1 Response of cashew seedlings of different varieties to salt stress

To assess the salt tolerance/susceptibility of cashew accessions, leaf discs from leaves of 4 months old cashew seedlings (6 varieties) were incubated over different concentrations of NaCl solutions *viz.,* 50, 100, 150 and 200 mM for 4 days under darkness. The extent of bleaching and chlorophyll loss was determined at the end of 4 days of salt treatments (Fig.2.1). At 200 mM salt stress, total chlorophyll content was high in Bhaskara with mean of 2.30 mg/g fresh weight and low in Vengurla-4 with mean value of 1.29 mg/g fresh weight among the cashew varieties. Bhaskara also maintained relatively higher chlorophyll stability index (81.8%) while it was low in Vengurla-4 (45.79%) (Fig. 2.2).

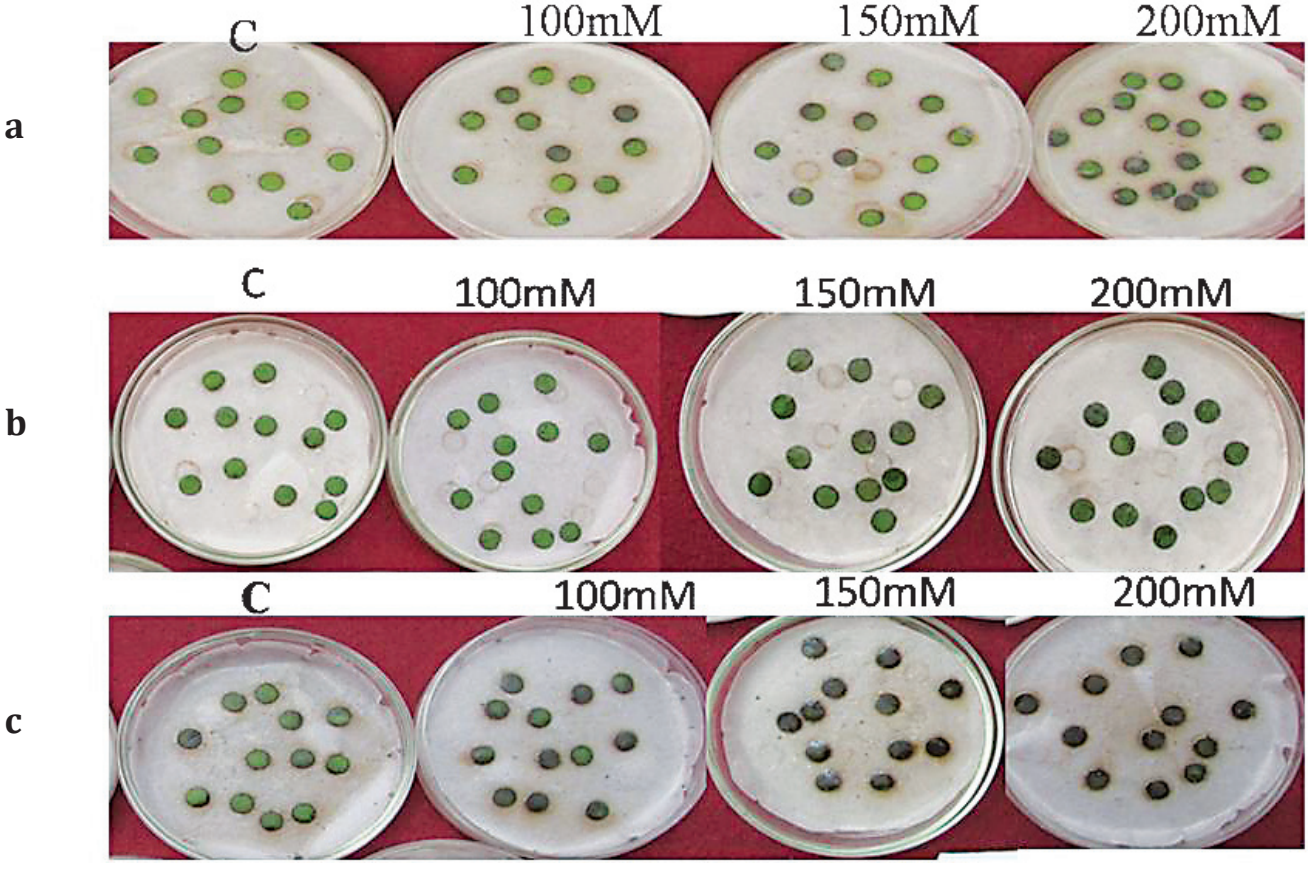


Figure 2.1: Response of cashew varieties to salt stress : a. VTH 30/4, b. Bhaskara and c. Vengurla-4. Where, C: Control, different concentrations of NaCl *viz.,* 50, 100, 150 and 200 mM.

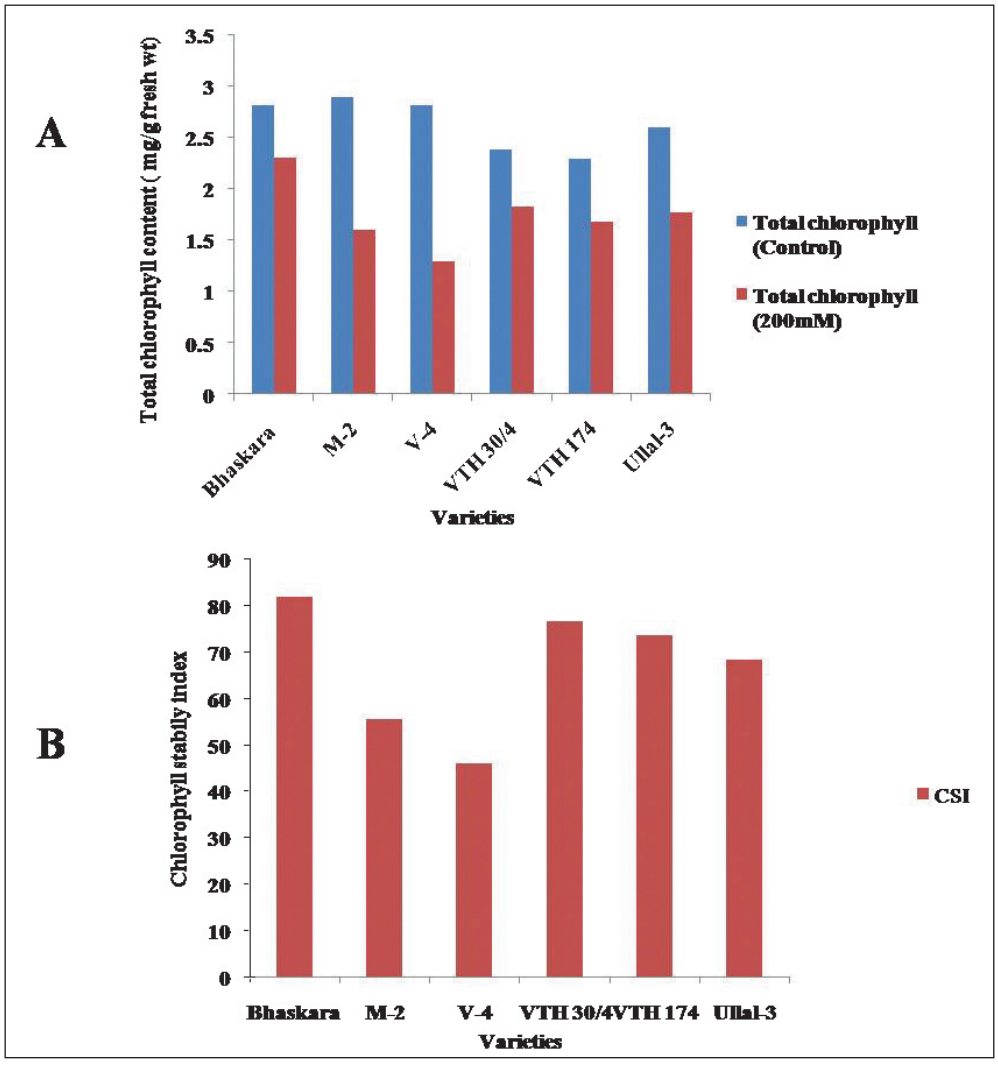


Figure 2.2: Extent of variation in total chlorophyll content of cashew varieties to salt stress. A. Total leaf chlorophyll content (mg/g fresh wt) in cashew varieties at 0 mM (control) and 200 mM (stressed) NaCl. B. Chlorophyll stability index of cashew varieties after salt stress.

2.8. ICAR Network Project on Micronutrient Management in Horticultural Crops for Enhancing Yield and Quality – Cashew

2.8.1. Preparation of district wise soil micronutrient status maps and micronutrient indexing of cashew orchards

The maps showing the spatial distribution of available micronutrients in cashew growing soils of Ratnagiri District, Maharashtra have been prepared (Fig. 2.3; 2.4; 2.5 and 2.6). 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 fertility, values between 1.5 and 2.5 considered as medium fertility and >2.5 as higher fertility. 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.

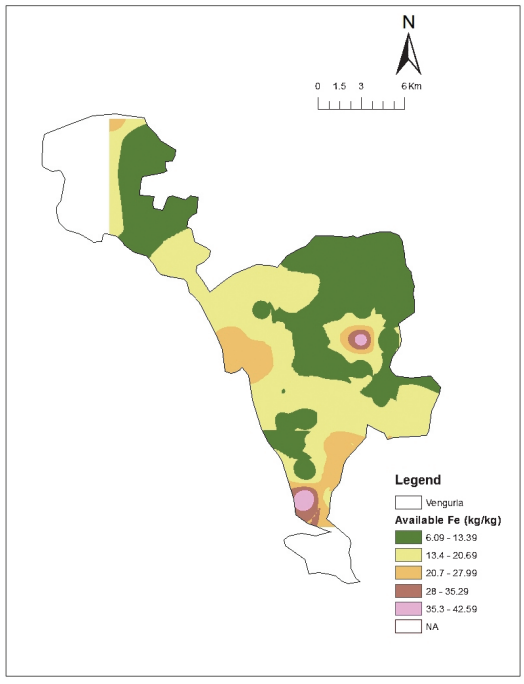


Fig. 2.3: Available Fe status map of cashew orchards of Ratnagiri district in Maharashtra

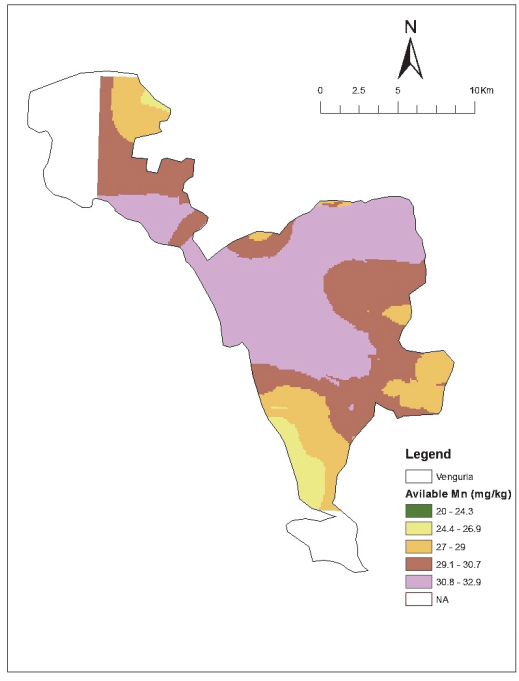


Fig. 2.4: Available Mn status map of cashew orchards of Ratnagiri district in Maharashtra

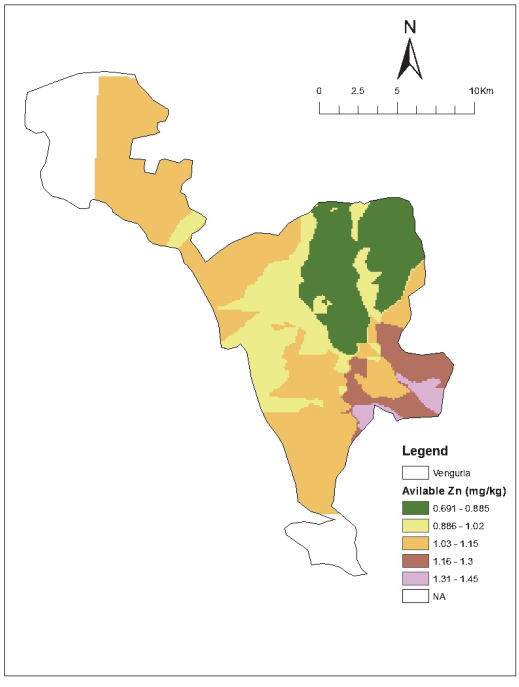


Fig. 2.5: Available Zn status map of cashew orchards of Ratnagiri district in Maharashtra

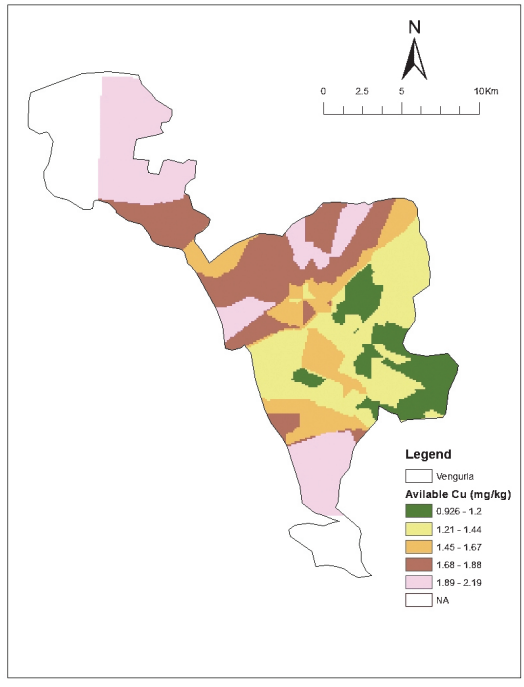


Fig. 2.6: Available Cu status map of cashew orchards of Ratnagiri district in Maharashtra

2.8.2. Micronutrient management in cashew

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 (cv. Bhaskara) were 6 years old (during first year of study) spaced at 5 m x 5 m.

The treatments were as follows:

T_1 : Boron 50 ppm

T_2 : Zinc 200 ppm

T_3 : Molybdenum 10 ppm

T_4 : Boron 50 ppm + Zinc 200 ppm

T_5 : Boron 50 ppm + Molybdenum 10 ppm

T_6 : Zinc 200 ppm + Molybdenum 10 ppm

T_7 : Boron 50 ppm + Zinc 200 ppm + Molybdenum 10 ppm

T_8 : Control.

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 (cv. Bhaskara) were initiated in the polyhouse. Cashew seedlings of two months old raised in coir pith medium with uniform height and stem diameter 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 acid washed sand had pH of 6.7 whereas, the organic carbon content, available N, P, K, Ca and Mg contents were negligible and suitable for treatment applications. Further observation on this study is in progress.

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

The rhizosphere soil samples from cashew orchards (Ten sub-samples 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 populations 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 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, which is used as an indicator of microbial activity of soil, was the 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. Similarly, 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.

3. CROP PROTECTION

3.1 Cashew Stem and Root Borer (CSRB)

3.1.1. Survey for indigenous natural enemies of CSRB

Surveys were done to identify natural enemies of the major pests of cashew *viz*., CSRB and TMB in cashew plots of ICAR-DCR and Karnataka Cashew Development Corporation (KCDC) plantations. Only *Metarhizium anisopliae* occurred on the grubs of CSRB. Particularly, trees in severe stages of infestation had grubs infected by *M. anisopliae.*

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

3.1.2. Identification, synthesis and field evaluation of volatile concentrates from frass of infested cashew trees

The frass material volatiles were concentrated by cold suction in n-hexane and dichloromethane, which were later characterised using Head-space analyser and GC-MS. Four components *viz.,* ketones, aldehydes, geraniol and butyrates were identified. These were blended in various ratios and field-tested for attraction to CSRB, using sticky cross-vane traps and bucket traps in various cashew plots having CSRB infested trees in both campuses (Kemminje and Shantigodu) of ICAR-DCR. Attraction of CSRB to these components was not recorded in field conditions and stereoisomers of these compounds are presently being evaluated under field situations.

Hanging- bucket trap fixed onto CSRB infested tree

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

Close up of Cross-vane sticky trap with bait

3.2 Tea Mosqutio Bug (TMB)

3.2.1 Assessing the diurnal rhythm of female sex pheromone activity in TMB and field evaluation of whole body extracts for field assays.

Laboratory reared virgin female bugs of *H. antonii* were used as bait in DELTA sticky traps to confirm the diurnal rhythm of attraction to males under field conditions. It was observed that the virgin females attracted highest numbers of males

(72/day/trap), while freshly mated females did not show any attraction to males. Older mated females could attract males after 3-5 days of first mating. The diurnal rhythm of attraction was observed to be during 8.30 am to 11.00 am in the mornings and during 3.30 pm to 5.00 pm during the evenings. The number of males attracted during the mornings (12-35 males/trap) surpassed the number of males attracted in the evenings (3-7 males/trap).

DELTA sticky trap with live virgin TMB female as bait

Males of TMB attracted to the virgin TMB female baited trap

3.2.2 Biology and predatory potential of the reduviid, *Sycanus galbanus* on TMB.

The reduviid predator *Sycanus galbanus* which predates on TMB in cashew ecosystem was reared on the nymphs and adults of TMB under laboratory conditions. Its biology and predatory potential on TMB were also recorded. The species had a life cycle of 68.92 ± 1.27 days, slightly male biased sex ratio (1.0 : 0.93) and had a predatory potential of 4.60 TMB adults/ nymphs/day, which was higher in comparison to the other reduviid predators on TMB. The total adult longevity was significantly higher in case of both males (74.00 ± 1.29 days) and females (81.10 ± 1.06 days). It was observed that this species does not have cannibalism tendency unlike other reduviids, which is a desirable attribute for mass multiplication.

3.2.2.1 Biology and morphology of *Sycanus galbanus* - an indigenous predator of TMB

Sycanus galbanus laid eggs on the bottom and sides of the rearing bottles and also on the underneath of muslin cloth cover. Eggs were brownish yellow in colour, endo-lateral of chorion yellow, exo-lateral brown; operculum was transparent white. Cylindrical shape, basal portion was wider than the apical portion, smooth and shiny outer surface. The operculum was extended and serrated. The fertilized egg turned reddish brown as the hatching time approached whereas the unfertilized eggs became black and shrunk after few days. The eclosion duration lasted for about 5 to 8 minutes. The egg duration was 17.00 ± 0.28 days and mean per cent egg hatchability was 95.5.

There were totally five nymphal instars with durations of 9.24±0.18, 7.72±0.22, 8.32±0.17, 10.40 ± 0.21 and 16.04 ± 0.19 days, respectively. The per cent survival was 90.24, 89.19, 95.80, 96.90 and 96.33 for the five instars respectively (Table 3.1). Body colour varied from yellow to brown with dark brown colouration at the tip of the abdomen. Ocelli were not noticeable in initial instars and were discernable in the fifth instar only. No cannibalism was observed in any of the instars.

Adults of *S. galbanus* exhibited distinct sexual dimorphism. Generally, males and females were similar in their external appearance with black body and yellow band on the wing, but varied in size and shape. Females were larger (2.8 cm length) with a round bulged abdominal base, whereas males were relatively small (2.4 cm in length) and lean, with a pointed abdominal base. The adult longevity and total duration of male lifecycle were 74.00 ± 1.29 days and 142.92 ± 2.56 days and that of female were 81.10 ± 1.06 days and 150.02 ± 2.33 days, respectively, which indicates that females survived for a longer period when compared to males.

Table 3.1: Biological parameters of *Sycanus galbanus* on wax moth larvae under laboratory conditions

Parameters observed		Duration (in days)
Incubation period (days)		17.00 ± 0.28
Stadial period (days)	I instar	9.24 ± 0.18
	II instar	7.72 ± 0.22
	III instar	8.32 ± 0.17
	IV instar	10.40 ± 0.21
	V instar	16.04 ± 0.19
I -V instars		68.92 ± 1.27
Fecundity/female (no.)		96.60 ± 5.65
Hatchability (%)		95.5
Survival rate (I-V) (%)		87.63
Sex ratio (male: female)		1:0.93
Pre-oviposition period (days)		14.00 ± 0.70
Oviposition period (days)		9.40 ± 1.20
Post-oviposition period (days)		13.90 ± 0.78
Adult longevity (days)	Male	74.00 ± 1.29
	Female	81.10 ± 1.06
Total longevity (days)	Male	142.92 ± 2.56
	Female	150.02 ± 2.33
(n=25; x ± SE)		

3.2.2.2 Predatory efficiency of *Sycanus galbanus*

The predatory efficiency of *S. galbanus* was assessed separately with different prey densities of 1,2,3,4 and 5 prey per predator for both wax moth larvae and its natural prey *Helopeltis spp.* for 5 continuous days in a 500 ml glass rearing bottles. For each experimental trial, 5 replicates were maintained. The number of prey killed was recorded at 24 hours interval. Prey number was maintained constant in the experiment by the introduction of new prey.

The following parameters were used for obtaining the 'disc' equation:

- x = prey density
- y = total number of prey killed in given period of time *(Tt)*
- y/x = attack ratio
- Tt = total time in days when prey was exposed to the predator
- b = time spent handling each prey by the predator *(Tt / k)*
- a = rate of discovery per unit of searching time *[(y/x)/Ts]*

The handling time 'b' was estimated at the time spent for pursuing, feeding and subduing on each prey. The maximum predation was denoted by the 'k' value and it was restricted to the higher prey density. 'a' was the rate of discovery and was defined as the proportion of the prey attacked successfully by the predator per unit of searching time. Assuming that the predatory efficiency is proportional to the prey density and to the time spent by the predator in searching the prey (Ts), and is expressed in a relationship as:

$$y = a\ Ts\ x \quad (1)$$

Since time available for searching is not constant, it is deducted from the total time (Tt) by the time spent for handling the prey. If one presumes that each prey item requires a constant amount of time 'b' for consumption, then

$$Ts = Tt - by \quad (2)$$

Substituting (2) in (1), Holling's 'disc' equation is arrived i.e.,

$$y = a\ (Tt - by)\ x \quad (3)$$

The data were subjected to linear regression analysis (Daniel, 1987). The reduviid killed more wax moth larvae and TMB at higher densities (Table 3.2 and Table 3.3). It exhibited a typical functional response and thus established the applicability of the second model of Holling's 'disc' equation.

Table 3.2: Functional response of *Sycanus galbanus* to TMB as prey

Prey density *(x)*	Prey attacked *(y)*	Max *'y' (k)*	Days/y *b=Tt/k*	All y's days *(b*y)*	Searching days *Ts=Tt-b*y*	Attack ratio *y/x*	Rate of discovery *{(y/x)/Ts}=a*	Disc equation *y'=a(Tt-b*y)x*
1	0.73	4.6	1.09	1.49	3.51	0.73	0.21	y'=0.81(5-1.09y)x
2	1.40			0.78	4.22	0.70	0.17	
3	1.16			0.94	4.06	0.39	0.10	
4	2.60			0.42	4.58	0.65	0.14	
5	4.60			0.24	4.76	0.92	0.19	

Table 3.3: Functional response of *Sycanus galbanus* to wax moth larvae as prey

Prey density (x)	Prey attacked (y)	Max 'y' (k)	Days/y b=Tt/k	All y's days (b*y)	Searching days Ts=Tt-b*y	Attack ratio y/x	Rate of discovery {(y/x)/Ts}=a	Disc equation y'=a(Tt-b*y)x
1	0.08	1.68	2.98	0.24	4.76	0.08	0.02	y'=1.99(5-2.98y)x
2	0.34			1.01	3.99	0.17	0.04	
3	0.82			2.44	2.56	0.27	0.11	
4	1.40			4.17	0.83	0.35	0.42	
5	1.62			4.82	0.18	0.32	1.81	

Eggs of *S. galbanus* laid on cloth

Nymphs of *S. galbanus* hatching from eggs

Vth instar nymph of *S. galbanus*

Adults of *S. galbanus* (Male-2.4 cm, Female-2.8 cm)

Predation of *S. galbanus* on TMB adult

3.3 Incidence of insect pests and their natural enemies

A total of 160 insect pests and natural enemies were documented in cashew and a set has been preserved in taxonomy collection of DCR. Occurrence of bud worms and flower eating caterpillars was comparatively high during January (Fig. 3.1), but later parasitoids had control over them. TMB incidence was low to medium compared to previous years and among the four species, *Helopeltis antonii* Sign., was the dominant. Other species like *H. bradyi* Waterhouse, *H. theivora* Waterhouse and *Pachypeltis maesarum* Kirkaldy were negligible. Maximum of 20% of eggs of TMB were found to be parasitized by *Telenomus cuspis* Rajmohana and Srikumar during December-March, 2016. Among the minor pests, thrips and apple and nut borer (ANB) were severe during January-April (Fig. 3.1). ANB incidence was up to 20%, while thrips damage was in around 40% of developing nuts. Other minor pests recorded include scale insects (*Ceroplastes sp.)*, aphids (*Toxoptera odinae* Van der Goot), mealy bugs (*Ferrisia virgata* (Cockerell)), thrips (*Scirtothrips dorsalis* Hood), ANB (*Thylacoptila paurosema* Meyrick, *Hyalospila leuconeurella* Ragonet,), slug caterpillar (*Parasa lepida*), tasar silk worm (*Antheraea mylitta* Drury), unidentified shoot beetles and flower beetles. Incidence of the scale insect was high during January on VRI-3 and Vengurla-1 in localized pockets, resulted in drying of tender shoots. But, the parasitoids (unidentified) caused 100% mortality of the scales subsequently.

Fig.3.1: Damage by apple and nut borer, thrips and flower eating caterpilars

3.3.1 Pest status of leaf miner on common varieties of cashew

Leaf miner *Acrocercops syngramma* M. (Lepidoptera: Gracillaridae) is one of the important pests of cashew (Fig. 3.2). 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. During peak pest infestation period, 100 number of miner infested leaves were collected randomly from the laterals of each variety and brought to laboratory to calculate leaf area as $Y = 0.71 * x$; R^2 value - 0.96, where, 'x' is the product of leaf length (l) and maximum width (w) following Rao and Sebastian (1994). The mean blotch area formed due to complete development of a leaf miner was also calculated variety wise using the trace paper method. To assess the pest status of leaf miner, the method developed by Jacob (1993) was adopted. The number of sample leaves observed was 150 in each variety. The total number of larvae present

in the sample leaf population was counted to work out the number of larvae in 50 leaves by using the formula: J = 50 X/n. Where, 'X' is the total number of larvae in the sample leaves, 'n' is the number of leaves in the sample. Then, minimum number of larvae required to cause a 10% loss (J_1) and 5% loss (J_2) in the photosynthetic area of 50 leaves was calculated. The value of 'J' is then compared to those of 'J_1' and 'J_2' for fixing the status of the pest. If 'J' is equal to or higher than J_1, the pest status was considered as 'high', if less than J_2, then pest status as 'low'; and if between J1 and J_2, as 'medium'.

Number of leaf miner larvae per infested cashew leaf varied widely among the varieties. A maximum of 45 larvae/leaf was recorded on Ullal-4 followed by V-7 (44 larvae), VRI-3 (41) and MDK-2 (40).

But, up to 15 and 16 larvae were seen on NRCC-Sel-2 and V-4 respectively. Within a single blotch, even up to five larvae were seen. In most of the

Fig. 3.2. Leaf miner infestation on lateral shoots

varieties, there was no significant correlation between the leaf area and the number of leaf miner larvae (Table 3.4). Mean leaf area damage (*i.e.,* a blotch) caused by individual leaf miner larva upon full development varied from 2.71 (V-1, V-4) to 3.16 cm^2 (Ullal-1) (Table 3.5). Considering the mean leaf area of infested leaves and the mean 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 V-1. Distribution of number of leaf miner larvae against the percentage of infested leaves revealed that, nearly 90 per cent of infested leaves had number of larvae between 1 and 10. Since, mean leaf area of V-1 variety itself was less compared to all other varieties, less number of larvae (17.4) would be sufficient for complete leaf damage followed by Ullal-1 and VRI-3. However in Bhaskara, mean leaf area was more (80.05 cm^2), while, the leaf area damage per leaf miner was less (2.75 cm^2), indicating that Bhaskara succumbs to less leaf miner damage followed by V- 4 and Ullal-3. The pest status of leaf miner remained as low to medium in all 11 cashew varieties (Table 3.6) during 2014-15.

Table 3.4: Correlation between number of leaf miner larvae and length, width and area of infested leaves among cashew varieties

Variety	Range of leaf miner larvae/leaf	Correlation coefficient		
		Leaf length	Leaf width	Leaf area
Ullal-1	1-24	0.236	0.306*	0.273*
Ullal-3	1-29	0.031	-0.172	-0.043
Ullal-4	1-45	0.564**	0.082	0.356**
V-1	1-35	0.014	0.041	0.001
V-4	1-16	- 0.210	- 0.272*	-0.245
V-7	1-44	0.271*	0.264*	0.247
NRCC -2	1-15	0.252	0.295*	0.285*
Bhaskara	1-32	0.304*	0.005	0.169
VRI-3	1-41	0.080	0.026	-0.007
Dhana	1-26	0.584**	0.225	0.437**
MDK-2	1-40	0.510**	0.373**	0.477**

Table 3.5: Variation in mean leaf area and leaf area damage per leaf miner among cashew

Variety	Mean leaf area of infested leaves (cm^2) mean ± SEM	Mean leaf area damage/ leaf miner (cm^2) mean ± SEM	No. of larvae required for a complete leaf damage
Ullal-1	63.42±5.82	3.16±0.18	20.1
Ullal-3	72.85±4.79	2.73±0.25	26.7
Ullal-4	67.10±3.86	3.06±0.10	21.9
V-1	47.23±3.49	2.71±0.13	17.4
V-4	75.03±8.41	2.71±0.14	27.7
V-7	80.10±5.24	3.09±0.11	25.9
NRCC -2	69.55±5.63	2.95±0.12	23.6
Bhaskara	80.05±6.24	2.75±0.16	29.1
VRI-3	62.98±4.20	3.11±0.09	20.3
Dhana	75.21±4.69	2.94±0.14	25.6
MDK-2	74.47±4.51	3.11±0.16	24.0

Table 3.6: Pest status of leaf miner among cashew varieties in 2014-15

Variety	J1	J2	Pest status in field		
			X	J	Status
Ullal-1	97.85	48.92	233	60.68	Medium
Ullal-3	130.04	65.02	213	55.43	Low
Ullal-4	106.90	53.45	187	48.72	Low
V-1	85.07	42.54	133	34.74	Low
V-4	134.91	67.45	103	26.82	Low
V-7	126.29	63.15	169	44.11	Low
NRCC -2	114.92	57.46	113	29.50	Low
Bhaskara	141.84	70.92	199	51.78	Low
VRI-3	98.73	49.36	109	28.51	Low
Dhana	124.66	62.33	219	57.07	Low
MDK-2	122.64	61.32	213	49.72	Low

3.3.2 New report - Egg Parasitoid of tropical Tasar silkworm in cashew plantations

Random surveys were undertaken at weekly intervals in cashew plantations of Puttur and Shantigodu of DCR, Puttur, Karnataka, for the occurrence of tasar silkworm from July 2014 to August 2015. Incidence of *Antheraea mylitta* was noticed on cashew between July - November, and the egg stage was seen only during July and August. Female moth laid its eggs individually both on the upper as well as under surface of young and semi-matured cashew leaves (Fig. 3.3a). Eggs laden leaves were collected from the field, kept separately in 250 ml glass containers and covered with muslin cloth. They were observed daily for any parasitoid emergence. The yellowish silkworm larvae hatched out from healthy unparasitized eggs within 6-7 days (Fig. 3.3b). Upon hatching, the larvae fed more than half the portion of chorion and gradually fed cashew leaves. Whereas, a few eggs failed to hatch in 7 days, from which, the eupelmid wasps emerged through the chorion at the lateral side of the egg by chewing out a tiny hole of 0.8 mm (Fig. 3.3c), in some cases it took nearly 20 days for parastoid emergence. The parasitoids were identified as *Anastatus leithi* (Eupelmidae: Chalcidoidea) (Fig. 3.3d) measuring 4.1 to 4.2 mm length. It is a solitary parasitoid, remained less active during 1st/2nd day after emergence, but later became very active and remained active till their death. The parasitoids actively fed the honey solution provided at 10%. A total of five parasitoids have emerged from a number of 42 field collected eggs, in which two emerged during August 2014 and the other three during August – September 2015. All the parasitoids emerged were males. They lived even up to 14 days under lab conditions when provided with a cotton swab dipped in 10% honey solution. The per cent parasitism on tasar eggs was recorded at 11.90%. In near future, these egg parasitoids may spread to other regions also and could cause considerable loss of tasar culture in our country. Hence, monitoring is required in traditional tasar growing areas for such parasitoids.

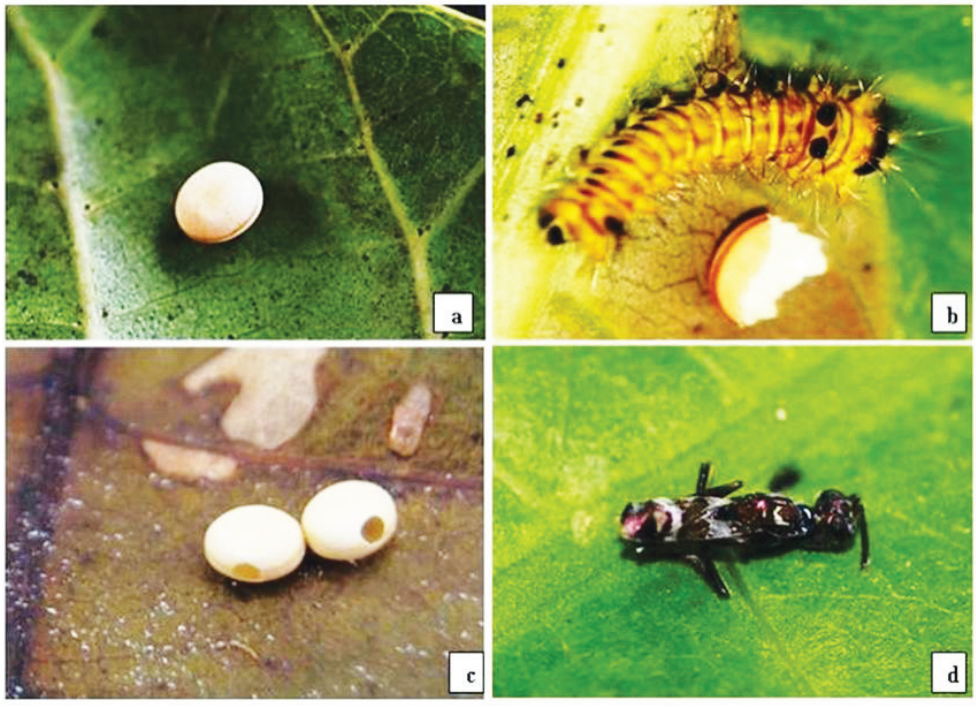


Fig. 3.3: Egg parasitoid of tropical tasar silkworm, a. Unparasitized tasar egg; b. Hatched tasar larva; c. Parasitized eggs with parasitoid emergence holes; d. Male *Anastatus leithi*

3.3.3 Pests of weed species

Insect pests on certain common weed species of the cashew plantations have been documented (Fig 3.4 a-h). Shoots of *Terminalia paniculata* young plants were found to be damaged by chrysomelid beetles namely, *Cryptocephalus bisexsignatus* and *C. sexsignatus* (Fig.3.4b) 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 (Fig.3.4c). The galls were sac like, sub-globose, and were unevenly thick. Some of the leaves almost turned into a mass of gall with hardly any portion of normal lamina left which later turned into brown colour and dried. Inside the leaf galls, three insect species namely a thrips, *Scirtothrips dorsalis,* and two wasps, *Megastigmus viggianii* and *Systole calycopterae* were seen. Besides galls, bark damage by a long horn beetle, *Celosterna scabrator* was also seenon *G. floribunda* (Fig.3.4d). The adult fed on the bark of young plants and caused death or breakage of the shoots.

Shoots of another common weed, *Chromolaena odorata* were found to be severely infested by *Aphis* sp. (Aphididae) during July-October which caused severe distortion of affected shoots and leaves. Upon severe infestation, plants remain even stunted (Fig. 3.4a). But soon after 2-3 weeks, aphid population was controlled by parasitoids and large number of predators like coccinellids and syrphids within a short period (Fig. 3.4a). The milk weed, *Calotropis gigantea* was found to be infested by many insect pests like *Corynodes peregrinus, Sebaethe indica, Erthesina fullo, Spilostethus* sp., *Leptocorisa acuta, Aphis nerii, Aulacophora foveicollis, Anosia chrysippus* etc. between May-July during all the years (Fig. 3.4g and h). Likewise, caterpillars of *Catopsilia crocale* were found defoliating severely on *Cassia alata* during July-September. Up to 25 eggs were seen on a compound leaf and the caterpillars fed

gregariously on the tender leaves leaving alone the midrib (Fig.3.4e). Larval and pupal periods were 8-9 and 6-7 days, respectively. Similarly on *Spermacoce* sp., severe defoliation was resulted by a chrysomelid beetle namely *O. bipunctata* (Fig. 3.4 f).

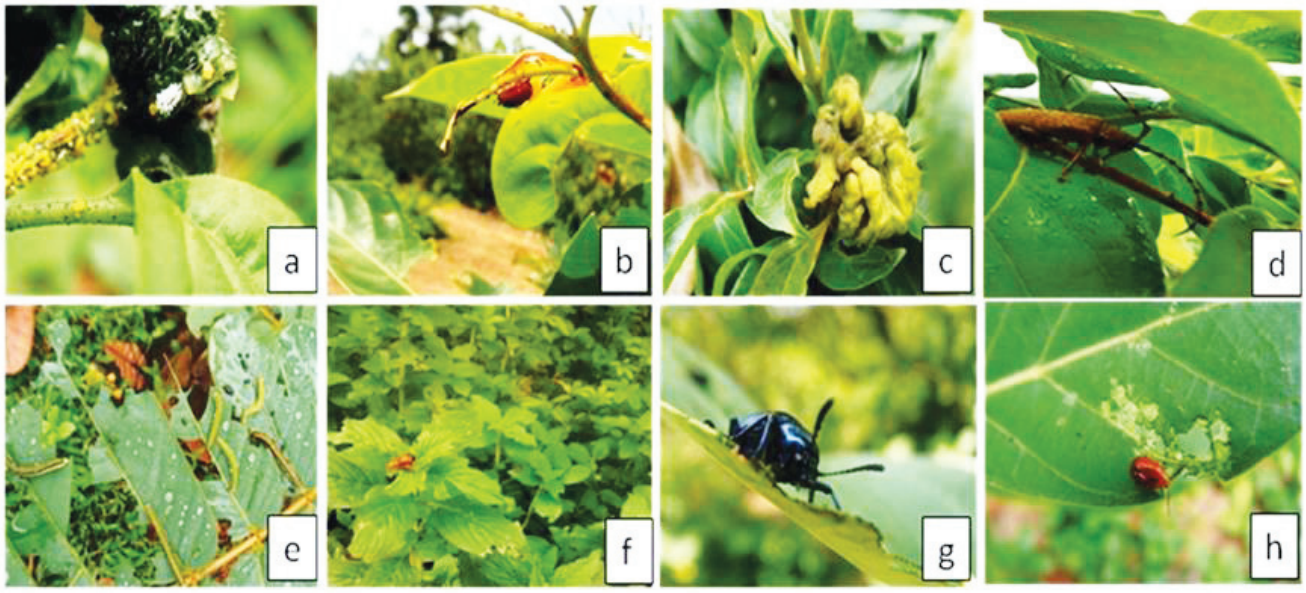


Fig. 3.4: Pests of weed species, a. *Aphis* sp. damage on *C. odorata*; b. *Cryptocephalus* sp. on *T. paniculata*; c. Leaf galls on *G. floribunda;* d. *C. scrabator* damage on *G. floribunda;* e. *C. crocale* damage on *C. alata;* f. *O. bipunctata* damage on *Spermacoce* sp.; g. *C. peregrines* damage on *C. gigamtea*; h. *S. indica* damage on *C. gigantea.*

The results showed that, severe defoliation caused by insects on certain weeds namely, *C. crocale on C. alata and Cryptocephalus bisexsignatus* and *C. sexsignatus* on *T. paniculata* can be exploited for biological control of these weed species. The study also suggests importance of weed management in cashew pest management.

3.4 Natural enemies of cashew pests

3.4.1 Diversity of mantid fauna in cashew plantations

In the cashew plantations, praying mantids are also one of the predators of cashew pests. The prey insects of most praying mantids include tea mosquito bug, leaf beetles, weevils, many dipteran flies, leaf and panicle feeding lepidopteran larvae, hoppers, cow bugs, ants, grass hoppers, moths and hemipterans. A total of 16 species of praying mantids, belonging to seven families and ten sub families were recorded to occur on cashew plantations of Puttur and Shantigodu regions of Karnataka. All-out-reach method was followed to find and collect praying mantids of different stages throughout the cashew plantations including tree base, litter, trunk, canopy of cashew trees, common weed plants inside the cashew plantations as well as wire fences around the plantations. Based on the number of occasions each mantid species was noticed, they were grouped into categories as, common (> 25 occasions), moderate (10-24), occasional (3-9) and rare (1-3).

Out of 16 species recorded, four mantid species namely, *Creobroter apicalis, Euantissa pulchra, Eomantis guttatipennis* and *Statilia maculata* were already reported from Karnataka, while ten mantid species were reported for the first time in Karnataka state but two species are yet to be identified (Table 3.7). Among the families, Hymenopodidae and Mantidae were the dominant, represented by five species each while, Iridopterygidae, Liturgusidae, Tarachodidae, Empusidae and Toxoderidae were represented by single species only (Fig. 3.5). Observations revealed that, though activities of praying mantids were

noticed throughout the year in cashew plantations, activity was very less during May-June. Nymphs and adults of various mantid species were sporadically noticed from the mid rainy season (July) to summer season (April), while mantids were frequent during flushing and flowering periods of cashew. During the onset of monsoon (June), adults of *Leptomantella parva* and *E. guttatipennis* were seen, while in July, *Amantis fumosa, Gongylus gongylodes, Ambivia undata, C. apicalis* were also noticed (Table 3.8). During the present survey, stages of *C. apicalis* and *E. pulchra* were recorded from September to April and August to June, respectively. Both the bark mantises, *H. similis* and *E. lata* were noticed throughout the year.

Different niche requirements were noticed for different praying mantid species. Among the mantids, *E. pulchra* and *E. pictipes* dominate the canopy area, while, *H. similis* dominates the trunk region of cashew. Though most species were noticed on canopy region of cashew, especially on tender shoots and leaves, two species were noticed on panicles, two on trunk, and two on ground. However, activities of *Amantis fumosa* were noticed only during night, and specimens were collected near the light source. There was variation in the colour and size of both male and female mantids of each species.

In most species, the female mantids were generally larger than the males, except *E. lata* and *H. similis.* Among the mantids recorded, *G. gongylodes* was the biggest (8.9 cm long female), followed by *H. membranacea* (8.0 cm long female) and *A. undata* (7.1 cm female). The smallest mantid species were *A. fumosa* (1.5 cm female), *Elmantis lata* (2.0 cm long female) and *Euantissa pulchra* (2.0 female). Oothecae of *E. pictipes, H. brunneriana, H. membranacea, E. pulchra, E. guttatipennis* and *L. parva* were noticed on shoots as well as leaves of cashew. However, oothecae of *E. lata* and *H. similis* were noticed on cashew trunk region, compound walls, fence stones, building walls etc. Nymphs of *H. brunneriana* were also noticed commonly on some weeds *i.e.*, *Getonia floribunda, Terminalia paniculata* and *Ixora* sp inside the cashew plantations. Different species of mantids are shown in Fig. 3.6.

Table 3.7: Mantid fauna recorded in cashew plantations of South West Karnataka

Scientific name of the species	Abundance		
Ephestisula pictipes (Wood-mason, 1879)*	Common	Acromantinae	Hymenopodidae
Ephestiasula sp.	Rare		
Hestiasula brunneriana Saussure, 1871*	Common		
Euantissa pulchra Fabricius, 1787	Common		
Creobroter apicalis Saussure, 1869	Moderate	Hymenopodinae	
Hierodula membranacea Burmeister, 1838*	Moderate	Paramantinae	Mantidae
Statilia maculata Werner, 1935	Occasional		
Elmantis lata Mukherjee & Hazra, 1983*	Moderate	Amelinae	
Amantis fumosa (Giglio-tos, 1915)*	Rare		
Ambivia undata Fabricius 1793*	Rare	Vatinae	
Leptomantella parva (Werner, 1933)*	Occasional	Caliridinae	Tarachodidae
Eomantis guttatipennis Stål, 1877	Occasional	Tropidomantinae	Iridopterygidae
Humbertiella similis Giglio-tos, 1917*	Common	Liturgusinae	Liturgusidae
Gongylus gongylodes (Linné, 1758)*	Rare	Empusinae	Empusidae
Toxoderopsis sp.*	Rare	Toxoderinae	Toxoderidae
Unidentified sp.	Rare	-	-

* = Species not reported earlier in Karnataka. - = Unknown

Table 3.8: Seasonality, colour, size and niche of praying mantids recorded in cashew plantations

Species	Period of occurrence	Niche	Mean Adult size (cm)		Colour of nymph / wing colour in adult	Oothecae	
			Female	Male		Size (cm)	colour
Ephestisula pictipes	August-March	Leaf	2.4	2.1	Green; brown	1.8 x 0.55	Creamy yellow
Ephestiasula sp.	April- July	Leaf	-	2.2	Brown	-	-
Hestiasula brunneriana	Throughout the year	Leaf and Weeds	3.2	2.4	Shiny green with Grey patches	1.3 x 0.7	Brownish white
Hierodula membranacea	June- April	Leaf, panicles	8.0	7.6	Yellow; Green	4.2 x 1.8	Whitish Brown
Creobroter apicalis	June- April	Shoot, Panicles	3.5	-	Green with yellow and pink markings	3.3 x 0.3	Brownish*
Euantissa pulchra	August- June	Leaf	2.0	1.7	Green with pink border	1.8 x 0.55	Creamy yellow
Humbertiella similis	Throughout the year	Bark, compound walls, buildings	3.5	3.85	Brownish Grey	1.6 x 1.0	Whitish grey
Elmantis lata	Throughout the year	Bark, compound walls	2.0	2.6	Black with specks in? Rudimentary in?	0.6 x 0.45	White
Leptomantella parva	October-May	Leaf	3.3	2.8	Green	0.45 x 0.3	Light Brown*
Amantis fumosa	July-April	-	1.5	1.3	Black	-	-
Eomanits guttatipennis	June-April	Leaf	3.2	2.4	Green	3.0 x 0.2	Canary yellow
Gongylus gongylodes	July-October	Ground	8.9	-	Yellowish brown	-	-
Statilia maculata	January-April	Ground, leaf	5.3	4.4	Green; yellow; Brown	2.1 x 0.7	Creamy white
Toxoderopsis sp.	April-November	Leaf	-	-	1st instar nymph-long, lean, grey in colour	1.2 x 0.5	Brownish yellow*
Ambivia undata	July-September	Leaf	7.1	-	Grey with black patches	-	-
Unidentified sp.	April- May	Leaf	-	-	Chocolate brown Nymph	-	-

*= Ootheca with a slender hornlike projection at one end, - = details not recorded

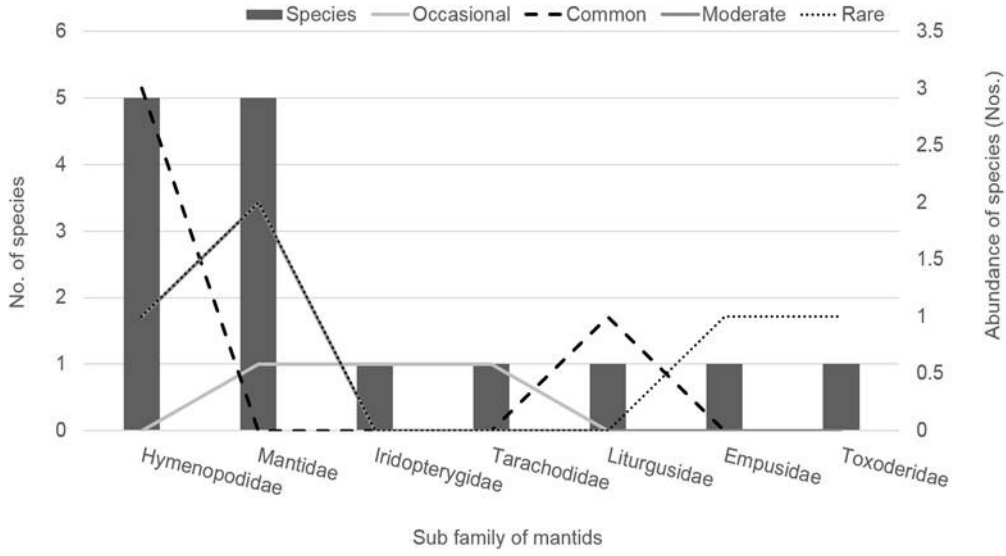


Fig. 3.5: Species richness and abundance of praying mantises across different families of praying mantises

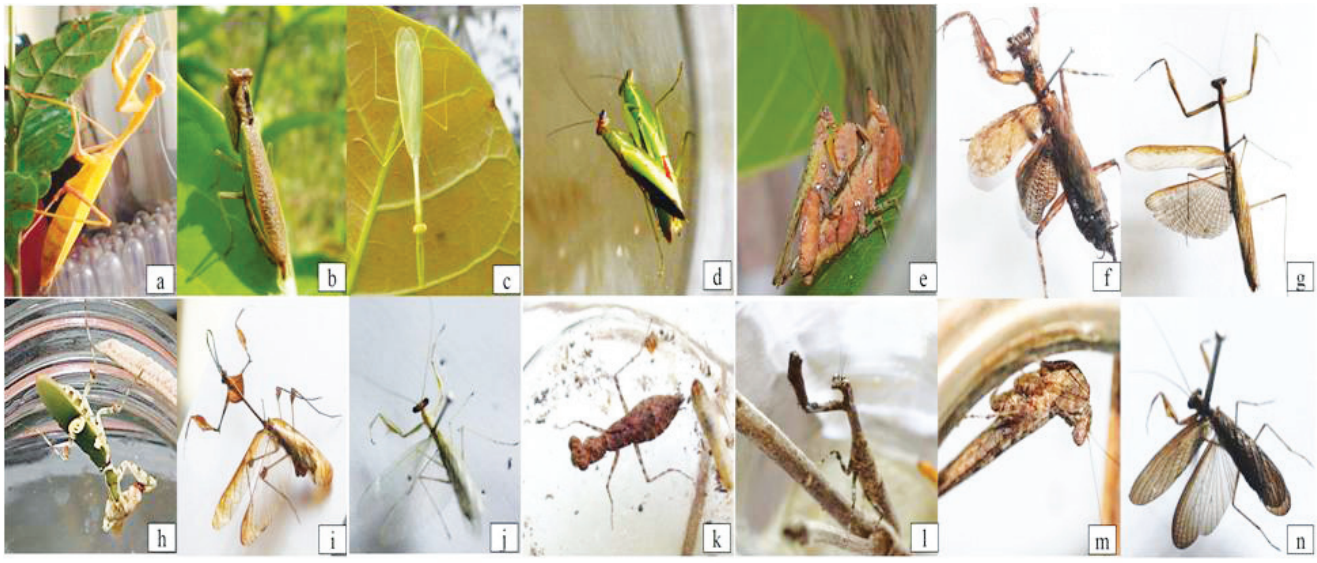


Fig. 3.6: Adult praying mantises, a. *Hierodula membranacea;* b. *Ephestiasula pictipes*; c. *Leptomantella parva*; d. Mating pair of *Euantissa pulchra*; e. Mating pair of *Hestiasula brunneriana*; f. *Humbertiella similis*; g. *Statilia maculata*; h. *Creobroter apicalis*; i. *Gongylus gongylodes*; j. *Eomantis guttatipennis*; k. *Elmanits lata*; i. *Ambivia undata*; m. *Ephestiasula* sp.; n. *Amantis fumosa*.

3.5 Pollinators of cashew

The flower visitors of cashew and a few common plants submitted at University of Agricultural Sciences, GKVK, Bengaluru were got identified. Among the bees, *Pseudapis* sp., *Braunsapis* sp., *Apis cerana indica*, *Ceratina* spp., *Seledonia* sp. and *Lasioglossum* sp. were recorded as frequent visitors of cashew flowers for pollen and nectar (Fig. 3.7). *Pseudapis* sp, *Braunsapis* sp. *Seledonia* sp. and *Ceratina* spp. had higher pollen

load per insect compared to *Apis* spp. Bee bowls of different colours and sizes were kept again in cashew plantations to record the diversity of pollinators.

Fig. 3.7: Bee foraging on cashew inflorescence (from left) *Seledonia* sp. and *Pseudapis* sp.

Foraging period and activity of certain pollinators have been recorded at preliminary level. Foraging activity started from 9.00 - 9.30 am onwards on cashew depending on the sunshine, but peak activity was observed between 10.00 to 12.00 Noon. Though *Apis cerana indica* visited flowers up to 5.30 pm, it mainly visited for nectar, which accidentally pollinated the hermaphrodite flowers as well. Attempts have been made to assess the peak foraging period of bees and pollination efficiency in cashew on the selected panicles by covering of panicles by nylon net bags, hand pollination and open pollination. Nesting sites of *Braunsapis* sp. *Ceratina* spp., and *Seledonia* sp. have been located in the dried twigs of cashew (Fig. 3.8c). While, nests of *Pseudapis* sp. was noticed in the barren lateritic soil. Attempts have been made to establish a colony of *Apis cerana indica* during cashew flowering season at Shantigodu. The colony established well with broods, showing the possibility of bee keeping in cashew plantations provided other pollen and nectar sources are also available.

Fig. 3.8: a. Pollen grains loaded on *Pseudapis* sp. after foraging; b. Pollen grains deposited on stigma after bee visit; c. Nest of *Braunsapis* sp. in a dried cashew shoot.

3.6 Survey and surveillance of important diseases of cashew

Cashew plants in DCR research plots were observed periodically for different diseases. The incidence or severity of diseases was recorded.

3.6.1 Wilt or rot disease

Wilt or rot disease was observed in 'Seed Orchard' and 'Apple evaluation plot'. The disease was noticed during rainy season (June- September). Initially the infected plants showed yellowing of older leaves and later the yellowing spread to young leaves as well (Fig 3.9). In advanced stage, the infected plants showed complete yellowing, leaf fall and death. The disease incidence ranged from 1 to 5%. The disease may be caused by *Pythium* sp. or *Phytophthora* sp. Bordeaux mixture (0.1%) application at initial stage of infection was found effective to check the disease.

Fig. 3.9: Seedling infected with wilt disease.

3.6.2 Black leaf spot or black mold disease

Black mold disease was noticed in 'Apple evaluation plot'. Symptoms of the disease were black to dark brown spots (colonies) on the leaves (Fig. 3.10), yellowing of foliage, leaf fall and shortening of internode length. It is considered to be caused by *Pilgeriella anacardii,* which is an obligate parasite. The disease occurred during September and severity was 1.0 - 60%. Severity of scoring of different germplasm lines indicated that the lines viz., NRC 301, NRC 75 and NRC 176 were less infected (<10.0%) while NRC 183 was severely infected (67.20%).Spraying of Bordeaux (0.1%) was found effective to control the disease.

Fig 3.10: Black leaf spot disease caused by P. anacardii

3.6.3 Sooty mold disease

The disease is caused by *Capnodium* spp. and presence of black powdery superficial spots on leaves has been typical identification symptom (Fig. 3.11). Disease was observed invariably in all seasons. However, the incidence was less during rainy season as powdery spots were washed easily by rain water. The disease is considered to be of minor importance.

Fig. 3.11: Sooty mold disease

3.6.4 Red rust disease

The disease is caused by red algae, *Cephaleuros* sp. It was identified by presence of orange to red colour spots on leaves (Fig. 3.12). It was noticed during rainy season and severity of disease was very less.

Fig 3.12: Red rust disease

3.6.5 Die back of shoot/twig rot/gummosis disease

Disease was observed in young orchards (Apple evaluation and Showcasing plots). The disease symptoms were die back of shoot tip, twigs and branches, the infected stems showed dark colour swelling with cracks and oozing of gummy exudates/transparent resins like fluid from the cracks (Fig 3.13a and b). The disease is considered to be caused by *Lasiodiplodia theobromae* (*Botryodiplodia theobromae*). The disease was severe during flushing stage (September-October) and the severity was ranged from 16 to 25%. Disease severity scoring of different germplasm lines indicated that none of the lines were free from the disease. Attempt is being made to isolate and identify the causal agent responsible for the disease.

Fig. 3.13 a: Die back of shoots/twigs

Fig. 3.13 b: Gummosis on stem

3.6.6 Inflorescence drying/die back disease

Inflorescence drying/die back disease was observed in all orchards (Apple evaluation, NCGB, DTD and Showcasing blocks). Characteristic symptoms observed for inflorescence blight were initially water soaked lesions on rachis and secondary rachis and later they became brown to black colour, gummy exudations from lesions and drying of floral branches, withering of floral parts and progressive die back of inflorescence (Fig. 3.14a and b). The disease was observed during January to March.

Observations on inflorescence drying of different accessions indicated that the severity of drying ranged from 9 to 30% among the accessions. However, the severity was more in NRC 301, NRC

140, NRC 176 and NRC 175. It is considered to be caused by *Gloeosporium mangiferae* and *Phomopsis anacardii* in association with Tea mosquito bug (TMB), *Helopeltis antonii.* Hence, apart from attempting to isolate the pathogen(s) responsible for the disease, a field trial was initiated to ascertain the association between the TMB and disease. Treatments such as i) Caging with nylon mesh and insecticidal spray (Lambda Cyhalothrin 0.003%); ii) Fungicidal spray (Mancozeb 0.2% + Carbendazim (0.1%); iii) Caging with nylon mesh; iv) Control, were imposed on four accessions NRC 301, NRC 140, NRC 176 and NRC 175 and observations on TMB and disease incidences are being made at periodical intervals.

Fig. 3.14a: Inflorescence drying

Fig. 3.14b: Inflorescence die back.

3.6.7 Nut rot disease

The disease symptoms observed initially were water soaked lesion or spot at base of the nut where it has attached and later symptoms spread to entire nut (Fig. 3.15). Finally the infected nuts become rotten and dried. Sometimes the infected nut became shriveled. The disease was observed in Showcasing block especially in H-130 and incidence was 20-40%. The disease was noticed during February.

Fig. 3.15: Symptoms of nut rot

During 2015-16, periodical observations on diseases of cashew indicated that seven diseases *viz*., wilt or rot, black leaf spot, sooty mold, red rust, die back of shoot/twig rot/gummosis, inflorescence drying/die back and nut rot occurs in different growth period of the crop (Table 3.9). Among the diseases, black leaf spot, die back of shoot/twig rot/gummosis disease and inflorescence drying/ die back disease have been found to be severe across the cultivars/lines while nut rot disease has been specific to certain line/hybrid.

Table 3.9. Periodical observations on diseases of cashew

Disease	Incidence/Severity range (%)	Period of occurrence	Remark
Wilt or rot disease	1- 5	June - September	Affect young orchard plants of <5-6 year old.
Black leaf spot	1-60	September	Affect all age plants but cause economic yield loss in young plants of <5-6 year old. Differential resistance has been observed.
Sooty mold	Less	All seasons but less during rainy season.	Minor disease
Red rust	Less	During rainy season	Minor disease
Die back of shoot/ twig rot/gummosis disease.	16 to 25	September-October	Affect all age plants but incidence is less in adult plants. Rare to find resistance source.
Inflorescence drying/die back disease.	9 to 30	January to March	Affect all age plants. Differential resistance has been observed. May cause economical yield loss.
Nut rot disease	20-40	February	Specific to certain variety/hybrid. May cause economical yield loss.

A Plant Pathology lab was established with certain facilities such as working platform, exhaust fans, mini autoclave, microwave oven, magnetic stirrer, pH meter, and refrigerator.

4. POST-HARVEST TECHNOLOGY

4.1 Design development of solar tunnel dryer for raw cashewnut and apple

Certain structural changes *viz*., air exhaust, lateral air vents and black ground surface have been provided to improve the efficiency of Poly House Solar Tunnel Dryer (PHSTD), accounting the resultant data of no load test conducted with the dryer. In view of differential rate of drying cashew apple slices, sensor based environment control assembly is designed to generate vapour pressure difference to enhance moisture diffusion from slices. This also aids in induced air flow inside the natural convection solar dryer to overcome the problem of low buoyancy. Phenolic compound present in cashew apple is the major hindrance in utilizing it either for food or feed. As the final product, cashew apple powder without tannin is warranted, detanning is carried out with either Poly Vinyl Pyrollidone (PVP) or Gelatin or Sodium Chloride (NaCl). Drying characteristics of treated and untreated cashew apple slices (cv. Bhaskara) revealed that the diffusion of moisture found to be faster in the case of untreated slices (Fig. 4.1) followed by slices treated with NaCl and PVP of different concentrations, but the changes are non-significant.

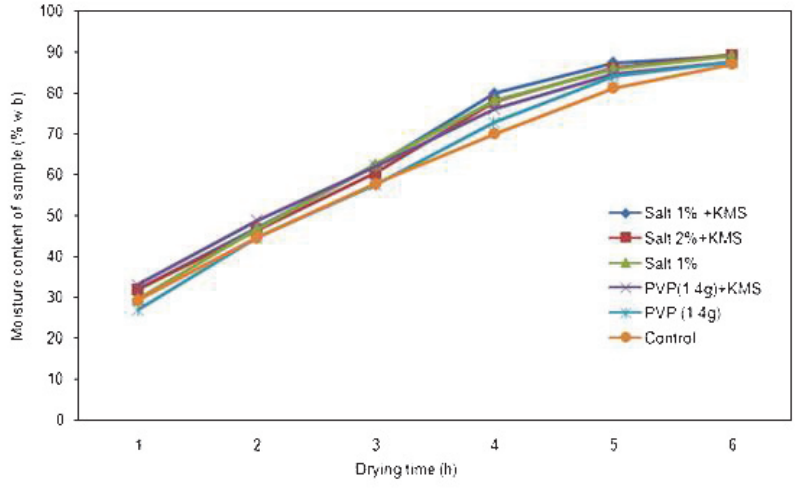


Fig. 4.1: Drying characteristics of tretaed and untreated cashew apple slices

Cashew Apple Powder (CAP), thus generated is analyzed for reduction in tannin and retention of ascorbic acid. Quality analysis of CAP prepared after solar drying revealed that tannin reduction observed to be maximum for the slices treated with NaCl (190 mg L^{-1}) (Fig. 4.2) followed by PVP and Gelatin. Similarly, NaCl treatment could retain maximum Vit. C (63%) (Fig. 4.3) than other treatments investigated.

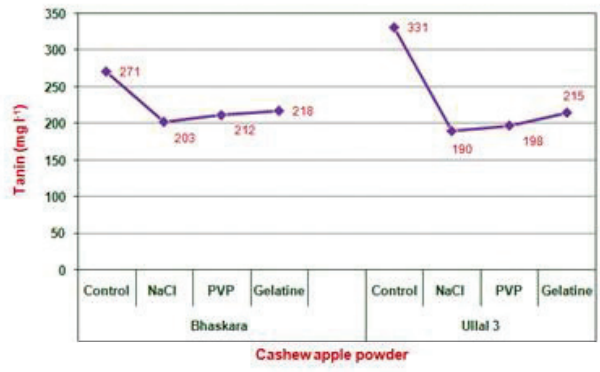


Fig 4.2: Reduction of tannin in untreated and treated CAP

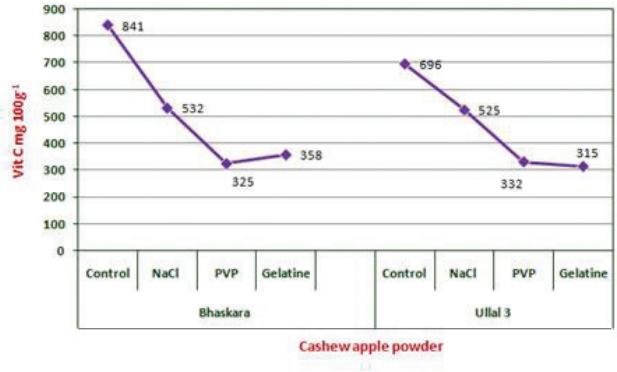


Fig. 4.3: Retention of Vit. C in untreated and treated CAP

In order to investigate the effect of size reduction on drying rate of cashew apple and associated problems of size reduction, ground cashew apple (paste), cashew apple cubes (≤ 1.0 cm3) and cashew apple slices having 1-2 mm thickness were dried under solar dryer. Rate of drying cashew apple paste found to be faster than cubes and slices. But the resultant product found to be sticky and developed problems during pulverization. Although, cube like pieces dried faster, but, non-uniform drying was noticed. Diffusion of moisture found to be uniform and the physical quality of end product showed better results for sliced cashew apple. An attempt has also been made to prepare cookies using CAP as substitution i.e. 30% of the main ingredient. Scientist (Animal Nutrition and Feed Technologist), Kerala Veterinary and Agricultural Sciences University, Kerala had been contacted for extended investigation of CAP as an admixture in animal feed and its effect on milch animals. Exploring the possibility of external funded project for detailed investigation as suggested.

4.2 Developing quality standards for raw cashewnuts

In view of poor response through e-mail contact, cashew processor, traders, farmers, organizations located in selected districts of Karnataka (Dakshina Kannada), Kerala (Kollam) and Tamilnadu (Panruti) were visited personally for want of information. Based on the information provided, certain problems have been identified (Table 4.1) which needs to be refined or revised, to develop a common standard/technique to assess quality of raw cashewnuts convenient to all stakeholders in the cashew supply chain.

Table 4.1. Status of assessing the quality of raw cashewnuts and inherent problems

Existing quality parameters	Inference	Problem identified
Number of nuts per kilo	Weight of the nuts.	Represent the weight of the nuts rather than size of the nuts. It is assumed that nut size is correlated to weight. As such there is no correlation between length, width, thickness representing the size and the weight of the nuts.
Surface colour of the nuts	Maturity of the nuts and nuts representing storage period (Fig. 4.4).	Highly subjective as no standards are available.

Existing quality parameters	Inference	Problem identified
Outturn	Assessing the quantity and quality of the edible portion of the nut i.e. kernel.	Normally inner quality of the kernels (when split into two) is assessed. But ultimate aim in cashewnut processing is the extraction of whole kernels and its quality is assessed based on surface characteristics rather than inner quality. Refined technique needs to be devised.
Representation of Outturn	Computed for 80 kg bags and represented in pounds (British standard).	Presumed to be a complicated calculation.
Identification of defective nuts	To work out the Kernel Percentage Recovery (KPR) at packaging and to estimate economic returns.	Standard protocol is not available for assessing physical quality of defective nuts. A portion of defective nuts in the range of 25-50% is accounted for outturn computation. Methodology differs with agents certifying the quality.
Moisture content of raw cashewnuts	Available moisture in raw nuts to either dry further or transport to storage system to improve its shelf life and keep stock for lean period.	Unscientific method of rubbing between the palm of the hand is followed (Subjective). Presently available moisture meter for agricultural commodities found to be unsuitable for raw cashewnuts.
Sampling of raw cashewnuts.	Drawing samples for quality assessment	Subjective and various methods are followed without any statistical technique.
Contribution of quality parameters.	To compute sale price for Raw cashew nut.	Only number of nuts and outturn is used and it is subjective (Intermediaries role decides the market).

Fig. 4.4: Variation in surface colour of the raw cashewnuts with reference to storage period

Among the parameters which influence the quality of cashew, primarily three parameters *viz*., Moisture Content (MC), Outturn (OT) and Nut Count (NC) are considered utmost importance to assess the quality and certain reputed agencies are engaged in certifying the quality. Normally imported nuts undergo testing before procurement and this procedure is seldom followed for domestic nuts. Sampling, methodology and instrumentation to assess the quality have been identified as areas needing immediate attention.

Technical survey report indicated that determining moisture content of raw cashewnuts is of prime importance than other parameter considered influencing the quality of raw cashewnuts during harvest, transportation, storage and processing. Understanding the crux of the problem, a private company is contacted i.e. M/s EMCON, Kerala to develop non-destructive, non-chemical and on-the-site measuring device. MoU has been prepared to take up collaborative research work in consultation with the private partner. Preliminary work on these lines initiated and anticipating administrative approval for collaborative research work.

In order to assess the quantum of defective nuts due to insect infestation in the bulk of cashewnuts, raw nuts harvested during the season at both the farms of this Directorate assessed for its quality in terms of good nuts, infected nuts, count, shelling outturn etc., Damage of three different pests viz., Tea Mosquito Bug (TMB), Thrips and Apple and Nut Borer (ANB) (Fig. 4.5) were assessed at preliminary level in the field harvested raw cashewnuts collected from the farms of this Directorate.

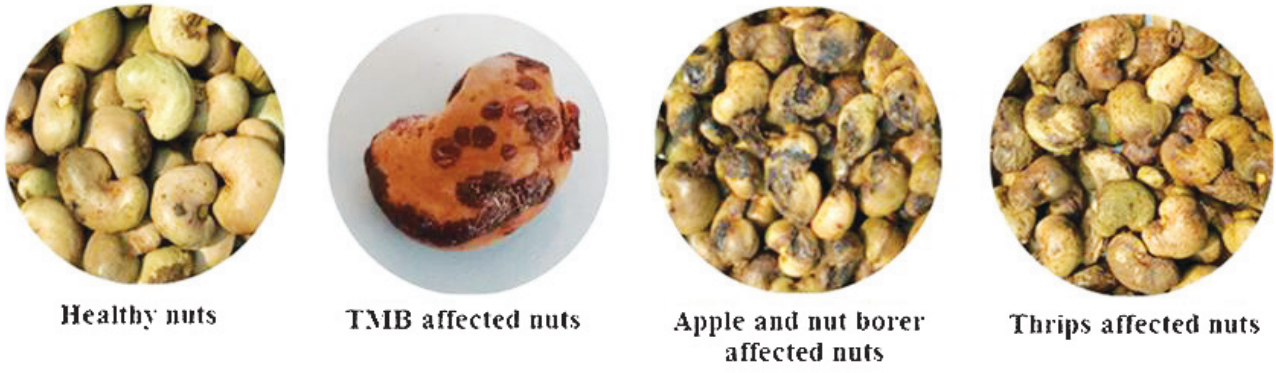


Fig. 4.5: Comparison of healthy and defective raw cashewnuts

Among the pests investigated, nut damage caused by Thrips was high (27%) followed by TMB (8.5%) and ANB (6.3%). Kernel damage found to be high in ANB infested nuts wherein 10% and 17% of total ANB infested nuts had shriveled and brown patched kernels (Fig. 4.6).

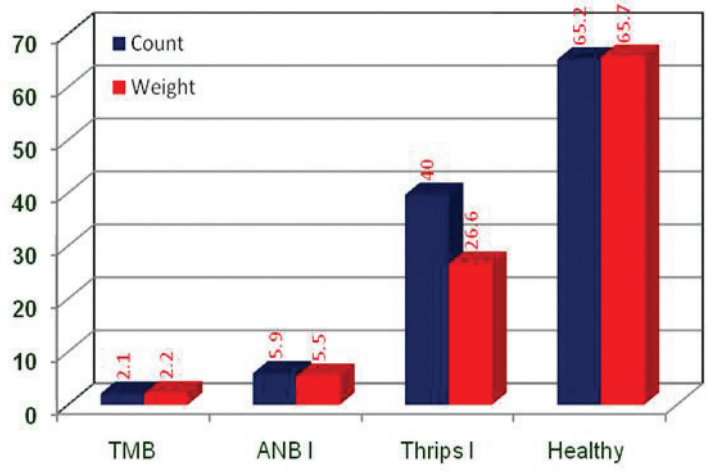


Fig. 4.6: Proportion of healthy and defective nuts harvested from farm (ICAR-DCR, Puttur)

4.3. Design and development of mechanical slicer for cashew apples

Firmness of cashew apples of different varieties harvested at six different growth phase from peanut stage to fully ripened stage (Fig. 4.7) is determined using texture profile analyzer in terms of bio-yield point.

Fig. 4.7: Various stages of cashew apple from peanut to ripened stage

On an average firmness of the cashew apple found to be in the range of 0.68 to 1.28 kg force irrespective of varieties and growth stage. Obviously, firmness of fruits has increased towards maturity phase or ripening. Among the varieties selected, Ullal 1 offered more resistance for penetration by the P 10 cylindrical probe and on the other hand, VRI 3 resulted as highly firm fruit (Fig. 4.8).

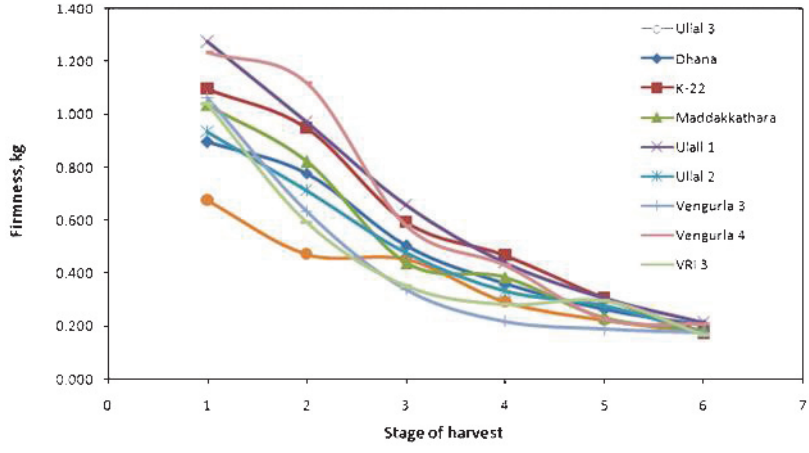


Fig. 4.8: Firmness of cashew apple of different varieties harvested at different stages

Comparing the rotational disc type blade and vertical reciprocating serrated blade employed for cutting or shearing food products, former one with specific bevel angle found to be appropriate mechanism for slicing high moisture pulpy fruit like cashew apple. Accordingly, multi disc cashew apple slicer developed and its performance was evaluated. Although cutting of slicer is proper, multiple discs load acting at a time on the fruit crushed it, leading to lose of some amount of juice content. Food processing machinery manufacturer located in Southern India were visited to explore the possibility of identifying / developing suitable mechanism for slicing cashew apple. Based on the information collected, suitable mechanism for slicing cashew apple has been designed and attempting to fabricate.

4.4. Award of Patent

Radial arm type cashew kernel extractor machine was designed to operate in sitting posture thereby it reduces the operator's drudgery experienced in the existing sheller (Fig. 4.9). It has 9.3 kg h^{-1} operational capacity and 88.1 per cent quantitative efficiency. This technology has been awarded with Government of India Patent (No. 272371) on 30.03.2016.

Fig. 4.9: Radial arm type cashew kernel extractor machine

4. 5. Value Added Products from Cashew Apple

4.5.1 Cashew apple cider

Efforts were made to identify the size of inoculums to be added to the media to obtain superior sensory quality of the cider. The quantity of active dry yeast added was 0.5, 1.0, 1.5, 2.0 and 2.5 g per liter of juice. An inoculum 1.5-2.0 g/L was observed to be the best with respect to the time of fermentation, colour, flavour and taste of the product. Based on these observations five different trials have been taken by using juice of four varieties namely Dhana, Madakathara-2, Vengurla-4 and germplasm collection NRC-301, and a mixture. Sensory evaluation of the prepared products consistently claimed that the cider prepared from mixed juices was found to be superior (Table 4.2), which attributed to contribution of flavor characteristics by different unidentified unique constituents of each variety. Cider prepared from germplasm collection NRC-301 has a positive appeal towards its colour characteristics owing to ability to retain red colour of skin in the juice unlike other varieties. The alcohol percentage measured with the help of hydrometer was in the tune of 3.5-5.5% v/v. The sugar contents of all varieties selected were in the range of 8.5 to 10.5%.

Table 4.2: Sensory analysis of Cashew apple cider.

Sample Code	Colour	Flavour	Body	Taste	Overall Acceptability
A	5.22	5.33	5.67	5.89	5.78
B	7.78	7.67	7.56	7.67	7.78
C	5.44	5.89	6.22	6.33	6.33
D	7.78	7.89	7.78	8.22	7.89
E	6.11	5.78	6.33	6.56	6.33
F	8.33	8.11	7.67	8.33	8.22
SEd	0.4502	0.4207	0.3425	0.3889	0.3822
CD(.05)	0.9052	0.8458	0.6886	0.7820	0.7685
CD(.01)	1.2077	1.1285	0.9187	1.0432	1.0253
CV%	14.09	13.17	10.57	11.51	11.49

4.5.2 Cashew apple jelly

The jelly preparation was tried with and without pectin addition. It was learnt that in the case of cashew apple without an external source of pectin, the quality jelly preparation was not possible. Hence the edible pectin was added at the rate of 0.5%, 1.0%, 1.5%, and 2%. The prepared product was tested for its sensory quality by different age group people (Table 4.3) and it was noticed that more than 1.0% pectin addition was essential to set a quality jelly (Fig. 4.10).

Table 4.3: Sensory analysis of Cashew apple jelly

Sample Code	Colour	Flavour	Texture	Taste	Overall Acceptability
A	5.78	4.78	4.89	5.56	5.22
B	5.78	4.89	5.44	5.00	5.33
C	6.56	5.89	6.00	5.78	5.78
D	7.33	6.78	6.78	6.89	6.44
E	8.00	7.56	8.33	8.11	8.11
F	7.22	7.00	7.22	6.78	6.67
SEd	0.4559	0.5574	0.4315	0.4468	0.3349
CD (.05)	0.9166	1.1208	0.8677	0.8983	0.6733
CD(.01)	1.2229	1.4953	1.1576	1.1985	0.8983
CV%	14.27	19.23	14.20	14.92	11.35

Fig. 4.10: Consistency of well set cashew apple jelly

4.5.3. Reduction in tannins in cashew apple juice by low cost food grade material

Earlier established methods of tannin reduction using gelatin, PVP, Activated Charcoal and Sago were checked for the efficacy of removal tannin from cashew apple juice (Table 4.4). Few results were matching with the earlier reports. To overcome the problems associated with earlier methodologies, considering the chemistry of tannins, different food grade materials *viz.*, defatted soybean meal/ flour (rich in proteins that bind tanins), Bajara flour in the form of dry powder or gruel (rich in iron), Maiz flour/ gruel (rich in starch, proteins capable of precipitating the tannins) and Potato (raw and cooked) have been identified.

Table 4.4. Effect of different concentrations of gelatin, PVP, Activated Charcoal and Sago on removal of tannin from cashew apple juice

Treatment	Juice Recovery	Absorbance (%)	Transmittance (%)	Tannin Reduction (%)
Control	70.0	0.1449	88.08	00.00
Sago 1%	89.0	0.0890	93.01	23.25
Sago 2%	87.0	0.1199	91.22	39.69
Sago 3%	81.0	0.1640	87.60	28.82
Sago 4%	89.5	0.2077	81.30	24.47
PVP 1%	91.0	0.1557	88.55	31.62
PVP 2%	88.0	0.2044	83.55	27.30
VP 3%	83.0	0.1888	87.84	30.26
PVP 4%	84.0	0.1353	91.70	34.43
Gelatin 1%	88.0	0.4996	58.79	26.41
Gelatin 2%	82.0	0.8534	42.62	24.69
Gelatin 3%	83.0	0.1935	82.96	33.58
Gelatin 4%	82.5	0.1259	53.69	25.56
Charcoal 2.5%	87.5	0.0421	96.35	15.12
Charcoal 5.0%	79.0	0.1138	87.60	13.23
Charcoal 7.5%	87.5	0.2091	77.55	7.93
Charcoal 10%	85.0	0.1817	80.58	9.52

4.5.4. Blended juice product

In order to prepare ready to serve (RTS) beverages, five different varieties/accession *viz.,* Vengurla-3, Dhana, Bhaskara, Ullal-3 and NRC-301 were chosen. The product was prepared from the cashew apple juice itself and compared with the RTS prepared by blending lime juice with different level of concentration keeping cashew apple concentration same. The product prepared (Sample Code:E) from 3% lime juice and 0.250 g citric acid/liter juice was found superior after conducting organoleptic evaluation based on 9 point hedonic scale (Table 4.5).

Table 4.5. Sensory analysis of cashew apple-lime and citric acid blended RTS

Sample Code	Colour	Flavour	Astringency	Taste	Overall Acceptability
A	3.9	4.5	5.4	4.9	4.5
B	4.9	5.1	5.7	5.0	5.0
C	4.7	4.4	5.4	5.7	5.2
D	6.2	6.4	6.7	7.0	6.4
E	7.6	7.6	7.8	8.2	7.9
F	6.1	6.2	6.4	6.6	6.4
SEd	0.5538	0.4480	0.5544	0.4753	0.3839
CD (.05)	1.1103	0.8983	1.1116	0.9530	0.7697
CD(.01)	1.4796	1.1971	1.4814	1.2700	1.0258
CV%	22.24	17.58	19.89	17.05	14.55

5. TRANSFER OF TECHNOLOGY

5.1 Transfer of Technology Programme in Cashew

5.1.1 Impact of Frontline Demonstrations (FLD) in Cashew

Study on impact of FLDs established by DCR was conducted during 2015-16 under this project. Methodology and Instrument to measure impact of FLD in Cashew was developed and the tool was used to measure impact of FLDs on area, production and productivity of cashew in South Karnataka. Data have been collected from FLD farmers who have completed at least 10 years under cashew cultivation and analyzed for measuring the impact of FLD on area, production and productivity of cashew, social and economic benefits accrued and adoption of recommended cashew production technologies in comparison with non FLD farmers of the region. The technology gap and extension gap existing in major cashew varieties were measured and documented along with the status of technology utilisation of FLD farmers in comparison with other cashew farmers.

5.1.2 Performance of major cashew varieties under FLD

Twelve major cashew varieties under FLD were studied to assess their performance (Table 5.1; Fig. 5.1). The variety 'Bhaskara' was identified for the highest yield under demonstration to the tune of 5.77 kg/tree closely followed by variety 'Ullal-3' (5.03 kg/tree). Variety Ullal-1 (4.79 kg/tree) and Madakkathara-2 (MDK-2: 4.60 kg/tree) also were found to give comparatively better yield in relation to other varieties. Varieties Priyanka (4.51 kg/tree) and ullal-4 (4.00 kg/tree) closely followed while varieties VRI-3, NRCS-2, Vengurla-7 and vengurla-4 were found to perform poorly both in FLD and Non-FLD plot.

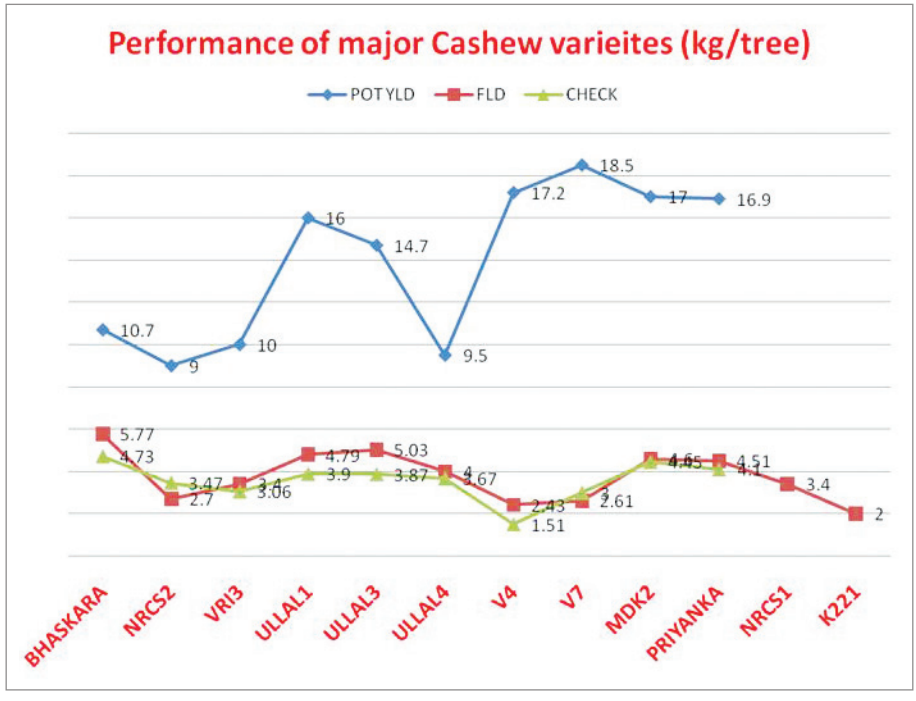


Fig. 5.1: Performance of major cashew varieties under FLD

Table 5.1: Impact of cashew varieties on production and productivity of cashew

Variety	Production (kg/tree)				Productivity (kg/ha)			
	Check	Rank	FLD	Rank	Check	Rank	FLD	Rank
Bhaskara	4.73	1	5.77	1	737.88	1	905.89	1
*NRCS-2	3.47	7	2.70	8	541.32	7	423.9	8
**MDK-2	4.45	2	4.60	4	694.2	2	722.2	4
Ullal-3	3.87	5	5.03	2	603.72	5	789.71	2
Ullal-1	3.9	4	4.79	3	608.4	4	752.03	3
Ullal-4	3.67	6	4.00	6	572.52	6	628	6
VRI-3	3.06	8	3.40	7	477.36	8	533.8	7
V-4 ***	1.51	10	2.43	10	235.56	10	381.51	10
V-7	3	9	2.61	9	468	9	409.77	9
Priyanka	4.1	3	4.51	5	639.6	3	708.07	5

* NRC Selection-2 ** Madakkathara-2 *** Vengurla-4 **** Vengurla-7

Variety Bhaskara recorded the highest productivity of 906 kg/ha under FLD against 738 kg/ha in Non-FLD farms. Ullal-3 yielded second highest productivity of 790 kg/ha among FLD farmers while variety Madakkathara-2 yielded second highest productivity (694 kg/ha) among Non-FLD farmers. Variety Ullal-1 recorded third highest productivity of 752 kg/ha among FLD plots while variety Priyanka recorded third place in productivity among non-FLD farmers with output of 640 kg/ha.

5.1.3 Technology and extension gap in major cashew varieties

Technology gap was the lowest in 'Bhaskara' (4.93 kg/tree) where as it was very high in 'Vengurla-7' (15.89 kg/tree) and 'Vengurla-4' (14.77 kg/tree), while extension gap was high in variety 'Ullal-3' (1.16 kg/tree). Very high technology gap was observed with respect to yields of all major cashew varieties grown in this region (Fig. 5.2).

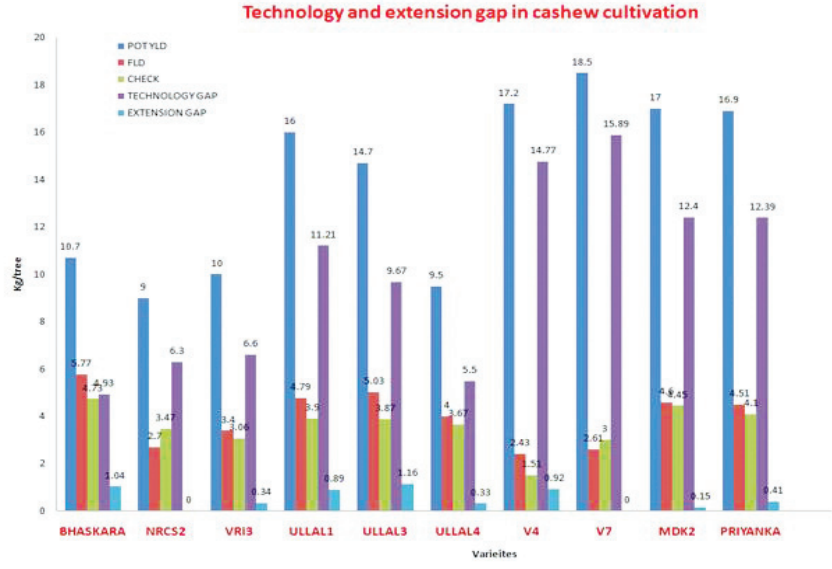


Fig 5.2: Technology and Extension gap in Cashew cultivation

5.1.4 Technology utilisation status of FLD and Non-FLD farmers

Technology utilisation status of demonstration farmers were found to decline after period of financial support and the Adoption Index of major cashew production technologies among these farmers were recorded as 48 against 40 in case of check farmers (Table 5.2). Majority (36%) of FLD farmers belonged to High adoption category while majority of check farmers (44%) belonged to medium adoption category.

Table 5.2: Technology utilisation status of FLD and Non-FLD farmers (n1+n2=129)

Cashew Production Technologies	Adoption Index		Farmers under various levels of adoption (%)					
			Check			FLD		
	Check	FLD	Low	Medium	High	Low	Medium	High
Planting and Initial Care	73	72	23	52	25	28	48	24
Soil and Water Conservation	48	53	33	35	32	26	30	44
Manures and Fertilizers	30	36	33	14	53	33	24	43
Pruning and Training	43	50	32	35	33	35	22	43
Plant Protection	20	30	45	26	29	37	33	30
Intercropping	22	30	75	20	5	63	4	33
Harvesting and Post Harvest	43	43	24	39	37	19	43	38
Overall Adoption Index	40	48	32	44	24	32	32	36

5.1.5 Constraints faced by FLD farmers

The major constraints faced by FLD farmers were identified (Table 5.3) as price fluctuations/ poor price (80%), low availability of labour (70%), attack of Tea Mosquito Bug (61%) and attack of Cashew Stem and Root Borer (36%). Other constraints reported were flower drying (35%), poor yielding varieties (23%), problems in collection of nuts/theft (21%), price control by processors (17%), lack of cashew farmers associations (11%) and lack of subsidy after third year of planting (33%).

Table 5.3: List of constraints faced by FLD cashew farmers

Constraints	FLD (%)	Non-FLD (%)
Poor price/Price fluctuation	80	83
Low availability of labour	70	71
TMB attack	61	41
CSRB attack	36	35
Flower drying	35	20
Poor yielding varieties	23	17
Collection of nuts / theft	21	13
Price control by processor	17	12
Lack of cashew farmer association	11	12
No subsidy after initial years	33	-

5.1.6 ICT usage of cashew farmers

Interesting patterns with respect to ICT usage of cashew farmers emerged from a study conducted to assess performance of recommended production technologies under FLDs. Study analyzed the ICT usage patterns of cashew farmers of south Karnataka while also attempting to identify the correlates and determinants of ICT usage. Results revealed that majority cashew farmers registered high levels of ICT usage. Use of modern media was wide but restricted largely for entertainment purpose. Usage of social media was very high among young members of cashew farmers' families but its utilisation for cashew cultivation was found rare.

5.1.7 Correlates and determinants of ICT usage of cashew farmers

Correlation analysis showed that four variables; Age of farmer (-.483**), Education (-.285*), Extension contact (.272*) and Extension participation (.432**) were having highly significant relationship with the ICT usage of cashew farmers. The regression analysis identified three variables; Age of farmer (-.386*), Occupation (.367**) and Extension participation (.641**) that significantly contribute to the ICT usage of cashew farmers explaining 57 per cent of variability in ICT usage of cashew farmers (Table 5.4).

Table 5.4: ICT usage of cashew farmers: Correlates and determinants

Coefficients[a]						
Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**
		B	**Std. Error**	**Beta**		
1	(Constant)	-.209	7.836		-.027	.979
	AGE	-.182	.071	-.386	-2.547	.015
	EDCN	-.508	.564	-.112	-.901	.373
	OCCPN	6.584	2.239	.367	2.941	.005
	FRMNGEXP	-.126	.073	-.291	-1.739	.090
	CSHWEXP	.058	.111	.072	.523	.604
	EXTNCNT	-.146	.129	-.211	-1.134	.263
	EXTNPRTPN	.476	.131	.641	3.638	.001
	CSMPLTNS	-.028	.128	-.034	-.219	.828
	NONCLTV	.325	.494	.080	.658	.514
	CSHWLND	5.987	2.796	.243	2.141	.038
	OTHCRPLND	-.258	.862	-.036	-.300	.766
	PLOTDIST	.001	.001	.145	.853	.399

a. Dependent Variable: ICTU

Model Summary				
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	.752[a]	.566	.439	4.269

a. Predictors: (Constant), PLOTDIST, EDCN, NONCLTV, EXTNPRTPN, CSHWEXP, CSHWLND, OCCPN, OTHCRPLND, AGE, CSMPLTNS, FRMNGEXP, EXTNCNT

5.1.8 Models predicting ICT usage of cashew farmers: Stepwise regression analysis

Stepwise regression was used to identify predictors and select models explained the variation in ICT usage of cashew farmers. In this analysis, two models were tested to examine the variation in adoption among the respondents (Table 5.5). Model 2 was found explaining up to 40 per cent of variability in ICT usage using the predictors; age (-0.488) and extension participation (0.438). The model 2 also had the lowest standard error of the estimate (4.405) thus making it the best model suited to predict adoption of cashew production technologies by farmers. Understanding the above dynamics in ICT usage can help researchers and extension agencies working in cashew sector to design better innovations and effective outreach strategies.

Table 5.5: Models predicting ICT usage of cashew farmers

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	19.317	2.905		6.651	.000
	AGE	-.227	.057	-.483	-3.977	.000
2	(Constant)	17.019	2.601		6.544	.000
	AGE	-.230	.050	-.488	-4.592	.000
	EXTNPRTPN	.325	.079	.438	4.121	.000
a. Dependent Variable: ICTU						

Model Summary			
R	R Square	Adjusted R Square	Std. Error of the Estimate
.483[a]	.233	.218	5.037
.652[b]	.425	.402	4.405

a. Predictors: (Constant), AGE

b. Predictors: (Constant), AGE, EXTNPRTPN

Database of 54 FLD cashew farmers representing 5 taluks of Dakshina Kannada district was compiled and maintained in MS Excel format and handed over the data for submission to Krishi Portal of ICAR, New Delhi. The database has data corresponding to 123 variables/status/ indices related to cashew cultivation, technology utilisation and socio-economic status of these farmers.

5.2 Impact of Cashew Production Technologies on Area, Production and Productivity of Cashew

5.2.1 Socio-economic impact of cashew cultivation in North Kerala

Ten major social and economic impact indicators were analysed to arrive at the socio-economic impact of cashew farming among the respondents (Table 5.6). Study on impact on cropping pattern didn't record much of change as

only 10 per cent of farmers increasing area under cashew over the years (0.05 acres) while only negligible per cent (7) of them purchased new lands (0.32 acres) for cashew cultivation. Impact on labour engagement was also low with only 25 per cent farmers hiring labour for cashew and only 9 per cent of them opting for increased family labour engagement (0.40). The hiring of labour was noticed particularly for harvesting operations with farmers mostly engaging one to two labourers during this period. A large majority (94%) reported no change in farm expenditure due to cashew cultivation, while 46 per cent of farmers reported an increase in farm income due to cashew cultivation. Farmers reported an average increase of ₹ 410/year in farm expenditure and ₹ 5240/year in farm income due to cashew cultivation. Resultant increase in family incomes was also reported by 36 per cent of the farmers to the average of ₹ 4320/year followed by an average increase of ₹ 460/year in their family expenditure.

Table 5.6: Socio-Economic impact of Cashew cultivation (n=68)

Impact Indicators	Increased		No change		Index
	f	%	f	%	
Impact on cropping pattern					
Area under cashew cultivation over the years	7	10	61	90	0.05
Purchase of new land and cashew cultivation	5	7	63	93	0.32
Impact on labour engagement					
Hired labour engagement for cashew	17	25	51	75	4.30
Family labour engagement for cashew	6	9	62	91	0.40
Impact on farm expenditure					
Cashew cultivation and farm expenditure	4	6	64	94	0.41
Impact on farm income					
Cashew cultivation and farm income	31	46	37	54	5.24
Impact on family income					
Cashew cultivation and family income	31	46	37	54	4.32
Impact on family expenditure					
Profit from cashew cultivation and family expenses	7	10	61	90	0.46
Impact on social participation					
Cashew cultivation and participation in social events	41	60	27	40	1.60
Impact on extension contact					
Contacts with extension agency and research institutes	32	47	36	53	1.47
Impact on mass media exposure					
Cashew cultivation and mass media exposure	32	47	36	53	1.47
Impact on opinion leadership					
Cashew cultivation and opinion leadership in his/her area	37	54	31	46	0.54

* for last 10 years of cashew cultivation for those respondents who reported an increase in indicators

Analysis of social impact presented a better picture in comparison to economic impact as majority (60%) of the farmers had reported the increased social participation while nearly half (47%) majority could increase their contacts with extension agencies and research institutes due to cashew cultivation. Majority (47%) reported increase in their mass media exposure while a majority (54%) reported an increase in their opinion leadership status due to cashew cultivation.

Classification of cashew farmers based on the social and economic benefits showed that nearly half of the cashew farmers (47%) belong to high social impact category while in case of economic impact majority (47%) belonged to low benefits category. Overall, nearly half of the cashew farmers (46%) recorded low levels of socio-economic impact (Table 5.7) accrued from cashew cultivation.

Table 5.7: Classification of farmers based on social and economic impact (n=68)

Categories	Social Impact			Economic Impact			Socio-economic Impact		
	f	%	Range	f	%	Range	f	%	Range
Low	31	45.58	<1.07	32	47.05	<0.56	31	45.58	<0.79
Medium	5	7.35	1.07-1.47	24	35.29	0.56-3.76	24	35.29	0.79-2.86
High	32	47.06	>1.47	12	17.64	>3.76	13	19.12	>2.86
Mean		1.27			2.16			1.83	
SD		0.39525			3.194884			2.073558	

Two data sets viz., one database of 75 representative cashew farmers representing 5 taluks of Dakshina Kannada district and another database of 68 representative cashew farmers representing Kannur and Kasaragode districts of Kerala, have been compiled and maintained in MS Excel format. The each database has data corresponding to 123 items of variables/status/indices related to cashew cultivation status of these farmers. Both the data sets in MS Excel format have been handed over for submission in Krishi Portal, ICAR, New Delhi.

5.3 Development of an Interactive and Dynamic Web space for Cashew Information Management at DCR

The Joomla database of the website (www.cashew.res.in) has been fine tuned. Fields such as About us, Research, Extension, Facilities, Staff, Library, AICRP, For farmers, Reports, FAQ, Tender, RTI, Office orders, RFD documents etc. have been continuously updated with new information.

5.4 Training programmes organized

5.4.1 National Training on Advances in Cashew Production Technology

The growing demand for cashew both at global and national levels has made it imperative to increase production and productivity of raw cashewnut, besides enhancing production of cashew apple for preparation of value added products. To achieve this and to provide better technology backstopping at stakeholder level, it is essential to know the current status of research and development in cashew in the country. The Directorate of Cashew Research, Puttur in collaboration with Directorate of Cashewnut & Cocoa Development, Kochi organized a National Level Training Programme on "Advances in Cashew Production Technology" from 21-23, May, 2015 with special emphasis on the latest concepts, methodologies, approaches and practices in the field of cashew research for the benefit of stakeholders

and a training manual was also been released during the programme (Fig. 5.3). A total of 39 participants from Development Departments, SAUs, Cashew and Forest Development Corporations and Horticulture Missions of Odisha, Andhra Pradesh, Tamil Nadu,

Fig. 5.3: Release of Training Manual during National training

Kerala, Goa and Karnataka had participated in the training. The training was coordinated by Dr. M.G. Nayak and Dr. Sajeev M.V. of the directorate.

5.4.2 Training on "Integrated Pest Management in Cashew" for organic cashew farmers of Maharashtra and Goa states

Pests and diseases account for nearly 30 per cent of crop loss in cashew. In this scenario, DCR, Puttur organized Training Programmes on "Integrated Pest Management in Cashew" with special emphasis on organic

Fig. 5.4: Participants of Maharashtra and resource persons

practices for the benefit of stakeholders. Two training programmes viz., one for 30 farmers from Maharashtra and another for 27 farmers from Goa were conducted during 8-9 December, 2015 and 28-29 January, 2016 respectively (Figs. 5.4 and 5.5). The training exposed the participants to integrated management of Tea Mosquito Bug, Cashew Stem and Root Borer, Major Diseases of Cashew and Minor Pests of Cashew along with

Fig. 5.5: Participants from Goa attending training programme

hands-on practical lab sessions. Both the trainings were coordinated by Dr. Sajeev M.V., Scientist (Agri. Extn.) of the directorate.

5.5 Exhibitions organized

The directorate arranged five exhibitions on cashew production technology and extension during 2015-16. The Directorate put up four off-campus exhibitions at UAHS, Shivamogga; Kukke Subrahmanya, KVK, Kankanady, CPCRI, Kasaragode and one on campus.

5.5.1 DCR Exhibition at Krishi Mela of UAHS, Shimoga (03-10-15 to 06-10-15)

More than 200000 farmers and several delegates visited the stall during the exhibition. Farmers were mainly from Shimoga district and several queries were made by them regarding cashew. Scientists and officers from various

organizations who were participating in the Krishimela also visited the stall and necessary information was provided.

5.5.2 DCR Exhibition at Krishi Mela of Sri Kukke Subrahmanya Temple, Kukke Subrahmanya (16-12-15 to 17-12-15).

More than 5000 farmers mainly from Dakshina Kannada district visited the stall during the exhibition. Officials from various organizations who were participating in the Krishimela also visited the stall and necessary information was provided.

5.5.3 DCR Exhibition at Krishi Mela of KVK, Kankanady (28-09-2015).

Around 2000 farmers attending the Krishi Mela visited the stall. Scientists from various organizations also visited the stall and necessary information was provided (Fig. 5.6).

Fig. 5.6: DCR Exhibition at KVK, Kankanady.

5.5.4 DCR Exhibition at CPCRI, Kasaragode. (12-03-16)

The Directorate put up an exhibition during the inauguration of Centenary Celebration at CPCRI, Kasaragode. Around 5000 farmers representing various districts of Kerala and Karnataka visited the DCR stall during the exhibition (Fig. 5.7). Since cashew is grown widely in Kerala, there was immense interest among the farmers. A lot of queries were raised on opportunities for utilization of cashew apple. Non availability of quality planting material of latest varieties was a great concern echoed by most farmers.

Fig. 5.7: DCR Exhibition at CPCRI, Kasaragode.

5.6 Frontline Demonstrations

Under project on transfer of technology programmes in Cashew, frontline demonstration plots established with financial assistance from NHM through DCCD, Kochi were monitored regularly by extension team of the directorate (Fig. 5.8). A total of 30 FLD plots established in Puttur, Sullia and Bantwal taluks of Dakshina Kannada district were visited during the year and technical advisory was provided to the farmers on pest management, pruning, fertilization and marketing aspects.

Fig. 5.8: Monitoring of FLD plots

5.7 Participatory Technology Development

Participatory technology development has been taken up under project on transfer of technology programmes in cashew with willing cashew farmers to assess and refine various cashew production technologies. Participatory technology development is presently tried in case of ultra high density planting in cashew, pruning and canopy management and suitability of varieties for high density and ultra high density planting in cashew. The plots were monitored regularly, technical advice were given and feedback was collected by the extension team of the directorate (Fig. 5.9).

Fig. 5.9: Extension team in PTD plots

5.8 E-extension in Cashew

E-extension was strengthened in cashew through Social Media during 2015-16. Under the project, a Facebook page for dissemination of latest cashew information and technical knowledge has been developed [ICAR-DCR PUTTUR] (Fig. 5.10). The page has been regularly edited, updated and uploaded with relevant content. All HRD programmes and farmer awareness programmes conducted at the Directorate were given wide publicity through DCR Facebook page. Availability of Cashew Grafts (variety wise) was posted and applications invited from time to time. During the period, 24 programmes have been publicized through 56 posts and 187 organizations/ stakeholders are actively following DCR Facebook page for updates.

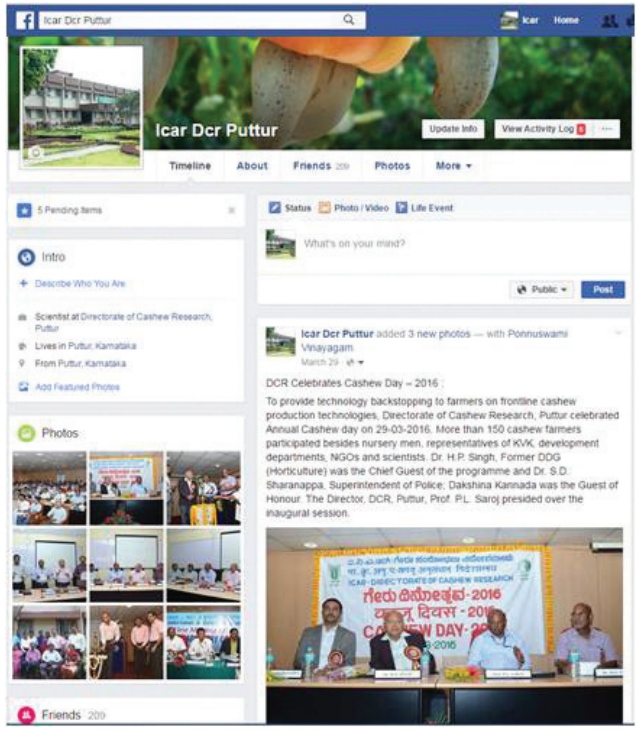


Fig. 5.10: Facebook page of DCR, Puttur

5.9 Advisory visits/ Consultancy

The scientists of this Directorate were requested for technical advice/lectures on various aspects of cashew production by different organizations. The team of scientists provided consultancy/lectures as and when requested and also participated as resource persons in various cashew related programmes.

6. PROGRAMMES ORGANIZED

6.1 Farmer meets organised

6.1.1 Foundation Day of ICAR-DCR: Innovative Cashew Farmers Meet: 2015

Directorate of Cashew Research, Puttur celebrated its foundation day on 18-06-2015. On this occasion 'Farmers Meet – 2015' was also organized in which more than 150 progressive cashew farmers participated besides nursery men, representatives of KVK, development departments, NGOs and scientists. Dr. S.D. Shikhamany, former Vice Chancellor, Dr. YSR Horticultural University, Andhra Pradesh was the Chief Guest of the programme and Dr. Sanjay S. Bijjur, Chief Conservator of Forests, Mangalore was the Guest of Honour. The Director, DCR, Puttur, Prof. P.L. Saroj presided over the inaugural session. Three selected innovative farmers were felicitated before the audience. Sri. K. Subhash Rai, innovative farmer from Kadamajalu, Puttur was felicitated for achieving high productivity of 1500 kg/ha in second year of planting through adoption of high density modes of planting (Fig. 6.1).

Fig. 6.1: Dr. S.D. Shikhamany, former Vice Chancellor, Dr. YSR Horticultural University, Andhra Pradesh felicitating innovative farmer

Sri. Purandhara Rai of Thingalady, Puttur was felicitated for being the pioneer in adopting ultra high density planting on a large scale and successfully establishing a state of the art processing factory in the area. Sri. M. Natesh from Paduvannur was felicitated for demonstrating high density technique with a yield of 2000 kg/ha. The awardees also shared their experiences.

Dr. S.D. Shikhamany, Chief Guest of the function, congratulated the past and present leadership of DCR. He highlighted the three major technology contributions of DCR as Softwood Grafting Technique, high yielding variety Bhaskara and High Density Planting method. He called for adoptable and sustainable technologies to combat low productivity in Cashew. He exhorted the farmers of this region to make the full use of recommended technologies to produce quality cashew in a sustainable and profitable way. He stressed on the need for 'anticipatory research' in cashew sector. Dr. Sanjay S. Bijjur, Guest of Honour, congratulated cashew farmers and scientists and stressed on the need for better productivity and income from cashew farming and called for focus on nutritional security and water security in cashew cultivation. He appreciated the adoption of latest technologies by innovative farmers. Prof. P.L. Saroj, Director, DCR pointed out the present status of cashew research and cashew cultivation in India. He called upon the farmers to follow the right technologies along with the proper recommendations as indicated by scientists to reap the benefits from cashew cultivation. He promised full cooperation of DCR to cashew farmers of the region and also congratulated the innovative farmers for their achievements. He observed that the achievements of these innovative farmers will motivate the other farmers to take up cashew cultivation in a scientific manner. Earlier, Dr. M.G. Nayak, Principal Scientist (Hort.), DCR welcomed dignitaries and participants and highlighted the

importance of sharing farmer's innovations for facilitating farmer to farmer learning. On this occasion a Catalogue V on 'Minimum Descriptors of Cashew Germplasm' was also released. The programme was coordinated by Dr. Sajeev M.V., Scientist (Ag. Extn) and came to an end with a farmer – scientist interaction session.

6.1.2 Cashew Day and Interaction meeting with tribal farmers

To provide technology backstopping to farmers on frontline cashew production technologies, Directorate of Cashew Research, Puttur celebrated Annual Cashew day on 29-03-2016. More than 150 cashew farmers participated besides nursery men, representatives of KVK, development departments, NGOs and scientists (Fig. 6.2).

Fig. 6.2: A glimpse of farmers on Cashew Day

Dr. H.P. Singh, Former DDG (Horticulture) was the Chief Guest of the programme and Dr. S.D. Sharanappa, Superintendent of Police; Dakshina Kannada was the Guest of Honour. The Director, DCR, Puttur, Prof. P.L. Saroj presided over the inaugural session. Dr. H.P. Singh, Former DDG (Horticulture) distributed the financial assistance to tribal farmers for cashew demonstration plots set up by DCR. Later, in the inaugural address, he stressed on the need for better management of cashew orchards utilizing the power of science and technology (Fig. 6.3). He appreciated the research achievements of DCR, Puttur and called for wider outreach of the technologies in collaboration with development departments. He opined that farmer producer associations may be started by cashew farmers so that farmers get more benefit from the crop. Earlier, Dr. S.D. Sharanappa, Superintendent of Police; Dakshina Kannada addressed the gathering and highlighted the importance of farming as the noblest profession (Fig. 6.4). He stressed upon sustainability in yield and income from cashew farming and called for the institutionalization of cashew processing at grass root level.

Fig. 6.3: Dr. H.P. Singh, Former DDG(Hort.) ICAR, addresses the gathering

Fig. 6.4: Dr. S.D. Sharanappa, Superintendent of Police, Dakshina Kannada addresses the gathering

In his presidential address, Prof. P. L. Saroj, Director, DCR called upon the farmers to follow the right technologies along with the proper recommendations as indicated by scientists to reap the benefits from cashew cultivation. He promised full cooperation of DCR to cashew farmers of the region and also congratulated the successful farmers for their achievements. He observed that the achievements of these farmers will motivate the new farmers to take up cashew cultivation in a scientific manner. Earlier, Dr. M.G. Nayak, Principal Scientist (Hort.), DCR welcomed dignitaries and participants and highlighted the work done by DCR in last three decades. On this occasion, an exhibition of cashew production technologies was organized along with field trip to various cashew research plots. Farmers in large numbers visited the exhibition and took part in field visits thereby gaining much exposure to latest cashew production technologies. Earlier two publications; 'Insect pests of cashew and their management' and 'Cashew cultivation practices' were released by the dignitaries. Innovative cashew farmers also shared their views on cashew cultivation during the programme. Set of pruning implements were also distributed to the beneficiary tribal farmers during the programme. The programme was coordinated by Dr. Sajeev M.V., Scientist (Ag. Extn) and came to an end with a farmer – scientist interaction session and Vote of thanks by Dr. G.S. Mohana, Senior Scientist of the Directorate.

6.2 Activities under Tribal Sub Plan (TSP) and North Eastern Hilly Region (NEH) Plan

6.2.1 Report on NEH programme

Two "Cashew Awareness Campaign" programmes were organized during 7th Mar. 2016, at Green Park, Dimapur and on 8th Mar. 2016, in Town Hall of Jalukie in Nagaland (Fig. 6.5). Around 50 farmers had participated in these campaigns along with personnel of Department of Horticulture., SASRD, Nagaland University, Medziphema and from Dept. of Hort., Govt. of Nagaland, Dimapur, who moderated the discussions in local Nagamese language. Details of interested farmers have been collected for area expansion in Chumukedima and Jalukie.

It was learnt that some farmers who had earlier planted cashew had either removed the plants or left them uncared, due to lack of local market for raw cashew nuts. Most farmers opined that the varieties distributed earlier to them had small sized nuts; on further enquiry, they mentioned the nut size was bigger when they were using fertilizers. Due to the constant promotion of organic cultivation and impetus / financial support given to pineapple and rubber cultivation, cashew has been relegated to a lesser position. In spite of lower yields, some farmers had annual income of more than ₹ 50000 from cashew due to extensive area of 10-15 acres.

Few enterprising cashew farmers adopted manual cutting of sundried nuts using an areca- cutter which fetched up to ₹ 100 for 100-150g of kernels locally. However, these farmers demanded funding for starting of homestead processing units in order to obtain higher quality of processed nuts. During field visits, farmers mentioned that TMB incidence and flower drying during foggy period was quite common and a low incidence of CSRB was noticed in some locations.

Fig. 6.5: Cashew farmers and other participants of the Cashew Awareness Campaign held at Jalukie, Nagaland

6.2.2 Area expansion and FLD under Tribal Sub Plan (TSP)

Under TSP program, 26 new FLD plots were established in tribal farmer fields of Dakshina Kannada district of Karnataka and Kasaragode district of Kerala (Fig. 6.6). The plots were visited by TSP team of DCR comprising of Dr. M.G. Nayak and Dr. Sajeev M.V. for identification of farmers, grouping of interested farmers at village level, identifying suitable plots and for provision of assistance during planting and aftercare. Also, 25 FLD plots established under TSP programme during 2014-15 were also monitored regularly and technical advice was provided on aftercare, pest management and manuring. Financial support amounting to the tune of Rs. 293800 to 26 tribal farmers as first year installment and Rs. 57190 as second year installment to 25 tribal farmers were also disbursed under TSP programme (Fig. 6.7 and 6.8). During 2015-16, the TSP team of the directorate made 127 field visits covering all FLD fields of tribal farmers and offered necessary technical support.

Fig. 6.6: Area expansion FLD under Tribal Sub Plan

6.7: Financial support to tribal farmers for adopting new technology

Fig. 6.8: Distribution of pruning implements to tribal farmers

6.3 World Soil Day celebrated at ICAR-Directorate of Cashew Research, Puttur

ICAR-Directorate of Cashew Research (DCR), Puttur organized World Soil Day on 5th December 2015. A total of 213 farmers from Dakshina Kannada District attended the function (Fig.6.9). Smt. T. Shankunthala Shetty, Hon'ble Member of Legislative Assembly, Puttur inaugurated the function (Fig. 6.10). In her address, she appreciated the efforts made by DCR for improvement of cashew production. She congratulated the Directorate for developing new technologies in cashew production and urged the authorities to deliver the new technologies to farmers through the extension agencies of State Government and Krishi Vigyan Kendras. Prof. P.L. Saroj, Director, DCR, in his introductory remarks, informed the gathering about the importance of soil health and nutrient management for sustainable crop production. He also briefed about the research activities of the institute and technologies developed. Shri Anna Vinayachandra, Former M.L.C., Karnataka Legislative Council, Sullia, was the Guest of Honour. In his speech, he highlighted the importance of soil by quoting examples appeared in national news papers. Dr. T.R. Rupa, Principal Scientist (Soil Science) gave a talk on Soil sampling, testing, fertilizer recommendation for better soil health and high yields. Earlier, Dr. M.G. Nayak, Principal Scientist, Puttur welcomed the dignitaries and participants. On this occasion, soil health cards developed at Soil Science laboratory, DCR were distributed to 20 cashew farmers. Before end of the programme, there was a farmer-scientist interaction, in which scientists clarified the doubts raised on soil health and plant nutrition by the farmers. The function ended with vote of thanks by Dr. G.S. Mohana, Senior Scientist.

Fig. 6.9: A glimpse of farmers on World Soil Day

Fig. 6.10: Dignitaries on the dias-on- World Soil Day at DCR, Puttur

6.4. Mera Gaon Mera Gaurav Programme

Under Mera Gaon Mera Gaurav programme, DCR has identified fifteen villages in Dakshina Kannada district. Scientists of the Directorate had visited the villages viz., Irde Bettampady, Arla Padavu, Nidpalli, Aaryapu, Balnadu, Jalsoor, Nellur Kembraje, Amara Mudnoor, Aletti (Fig. 6.11) and collected the base line data viz., details about the farmer, farm holding, crops, package of practices adopted, general and agricultural problems faced by the famers.

Fig. 6.11: Interaction during Mera Gaon-Mera Gaurav Programme

ADDITIONAL INFORMATION

7. LINKAGES / COLLABORATION

Organization	Area of collaboration
National Bureau of Agriculturally Important Insects (NBAII), Bengaluru	Identification of kairomones/ pheromones of major pests of cashew.
Indian Institute of Horticultural Research (IIHR), Bengaluru	Biosystematics of tea mosquito bug and natural enemies.
University of Agricultural Sciences (UAS), GKVK, Bengaluru	Identification of arthropod fauna associated with cashew.
Indian Agricultural Research Institute (IARI), New Delhi	
Directorate of Cashewnut and Cocoa Development (DCCD), Kochi	Training programmes for farmers and frontline demonstrations.
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.
IARI-Indian Type Culture Collection, New Delhi	Identification of plant pathogens

8. TRAINING AND CAPACITY BUILDING

Training programmes attended by Scientist		
Janani, P	• Undergone professional attachment training at Central Institute for Subtropical Horticulture, Lucknow	15th May 2015 to 12th August 2015
Prabha Susan Philip	• Undergone 'FOCARS Training' at ICAR-NAARM, Hyderabad.	1st July 2015 30th September 2015
Prabha Susan Philip	• Undergone 'Professional Attachment Training' at ICAR-Indian Society of Soil Science, Bhopal.	12th November 2015 11th February 2016
Prabha Susan Philip	• Undergone a short training course on 'Geoinformatics on natural resource management and climate change mitigation' held at ICAR-IISS, Bhopal	20-29, November 2015
Loganathan, M., Babli Mog, Rajkumar Arjun Dagadkhair	• Participated in National Level Training Programme on "Advances in Cashew Production Technology" held at DCR, Puttur.	21-23, May, 2015
Training programmes attended by Technical staff		
Abdulla P.	• Participated in Competence enhancement training programme for technical officers held at ICAR-NAARM, Hyderabad.	19-28, August, 2015

Training programme organized at ICAR-DCR, Puttur

Topic	No. of participants	Duration
National Training Programme on "Cashew Production Technology" at DCR, Puttur	39	21-23, May, 2015
Training on "Integrated Pest Management in Cashew" for organic cashew farmers of Maharashtra.	30	8-9, December, 2015
Training on "Integrated Pest Management in Cashew" for organic cashew farmers of Goa.	27	28-29, January, 2016

Status of Budget (2015-16) for training and capacity building

Allocation : Rs. 2.0 lakhs **Utilization : Rs. 1.97 lakhs**

Budget (Approx.) proposed for training (2016-17) : Rs. 2.0 lakhs

9. PUBLICATIONS

9.1 Research Publications

9.1.1 International

Adiga, J.D., Eradasappa, E., Mohana, G.S., Thimmappaiah, Meena, R.K. and Bhat, M.G. 2015. A Quest for Dwarf and Compact Hybrids in Cashew (*Anacardium occidentale* L.), *Vegetos.* **28**(1): 26-30.

Vanitha, K., Bhat, P.S., Ravi Prasad, T.N. and Srikumar, K.K. 2015. Species composition of ants in cashew plantations and their interactions with cashew. *Proc. Nat. Acad. Sci., India: Biological Section, B. DOI: 10.1007/ s40011-015-0600-3.*

9.1.2 National

Adiga, J.D., Eradasappa, E., Mohana, G.S., Meena, R.K. and Nayak, M.G. 2016, Seedling selection in open pollinated genotypes of cashew (*Anacardium occidentale*). *Indian Journal of Agricultural Sciences*. **86**(1): 82–5

Balasubramanian, D. 2015. Comparative Performance of Mechanized Peeling machines. *Journal of Plantation Crops.* **42**(3):323-328.

Balasubramanian, D. 2015. Failure force and energy of in-shell cashewnuts under uni-axial compression loading Influenced by moisture content. *Journal of Bioresource Engineering and Technology*. **2**:8-16.

Balasubramanian, D. and Joycy, R.L.K. 2015. Moisture dependant physio-mechanical properties of processed cashew kernels. *Journal of Plantation Crops.* **43**(1): 74-82.

Balasubramanian, D., Saroj, P.L., Meena, R.K. and Vanitha, K. 2015. Research status of technological developments of cashew in India. *The Cashew and Cocoa Journal*. **4**(1):13-20.

Loganathan, M., Manjunath, M., Saha, S., Akhilesh Kumar, Rai, A.B. and Singh, B. 2015. Comparative efficacy of different fungicides in the control of chilli anthracnose. *Indian Journal of Plant Protection* **43**:214-216.

Sajeev, M.V. and Saroj, P.L. 2015. Social and economic benefits of cashew (*Anacardium occidentale*) cultivation in Dakshina Kannada, Karnataka: An analysis of the impact, its determinants and constraints. *Indian Journal of Agricultural Sciences*. **85**(6): 821–6.

Sajeev, M.V., Saroj, P.L. and Meera Manjusha, A.V. 2015. Technology adoption and socio-economic determinants of Cashew farming in North Kerala. *Journal of Plantation Crops*. **43**(1):9-16.

Vanitha, K. 2015. A report on the occurrence of eulophid parasitoids on the Cashew Leaf Miner *Acrocercops syngramma Meyrick* (Insecta: Lepidoptera: Gracillariidae). *Journal of Threatened Taxa.* **7**(12): 7933 –7936.

Vanitha, K., Bhat, P.S., Raviprasad, T.N. and Srikumar, K.K. 2015. Occurrence, Damage, Colour Morphism and Natural Enemies of *Monoleptalongitarsus* Jacoby (Coleoptera: Chrysomelidae), A Defoliating Pest of Cashew. *The Indian Forester*. **141**(6): 687-692.

Vanitha, K., Bhat, P.S. and Raviprasad, T.N. 2015. Pest status of leaf miner, *Acrocercopssyngramma M*. on common varieties of cashew in Puttur region of Karnataka. *Pest Management in Horticultural Ecosystems*. **21**(1): 55-59.

Vasanthi, P. and Raviprasad, T.N. 2015. Incidence of *Batocerarufomaculata* De Geer (Coleoptera:Cerambycidae) on cashew. *J. Ent. Zool. Studies*. **3**(6): 174-177.

9.2 Papers presented in Symposia/ Workshops/Seminars

Balasubramanian, D. 2015. Researchable areas in Post Harvest technology of Cashew. In. Making Engineering Scientists for Stake holders and for Nation. ICAR-Engineering Scientists Meet conducted by Division of Agricultural Engineering, ICAR at NASC, New Delhi from 13-14 April, 2015.

Balasubramanian, D. 2016. Achievements of ICAR-DCR in Intellectual Property and Technology Management. In: Annual Meet cum Workshop conducted by Zonal Technology Management Unit (ZTMU-South Zone), ICAR-Indian Institute of Horticulture Research, Bangalore on 8th February, 2016.

Balasubramanian, D. 2016. Processing and value addition of cashew. In: State level seminar on cashew entitled Strategies for sustainable development of cashew in Karnataka, conducted by College of Horticulture, Bidar, Karnataka from 8-9 March, 2016.

Janani, P. and Prabha, S.P. 2016. Problems in cashew cultivation in India. In: Seminar on Strategies for sustainable development of cashew in Karnataka, College of Horticulture, held at Bidar on 8-9th March 2016.

Mohana, G.S., Eradasappa, E., Adiga J.D., Saroj, P.L. and Bhat, P.G. 2015. Development of dwarf and high yielding genotypes in cashew: Prospects of back cross breeding. In: International symposium on biodiversity, agriculture, environment and forestry, held at Ooty, Tamil Nadu during 11-12th December 2015.

Nayak, M.G. and Mohana, G.S. 2016. Development of DUS guidelines in cashew. In: Tenth DUS Review meeting held at MPKV Rahuri, Maharastra on 26th February, 2016.

Rupa, T.R. 2015. Soil and nutrient related constraints and their management in horticultural crops–cashew. In: ICAR-Sponsored winter school on 'Utilization of Degraded Land and Soil through Horticultural Crops for improving Agricultural productivity and Environmental Quality' held at ICAR-National Research Centre on Seed Spices, Tabiji, Ajmer, during 3-23 December, 2015.

Rupa, T.R. 2015. Soil sampling, testing, fertilizer recommendation for better soil health and high yields. In: World Soil Day organized at ICAR-DCR, Puttur on 5th December, 2015.

Rupa, T.R., Kalaivanan, D., Vijay Singh and Srividya, B.R. 2015. Optimizing nutrient management for irrigated mature cashew plantations. In: National Seminar on Development in Soil Science. In: 80th Annual Convention of the Indian Society of Soil Science (ISSS) held at University of Agricultural Sciences, GKVK, Bengaluru during 5-8 December, 2015.

Sajeev M.V., Nayak, M.G. and Saroj, P.L. 2016. 'ICT usage of cashew farmers: An enquiry of patterns and determinants. In: 8th GCRA International Conference on "Innovative Digital Applications for Sustainable Development", UAS, GKVK, Bengaluru, 5-7, January, 2016.

Saroj, P.L, Balasubramanian, D. and Janani, P. 2016. Technological Advancement in Cashew for Coastal regions in India. In: National Symposium on Innovations in Coastal Agriculture – Current Status and Potentials under Changing Environment, conducted by Indian Institute of water Management, Bhubaneshwar, Odisha from 14-17 January, 2016.

Saroj, P.L. 2016. Conservation, characterization, breeding and improvement in cashew. In: National Seminar on Strategies for Development of Cashew, held at RFRS, Vengurla held on 19th February, 2016.

Saroj, P.L. 2015. Road Map for Cashew Development in West Coast Plains and Ghats Agro Climatic Zone. In: One day Workshop on preparation of road map for the agricultural development held at CCARI, Goa on 16th October, 2015.

Vanitha, K. 2016. Seasonality, life cycle and breeding of an ant mimicking mantid, Euantissa pulchra F. occurring in cashew plantations. In: XV AZRA International Conference on recent advances in life sciences held at Ethiraj College for women, Chennai, Tamil Nadu during 11-13 February, 2016.

Vanitha, K. and Raviprasad, T.N. 2016. Diversity of flower visitors in cashew plantations: seasonality, pollinating flora and their foraging behaviour. In: XV AZRA International Conference on recent advances in life sciences held at Ethiraj College for women, Chennai, Tamil Nadu during 11-13 February, 2016.

9.3 Book Chapters/ Lecture Notes

Bhat, P.S., Raviprasad, T.N. and Vanitha, K. 2016. Insect pests of Cashew and their management. In: *Insect Pest Management of Fruit Crops* (Ajay Kumar Pandey and Promod Mall, Eds.), Biotech Books, New Delhi, pp. 423-436.

Balasubramanian D. and P L Saroj. 2015. Cashew. In: *Managing post harvest quality and losses in Horticultural crops*, Vol 3, (Eds. K L Chadha and R.K. Pal), Daya Publishing house, New Delhi, India. PP. 581 – 595.

Loganathan, M. and Vanitha, K. 2015. Management of diseases of cashew. In: Training manual on *'Integrated pest management in cashew'*. Lecture notes Series.25. ICAR- DCR, Puttur, pp. 21-23.

Mohana, G.S., Eradasappa, E., Adiga, J.D., Saroj, P.L. and P.G. Bhat, 2015, Development of High Yielding Genotypes in Cashew: Prospects of Back Cross Breeding. In: *Proceedings of the International Symposium on Biodiversity, Agriculture, Environment and Forestry*. Association for the Advancement of Biodiversity Science, p. 124.

Raviprasad, T.N. and Vanitha, K. 2015. Tea mosquito bug and its management. In: *Training manual on 'Integrated pest management in cashew'*. Lecture notes Series.25. ICAR-DCR, Puttur, pp. 8-11.

Rupa, T.R. 2015. Nutrient Management in cashew. In: *Advances in Cashew Production Technology,* Lecture Notes Series 24, pp. 73-77.

Rupa, T.R. 2015. Soil and nutrient related constraints and their management in horticultural crops – cashew. In: *Compendium of winter school on Utilization of Degraded Land and Soil through Horticultural Crops for improving Agricultural productivity and Environmental Quality* (Aishwath, O.P., Singh Balraj., Dubey, P.N. and Mishra, B.K., Eds.), ICAR-National Research Centre on Seed Spices, Tabiji, Ajmer, pp. 113-118.

Sajeev, M.V. 2015. Transfer and Impact of cashew production technologies, In: *Advances in Cashew Production Technology,* Lecture Notes Series 24, ICAR-DCR, Puttur, pp. 96-108.

Sajeev, M.V. 2015. Transfer and Impact of cashew production technologies. In: *E-manual on Advances in Cashew Production Technology,* ICAR-DCR, Puttur. pp. 96-108.

Sajeev, M.V. and Nayak, M.G. 2015. Participatory Technology Development and Transfer in Cashew: Experiences from farmers' field. In: *Training Manual, Participatory Technology Transfer Approaches for Plantation Crops*, ICAR-CPCRI, Kasaragode, pp. 100-116.

Sajeev, M.V. and Thamban, C. 2015. Farming System Research/Extension approach for technology transfer in plantation crops, In: *Training Manual, Participatory Technology Transfer Approaches for Plantation Crops,* ICAR-CPCRI, Kasaragode, pp. 204-217.

Saroj, P.L. and Rupa, T.R. 2015. Prospects of Cashew Cultivation under Changing Climatic Conditions. In: *Climate Dynamics in Horticultural Science,* (Editors: M.L. Choudhary, V.B. Patel, Mohammed Siddique and S. Sheraz Mahdi), Vol. 1, CRC Press, Suite, pp. 85-104.

Saroj, P.L., Mohana, G.S. and Adiga, J.D. 2016. Crop Improvement in cashew. In: *Proceedings of the National Seminar on Strategies for Development of Cashew,* during 19-20th February, 2016, Regional Fruit Research Station, Vengurle-416516, Sindhdurg, Maharastra, pp. 7-18.

Srikumar, K.K., Bhat P.S., Raviprasad T.N., Rajmohana K. and Vanitha K. 2015. Studies on Egg Parasitoids of *Helopeltis spp.* (Hemiptera: Miridae. In: *Biopestides: Innovations and Practices* (Sahayaraj and Selvaraj, Eds.), First edition, Smith and Franklin, pp. 159-166.

Vanitha, K. 2015. Management of minor pests of cashew. In: *Training manual on 'Integrated pest management in cashew'*. Lecture notes Series.25. ICAR- DCR, Puttur, pp: 15-20.

Yadukumar, N. and Rupa, T.R. 2015. Irrigation and Fertigation in Cashew. In: *Advances in Cashew Production Technology,* Lecture Notes Series 24, pp. 78-81.

9.4 Technical Reports / Compendia

Annual Report, 2014-15. ICAR-Directorate of Cashew Research, Puttur, p. 116 (Eds: P.S. Bhat and T.R. Rupa).

Annual Report, 2014-15. All India Co-ordinated Research Project on Cashew. ICAR-Directorate of Cashew Research, Puttur, p. 167 (Ed: T.N. Raviprasad).

Cashew News, 2015. ICAR-Directorate of Cashew Research, Puttur, Vol.20 (1), p. 12 (Eds: T.R. Rupa and M.V. Sajeev).

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Report on concluded AICRP-Cashew Trails 2014-15. ICAR-Directorate of Cashew Research, Puttur, p. 64 (Eds. Saroj, P.L. and Mohana, G.S.).

9.5 Extension Bulletins / Pamphlets

Nayak, M.G., Bhat, P.S. and Sajeev, M.V. 2015. Sudharitha Geru Besaya (Kannada)-Revised.

Nayak, M.G., Mohana, G.S., Bhat, P.S., Saroj, P.L. and Swamy, K.R.M. and Bhat, M.G. 2015. Minimum descriptors of cashew germplasm accessions. Catalogue-V, ICAR-Directorate of Cashew Research, Puttur, p. 44.

Saroj, P.L., Nayak, M.G., Raviprasad, T.N., Rupa, T.R. and Sajeev, M.V. 2015. Cashew Cultivation Practices (English).

9.6 Technical Bulletin

Vanitha, K. and Saroj, P.L. 2015. Insect pests of cashew and their management. ICAR-DCR Technical Bulletin No. 27, p. 68.

Zote, V.K., Gajbhiye, R.C., Salvi, B.R. and Salvi, S.P. 2015. Minor pests of cashew in Konkan region (Eds. Vanitha, K. and Mohana G.S.), p. 32.

9.7 Technical / Popular Articles

Adiga, J.D., Mohana, G.S., Meena, R.K., Eradasappa, E., Nayak, M.G., Saroj, P.L. and Bhat, M.G. 2015. H-126: First Jumbo nut cashew hybrid from ICAR-DCR. *Cashew News* **20**(1): 3-5.

Balasubramanian, D. 2016. Major suppliers of raw cashewnut to India. Ingredients South Asia. Eds. Francis. Safron Media Private Limited, Mumbai, India.

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Rupa, T.R. and Srividya, B.R. 2016. Spatial variability of available micronutrients in cashew orchards of Konkan region, Maharashtra, *Cashew News*, **20**(2): 3-5.

Saroj, P.L. and Singh, K. 2015. The Cashew: Equally healthy for mankind. *NAAS News,* **15**(4):11-14.

Saroj, P.L. and Nayak, M.G. 2016. High density orcharding in cashew. *Cashew Week*, **16**(4):13-14.

Saroj, P.L. 2015. Cashewnut-a valuable nutritional package. *ICAR News* **21**(4):7-8.

Vanitha, K. Saroj, P.L. and Bhat, P.S. 2015. Indian tropical tasar silkworm on cashew plantations. *ICAR Newsletter,* **22**(1): 8-9.

9.8 Scientific / teaching reviews

Training manuals:

- Training manual on Advances in Cashew Production Technology (Series No: 24), 2015, prepared for circulation among participants of National training on Advances in Cashew Production Technology held during May, 2015 (Eds: M.G. Nayak and Sajeev M.V.), p 121.
- Training manual on Integrated Pest Management in Cashew (Series No: 25), 2015, prepared for circulation among participants of training programme on Integrated Pest Management in Cashew held during December, 2015 (Ed: Sajeev M.V.), p 27.

E-manuals:

- E-manual on Advances in Cashew Production Technology (Series No: 24), 2015, prepared for circulation among participants of National training on Advances in Cashew Production Technology held during May, 2015 (Eds: M.G. Nayak and Sajeev M.V.), p 121.
- E-manual on Integrated Pest Management in Cashew (Series No: 25), 2015, prepared for circulation among participants of training programme on Integrated Pest Management in Cashew held during December, 2015 (Ed: Sajeev M.V.), p 27.
- E-manual on Integrated Pest Management in Cashew (Series No: 26), 2016, prepared for circulation among participants of training programme on Integrated Pest Management in Cashew held during January, 2016 (Ed: Sajeev M.V.), p 26.

10. राजभाषा कार्यान्वयन एवं प्रगति

राजभाषा कार्यान्वयन समिति

1.	प्रो. पी. एल. सरोज	अध्यक्ष
2.	डॉ सजीव एम. वी.	सदस्य
3.	श्री वी. रघुरामन्	सदस्य
4.	श्री राजकुमार अर्जुन दागडखैर	सदस्य
5.	श्री विजय सिंह	सदस्य
6.	श्री सीताराम के	सदस्य
7.	श्रीमति रेश्मा के	सदस्य
8.	श्री प्रकाश जी भट्	सदस्य सचिव

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

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

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

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

राजभाषा अधिनियम 1963 धारा 3(3) के अनुपालन के लिए 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 पखवाड़ा समारोह आयोजन किया गया । इस अवसर पर कर्मचारियों के लिए विभिन्न प्रतियोगिताओं जैसे हिंदी निबंध लेखन, प्रारूप, टिप्पण एवं मसौदा लेखन प्रतियोगिता, क्विझ प्रतियोगिता आदी आयोजित की गई है। प्रतियोगिताओं के विजेताओं को पुरस्कार भी वितरण किया जाता 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 जाता है।

मुख्य अतिथि द्वारा संबोधन

राजभाषा नियम 1976 नियम 11 के अनुपालन हेतु आवश्यक सामग्रियों जैसे प्रपत्र, रबड़ की मोहरें, नाम पट् 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 करने के लिए कोशिश जारी है। सभी हिन्दी गतिविधियों का विवरण वेबसाइट पर दिया जाता है।

हिंदी कार्यशाला

सरकारी काम काज में हिंदी का प्रयोग बढ़ाने के लिए एवं हिंदी में कार्यसाधक ज्ञान प्राप्त कराने हेतु निदेशालय में नियमित रूप से कार्यशालाओं को आयोजन किया गया। अनुभवी मार्गदर्शकों की मार्गदर्शन में मसौदा लेखन, टिप्पणी, अनुवाद एवं राजभाषा नियम अधिनियम पर हिंदी कार्यशाला आयोजित की गई और उन्हें अभ्यास भी किया गया।

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

पुत्तूर नगर राजभाषा कार्यान्वयन समिति

पुत्तूर नगर और आस पास के केन्द्र सरकारी कार्यलयों में राजभाषा हिन्दी का कार्यान्वयन सुनिश्चित करने की दृष्टी से पुत्तूर और विट्टल में स्थित केंद्रीय सरकार के कार्यालय, उपक्रम, बैंक सहित 22 सदस्य कार्यालय सम्मिलित नगर राजभाषा कार्यान्वयन समिति (नराकास) की घटन की गई है। पुत्तूर नराकास की 27वीं अर्धवार्षिक बैठक दिनांक 25.07.2015 को और दिनांक 27.01.2016 को 28वीं अर्धवार्षिक बैठक निदेशक महोदय की अध्यक्षता में आयोजित की गई।

बैठक में सदस्य कार्यालयों के राजभाषा कार्यान्वयन से संबंधित अर्धवार्षिक प्रगति रिपोर्ट समीक्षा किया जाता है। जब कभी काजू अनुसंधान निदेशालय की ओर से हिंदी कार्यशाला, प्रशिक्षण आयोजित की जाती है नराकास के सदस्य कार्यालयों को भी आमंत्रित किया जाता है और संयुक्त रूप से बैठक का आयोजन किया जाता है।

निदेशालय में निम्नलिखित रिपोर्ट हिंदी में प्रकाशित किया गया:

1. निदेशालय के वार्षिक प्रतिवेदन (वर्ष 2014–15) पूर्ण रूप से हिंदी में।
2. अखिल भारतीय समन्वित काजू अनुसंधान परियोजना, वार्षिक प्रतिवेदन सारांश (वर्ष 2014–15)।
3. काजू समाचार में हिंदी समिती की गतिविधियों के बारे में प्रतिवेदन।
4. दैनंदिन प्रयोग में आने वाले फार्मों 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 / RECOGNITION

Institution

ICAR-DCR has been awarded with ISO 9001:2008 on 19th March, 2016 for Quality Management System.

ICAR-DCR has been awarded with Government of India Patent (No. 272371) on 30.03.2016 for the patent filed entitled "Radial arm type cashew kernel extracting machine".

Individual/Team

Awards

K.P.V. Menon best poster award bagged by Dr. Loganathan, M. for poster entitled "Diagnostics and management of *Fusarium* wilt infecting tomato and chilli" presented during the 67th Annual Meeting and National Symposium on "Understanding host-pathogen interaction through science of Omics" conducted by Indian Phytopathology Socienty at Indian Institute of Spices Research, Kozhikode, Kerala on March 16-17, 2015

Best Paper Award bagged by Dr's. Sajeev, M.V., Nayak, M.G. and Saroj, P.L. for presentation of the paper 'ICT usage of cashew farmers: An enquiry of patterns and determinants'. In: 8th GCRA International Conference on "Innovative Digital Applications for Sustainable Development" held at UAS, GKVK, Bengaluru during 5-7, January, 2016.

Prof. P. Kameswara Rao Award - 2015-16 bagged by Dr. Vanitha, K. for best research paper oral presentation made on 'Seasonality, life cycle and breeding of an ant mimicking mantid, *Euantissa pulchra* F. occurring in cashew plantations' during XV AZRA International Conference on recent advances in life sciences held at Ethiraj College for women, Chennai, Tamil Nadu, during 11-13 February, 2016.

Awarded Degree in 'Doctor of Philosophy' to Smt. Vasanthi, P., Research Scholar at Mangalore University, Mangalagangothri for her thesis entitled "Studies on biology and population dynamics of Cashew Stem and root Borers, with special reference to management approaches for *Plocaederus* spp" (Guided by Dr. Raviprasad, T.N.).

12. RAC / RC / IMC / JISC MEETINGS

12.1 Research Advisory Committee

Dr. R.R. Hanchinal, 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, PO Bangalore-560032	Member
Dr. C.A. Viraktamath, Professor, Department of Entomology, University of Agricultural Sciences, GKVK, Bangalore	Member
Dr. R.T. Patil, Former Director, CIPHET, Ludhiana, Technocrat Institute of Technology, Anand Nagar, Bhopal- 462021	Member
Dr. M.R. Hegde, Principal Scientist, Indian Institute of Horticultural Research, Hesaraghatta Lake, Bangalore	Member
Prof. P. L. Saroj, Director, DCR, Puttur	Member
Dr. T. Janakiram, ADG (H-I), ICAR, KAB-II, Pusa, New Delhi-110012	Member
Shri. Vishnu Vasanth Bhandarakara, Post- Karki, Honnavara Taluk, Uttara Kannada district	Member
Sharada R. Rai, Shreya, Mogarodi, Kaniyooru post, Belthangadi Taluk, Dakshina Kannada district	
Dr .G.S. Mohana, Member Secretary, Sr. Scientist, Directorate of Cashew Research, Puttur	Member Secretary

The first meeting 7th RAC was held during 06-07th January, 2016. The RAC visited the demonstration plot of cashew varieties, cashew field gene bank, showcasing block and cashew apple experiments of ICAR-DCR. Further, the cashew orchards of farmers were also visited. On both days, presentations on research progress in crop improvement, crop management, crop protection and post harvest technology were made by scientists of DCR. The RAC appreciated the efforts of scientists in various experiments and gave specific suggestions to improve the quality of research. Further, the committee felt that need based collaboration with other research institutes may be initiated and services of KVKs/NGOs may be utilized for transfer of technologies generated by the DCR and in germplasm survey and collection. It recommended that the Scientists of DCR should be deputed to visit cashew research institutes in other cashew growing countries such as Brazil, Australia, African countries, China (Hainan) etc. for scientific exposure. For this purpose short term study tours, germplasm collection surveys etc. may be proposed. The committee felt that cashew museum at the Directorate should be upgraded. Looking to the achievements and contributions made by DCR over the last 30 years, Chairman and the Members of RAC felt that ICAR may consider upgrading DCR into Indian Institute of Cashew Research (IICR). The meeting was concluded with remarks by the Chairman and members of RAC followed by vote of thanks by Dr. TN Ravi Prasad, Scientist In-charge, PME cell.

RAC Meeting in progress

RAC Meeting in progress

Field visit at DCR - Research farm

Visit to cashew gene bank

Visit to Farmer's field

Visit to Farmer's field

12.2 Institute Management Committee

Name and Address	Status
Prof. P.L. Saroj, Director, ICAR-DCR, Puttur - 574 202, Karnataka.	Chairman
Assistant Director General (Hort-I), ICAR, Krishi Anusandhan Bhavan-II, New Delhi - 110 012	Member
The Joint Director of Horticulture, (Plantation Crops and Plant Protection), Directorate of Horticulture, Govt. of Karnataka, Lalbagh, Bengaluru - 4, Karnataka	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. Sudha Mysore, Principal Scientist, ICAR-IIHR, Hesaraghatta Lake post, Bengaluru - 560 089.	Member
Dr. Ramanathan, Principal Scientist, ICAR-CTCRI, Thiruvananthapuram, Kerala - 695 017	Member
Dr. T.N. Raviprasad, Principal Scientist, ICAR-DCR, Puttur - 574 202, Karnataka.	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
Dr. T.N. Raviprasad, Principal Scientist (Ent) & I/c PME Cell, DCR, Puttur-574202, DK District, Karnataka	Member
The Finance and Accounts Officer, ICAR-CPCRI, Kasaragod - 671 124, Kerala	Member
Shri. K.M. Lingaraja, Asst. Administrative Officer (E) & Administrative Officer in-charge, ICAR-DCR, Puttur- 574 202, Karnataka	Member Secretary

The Institute Management Committee (IMC) met twice on 13-10-2015 and 26-02-2016. The activities of the Directorate were appraised to the IMC during the meetings. The IMC reviewed the progress made during the period. The recommendations emanated were compiled and sent to Council. The approved recommendations were duly circulated to all the members of this Directorate.

Progress of IMC meeting

12.3 Institute Research Committee

In order to review the ongoing research programs under Crop Improvement, Management, Protection, Post Harvest Technology and Transfer of Technology, 28th meeting of Institute Research Council (IRC) was held at the Directorate of Cashew Research, Puttur on 20th October 2015 under the Chairmanship of Prof. P. L. Saroj, Director, DCR, Puttur. The meeting was started with the welcome by Dr. Mohana, G.S., Senior Scientist and Member Secretary, IRC. This was followed by introductory remarks of Prof. P. L. Saroj, Director, DCR, Puttur. He highlighted the importance of IRC meeting and need for in-depth deliberations regarding various projects. However, the Chairman expressed his concern about better management of all field experiments, timely submission of RPPs and development of research database in consultation with PME cell.

As Member Secretary, Dr. Mohana presented the Recommendations and Action Taken Report of the 27th IRC meeting which was agreed by the house. The progress of various research projects along with new project under crop improvement, crop management, crop protection, transfer of technology, post harvest technology, food technology and plant physiology were presented by the scientists of DCR. The results were discussed in detail and recommendations pertaining to different research projects were drawn. The meetings came to close with vote of thanks by Dr. Mohana, G.S., Member Secretary, IRC.

Progress of IRC meeting

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. ICAR Consortia / Network projects

- Micronutrient Management in horticultural crops for enhancing yield and quality (Participating centre).
- Consortium research projects (CRP) on borers in network mode.
- Out Reach Programme on Management of sucking pests in Horticultural crops.
- CRP on Agro-biodiversity.

D. Externally Funded Projects

- Development of Morphological Descriptors and DUS Test Guidelines for Cashew (Anacardium occidentale L.) – PPV&FRA.
- Evaluation of indigenous strain of fungal pathogen Beauveria bassiana against Helopeltis sp. on guava, cashew and tea - DST.

12.4. Institute Joint Staff Council

1	Prof. P.L. Saroj	Chairman, IJSC
2	Dr. T.R. Rupa	Member (Official side) / Dr. Babli Mog from Feb, 2016
3	Dr. Mohana, G.S.	Member (Official side)
4	Dr. K. Vanitha	Secretary (Official side)
5	Sri. K.M. Lingaraja	Member (Official side) / Sri. V. Raghuraman from Nov, 2016
6	Sri. R. Arulmony	Member (Official side)
7	Smt. K. Padminikutty	Member (Staff side)
8	Smt. Reshma, K.	Member (Staff side)
9	Sri. Ravishankar Prasad	Secretary (Staff side)
10	Sri. K. Babu Poojari	Member (Staff side) & CJSC member
11	Sri. Veerappa Gowda	Member (Staff side)

The IJSC meetings were held on 30th March, 2015, 30th June, 2015, 30th September, 2015, 30th December, 2015 and 30th March, 2016 under the chairmanship of Director, ICAR-DCR, Puttur at Kemminje campus of DCR and the agenda items were discussed for the benefit of DCR staff members.

ANNEXURES

Annexure - I

Ongoing Research Projects/Experiments

Crop Improvement

Sl. No.	Project	PI	Co-PI
1.1	Collection, conservation, evaluation and documentation of cashew germplasm [1986 – Long term]	MG Nayak	Mohana, G.S. and Vanitha, K.
1.2	Genetic improvement of cashew for yield and quality traits [1986 – Long term]	Mohana GS	Nayak, M.G., Saroj, P.L. and D. Rajkumar Arjun
1.2.1	Development of dwarf and compact cashew hybrids suitable for high density planting [2013 – 2023]	Mohana GS	Janani, P.
1.8	Genetic analysis of mapping population through molecular markers for important traits in cashew [2012 – 2018]	Mohana GS	Nayak, M.G.
1.9	Development and evaluation of back cross progenies of promising hybrids for dwarf stature and high yield [2013-2025]	Mohana GS	Nayak, M.G.
1.10	Evaluation of cashew apple germplasm for cashew apple yield and quality traits [2013-2020]	Saroj PL	Nayak, M.G., Vanitha, K. Loganathan, M. and D. Rajkumar Arjun
	New Project: Identification and evaluation of cashew genotypes for Cashew Nut Shell Liquid content [2016-2024]	Mohana GS	Nayak, M.G. and Balasubramanian, D.
	PPV FRA Development of morphological descriptors and DUS test guidelines for cashew [2015-2018]	Nayak MG	Mohana, G.S. and Saroj, P.L.
	CRP-Agro biodiversity [2015-2017]	Mohana GS	-

Crop Management			
2.11	Performance of high yielding varieties of cashew in different high density planting system [2006 – 2015]	P Janani	Babli Mog
2.15	Rootstock studies in cashew [2007 - 2015]	P Janani	Nayak, M.G.
2.18	Effect of Paclobutrazol (PBZ) on growth and yield of cashew [2009 – 2015]	Babli Mog	Janani, P.
2.19	Irrigation requirement for cashew under high density planting system. [2011 – 2015]	Prabha Susan Philip	Babli Mog
2.20	Organic farming in cashew [2011 – 2016]	Prabha Susan Philip	Raviprasad, T.N.
2.21	Establishment of nutrient diagnostic norms in cashew [2013-2018]	Prabha Susan Philip	Nayak, M.G.
2.22	Physiological Responses of cashew to salt and drought stresses [2015-2017]	Babli Mog	Prabha Susan Philip
	New project: Development of cashew based cropping system under rain fed condition of Karnataka [2016- 2019]	P Janani	Prabha Susan Philip
	Net work project Micronutrient Management in Horticultural Crops for Enhancing Yield and Quality – Cashew [2014-2017]	Prabha Susan Philip	-
Crop Protection			
3.17	Bio-diversity of arthropod fauna in cashew eco-system [2010- 2015]	K Vanitha	Raviprasad, T.N.
3.19	3.19a and 3.19b were merged into 3.19. Evaluation of indigenously occurring natural enemies for their efficacy in managing of Cashew Stem and Root Borers (CSRB) and Tea Mosquito Bug (TMB) [2012 - 2015]	TN Raviprasad	Vanitha, K. and Rajkumar (CPCRI, Kasargod)

3.21	Diversity and bio-ecology of insect pollinators and their efficiency in increasing yield of cashew [2014-2019]	K. Vanitha	Raviprasad, T.N.
	New project: Survey and surveillance of important diseases of cashew [2015-2020]	Loganathan M	Raviprasad, T.N.
	Flag ship project Investigations on semio-chemicals for management of TMB and CSRB [2014-2019]	TN Raviprasad	Vanitha, K. and Bhaktavatsalam, N. (NBAIR, Bengaluru)
	Net work project ORP on Management of sucking pests in Horticultural Crops (Network Project - ICAR funded through IIHR, Bangalore) [2012-2017]	TN Raviprasad	Vanitha, K.
	CRP on Borers [2014-2019]	TN Raviprasad	-
Post Harvest Technology			
4.15	Design, development and evaluation of solar tunnel dryer for cashew apple [2012-15]	D Balasubramanian	D Rajkumar Arjun
4.16	Developing quality standards for raw cashew nuts [2014-17]	D Balasubramanian	Vanitha, K.
4.17	Design and development of mechanical slicer for cashew apple [2014-16]	D Balasubramanian	-
4.18	Reduction of tannins from cashew apple juice by using low cost food grade materials [2014-2017]	Rajkumar Arjun D	Janani, P.
4.19	Screening of cashew varieties to specify use of cashew apple in value added products [2014-2017]	Rajkumar Arjun D	Sajeev, M.V.
Transfer of Technology			
5.1	Transfer of Technology programmes in Cashew [1986 – Long term]	Sajeev MV	Nayak, M.G. and Balasubramanian, D.
5.2	Impact of cashew production technologies on area, production and productivity of cashew [2011 – 2015]	Sajeev MV	Mohana, G.S.

Annexure - II

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

Balasubramanian, D.	Delivered lecture on 'Utilization of Cashew apple' in DCCD sponsored training programme conducted for Women Self Help Group at Krishi Vigyan Kendra, Fisheries College, Mangalore.	10th April, 2015
Balasubramanian, D.	Participated in Making Engineering Scientists for Stake holders and for Nation. ICAR-Engineering Scientists Meet conducted by Division of Agricultural Engineering, ICAR at NASC, New Delhi.	13-14th April, 2015
Raviprasad, T.N.	Participated in First Workshop of Nodal Officers of Knowledge based Resources Information Systems Hub for Innovations in Agriculture (KRISHI) organized by ICAR-IASRI, New Delhi at NASC Complex, New Delhi.	19th August, 2015
Raviprasad, T.N.	Moderated the 2nd Round Table Meet under the Consortium Research Platform (CRP) on Borers of Horticultural crops conducted at this Directorate.	19 August, 2015
Vanitha, K.	Participated in the 2nd Round Table Meet on CRP on borers conducted at this Directorate.	19th August 2015
Sajeev, M.V.	Participated in Farmers' Meet during exhibition at KVK, Kankanady.	28th September 2015
Sajeev, M.V.	Participated in Krishi Mela at UAHS, Shivamogga.	03-06 October 2015
Vanitha, K.	Participated in the Annual Group Meeting of AICRP on Cashew held at Vengurle, Maharashtra.	4th October, 2015.
Mohana, G.S.	Participated in AICRP Annual General Body Meeting at RFRS Vengurle, Maharastra.	2-4th November, 2015
Balasubramanian, D	Exposure training program for Women farmers' under WRD Coastal Karnataka held at DCR, Puttur	5th November 2015
Saroj, P.L.	Recognized as Co-Chairman for the Session – VI "Propagation techniques for quality planting material production". In: National Conference on Temperate Fruits and Nuts – A Way Forward for Enhancing Productivity and Quality, organized by Horticultural Society of India and ICAR- CITH, held at Srinagar.	7-9th November 2015.
Mohana, G.S. Nayak, M.G.	Participated in Indo US bilateral workshop on DUS testing at New Delhi organized by PPV FRA, New Delhi.	23-24th November, 2015.
Balasubramanian, D	Delivered lecture on "Processing technology on Cashew and demonstrated mechanized cashew processing" during the 'National level training program on cashew' at RARS, Maharashtra.	8-9th November 2015.

Balasubramanian, D	Delivered lecture on 'Starting small scale cashewnut processing' for Agricultural officers from Goa conducted at ICAR- DCR, Puttur	16th Novemeber 2015.
Saroj, P.L.	Participated in Golden Jubilee of Green Revolution in India held at AP Shinde Symposium Hall, NASC, New Delhi.	27th November, 2015
Rupa, T.R. and Prabha Susan Philip	Participated in 80th Annual Convention of the Indian Society of Soil Science (ISSS) at University of Agricultural Sciences, GKVK, Bengaluru.	5-8th December, 2015
Mohana, G.S.	Participated in International symposium on biodiversity, agriculture, environment and forestry, Ooty, Tamil Nadu.	11-12th December, 2015
Babli Mog	Participated in Third International Plant Physiology Conference held at JNU, New Delhi.	11-14th December 2015
Sajeev, M.V.	Participated in Eighth GCRA International Conference on "Innovative Digital Applications for Sustainable Development", UAS, GKVK, Bengaluru.	5-7th January, 2016
Saroj, P. L.	Participated in Eleventh National symposium on Innovations in Coastal Agriculture – Current Status and Potentials under Changing Environment held at ICAR-Indian Institute of Water Management, Bhubaneswar.	14-17th January, 2016
Mohana, G.S.	Participated in CRP-AB Southern cluster meeting at IISR, Calicut.	27th January, 2016
Balasubramanian, D.	Participated in Annual Meet cum Workshop conducted by Zonal Technology Management Unit (ZTMU-South Zone), ICAR-Indian Institute of Horticulture Research Institute, Bangalore.	8th February, 2016
Vanitha, K.	Participated in XV AZRA International Conference on recent advances in life sciences at Ethiraj College for women, Chennai, Tamil Nadu.	11-13th February, 2016
Raviprasad, T.N.	Participated in Annual Review Meeting 2004-15 of the ORP on Management of Sucking Pests at Indian Institute of Horticultural Research, Bengaluru, held on 13th February 2016	13th February, 2016
Saroj, P.L.	Participated in National Seminar on Strategies for Development of Cashew at RFRS Vengurla	19th February, 2016
Nayak, M.G. Mohana, G.S	Participated in Tenth DUS Review meeting at MPKV Rahuri, Maharastra	26-27th February, 2016
Balasubramanian, D.	Participated in State level seminar on cashew entitled Strategies for sustainable development of cashew in Karnataka conducted by College of Horticulture, Bidar, Karnataka	8-9th March, 2016
Sajeev, M.V.	Participated in Farmers' Meet during exhibition at CPCRI, Kasaragode	12th March 2016

Annexure - III

Radio Talk / TV Programme

Nayak, M.G.	Technologies for yield enhancement in cashew-All India Radio, Mangalore.	16th May 2015
Raviprasad, T.N.	Management of Tea Mosquito Bug using conventional and biological methods by DD Chandana (Kannada) TV channel	9th October, 2015
Nayak, M.G.	A talk on high density planting (in kannada language) of cashew was telecast by Doordarshan (Chandana) and DD-1 in Krishi Darshan programme.	9th October 2015
Raviprasad, T.N.	Pest management in Cashew" in Kannada, on DD-Chandana channel.	10th October, 2015
Raviprasad, T.N.	Non insecticidal approaches for pest management by All India Radio, Mangaluru, Karnataka	29th December 2015
Nayak, M.G.	A talk on cashew varieties was delivered and recorded by Doordarshan for telecast	29th March 2016

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.

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

Name and Designation	Address	Date of visit
Dr. S.B. Dandin	Former Vice Chancellor, UHS, Bagalkok	21.5.2015
Dr. S.D. Shikhamany	Former Vice Chancellor, Dr. Y.S.R. Horticultural University, Hyderabad	18.6.2015
Dr. OPS Khola	Principal Scientist & Head, IISWC Regional Centre, Udhagamandalam	07.8.2015
Shri. A.M. Annaiah	IFS (Retd), Bangalore	29.9.2015
Dr. P. Chowdappa	Director, CPCRI, Kasaragod	08.12.2015
Smt. Shakuntala Shetty	Hon'ble M.L.A., Puttur	08.12.2015
Dr. S.K. Pandey	Former Director, CPRI, Shimla	29.1.2015
Dr. T. Janakiram	ADG (Hort. Sci. I), ICAR, New Delhi	06.1.2016
Dr. R.R. Hanchinal	Chairperson, PPV & FRA, Govt. of India	6-7.1.2016
Dr. S.N. Puri	Ex-Vice Chancellor, CAU, Imphal	08.1.2016
Dr. Brahma Singh	Former Director, Life Science, DRDO, New Delhi	19.2.2016
Dr. V.S. Korikanthimath	Ex-Director, ICAR-CCARI, Goa	19.2.2016
Dr. N. Subhash	Retd. Professor & Head, Plant Tissue Culture Lab, Anand Agri. University, Anand, Gujarat	19.2.2016
Shri. Venketesh N. Hubballi	Director, DCCD, Kochi	23.2.2016
Dr. Hanami Shetty	Dean, College of Horticulture, Arabhavi	23.2.2016
Dr. H.P. Singh	Former DDG (Hort), ICAR, New Delhi	27-30.3.2016
Dr. I.P. Singh	Principal Scientist, Indian Institute of Citrus Research, Nagpur	28.3.2016
Dr. B.R. Salvi	Associate Director of Research, Regional Fruit Research Station, Vengurla	28.3.2016
Dr. B.K. Pandey	Principal Scientist (Plant Pathology), ICAR, KAB-II, New Delhi	28.3.2016
Dr. S.D. Sharanappa	Supdt. of Police, Mangalore	29.3.2016

ANNEXURE - VI

Personnel

Staff Position as on 31.3.2016

Category	Sanctioned	Filled	Vacant
Director (RMP)	1	1	-
Scientific	17	13	4
Technical	19	14	5
Administrative	15	10	5
Canteen staff	1	1	-
Skilled Support Staff	37	25	12
Total	**90**	**64**	**26**

Research Management Position		
1.	Prof. P.L.Saroj	Director
Scientific		
1.	Dr. M. Gangadhara Nayak	Principal Scientist (Horticulture)
2.	Dr. P. Shivarama Bhat	Principal Scientist (Agricultural Entomology) (up to 30.5.2015)
3.	Dr. T.R. Rupa	Principal Scientist (Soil Science-Soil Physics and soil and water conservation) (up to 18.02.2016)
4.	Dr. T.N. Raviprasad	Principal Scientist (Agricultural Entomology)
5.	Dr. D. Balasubramanian	Principal Scientist (Agricultural Structures and Processing Engineering)
6.	Dr. J. Dinakara Adiga	Senior Scientist (Horticulture) (on Lein)
7.	Dr. M. Loganathan	Senior Scientist (Plant Pathology)
8.	Dr. G.S. Mohana	Senior Scientist (Genetics & Cytogentics)
9.	Dr. M.V. Sajeev	Scientist (Agricultural Extension)
10.	Dr. Ramkesh Meena	Scientist (Horticulture) (up to 03.12.2015)
11.	Sri E. Eradasappa	Scientist (Plant Breeding) (on Study Leave)
12.	Dr. (Mrs.) K. Vanitha	Scientist (Agricultural Entomology)
13.	Sri. Rajkumar Arjun	Scientist (Food Technology)
14.	Dr. Babli Mog	Scientist (Plant Physiology)

15.	Dr. P. Janani	Scientist (Spices, Plantation, Medicinal and Aromatic Plants)
16.	Ms. Prabha Susan Philip	Scientist (Soil Science)
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	Sr. Technical Officer
6.	Sri. Lakshmipathi	Sr. Technical Officer (up to 09.02.2016)
7.	Sri. K.V. Ramesh Babu	Sr. Technical Officer
8.	Sri. N. Manikandan	Sr. Technical Officer
9.	Sri. R. Muthuraju	Technical Officer
10.	Sri. K. Seetharama	Technical Officer
11.	Sri. M. Bhojappa Gowda	Technical Officer
12.	Sri. Vijay Singh	Technical Assistant
13.	Sri. Ravishankar Prasad	Technical Assistant
14.	Sri. K. Babu Poojari	Technical Assistant
15.	Sri. P. Honnappa Naik	Sr. Technician
Administration		
1.	Sri. V. Raghuraman	Administrative Officer
2.	Sri. K.M. Lingaraja	Asst. Administrative Officer
3.	Smt. M. Rathna Ranjini	Asst. Administrative Officer
4.	Sri. O.G. Varghese	Private Secretary
5.	Smt. B. Jayashri	Personal Assistant (Superannuated on 31.01.2016)
6.	Smt. K. Reshma	Personal Assistant
7.	Ms. Winnie Lobo	Assistant
8.	Smt. M. Leela	Assistant
9.	Sri. Umashankar	Upper Division Clerk
10.	Smt. K. Padminikutty	Upper Division Clerk
11.	Sri. K. Balappa Gowda	Gestetner Operator

ANNEXURE - VII

Result Framework Document (RFD)

भाकृअनुप
ICAR

Directorateof Cashew Research (2014 –2015)

ICAR-Directorate of Cashew Research, Puttur, Karnataka

Section 1
Vision, Mission, Objectives and Functions

Vision :

Accomplishing self sufficiency in raw nut production in cashew to support stakeholders.

Mission :

Increasing the production and productivity of cashew.

Objectives :

1) Conservation of genetic resources/ germplasm for sustainable use

2) Production management and value addition.

3) Transfer of technology through various media

Functions :

- To conduct missionoriented research on all aspects of cashew for improving productivity and quality with special reference to export.
- To serve as a national repository for cashew germplasm and a clearing house for research information on cashew.
- To act as centre for training in research methodologies and technology updating of cashew and to coordinate national research projects.
- To provide consultancy regarding cashew production technology.
- To generate quality planting material.
- To collaborate with national and international agencies for achieving the mandate.

Section-2

Inter se priorities among Key Objectives, Success Indicators and Targets

Sl. No.	Objective(s)	Weight	Action(s)	Success Indicator(s)	Unit	Weight	Target/Criteria Values				
							Excellent 100%	Very Good 90%	Good 80%	Fair 70%	Poor 60%
1	Production management and value addition	50	Development of improved Production protection and post harvest technologies	Improved production, protection and post harvest technologies in process of development	Number	36	5	4	3	2	1
			Production of elite and disease free planting material	Number of grafts produced	Number (in lakhs)	14	1.8	1.5	1.2	0.9	0.6
2	Conservation of genetic resources / germplasm for sustainable use	20	Collection, characterization and conservation of germplasm	Accessions added / characterized in germplasm	Number	10	5	4	3	2	1
			Breeding of varieties for good traits and tolerance to biotic and abiotic stress	Hybrids and Selectons under process of development and evaluation	Number	10	5	4	3	2	1
3	Transfer of technology through various media	10	Effective dissemination of scientific and technical knowhow	TOT programmes conducted	Number	5	5	4	3	2	1
				Publication of extension literature, radio talks and TV program	Number	5	5	4	3	2	1
*	Publication/ Documentation	5	Publication of the research articles in the journals having the NAAS rating of 6.0 and above	Research articles published	No.	3	4	3	2	1	0
			Timely publication of the Institute Annual Report (2013-2014)	Annual Report published	Date	2	30.06.2014	02.07.2014	04.07.2014	07.07.2014	09.07.2014

Sl. No.	Objective(s)	Weight	Action(s)	Success Indicator(s)	Unit	Weight	Target/Criteria Values				
							Excellent 100%	Very Good 90%	Good 80%	Fair 70%	Poor 60%
*	Fiscal resource management	2	Utilization of released plan fund	Plan fund utilized	%	2	98	96	94	92	90
*	Efficient Functioning of the RFD System	3	Timely submission of Draft RFD 2014-2015 for approval	On-time submission	Date	2	May 15, 2014	May 16, 2014	May 19, 2014	May 20, 2014	May 21, 2014
			Timely submission of Results for 2013-2014)	On-time submission	Date	1	May 1 2014	May 2 2014	May 5 2014	May 6 2014	May 7 2014
*	Enhanced Transparency/ Improved Service delivery of Ministry / Department	3	Rating from Independent Audit of implementation of Citizens'/ Clients' Charter (CCC)	Degree of implementation of commitments in CCC	%	2	100	95	90	85	80
			Independent Audit of implementation of Grievance Redress Management (GRM) system	Degree of success in implementing GRM	%	1	100	95	90	85	80
*	Administrative Reforms	7	Update organizational strategy to align with revised priorities	Date	Date	2	Nov.1 2014	Nov.2 2014	Nov.3 2014	Nov.4 2014	Nov.5 2014
			Implementation of agreed milestones of approved Mitigating Strategies for Reduction of potential risk of corruption (MSC)	% of implementation	%	1	100	90	80	70	60
			Implementation of agreed milestones for ISO 9001	% of implementation	%	2	100	95	90	85	80
			Implementation of milestones of approved Innovation Action Plans (IAPs)	% of implementation	%	2	100	90	80	70	60

Section-3

Trend Values of the Success Indicators

Sl. No.	Objective	Action	Success Indicator	Unit	Actual Value for FY 2012-2013	Actual Value for FY 2013-2014	Target Value for FY 2014-2015	Projected Value for FY 2015-2016	Projected Value for FY 2016-2017
1	Production management and value addition	Development of improved production, protection and post harvest technologies	Improved production, protection and post harvest technologies in process of development	Number	4	6	4	4	4
		Production of elite and disease free planting material	Number of grafts produced	Number (in lakhs)	1.45	1.5	1.5	1.5	1.6
2	Conservation of genetic resources / germplasm for sustainable use	Collection, characterization and conservation of germplasm	Accessions added / characterized in germplasm	Number	17	5	4	4	4
		Breeding of varieties good traits and tolerance to biotic and abiotic stress	Hybrids and selections under process of development and evaluation	Number	5	5	4	4	4
3	Transfer of technology through various media	Effective dissemination of scientific and technical knowhow	TOT programmes conducted	Number	7	6	4	6	7
			Publication of extension literature, radio talks and TV program	Number	7	4	4	6	7
*	Publication/ Documentation	Publication of the research articles in the journals having the NAAS rating of 6.0 and above	Research articles published	No.	2	3	3	3	3
		Timely publication of the Institute Annual Report (2013-2014)	Annual Report published	Date	-	-	-	-	-

Sl. No.	Objective	Action	Success Indicator	Unit	Actual Value for FY 2012-2013	Actual Value for FY 2013-2014	Target Value for FY 2014-2015	Projected Value for FY 2015-2016	Projected Value for FY 2016-2017
*	Fiscal resource management	Utilization of released plan fund	Plan fund utilized	%	99.89	89.8	96	96	96
*	Efficient Functioning of the RFD System	Timely submission of Draft RFD 2014-2015 for approval	On-time submission	Date	-	-	May 16, 2014	-	-
		Timely submission of Results for 2013-2014	On-time submission	Date	-	-	May 2, 2014	-	-
*	Enhanced Transparency/ Improved Service delivery of Ministry / Department	Rating from Independent Audit of implementation of Citizens'/Clients' Charter (CCC)	Degree of implementation of commitments in CCC	%	-	-	95	-	-
		Independent Audit of implementation of Grievance Redress Management (GRM) system	Degree of success in implementing GRM	%	-	-	95	-	-
*	Administrative Reforms	Update organizational strategy to align with revised priorities	Date	Date	-	-	Nov.2, 2014	-	-
		Implementation of agreed milestones of approved Mitigating Strategies for Reduction of potential risk of corruption (MSC)	% of implementation	%	-	-	90	-	-
		Implementation of agreed milestones for ISO 9001	% of implementation	%	-	-	95	-	-
		Implementation of milestones of approved Innovation Action Plans (IAPs)	% of implementation	%	-	-	90	-	-

Section 4(a)

Acronyms

Sl.No.	Acronym	Description
1.	TV	Television
2.	TOT	Transfer of Technology
3.	INM	Integrated Nutrient Management
4.	AICRP	All India Coordinated Research Project
5.	NGOs	Non Government Organizations

Section 4(b): Description and definition of success indicators and proposed measurement methodology

Sl No.	Success Indicator	Description	Definition	Measurement	General Comments
1	Improved production, protection and post harvest technologies in process of development	Developing technologies to improve input use efficiency and increase Benefit: cost ratio of growers and processors	Input use efficiency refers to judicious use of agricultural inputs to increase cashew production per unit of inputs used. Also development of new technologies to improve post harvest utilization of cashew.	Developing packages related tofoliar nutrition, INM, spacing for high yielding varieties, plant protection schedules etc.	Improving nutrient use efficiency, productivity and pest management are most important factors to increase productivity of cashew. Further, there is a need to develop advanced technologies for processing of cashew for better quality products.
2	Number of grafts produced	Production of planting material through soft wood grafting	It is an asexual method of propagation by which new planting material is produced.	Number(in lakhs)	In cashew planting material mainly consists of soft wood grafts.
3	Accessions added/ characterized in germplasm	Germplasm are genetic resources of cashew which are source of genetic variability	Germplasm is collection of all cultivars, wild species etc for conservation and utilization	Number of accessions added/characterized	--

Sl No.	Success Indicator	Description	Definition	Measurement	General Comments
4	Hybrids and selections under process of development and evaluation	Source materials for improved varieties to be evaluated	Best performing hybrids/ selections will be identified for their evaluation before release	Number of hybrids, selections under process of development and evaluation	--
5	TOT programmes conducted	Capacity building activities to improve knowledge and skill of cashew growers, extension workers etc.	Training is a process of acquiring new skill, attitude and knowledge through various means	Number	--
6	Publication of extension literature, radio talks and TV program.	Creating awareness through print and mass media methods	Dissemination of knowledge through popular articles, pamphlets ,radio talk and TV programme	Number	--

Section 5:

Specific performance requirements from other departments that are critical for delivering agreed results

Location Type	State	Organisation Type	Organisation Name	Relevant Success Indicator	What is your requirement from this organisation	Justification for this requirement	Please quantify your requirement from this Organisation	What happens if your requirement is not met
Multilocation	Karnataka, Kerala, North Eastern States	State Departments, Cashew Development Corporations, Plantation Corporations,NGOs	State Departments of Horticulture, State Cashew Development Corporations etc	Number of grafts produced	Indent for planting material of cashew.	Indents given	Number of planting material will be produced as per the indent	Less or more number of planting materials will be produced.

Section 6 :

Outcome/Impact of activities of Department/ Ministry

S. No.	Outcome/Impact	Jointly responsible for influencing this outcome/impact with the following organisation(s)/ department(s)/ministry(ies)	Success Indicator(s)	Unit	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017
1	Production of quality planting materials of cashew, awareness of stakeholders & capacity building	State department of horticulture/National horticulture mission/ AICRP-Cashew	Production /distribution of quality and disease-free planting materials	Number (in lakhs)	1.50	1.50	1.50	1.50	1.60
			Awareness of stakeholders & capacity building through training/ demonstrations	Per cent increase in awareness among stakeholders	70	70	70	75	80

Classification of Success Indicators according to its Category

Sl. No.	Success indicator	Input	Activity	Internal Output	External Output	Outcome	Measures Qualitative Aspects
1.	Improved production, protection and post harvest technologies in process of development	False	True	False	False	False	False
2.	Number of grafts produced	False	False	False	False	True	True
3.	Accessions added /characterized in germplasm	False	True	False	False	False	False
4.	Hybrids and selections under process of development and evaluation	False	True	False	False	False	False
5.	TOT programmes conducted	False	False	False	False	True	True
6.	Publication of extension literature, radio talks and TV program	False	False	False	False	True	True

Table for setting agreed performance targets

S.No.	Success indicator (s)	Past Achievements of the Success Indicators							Mean of the Achievements	Projected value of the success indicator for 2014-15 as per the approved RFD 2013-14
		VII 2007-2008	VI 2008-2009	V 2009-2010	IV 2010-2011	III 2011-2012	II 2012-2013	I 2013-2014		
1.	Improved production, protection and post harvest technologies in process of development	2	1	2	3	5	6	6	5.7	4
2.	Number of grafts produced (lakhs)	2.6	0.98	1.01	3.91	2.05	1.5	1.5	1.91	1.7
3.	Accessions added/characterized in germplasm.	4	14	0	0	1	15	5	4.5	4
4.	Hybrids and selections under process of development and evaluation	5	5	5	5	5	4	5	4.85	4
5.	TOT programmes conducted	18	4	10	2	3	5	6	5.0	7
6.	Publication of extension literature, radio talks, TV program	2	2	7	6	20	7	4	6.0	7

Annual (April 1, 2014 to March 31, 2015) Performance Evaluation Report of RFD 2014-2015 of RSCs i.e. Institutes

Name of the Division : HORTICULTURAL SCIENCE

Name of the Institution : ICAR-DIRECTORATE OF CASHEW RESEARCH

RFD Nodal Officer : J. Dinakara Adiga

Sl. No.	Objective(s)	Weight	Action(s)	Success Indicator(s)	Unit	Weight	Target/Criteria Values					Achievements	Performance		Percent achievements against Target values of 90% Col.	Reasons for shortfalls or excessive achievements, if applicable
							Excellent 100%	Very Good 90%	Good 80%	Fair 70%	Poor 60%		Raw score	Weighted raw score		
1	Production management and value addition	50	Development of improved production, protection and post harvest technologies	Improved production, protection and post harvest technologies in process of development	Number	36	5	4	3	2	1	5	100	36	125.0	Achievement falls under excellent category which is desirable.
			Production of elite and disease free planting material	Number of grafts produced	Number (in lakhs)	14	1.8	1.5	1.2	0.9	0.6	1.8	100	14	120.0	Achievement falls under excellent category which is desirable.
2	Conservation of genetic resources/ germplasm for sustainable use	20	Collection, characterization and conservation of germplasm	Accessions added /characterized in germplasm	Number	10	5	4	3	2	1	5	100	10	125.0	Achievement falls under excellent category which is desirable.
			Breeding of varieties for good traits and tolerance to biotic and abiotic stress	Hybrids and selections under process of development and evaluation	Number	10	5	4	3	2	1	5	100	10	125.0	Achievement falls under excellent category which is desirable.

Sl. No.	Objective(s)	Weight	Action(s)	Success Indicator(s)	Unit	Weight	Target/Criteria Values					Achievements	Performance		Percent achievements against Target values of 90% Col.	Reasons for shortfalls or excessive achievements, if applicable
							Excellent 100% 90%	Very Good	Good 80%	Fair 70%	Poor 60%		Raw score	Weighted raw score		
3	Transfer of technology through various media	10	Effective dissemination of scientific and technical knowhow	TOT programmes conducted	Number	5	5	4	3	2	1	5	100	5	125.0	Achievement falls under excellent category which is desirable.
				Publication of extension literature, radio talks and TV program	Number	5	5	4	3	2	1	5	100	5	125.0	Achievement falls under excellent category which is desirable.
*	Publication/ Documentation	5	Publication of the research articles in the journals having the NAAS rating of 6.0 and above	Research articles published	No.	3	4	3	2	1	0	4	100	3	133.3	Achievement falls under excellent category which is desirable.
			Timely publication of the Institute Annual Report (2013-2014)	Annual Report published	Date	2	30 .06 .2014	02 .07 .2014	04 .07 .2014	07 .07 .2014	09 .07 .2014	16 -6 -2014	100	2		
*	Fiscal resource management	2	Utilization of released plan fund	Plan fund utilized	%	2	98	96	94	92	90	100	100	2		

Sl. No.	Objective(s)	Weight	Action(s)	Success Indicator(s)	Unit	Weight	Target/Criteria Values					Achievements	Performance		Percent achievements against Target values of 90% Col.	Reasons for shortfalls or excessive achievements, if applicable
							Excellent 100% 90%	Very Good	Good 80%	Fair 70%	Poor 60%		Raw score	Weighted raw score		
*	Efficient Functioning of the RFD System	3	Timely submission of Draft RFD 2014-2015 for approval	On-time submission	Date	2	May 15, 2014	May 16, 2014	May 19, 2014	May 20, 2014	May 21, 2014	April 28, 2014	100	2		
			Timely submission of Results for (2013-2014)	On-time submission	Date	1	May 1 2014	May 2 2014	May 5 2014	May 6 2014	May 7 2014	April, 24, 2014	100	1		
*	Enhanced Transparency / Improved Service delivery of Ministry/ Department	3	Rating from Independent Audit of implementation of Citizens'/ Clients' Charter (CCC)	Degree of implementation of commitments in CCC	%	2	100	95	90	85	80	100	100	2		
			Independent Audit of implementation of Grievance Redress Management (GRM) system	Degree of success in implementing GRM	%	1	100	95	90	85	80	100	100	1		
*	Administrative Reforms	7	Update organizational strategy to align with revised priorities	Date	Date	2	Nov. 1 2014	Nov. 2 2014	Nov. 3 2014	Nov. 4 2014	Nov. 5 2014	Oct, 9 2014	100	2		

Sl. No.	Objective(s)	Weight	Action(s)	Success Indicator(s)	Unit	Weight	Target/Criteria Values					Achievements	Performance		Percent achievements against Target values of 90% Col.	Reasons for shortfalls or excessive achievements, if applicable
							Excellent 100% 90%	Very Good	Good 80%	Fair 70%	Poor 60%		Raw score	Weighted raw score		
			Implementation of agreed milestones of approved Mitigating Strategies for Reduction of potential risk of corruption (MSC)	% of implementation	%	1	100	90	80	70	60	100	100	1		Achievement falls under excellent category which is desirable.
			Implementation of agreed milestones for ISO 9001	% of implementation	%	2	100	95	90	85	80	0	0	0		ISO certificate could not be obtained in time due to non bidding in the first tender notice
			Implementation of milestones of approved Innovation Action Plans	% of implementation	%	2	100	90	80	70	60	100	100	2		Achievement falls under excellent category which is desirable.

Total Composite Score: 98.00
Rating: Excellent

Procedure for computing the Weighted and Composite Score

1. **Weighted Score of a Success Indicator = Weight of the corresponding Success Indicator x Raw Score / 100**
2. **Total Composite Score = Sum of Weighted Scores of all the Success Indicators**

"Approved by RFD committee"

(Sd/-)
Director

ANNEXURE - VIII

Budget (2015-16)

(₹ in lakhs)

Sub-head	Plan		Non-plan	
	Provisions made in RE 2015-16	Expenditure	Provisions made in RE 2015-16	Expenditure
Establishment charges	-	-	-	-
wages	-	-	538	487.06
O.T.A	-	-	-	-
TA	6.00	6.00	2.00	2.00
Other charges(contingency)	121.5	121.58	22.00	22.23
H.R.D	2.00	1.97	-	-
Works	160.90	160.88	-	-
Equipment	20.00	20.02	-	-
Library	18.00	17.79	-	-
Vehicle	-	-	-	-
Annual Repairs/Maintenance	-	-	-	-
Information Technology	5.00	4.94	-	-
Furniture and fixture	7.00	7.27	-	-
TSP	6.75	6.71	-	-
NEH	-	-	-	-
Total	347.15	347.16	562.00	511.29

Revenue generation (2015-16)

Particulars	Revenue generation (Rupees in Lakhs)
DCR	55.55

ANNEXURE - IX

Meteorological Data (2015-16)

Month	Temperature (°C)		Humidity (%)		Rainy Days	Rainfall (mm)	Mean wind velocity (Km/h)	Sunshine Hours (h)	Pan Evaporation (mm)
	Max	Min	FN	AN					
April	35.1	20.2	75	59	4	279.8	2.6	7.1	4.5
May	32.9	22.5	87	65	13	536.9	2.1	6.4	2.8
June	32.3	21.0	80	81	21	998.6	2.9	7.2	2.8
July	35.2	23.0	90	83	29	498.4	2.0	2.1	2.5
August	30.8	24.2	90	77	20	194.3	2.1	3.4	3.7
September	32.6	23.6	89	73	17	181.4	2.0	3.8	2.9
October	34.7	24.5	80	61	10	115.8	2.0	6.3	2.7
November	34.3	23.3	76	58	6	24.2	3.1	5.3	2.3
December	34.4	22.3	74	49	2	0	1.7	7.7	2.9
January	34.6	22.1	79	41	0	0	1.7	7.6	7.3
February	34.9	22.4	75	39	0	0	2.2	7.7	4.0
March	35.3	25.1	76	45	0	0	2.8	8.0	4.4
					Total	**2829.4**			

Rainfall is monthly total. Other parameters are monthly mean values.

ANNEXURE - X

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	*

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

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