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2016-17

भाकृअनुप-काजू अनुसंधान निदेशालय
पुत्तूर – 574 202, कर्नाटक

ICAR-Directorate of Cashew Research
Puttur - 574 202, Karnataka

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पुत्तूर-574 202, दक्षिण कन्नड़, कर्नाटक

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प्रस्तावना

स्थायी कृषि प्रणलियों के भीतर 'उच्च उत्पादकता' विकासशील देशों में अर्थिक विकास और गरीबी उन्मूलन के लिए एक आवश्यकता है। विशेष रुप से काजू घरेलू संसाधनों में कई संसाधन गरीब किसानों, व्यापारियों और प्रसंस्करण उद्योग की आजीविका में महत्वपूर्ण भूमिका निभा सकता है। बावजूद, पोषण सुरक्षा का समर्थन करके, निर्यात मांग को पूरा करके राष्ट्रीय अर्थव्यवस्था में योगदान करके, काजू की उत्पाकता बढ़ाने के लिए प्रयास किये गए हैं। यह इस निदेशालय का मुख्य जनादेश है। लेकिन फिर भी एक अंतर यह है कि वैश्विक परिदृश्य कि तुलना में राष्ट्रीय उत्पादकता में प्रासंगिक अनुशासन में बुनियादी, सामजिक और व्यावहारिक अनुसंधान दुनिया में भारत की स्थिती को कम करने के लिए एक प्रयास जारी है।

मुझे इस निदेशालय के अनुसंधान और विस्तार के तहत किए गय शोध उत्पादन और महत्वपूर्ण उपलब्धियों को उजागर करते हुए आई.सी.ए.आर. काजू अनुसंधान निदेशालय, पुत्तूर, कर्नाटक के वार्षिक रिपोर्ट 2016-17 को पेश करने के लिए अत्यंत खुशी होता है।

आनुवांशिक संसाधन प्रबंधन में, छत्तीसगढ़ और ओडिशा राज्य से राष्ट्रीय काजू फील्ड जीन बैंक (एन.सी.एफ.जी.बी) में जोड़ने के लिए किए गए जर्म प्लाजम सर्वेक्षण के माध्यम से तीन अलग-अलग प्रकार के किस्मों को एकत्र किए गए। बौने और लोकप्रिय प्रकारों के बीच क्रासं के माध्यम से प्राप्त किए गए काजू संकरों का मूल्यांकन करते समय दो प्रकार के प्रजनन अर्थात् , सेलेक्षन-2 x एन.आर.सी.सी.-492 और उल्लाल-3 x तलिपारम्बा की पहचान की गई। तीन परियोजनाओं की सिफारिशों के साथ निष्कर्ष निकाला गया है कि पैक्लोबुट्राजोल पूर्व फ्लशिंग चरण में 51% तक बढ़ोतरी के साथ वृद्धि को नियंत्रित करने में प्रभावी पाया गया। उच्च घनत्व वाली रोपण प्रणाली (500 वृक्ष / हेक्टेयर) के अन्तर्गत कुछ किस्मों अर्थात, भास्कर और उलाल-3 ने 10.39 टन / हेक्टेयर और 10.43 टन / हेक्टेयर का आठ तुडाई के संचयी पैदावार में बेहतर प्रदर्शन किया। काजू पर कार्यरत चयनित ए.आई. सी.आर.पी. केंद्रों से मिली मिट्टी की सूक्ष्म पोषक स्थिति 'मध्यम' श्रेणी के रूप में वर्गीकृत है जो पोषक तत्व सूचकांक पर आधारित है।

जैविक काजू खेती में कीट प्रबंधन करते समय चाय मच्छर का नियंत्रण में जैविक कीटनाशियों का प्रयोग या 'रेडुविड्स' का जारी इतना प्रभावी नहीं रहा। TMB और CSRB के प्रभावी प्रबंधन करने के लिए रणनीतिक योजना जारी है। कीटों की विविधता काजू में बहुत ज्यादा है। 'अपिड' और 'हेलिसिटिडे' के मधुमक्खीयों ने परागन करने में बहु मुख्य सेवा दे रहें हैं। फंजिसाइड 'मेटेराम 55% + पाडराक्लोस्ट्रोबिन 5WG (3 g/l)' की मिश्रण बीज गलने के रोग के खिलाफ प्रभावी रहा। काजू फलों को सुखाने के लिए अस्थायी 'सोलार टनल ड्रायर' का विकास किया गया। फलों को ज्यादा स्थिर रहनेवाला अनाकर (अमोरफस) रूप में रखने का प्रोटाकाल मानकीकृत किया गया। काजू फल का पौडर से विभिन्न उत्पाद बनाने का तंत्रज्ञान विकास किया गया और उनके उत्पादन खर्च का मूल्यांकन किया गया। शक्ति से चालित 'काजू फल स्लाइझर' विकास किया गया और उसका कार्य निष्पादन का मूल्यांकन किया गया। वाणिज्यीकरण करने के लिए, काजू फल और नींबू मिश्रित RTS पेय और एक मादक पेय ''सिडार'' बनाने का तंत्रज्ञान का मानकीकरण किया गया। तकनीकी हस्तांतरण के तहत, महाराष्ट्र में सिफारिश की गई काजू उत्पादन तकनिकों का प्रभाव का दस्तावेज किया गया। वर्ष के दौरान, आईसीएआर-डीसीआर में विकसित काजू खेती से संबंधित तंत्रज्ञानों को दो किसानों का मुलाकात, चार प्रशिक्षण और चार प्रदर्शनियों के सहायता से प्रसारित किया गया।

वर्ष 2016-17 में इस निदेशालय के अनुसंधानिक व भौतिक लक्ष्यों को पूर्ति करने में संपूर्ण सहायता और प्रेरणा देने के लिए सचिव, डेयर और महानिदेशक, आई.सी.ए.आर को मैं आभार प्रकट करता हूँ।

नए चुनौतियों को सामना करने के लिए कठिण प्रशिक्षण कर रहे इस निदेशालय के वैज्ञानिक और अन्य कर्मचारियों को धन्यवाद प्रकट करता हूँ और इस प्रकाशन को सही समय पर प्रकाशित करने के लिए प्रकाशन समिति की प्रशंसा करता हूँ।

स्थान : पुत्तूर, कर्नाटक
दिनांक : 15 जून 2017

(एम.जी. नायक)
निदेशक (प्रभारी)

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PREFACE

Higher productivity within sustainable agricultural systems is a requirement for economic development and poverty alleviation in the developing world. Cashew in particular can play an important role in the livelihood of many resource-poor farmers, traders and processing industries in the domestic front. Despite, supporting nutritional security, it helps to meet the export demand and escalate national economy. Over the years, concerted efforts are taken up to enhance the productivity of cashew, the prime mandate of this Directorate. But still there exists a gap of 32.3% in national productivity in comparison to global scenario. Basic, strategic and applied research in pertinent discipline have been continuing to bridge the gap to auger India's position in the world.

I feel utmost privileged to bring out the Annual Report 2016-17 of ICAR-Directorate of Cashew Research, Puttur, Karnataka, highlighting the research output and significant achievements made under research and extension front by this Directorate.

In genetic resource management, three distinct accessions were collected through germplasm survey conducted in Chattisgarh and Odisha state to add up in the National Cashew Field Gene Bank (NCFGB). Two promising types of progenies viz., Selection-2 x NRC-492 and Ullal-3 x Taliparamba were identified while evaluating cashew hybrids obtained through crosses between dwarf and popular types. Three projects are concluded with the recommendations that Paclobutrazol application at pre-flushing stage found to be effective in controlling the growth with a yield increment up to 51%. Under high density planting system (500 tree /ha), certain varieties viz., Bhaskara and Ullal-3 performed better in terms of cumulative yield of 10.39 t ha^{-1} and 10.43 t ha^{-1} for eight harvests respectively. Nutrient deficiency symptoms in cashew have been identified and documented. Micronutrient status of soils collected from selected AICRP Centres' on cashew is classified as 'Medium' category based on Nutrient index.

Managing the pests in organic cashew reveal that spraying biopesticide or release of Reduvids had less effective in controlling TMB infestation. Strategic approaches are underway for effective management of 'Tea Mosquito Bug' and 'Cashew stem and root borer'. Pest diversity found to be very high in cashew and bees of 'Apidae' and 'Halicitidae' observed to provide real pollination service. A combined fungicide, Meteram 55 % combined with Pyraclostrobin 5 WG (3g/l) was partially effective against nut rot disease in cashew. A make shift solar tunnel dryer for cashew apple is developed and protocol to convert cashew apple in to more stable amorphous form has been standardized. Technical know-how for various cashew apple powder based products has been developed and its production cost worked out. A power operated cashew apple slicer has been developed and its performance evaluated. Technique of cashew apple and lime blended RTS beverage and 'Cider' an alcoholic beverage have been standardized for commercialization. Under transfer of technology, investigation on impact of recommended cashew production technologies in Maharashtra has been documented. During the year, field oriented technologies developed at ICAR-DCR have been disseminated through two farmers meet, four exhibitions and four farmers trainings.

I express my deep sense of gratitude and reverence to the Secretary, DARE and Director General, ICAR and DDG (Hort.), ICAR for their rigorous support, constant encouragement and guidance to meet the research and physical targets of this Research Directorate during 2016-17.

I would like to thank all the scientific and other staff of this Directorate who worked hard to meet the new challenges and appreciate the publication committee in bringing this publication in time.

Place : ICAR-DCR, Puttur
Date : 15th June, 2017

(M. Gangadhara Nayak)
Director (Acting)

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INTRODUCTION

Research on cashew in India was first initiated in early 1950s. Indian Council of Agricultural Research (ICAR), sanctioned ad hoc schemes to 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 Vengur¬la) were assigned the research component on cashew under AICS and CIP. During the V and VI plan periods three more Centres (Bhubanes¬war, 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 Plan¬ning 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, ITMU, 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.

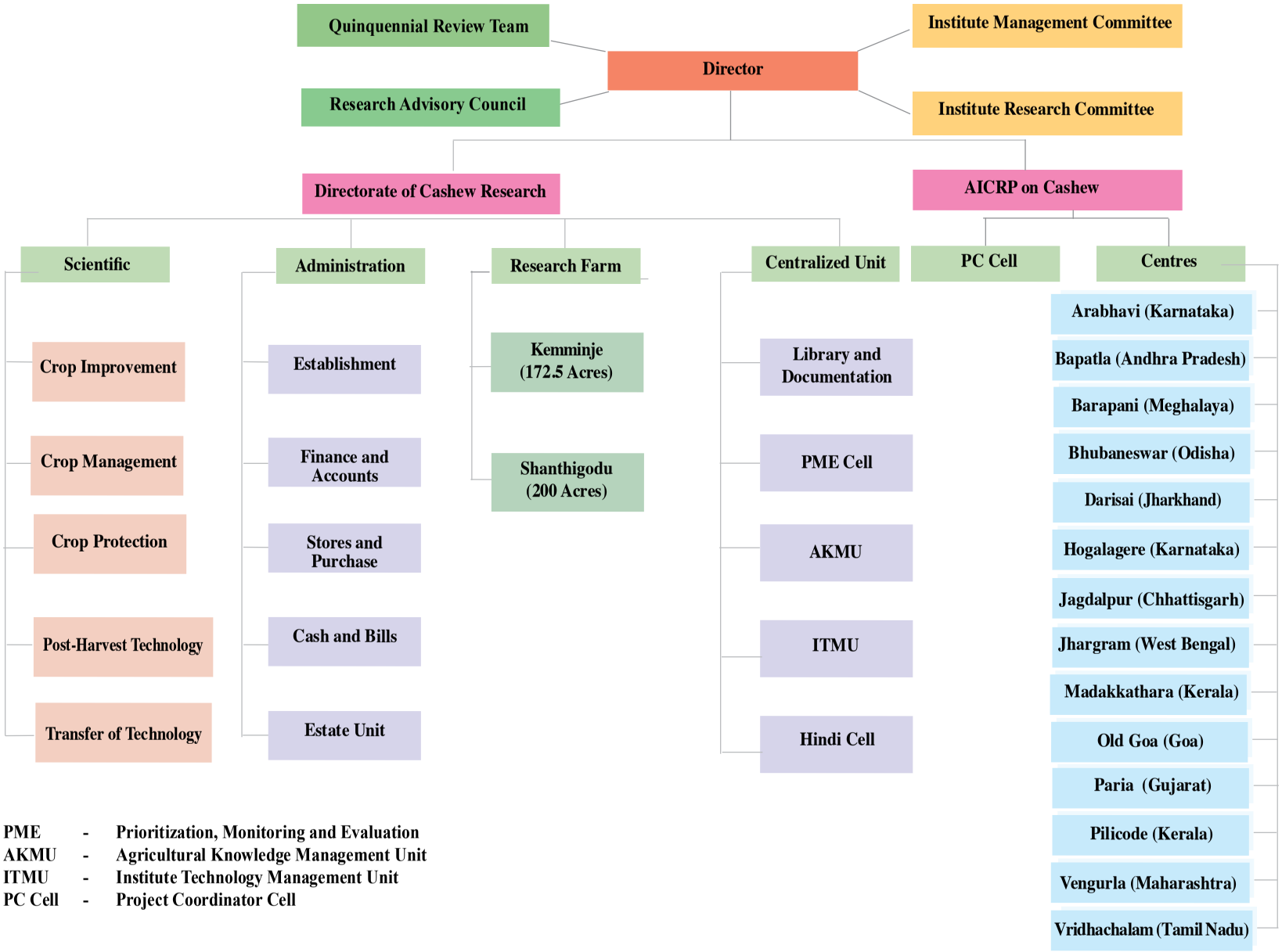
Mission

- 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.

Organogram of ICAR-Directorate of Cashew Research



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

कार्यकारी सारांश

भा.कृ.अनु.प. के काजू अनुसंधान निदेशालय का अनुसंधान विकास एवं विस्तार छह विभिन्न अनुसंधान कार्यक्रमों के अंतर्गत प्रगतिपथ पर है जिन में (i) काजू जननद्रव्य (ii) बागवानी एवं पादप शरीर क्रिया विज्ञान के हस्तक्षेप में उत्पादन क्षमता बढ़ाना (iii) एकीकृत मिट्टी और पोषक प्रबंधन (iv) कीट और रोग प्रबंधन (v) कटाई उपरांत तकनीकी एवं उत्पाद विविधीकरण का विकास और (vi) काजू में ज्ञान प्रबंधन एवं असर पडताल इन माध्यमों से निदेशालय के अधिदेश को पुरा करने का कार्य प्रगती पथ पर है। इस के अतिरिक्त एक फ्लैगसिप, चार नेटवर्क / भागीदारी और दो बाह्य वित्त पोषित परियोजनाएँ भी शामील हैं।

वर्ष 2016–17 के दौरान छत्तीसगड और ओडीसा राज्यों में किये गए सर्वेक्षण में तीन स्पष्टत या भिन्न ऐक्सेसनों को जननद्रव्य सर्वेक्षण के अन्तर्गत पाया गया है और राष्ट्रीय काजू फिल्ड जीन बैंक में जोड जिया गया है। अधिकतम विविधता एवं न्यूनतम ऐक्सेसन संख्या के प्रतिधारण को सुनिश्चित करने के लिए एक उन्नत रणनीती जिस्में अनुमानिक तकनीक को कोर संग्रह के विकास के लिए अपनाया गया है। 128 अंत: स्राब्दी संकरों के मूल्यांकन में यह पाया गया है की उनकी उत्पादन क्षमता कम है और इस कारण निरूपयोगी माना गया। बौना और लोकप्रिय संयजनों के मूल्यांकन में सेलेक्सन–2 x NRC-492 एवं उल्लाल–3 x तालिपारंबा यह दोनों के संततियों को उत्कृष्ठ पाया गया है। पेढ की ऊंचाई, घेरा और चंदवा प्रसार जैसे मापदडों की पोलीमोर्फिजम और रूपात्मक पुष्टि करने के लिए पिस्ता (9) और बादाम (21) SSR प्रायमरों की उल्लाल–3 x NRC - 492 के 93 संततियों में जाँच किया। उच्च घनत्व रोपन हेतु बौने और घने संकरों के विकास के अंतर्गत दो संयोजनों को उत्कृष्ठ पाया गया जिन में पेड़ संख्या 46–2 (मडकतारा–2 x NRC-492) ने 1.17 किलो/पेड़ उत्पादन दिया जिसकी ऊंचाई 4.25 मीटर थी और पेड़ संख्या 5.5 (वेंगुर्ला–4 x NRC–492) की उपज 1.90 किलो/पेड़ और ऊंचाई लगभग 3.8 मीटर पायी गई। काजू जिनोटायपों में काजू छिलका द्रव (CNSL) की उपलब्धता को पहचानने और मुल्यांकन करने हेतु 110 ऐक्सेसनों को उनकी CNSL मात्रा को जाँचा गया है।

पेक्लोब्यूट्राझोल (PBZ) को मिट्टी में पौध बेसिन में पौध कलिकायन काल में डालने से पौध वृद्धी, छत्रक फैलाव और संधि वृद्धि में कमी पायी जाने के साथ साथ 51% प्रति पौध उपज वृद्धि पाये जाने के सुझाव के साथ इस प्रकल्प को समाप्त कर दिया गया है। उच्च उपज वाली किस्मों के विभिन्न सघन रोपन परिक्षणों से यह सुझाव पारित हुवा है की, बाकी सघनता रोपनों से कम सघन रोपनों (200 पौधे प्रति हेक्टीयर) में अधिक उपज पायी गई (8.49 केजी/पौधा, किस्म–भास्करा) तथापि, उच्च सघन पौध रोपन का संयोग प्रारंभिक वर्षो में उत्तम संचयी उपज से है।

कम सघन रोपनों में मूल्यांकन किये गये किस्मों के बीच यह निश्पन्न हुवा है की 8वे तुडाई में उच्चतम उपज 'भास्करा' किस्म (8.49 केजी / पौधा) और उल्लाल–3 (8.05 केजी/पौधा) में पायी गई। परंतु, पुत्तूर क्षेत्र में भुगोल – विषयक स्थानों और पर्यावरण विषयक स्थितियों में प्रति हैक्टयर उच्चतम संचयी उपज (8.86 पौधा/प्रति हेक्टीयर) जो 500 पौधे प्रति हेक्टयर वाले उच्च सघन रोपनों में 8 वर्षो की तुडाई में भास्करा (10.39 पौधा/हेक्टीयर) और उल्लाल (10.43 पौधा/प्रति हेक्टीयर) किस्मों के साथ पायी गई। सुयोग्य पोषन प्रबंधन, प्रशिक्षण एवं छटाई परिचालन, पौध संरक्षण उपायों और दूसरे परिचलनों को योग्य समय पर करने पर उच्च सघन रोपन प्रणाली अधिक पौधों को प्रति इकाई क्षेत्र में समा लेकर और उच्च नट उपज देने के कारण ज्यादा फायदेमंद और अपनाने के काबील है ऐसा सामन्य सुझाव पारित किया गया।

सूक्ष्म पोषक तत्व प्रबंधन नेटवर्क प्रोजेक्ट के तहत काजू के अपर्याप्तता लक्षणों को पहचान कर दस्तावेज बनाए गए है। नायट्रोजन (N), फोस्फोरस(P), पोटेसियम (K) और मेग्नेसियम (Mg) गतिशील एलिमेंट होने के कारण इनके गमलों के निचले/पुराने पत्तोंमें अपर्याप्तता लक्षणों को पाया गया तथा लोह (Fe) और सल्फर (S) के अपर्याप्तता लक्षण नये पत्तों में देखे गए। अंतस्थ पत्तों में केलसियम (Ca) और बोरॉन के अपर्याप्तता लक्षणों को पाया गया और मध्यवर्ती पत्तों में झींक (Zn), कोपर (Cu), मोलिब्डेनम (Mo) एवं मेंगनिज (Mn)

के कमी के लक्षण पाये गए। मिट्टी के प्राचलों पर जैविक व अजैविक पोषकों के स्त्रोतों का परिणाम के अध्ययन ने यह दर्शाया है की नियंत्रीत मिट्टी के मुकाबले जैविक कार्बन की मात्रा जैविक खाद डाले हुए मिट्टी में ज्यादा है। 500g N/ पेड़ आपूर्ती के लिए FYM + 125g P_2O_5 / पेड़ आपूर्ती के लिए रॉक फोस्फेट और 125g K_2O/पेड़ आपूर्ती के लिए लकडी की राख, 500g N/पेड़ आपूर्ती के लिए पोल्ट्री मेन्यूर और जमिन पर उपलब्ध पुन: इस्तेमाल करने योग्य काजू जैवपिंड और खर-पतवार + हरित मेन्यूर से तयार कंपोस्ट के उपचार से नियंत्रीत मिट्टी की तुलना में उपचार किये गऐ मिट्टी में जैविक कार्बन की मात्रा अति अधिक दर्ज की गई। मिट्टी में उपलब्ध नायट्रोजन की मात्रा अलग-अलग उपचारों के तहत 301 से 464 केजी / हेक्टीयर की रेंज में पायी गई, जहाँ शिफारिश किया गया NPK खाद और FYM + जैविक केक + पुन: इस्तेमाल करने योग्य काजू जैवपिंड + जैविक खाद मिश्रण मे उच्चतम दर्ज की गई और नियंत्रीत एवं जमीन पर उपलब्द काजू जैवपिंड उपचारीत मिट्टी में न्यूनतम पाया गया। जैविक काजू फिल्ड में कीट प्रबंधन के लिए अलग अलग प्रयास लिए गये जिन में जैविक कीटनाशक का छिडकाव, निंबीसीडीन, बिवेरिया बेसिना (फफुँद) और इनूडेटीव रेडूवीड्स (सायनाकस) को TMB के नियंत्रण के लिए कम प्रभावशाली पाया गया।

उच्च सघन रोपनों में अनुकुलतम सिंचाई की जरूरत पर मिला परिणामस्वरूप डेटा यह दर्शाता है कि, काजू की उपज 5x4, 6x4 और 10x5 के अंतर पर कृमश: 2.8 से 4.5 केजी, 3.2 से 4.9 केजी और 3.1 से 4.6 केजी पायी गई है। कम उत्पादन देनेवाले बागानों में प्रतिबंधक पोषक तत्वों का मुल्यांकन और काजू के पोषक तत्व मानदंडों की स्थापना करने के लिए 5 से 20 साल पुराने 420 काजू बागानों का क्षेत्रीय सर्वे पुत्तूर (कर्नाटक), वेंगुर्ला (महाराष्ट्र), भुवनेश्वर (ओडीसा), बापटला (अंध्रप्रदेश), पिलिकोड (केरल) और वृद्धाचलम (तमिलनाडु) क्षेत्रों में संपन्न हुआ। इन काजू बागानों की मीट्टी का सूक्ष्म पोषन तत्वोंकी स्थिती का पोषक तत्व सूची (NI) के रूप में मुल्यांकन किया गया है। पोषक तत्व सूची के आधार पर अखिल भारतीय समन्वित काजू अनुसंधान परियोजना के चार केंद्रों का सर्वेक्षण किया गया जिस में पुत्तूर (2.81, 2.89), वेंगुर्ला (2.74, 3.00), भूवनेश्वर (2.92, 2.79) और बापटला (3.00, 2.96) में DTPA-Fe और DTPA-Mn के संबंध में NI उच्चतम दर्ज की गई। DTPA-Zn को माध्यम श्रेणी मे पाया गया।

काजू ऐक्सेसनों पर साल्ट और सुखे का परिनाम वर्णन करने के लिए सिड अस्से को प्रथम स्थर पर मुल्यांकन और मानकीकरण किया गया। नमक के चार लेवल के उपचार (50, 100, 150 और 200mM) करने पर 15 और 24 दिनों में काजू किस्मों में असमान अंकुरिकरण देखा गया। यह पाया गया की, अंकुरिकरण प्रतिशत और गमलें की विगर सूची पर नमक का प्रभाव ज्यादा है। एक विकल्प के रुप में काजू किस्मों को नमके पानी से (50 से 500mM) दो हफ्तों तक नियमित सिंचाई किया। यह सामने आया की कम नमक (50mM) उपचार से पौधे हरेभरे और तरोताजा थे जबकि उच्च (500mM) नमक की मात्रा में क्लोरोसीस और मृत नेकराटीक दाग देखे गए।

कर्नाटक काजू विकास कार्पोरेशन (KCDC) के रोपनों में चुनिंदा EPN प्राजातीयों को मिट्टी में जीवित रहने की क्षमता और कोलिओप्टेरान पर संक्रमन करनेवाली EPN की वायरुलंस का मुल्यांकन किया गया। काजू के परिस्थिति की तंत्र से प्राप्त मिट्टी के नमूने, जीनसे सभी तीन EPN प्रजातियों को डाला गया था, जिनको 120 दिन तक CSRB सुँडी पर चराया गया था, उनमें मृत्यू उत्प्रेरण क्षमता 90 प्रतिशत से ज्यादा पायी गयी।

अधिक जैविक मात्रा वाली मिट्टी और छायादार क्षेत्र की मिट्टी में EPN संक्रमित अल्पवयस्कों अपेक्षाकृत ज्यादा जिवित पाया गया। स्थानिय पाये जाने वाले प्राकृतिक शत्रुओं की TMB के विरुद्ध प्रभावो त्पादकता मुल्यांकन के तहत प्रयोग मैंटीड्स की पालन पद्धती को प्रयोगशाला में विकसीत कर विभिन्न प्रजातियों का जिवन चक्र भी दर्ज किया गया है। सेमिओ रसायनों की क्षेत्रीय जाँच में यह पाया गया है कि TMB प्रबंधन में प्रकरन के बाद चार - पांच दिनों में अप्रयुक्त मादा को नर से ज्यादा प्रतिक्रिया प्राप्त हुई। जिसे यथा संभव सर्वोत्तम मिलन आयु कहाँ जाता है। इसके व्यतिरिक्त संपूर्ण शरीर उद्घटण डाय-क्लोरोमिथेन / एनहेक्जेन अथवा मिथानाल को चिपचिपे जाल में रखकर क्षेत्रीय परिस्थितीयों में प्रतिक्रिय मिल सकती है।

सांयोगीक सर्वेक्षण में इस निदेशालय में विभिन्न कीट एवं उनके प्राकृतिक शत्रुओं खोज की गई जिसमें लगभग 191 किडा किट प्रजातियाँ और 123 प्राकृतिक शत्रु पाये गए हैं। काजू के किटों की विविधता सूचियाँ तयार की गई है जिस में रिचनेस सूचि 191 और शानोन सूचि 4.35 होना यह दर्शाता है की काजू में कीट सघनता अधिक है।

एक विषेश जाँच में यह पता चला है कि, विभिन्न प्रजातियों के फल खाने वाली सुँडी को प्रति पेनिकल 4–14 की संख्या में पाया गया और कीट प्रादूभवि की शुरुवात सितंबर के दौरान होकर आगे नवम्बर / डिसेंबर तक विस्तारण देखा गया।

सभी परागण कारकों के बीच एपिडी (9 प्रजातियाँ) और हेलिक्टीड (5 प्रजातियाँ) को काजू के मुख्य परागण सेवा का हक जाता है। काजू के परागण कार्यों की विविधता सूचि शानोन सूचि के रूप मे 2.3 तक पहूँची है। परागण कीटों के खाध्य द्यडुंने के बरताव के अध्ययन पर यह पता चला है कि, औसत पराग कणों की हर वर्तिकाग्र पर सुबह 10.00 से 10.30 तक 0.2 और शाम की 2.65 यह दर्शाता है कि फलों को उसी दिन के दौरान विविध मधुमक्खीयों से बार बार भेट दी गई है। इसके अलावा यह देखा गया की ब्राऊनसापिस प्राजाती को सुबह 9.00 से दोपहर 1.30 बजे तक सबसे ज्यादा पाया गया जिसके बाद सूडापिस ए सेरेना और सेराटीना प्रजातियों को पाया गया। मधुमक्खीयों की भेट और को नट स्थापन करने की कार्यकुशलता को भी दर्ज किया गया है जिस में अधिकतम नट स्थापन क्रिया सुबह 10 बजे से दोपहर 1.00 बजे तक पायी गई। यह ज्यादा महत्वपूर्ण है कि सेरेना प्रजाती की बस्तीया एक महिने के अंदर लगभग 2 लीटर शहद जमाने से सफल रही लेकिन वह केवल काजू पर ही जिवित नहीं रह सकती यह एक प्रतिबंधक कारक है।

काजू के रोगों पर अवलोकन करने पर यह पता चला कि काले दागोंवाले पत्तों का रोग सितंबर महिने में ज्यादा गंभीर होता है और रहनी सडांध/गमोसीस जैसे रोग पहले वर्ष की तुलना में नवंबर महिने में कम पाये गए। सभी काजू किस्मों में फूल सुखना, डायबेक जैसे रोग कम–ज्यादा प्रमाण में पाये गए। नट सडांध का कारण बना फफुँद रोगकारक भी अलग कर पेहचाना गया है। TMB और फुलों के संक्रमण के संबंधों को जाँचने के बाद यह पता चला कि, फफुँद भी संक्रमण की एक वजह है। मेटेराम 55% + पायराक्लोस्ट्रोबीन 5WG (3g/l) का संयुक्त मिश्रण के उपयोग से H130 पर उपयोग करने से 65% से ज्यादा रोग प्रतिबंध किया गया है।

किसानों के लिए मैत्रीपूर्ण काजू नट और सेब को सुखाने के लिए और सुरंग ड्रायर (PHSTD) का विकास कर काजू नट और सेब को सुखाने के गुणधर्मों का भी मुल्यांकन किया गया है। पूर्व नमी के आधार पर सेब को 16% नमी तक लाने के लिए 7 से 11 घंटों का समय लगा। संवहन ड्राइंग (CD) के मुकाबले PHSTD से प्राप्त पावडर के सतह के रंगों के गुण धर्म अधिक अच्छे थे। CD और PHSTD से प्राप्त पावडर मे टैनिन की मात्रा 0.39 से 0.55 PPM और 0.42 से 0.58PPM क्रमश: पाया गया। विभिन्न किस्मों के सेब से प्राप्त पावडर में विटामीन सी की मात्रा 147 से 372 mg/100g पायी गई और नमक पानी के साथ उपचार और सुखाने के समय के रेडीयेशन परिणामों के कारण विटामीन सी में कमी पायी गई है।

जलदी सडने वाले काजू सेब को अनाकार पावडर में रूपांतरित करने की विज्ञप्ति का मानकीकरण किया गया है। इथेनाल (2.5%) और NaOH (2.5%) के माध्यम से सेब का लाय पिलींग करने से छिलके को संपुर्ण निकाला गया और मुदे को भी कम खोया गया। पुनर्गठित RTS, जाम, जेली, लड्डू, बर्फी और कुकीज को सेब की पावडर से बनाने की तकनिक भी विकसीत की गयी है। इसके अलाव 38% इथेनाल भी काजू सेब की पावडर से बनाया गया। काजू सेब पावडर निर्माण और कच्चे काजू नट को सुखाने का खर्चा क्रमश: रु. 20/kg और रु. 0.94/kg है।

विभिन्न मूलों से प्राप्त कच्चे काजू के मानकों के विकसित करने के संबंध में भौतिक मापदंडों का विश्लेषण किया गया है। नट और कर्नेल वजन के बीच मजबूत संबंध अभिव्यक्त करता है कि फ्लीटिंग टेस्ट जो गुणवत्ता का आकलन करने के लिए प्रचलित है, प्रारंभिक संकेतक के रुप में उपयोग होना चाहिए नाकी पुष्टि परीक्षण के रूप में। नट का आकार और वजन के बीच का संबंध यह दर्शाता है कि यह गुणवत्ता के आकलन के लिए तकनीक के रुप में काम कर सकता है और इसी उद्देश्य के लिए गैजेट के विकास का सुझाव भी देता है। एक मोटर संचालित मल्टी डिस्क काजू सेब स्लाइसर विकसीत की है। परिक्षण के परिणाम बताते है कि कुल डिस्क लोड फलोंके शरीर पर कर्तन के बजाय कुचल देता है। इसके अलावा, 0.7 मिमि मोटी होने वाले ब्लेड के विरूपण के चलते स्लाइसींग एक समान नहीं आती है। ऊर्ध्वाधर फीड करने के दोष, क्षैतिज स्लायसींग के दोष पहचान कर वैकल्पिक डिजाईन का सुझाव दिया गया। काजू सेब पल्प का 10° C के नीचे संग्रहण पुष्टि करता है कि ''विटमिन सी'' जो 338 से 282mg/100ml कम हो गया छोडकर बाकी रासायानिक घटकों में कोई परिवर्तन नहीं हुआ। काजू सेब–नींबू मिश्रित आर.टी.एस के पोषण और कार्यात्मक गुणों का विश्लेषण किया गया और वाणिज्यिक निंबू पेय के

साथ तुलना की गई। काजू से तय्यार एक मादक पेय 'सिडार' के शेल्फ लाइफ की जांच से पता चला कि आँटीआक्सिडेंट गतिविधि 6 महिने के भंडारण के बाद 22% कम हो गई। फुड ग्रेड एजंटों का उपयोग करके काजू सेब रस में टैनिन को कम करने का प्रयास किया गया, जिसके बाद छानने की तकनीक का प्रयोग भी किया गया।

काजू में प्रौद्योगिकी हस्तांतरण कार्यक्रमों के तहत दक्षिण कर्नाटक में काजू के फ्रंट लाईन प्रदर्शन (FLD) द्वारा एक दस्तावेज का निर्माण कर काजू उत्पादन प्रौद्योगिकियों को स्वीकार करने हेतु सामाजिक - निजी (12), सामाजिक - आर्थिक (10) और प्रौद्योगिकी निर्धारकों का वर्णन किया है। महाराष्ट्र के रत्नागिरी और सिंधुदुर्ग जिलों में काजू के क्षेत्र, उत्पादन और उत्पादकता पर शिफारिश की गई काजू उत्पादन तकनीकों का प्रभाव काजू के किस्मों (अधिकतम V-4 - 57% और न्यूनतम V-1 - 1%) के अनुसार मापा गया, उत्पादन पर किस्मों (उच्चतम V-4 - 7.74 केजी / पेड़ और न्यूनतम 1-5.10 केजी/पेड़) सामान्य घनत्व (उच्चतम V-4 - 511 केजी/हेक्टेर और न्यूनतम V-1-316 केजी/हेक्टेर), किस्मों के उच्च घनत्व के तहत उत्पादकता पर (उच्चतम V-4 - 1524 केजी/हेक्टेर और न्यूनतम V-1 - 688 केजी/हेक्टेर) और प्रौद्योगिकी उपयोग की स्थिति को विस्तार से अध्ययन किया गया। महाराष्ट्र में विभिन्न काजू किस्मों और प्रौद्योगिकियों के इस्तमाल में प्रोद्योगिक अंतर केरळ और कर्नाटक के साथ तुलनात्मक अध्ययन किया गया।

कई किसान सम्मेलनों में डीसीआर के होनहार प्रौद्योगिकियों को प्रचारित किया गया। इस वर्ष के दौरान दो किसान सम्मेलनों का आयोजन किया गया जैसे ''डीसीआर फाउंडेशन डे सह काजू किसान मीटींग - 2016'' और ''काजू किसान मेला - 2017'' शामील थे। जिसमें 500 अधिक किसान सक्रिय तोर पर भाग लिए थे साथ ही में 3 अभिनव किसानों का सत्कार कर उनके नवाचारों को दर्ज किया गया। काजू उत्पादन तकनीक और विस्तार पर चार डीसीआर प्रदर्शनियों का आयोजन किया गया। टीएसपी कार्यक्रम के अंतर्गत दक्षिण कन्नड़, कर्नाटक के अदिवासी किसान क्षेत्रों मे 40 नए एफएलडी प्लाट स्थापित किए गए थे। वर्ष के दौरान क्षेत्रीय दौरे के माध्यम से काजू और कोको विकास योजना के निदेशालय के तहत स्थापित जिला के विभिन्न तालुकों में किसान प्रतिभागियों का काजू प्रदर्शन क्षेत्र का भी निरीक्षण किया गया। काजू के उच्च घनत्व (5 x 5 मीटर) और अल्ट्रा हाई घनत्व (3 x 3 मीटर) पौधों पर भागीदारी प्रौद्योगिकी विकास और प्रदर्शन चयनित किसान भूखंडों में किया गया। विभिन्न काजू किस्मों पर छंटाई का प्रभाव और उच्च घनत्व रोपण के तहत विविधतापूर्ण प्रदर्शन का नियमित रूप से निरीक्षण किया गया। वर्ष 2016-17 में सामाजिक मीडिया के माध्यम से काजू में ई-एक्सटेंशन मजबूत किया गया। नवीनतम काजू सूचना और तकनीकी ज्ञान के प्रसार के लिए फेस बुक पेज को नियमित रूप से अद्यतन किया गया। काजू अनुसंधान पर प्रासंगिक जानकारी को समय - समय पर संस्थान के वेब पेज में अद्यातन किया जाता है ताकि हितधारकों को प्रभावी रूप से सेवा प्रदान किया जा सके।

EXECUTIVE SUMMARY

Research, development and extension activities of ICAR-Directorate of Cashew Research, Puttur have embarked on six mega research programmes viz., i) Cashew germplasm; ii) Enhancing productivity through horticultural and physiological interventions iii) Integrated soil and nutrient management; iv) Pest and disease management; v) Development of post harvest techniques and product diversification and vi) Knowledge management and impact assessment in cashew, to fulfill the mandates of this Directorate. Besides, one flagship programme, four consortia or network projects and two externally funded projects are being implemented to address various issues of cashew industry.

During the year 2016-17, three distinct accessions were collected through germplasm survey conducted in Chattisgarh and Odisha state to add up in the National Cashew Field Gene Bank (NCFGB). An advanced M strategy with heuristic technique adopted in developing core collections in cashew which ensures retention of maximum diversity with minimum number of accessions. Evaluation of 128 numbers of interspecific hybrids revealed that the yield levels found to be very low and hence per se these hybrids are not useful. Two promising types of progenies viz., Selection-2 x NRC-492 and Ullal-3 x Taliparamba were identified while evaluating cashew hybrids obtained through crosses between dwarf and popular types. Pistachio (9) and almond (21) SSR primers in parents were screened in the progenies of Ullal-3 x NRC-492 to confirm polymorphism and the morphological parameters such as plant height, girth and canopy spread were recorded on these 93 progenies. Towards developing dwarf and compact cashew hybrids for high density planting, two promising crosses viz., Madakkathara-2 x NRC-492 yielded 1.17 kg/plant having a height of 4.25 m and Vengurle-4 x NRC-492 recorded the yield of 1.90 kg/plant having height of around 3.8 m. In order to identify and evaluate cashew genotype for cashewnut shell liquid (CNSL) available in 110 accessions were quantified.

Among fourteen cashew apple accessions along with check (Vengrula-8) evaluated, it was observed that the maximum mean height (3.84 m) recorded in NRC 175 and NRC 389, while minimum height (2.44 m) found in Vengurla-8. The highest mean girth (48.75 cm) and canopy spread (5.60 m) were recorded in NRC 112 and NRC 175, while the lowest girth (29 cm) and mean canopy spread (4.16 m) recorded in Vengurla-8. Pest incidence, primarily the 'tea mosquito bug' and 'thrips' showed differential reactions with the accessions during flowering season with a maximum damage grade of 1.7% (NRC 140) and 1.23 % (NRC 175) respectively. While examining fourteen lines, NRC 301, NRC 493, and NRC 176 were found to be resistant to black leaf spot disease and NRC 183 moderately susceptible to shoot die back/twig rot/gummosis. DUS test guidelines for cashew was developed and approved during the task force meeting held at this Directorate. A Decision Support System (DSS) for data management of cashew germplasm was developed.

Project on effect of Paclobutrazol (PBZ) on growth and yield of cashew concluded with a suggestion that the soil application of PBZ at pre-flushing stage found to be effective in reducing the plant height, canopy spread and intermodal length with a yield increment up to 51% per plant over control. While assessing the performance of high yielding varieties of cashew in different density planting, it is recommended that lower plant density (200 plant ha^{-1}) with different varieties recorded higher yield (kg/tree) than other plant densities in the later part of orchard life. However, higher density is associated with better cumulative yield. Among the different varieties investigated, under lower plant densities revealed that yield per plant in the 8^{th} harvest is higher in the variety 'Bhaskara' (8.49 kg/tree) and Ullal-3 (8.05 kg/tree). But significantly higher cumulative nut yield ha^{-1} (8.86 t ha^{-1}) was observed in high density planting accommodating 500 plant ha^{-1} with the variety Bhaskara (10.39 t ha^{-1}) and Ullal-3 (10.43 t ha^{-1}) over a period of 8 harvests in cashew in the geographical location and environmental conditions specific to Puttur region.

It is concluded with a general recommendation that high density planting system which is highly remunerative can be adopted due to accommodation of more plants per unit area with higher nut yield, provided proper nutrient management; training and pruning operation; plant protection measures and other operations should be taken up at appropriate time.

Deficiency symptoms of cashew were identified and documented under the network programme on 'Micronutrient management in horticultural crops for enhancing yield and quality'. Nutrient deficiency symptoms appeared in older/lower leaves of the potted plants in case of Nitrogen (N), Phosphorus (P), Potassium (K) and Magnesium (Mg) being mobile elements inside the plant system, whereas Iron (Fe) and Sulphur (S) deficiency symptoms developed in the younger leaves. Calcium (Ca) and Boron (B) deficiency symptoms developed in the terminal buds/ leaves and Zinc (Zn), Copper (Cu), Molybdenum (Mo) and Manganese (Mn) symptoms observed in middle and younger leaves.

Studies on influence of organic and inorganic sources of nutrients on soil parameters indicated that organic manures caused increase in organic carbon content of soil over control. The treatments FYM to supply 500 g N/tree + rock phosphate to supply 125 g P_2O_5/tree and wood ash to supply 125 g K_2O/tree, poultry manure to supply 500 g N / tree and *In situ* composting using recyclable cashew biomass and weeds + Green manuring recorded the highest content of organic carbon whereas the least was observed in 'Control'. Available nitrogen in soil under different treatments ranged from 301 to 464 kg ha^{-1}, recording the highest values in 'recommended NPK fertilizer' and 'FYM + Organic cakes + recyclable cashew biomass + biofertilizer consortia' with minimum under 'control' and *'In situ* composting using recyclable cashew biomass and weeds'. Various modes of managing the pests in the organic cashew field like spraying biopesticide 'Nimbicidine', *Beauvarria bassiana* an entamopathogenic fungal culture and inundative release of Reduvids, *Sycanus* sp. found to be less effective in controlling TMB infestation.

Resultant data on optimizing irrigation need for cashew under high density planting infer that yield varied from 2.8 to 4.5 kg, 3.2 to 4.9 kg and 3.1 to 4.6 kg for 5 x 4 m, 6 x 4 m and 10 x 5 m spacing. A regional survey was carried out in 420 cashew orchards of 5 to 20 years old in Puttur (Karnataka), Vengurla (Maharashtra), Bhubaneswar (Odisha), Bapatla (Andhra Pradesh), Pilicode (Kerala) and Vridhachalam (Tamil Nadu) regions in order to develop diagnostic norms and to evaluate the yield limiting nutrients in low yielding orchards. The micronutrient status of soils collected from these cashew orchards was estimated in terms of nutrient index (NI). Based on the NI values, cashew orchard soils of four AICRP Centre's surveyed viz., Puttur (2.81, 2.89), Vengurla (2.74, 3.00), Bhubaneswar (2.92, 2.79) and Bapatla (3.00, 2.96) showed high NI values with respect to DTPA-Fe and DTPA-Mn. DTPA- Zn and classified under 'Medium' category.

While characterizing the physiological response of cashew accessions to salt and drought, seed assay was carried out as the first level of screening and standardized. Differential germination of the cashew varieties observed after 15 and 24 days of salt application i.e. four level of NaCl treatments (50, 100, 150 and 200 mM). It was observed that the effect was high, evident from germination parameters viz., germination percentage and seedling vigour index. As an alternative, seedlings of cashew varieties were irrigated with NaCl ranging from 50 to 500 mM for two weeks continuously. Results evinced that at lower salt treatments, seedlings were green and fresh whereas its showed salt induced damages such as chlorosis and dead necrotic spots at higher salt treatment (500 mM).

Field evaluation of selected EPN species on soil survival and virulence of the coleopteran infecting EPN was investigated in Karnataka Cashew Development Corporations plantations. Soil samples recovered from cashew ecosystem which were treated with all three species of EPN could induce mortality of more than 90 per cent, when baited with CSRB grubs up to 120 days. It was also confirmed that comparatively higher survival of EPN infective juveniles (IJs) in those soils having more organic matter and under shaded conditions. As a part of evaluating indigenously occurring natural enemies for their efficacy against TMB, successful laboratory level rearing methodology

of praying mantids was developed and life cycle of different species was documented. Field trial on semio-chemicals for the management of TMB indicated that TMB virgin females at 4 - 5 days after emergence elicited higher response from the males under field condition which is the optimal "calling age". Moreover, whole body extracts (WBE) in di-Chloromethane / n-hexane or methanol, when used as baits in sticky traps could elicit response under field conditions. Extensive field survey conducted to assess the level of incidence of CSRB delineates that the intensity of CSRB in coastal regions of Odisha viz., Nimapada, Begunia, Gop, Nadia coconut farm, Talbania was lower than 2.0 per cent; however, it ranged between 4.0 and 5.0 per cent in Shankarpur, Padalpur, Mahishapat, Kapilas, Khamakya Nagar, Mundali, Gajmara, Kaimati via Kapilas and Bhapur. Incidence of CSRB in cashew growing tracts of West Godavari and Vizianagaram districts was lesser than 1.0 per cent in Narasipatnam, Tallepalem, Manivalasa and Kotavurtla, and Kothakota, but was slightly higher ; 2.0 to 3.0 per cent at Relli, Kothavalasa, Mudunoor and Srungavarpukota.

Random surveys at this Directorate for various pests and their natural enemies discovered around 191 insect pest species and 123 natural enemies in the cashew fields. Diversity indices of cashew pests were worked out i.e. species richness was 191 and the Shannon index was 4.35, indicating that the pest diversity was very high in cashew. An exclusive study indicated that Intensity of different species of inflorescence caterpillars (flower eating caterpillars) was found to vary from 4 – 14 larvae per inflorescence in different varieties and the pest incidence began during September and extended up to November / December. Among the pollinators of cashew which indirectly aids in enhancing yield, it was observed that bees of apidae (9 species) and halictidae (5 species) provide real pollination service. Diversity indices of cashew pollinators in terms of Shannon diversity index was arrived at 2.3. Studies on foraging behavior of pollinator species indicated that the mean number of pollen grains per stigma was 0.2 during morning i.e. 10.00 A.M to 10.30 A.M and 2.65 in the evening confirming that the flowers were revisited by several species of bees during the day. Besides, it was found that Braunsapis sp. was the most abundant between 9 A.M - 1.30 P.M followed by *Pseudapis* sp, A. cerana and *Ceratina* sp. Efficiency of bee visits on nut set in cashew was also recorded and it was found that bee visit between 10.00 A.M and 1.00 P.M results in more nut set. More importantly, colonies of A.cerana prospered well and produced ~ 2 litres of honey within a month period, but the limiting factor is that this species cannot survive on cashew alone as a bee-flora.

Periodical observations on diseases of cashew indicated that black leaf spot disease was severe during September while die back of shoot/twig rot/gummosis occurred during November with less severity than the previous year. Inflorescence drying/die back was severe across the cultivars. A fungal pathogen responsible for nut was isolated. While ascertaining the association between TMB and inflorescence infection, it indicated the involvement of fungal pathogen in causing the disease. A combined fungicide, Meteram 55 % + Pyraclostrobin 5 WG (3g/l) was effective against nut rot disease in H130 under field conditions as it reduced more than 65 per cent of the disease incidence.

A farmer friendly poly house solar tunnel dryer (PHSTD) for cashewnut and apple (make shift) was developed and the drying characteristics of cashew apples and raw cashewnuts were investigated. Depending on the initial moisture content of the cashew apple, total time required to bring down its moisture to 16 per cent (w.b) ranged from 7 to 11 h. Surface colour characteristics of cashew apple powder obtained after PHSTD is comparatively better than powder generated after convective drying (CD). Biochemical assay indicated that tannin content ranged from 0.39 to 0.55 ppm and 0.42 to 0.58 ppm for the CAP obtained by CD and PHSTD respectively. Vitamin C content in CAP prepared using mixed varieties resulted in the value ranged between 147 and 372 mg per 100 g and leaching while treating with NaCl and radiation effect during drying were identified as due reasons for its reduction. A protocol for converting perishable cashew apple in to amorphous cashew apple powder utilizing PHSTD was standardized. Lye peeling of cashew apples with ethanol (2.5%) and NaOH (2.5%) resulted in complete removal

of skin with negligible loss of pulp. Technical know-how for the preparation of various CAP based products viz., Reconstituted RTS, Jam, Jelly, Laddu, Burfi, Cookies was developed. Besides, bio ethanol could be prepared using CAP yielding 38% concentration. Cost of production of CAP and cost of drying raw cashewnuts were worked out to be Rs 20/- per kg and Rs 0.94 per kg respectively.

In relation to develop quality standards for raw cashewnuts, physical parameters of raw nuts obtained from various origins were analyzed. Strong correlation between nut and kernel weight expresses that floating test which is in vogue to assess the quality should serve as preliminary indicator and not a confirmatory test. Relation between nut size and nut weight signifies that it could serve as technique to assess quality and suggests development of grading gadget for the purpose. A motor operated multi disc cashew apple slicer is developed. Test results indicated that the total disc load acted on the fruit body crushing it rather than shearing. Moreover, slicing is not uniform in a continuous run due to distortion of blades having 0.7 mm thick. Demerits in using the vertical feed, horizontal slicing machine were identified and alternative design suggested. Storage studies on cashew apple below - 10^0C confirm that there was no change in the biochemical constituents except Vitamin C which reduced from 338 to 282 mg/100ml after 6 months. Nutritional and functional properties of CA-Lime blended RTS were analyzed and compared with commercial lime based beverage. Investigation on shelf life of 'Cider', an alcoholic beverage prepared from cashew apple revealed that its antioxidant activity reduced by 22 per cent after 6 months storage. An attempt was made to reduce tannin in cashew apple juice using food grade agents followed by filtration technique.

Under transfer of technology programmes in cashew, a document delineating socio-personal (12), socio-economic (10) and technology correlates and determinants in adoption of technologies for cashew production by the Front Line Demonstration (FLD) of cashew in South Karnataka was prepared. Impact of recommended cashew production technologies on area, production and productivity of cashew in Ratnagiri and Sindhudurg districts of Maharashtra was measured in terms of coverage of cashew varieties (Maximum V-4 – 57% and Minimum V-1 - 1%); varieties on production (Highest V-4 – 7.74 kg/ tree and lowest Vi1 – 5.10 kg / tree), varieties on productivity under normal density (Highest V-4 – 511 kg/ha and lowest V1 – 316 kg / ha), varieties on productivity under high density (Highest V-4 – 1524 kg/ha and lowest V1 – 688 kg / ha); and status of technology utilization were studied in detail. Technology gap existing in different cultivated cashew varieties and utilization of technologies in Maharashtra were also investigated and compared with Kerala and Karnataka.

Promising DCR technologies were disseminated to farmers through several farmers' meets. During the year, two farmers meet such as 'DCR Foundation Day cum Cashew Farmers Meet-2016' and 'Cashew farmers' fair-2017' were organized, in which more than 500 farmers actively participated and six innovative farmers were felicitated and the innovations were documented. Four DCR exhibitions on cashew production technology and extension at various venues were arranged. Under TSP program, 40 new FLD plots were established in tribal farmer fields of Madikeri and Dakshina Kannada, Karnataka. Farmer participatory Cashew demonstration plots in different taluks of the district established under Directorate of Cashew and Cocoa Development Scheme were also monitored through field visits during the year. Participatory Technology Development and Demonstration on high density (5x5 m) and ultra high density (3x3 m) plantings of cashew was carried out in selected farmer plots. Effect of pruning on different cashew varieties and varietal performance under high density planting were monitored regularly. E-extension was strengthened in cashew through Social Media during 2016-17. The Face book page for dissemination of latest cashew information and technical knowledge was developed updated regularly. Pertinent information on cashew research is periodically updated in the institute web page to serve the stake holders effectively.

RESEARCH ACHIEVEMENTS

1. CROP IMPROVEMENT

1.1 Genetic Resources of Cashew

1.1.1 Germplasm survey and collection

During the year 2016-17, germplasm survey was conducted at Chattisgarh state i.e. Natiyanavagoan of Kanker district, Shinganpur village in Kondagaon district, Bukhawand, Rajnagar, Koudavand, Chondiguda, Chitrakot, Ghirola, Turinor, Mundapal, Theerthaghad areas in Bastar district and Odisha i.e. Nagrnar, Surili, Chandil areas of Koraput region. A total of three germplasm accessions i.e. accession resembling tomato fruit, accession with bold nut and dark green leaves and, accession with bold nut and big apple were collected (Fig 1.1). Besides, a medium to bold size nut also collected from germplasm evaluation block of Cashew Research Station, Jagadalpur.

Fig. 1.1: Glimpses of germplasm survey in Chattisgarh

1.1.2 Germplasm conservation

The planting material of new collections was prepared in order to include in the evaluation block of National Cashew Field Gene Bank (NCFGB). The planting material for the establishment of core collection of NCFGB and gap filling in conservation block was also prepared for planting in the ensuing season.

1.1.3 Germplasm evaluation

Six accessions planted during 2005-06 were evaluatd as per IPGRI descriptor during the season, characterized and grouped (Table 1.1). All the six accessions evaluated have upright and open canopy with extensive branching behaviour. Besides, they were mid season flowering types with yellow or red coloured new flushes. All the accessions had big apple (<52 g) and apples were conical to obovate with yellow colour in 3 accessions and the remaining had yellow to red colour. Majority had medium flowering duration (60-90 days) while only one had short flowering duration. Five of them had intermediate nut weight (5-7 g), while one had bold nut (> 7g) and apple to nut ratio found to be medium (6-12). All the accessions had high shelling percentage (>28%) with medium shell thickness and medium kernel weight. Five of the accessions recorded lower cumulative yield while one had medium cumulative yield (9-18 kg) in 6 annual harvests.

Table 1.1: Details of accessions characterized during the fruiting season in the year 2016

Data Field	Descriptor		Descriptor State	No. of Accessions
7	Tree habit	3	Upright and compact	0
		5	Upright and open	6
		7	Spreading	0
9	Leaf shape	1	Oblong	0
		2	Obovate (Club-shaped)	3
		3	Oval	3
16	Branching pattern	1	Extensive	5
		2	Intensive	1
19	Colour of young leaves	1	Red	0
		2	Yellow red	5
		3	Green red	1
		4	Purple	0
28	Season of flowering	3	Early (Nov-Dec)	0
		5	Mid (Dec-Jan)	6
		7	Late (Jan-Feb)	0
31	Mature cashew apple colour	1	Yellow	3
		2	Red	2
		3	Yellow red	1
		4	Red purple	0
32	Shape of cashew apple	1	Cylindrical	0
		2	Conical-obovate	6
		3	Round	0
		4	Pyriform	0
50	Attachment of nut to cashew apple	3	Loose	3
		5	Intermediate	2
		7	Tight	1

Data Field	Descriptor		Descriptor State	No. of Accessions
35	Nut weight	3	Low (<5 g)	0
		5	Intermediate (5-7 g)	5
		7	High (>7 g)	1
43	Weight of cashew apple	3	Low (<27 g)	0
		5	Medium (27-52 g)	0
		7	High (>52 g)	6
60	Flowering duration	3	Short (<60 days)	1
		5	Medium (60-90 days)	5
		7	Long (>90 days)	0
62	Apple to nut ratio	3	Low (<6)	0
		5	Medium (6-12)	6
		7	High (>12)	0
63	Shelling percentage	3	Low (<18 %)	0
		5	Intermediate (18-28 %)	0
		7	High (>28%)	6
64	Kernel weight	3	Low (<1.2 g)	0
		5	Intermediate (1.2-2.5 g)	6
		7	High (>2.5 g)	0
57	Shell thickness	3	Thin (<2.5 mm)	0
		5	Intermediate (2.5-4.0 mm)	6
		7	Thick (>4.0 mm)	0
65	Attachment of peel to kernel	3	Loose	3
		7	Tight	3
68	Cumulative yield per plant (6 annual harvests)	3	Low (<9 kg)	5
		5	Medium (9-18 kg)	1
		7	High (>18 kg)	0

1.1.4 Development of core collection in cashew through Advanced Maximization Strategy with Heuristic Approach

Cashew being a perennial tree crop, it needs more land and other resources to maintain accessions. As it is highly cross pollinated, conservation through seeds is not feasible and tissue culture efforts to regenerate plants from mature explants have not been successful. Hence for efficient conservation and utilization of germplasm, it is essential to focus on very important accessions i.e. core collection representing the spectrum of diversity present in base collection.

Hitherto, approaches based on stratified clustering and genetic distance sampling were used for developing core collections in different crops. However, these methods have resulted in skewed quantitative trait variances in core sets. Hence, a relatively new technique, the Advanced

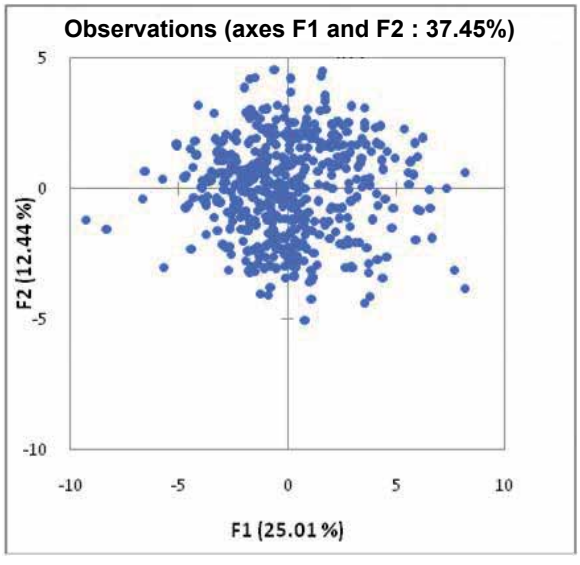
M strategy with Heuristic Approach was deployed which ensures retention of maximum diversity with minimum number of accessions. The base collection of 478 accessions with 68 characters was subjected to analysis resulting in core collection of 49 accessions. Further, another core collection of similar number was constituted by K-Means clustering for comparing the efficiency of two approaches. The validation parameters like Mean Difference (MD %), Variance Difference (VD %), Coincidence Rate (CR %), Variable Rate (VR %) and Class Coverage (CC %), PCA distribution patterns, Range, Mean, Varaince, Skewness, Kurtosis, CV (%) for 27 quantitative characters and Shanon-Weaver diversity and Nei's diversity indices for 41 qualitative characters were worked out (Table 1.2 and 1.3). The results revealed that core collection made out of heuristic approach was able to efficiently represent and retain the diversity compared to core made out of clustering (Fig 1.2). Hence, future conservation and breeding efforts will be concentrated on this heuristic core collection of cashew.

Table 1.2: Validation parameters for assessing the efficiency of core collection methods

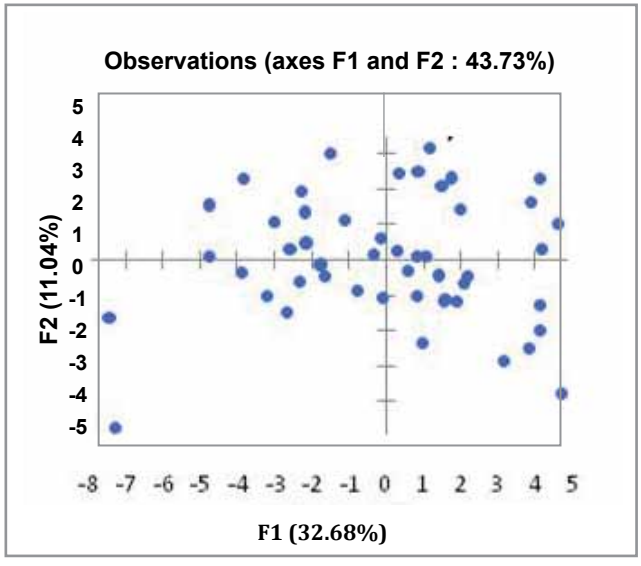
Particulars	Power Core	Cluster Core
No. of accessions	49	49
Variables	68	68
Mean Difference %	4.94	-0.87
Variance Difference %	41.01	6.16
Coincidence Rate %	95.37	69.09
Variable Rate %	129.54	97.35

Table 1.3: Mean values of SW and Nei's Diversity Index for 41 qualitative characters

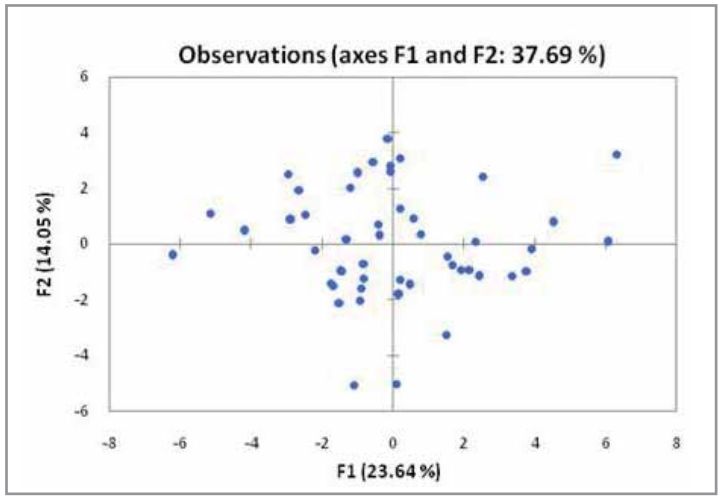
Shanon Weiver index			Nei's Diversity Index		
Power Core	Base Collection	Cluster Core	Power Core	Base Collection	Cluster Core
0.63	0.55	0.53	0.37	0.33	0.32



Base collection



Power Core



Cluster Core

Fig. 1.2: PCA distribution patterns for base, power core and cluster core collections

1.2 Genetic improvement of cashew for yield and quality traits

1.2.1 Evaluation of Interspecific hybrids

A total of 128 interspecific hybrids which were planted during the year 2009, involving Ullal-3 x *A. microcarpum*, *A. microcarpum* x Ullal-3, Bhaskara x *A. microcarpum* , Ullal- 1 x *A. othonianum,* Ullal-1 x *A. microcarpum, A. microcarpum* x Vengurle-4, Vengurle-4 x *A. microcarpum* and *A. microcarpum* x Bhaskara had been evaluated for yield and yield attributes. The descriptive statistics of these characters are depicted in the table 1.4. It is evident that yield levels are very low and hence per se these hybrids may not be useful. Further, there was high incidence of tea mosquito bug in this plot and none of the interspecific hybrids seems to be tolerant for the pests.

Table 1.4: Descriptive statistics of inter-specific hybrids (N=128)

Character	Minimum	Maximum	Mean	SD	Kurtosis	Skewness
Plant Height (m)	2.75	9.5	5.87	1.17	1.84	0.50
Canopy Spread (EW)	1.5	10.2	5.70	1.24	3.24	0.62
Canopy Spread (NS)	1.5	9.5	5.62	1.25	1.75	0.25
Stem Girth (cm)	20	126	70.06	12.29	4.37	0.22
Yield (kg/plant)	0.01	1.22	0.24	0.24	2.67	1.67

1.2.2 Evaluation of cashew hybrids

A total of 153 hybrids generated by crossing many germplasm accessions and planted during the year 2008 were evaluated for yield and yield attributes. Table 1.5 shows the descriptive statistics of different characters including yield. However, the yield levels are low and the chance of selection of superior hybrid is very less in this population.

Table 1.5: Descriptive statistics of cashew hybrids (N=153)

Character	Minimum	Maximum	Mean	SD	Kurtosis	Skewness
Plant Height (m)	2.5	6.9	4.98	0.75	0.88	-0.23
Canopy Spread (EW)	2.5	8.0	5.36	1.05	0.70	0.44
Canopy Spread (NS)	2.5	8.25	5.31	1.08	0.07	0.35
Stem Girth (cm)	31	114	70.36	14.53	0.32	0.11
Yield (kg/plant) (N=145)	0.006	2.62	0.55	0.54	1.12	1.21

1.2.3 Evaluation of cashew hybrids obtained from crosses involving dwarf types and popular types

The progenies of cross between popular varieties of cashew and dwarf types (190 Nos.) available in germplasm (NRC-492, Kodippady and Taliparamba) were evaluated (planted during 2008) for yield and ancillary characters. Table 1.6 depicts the descriptive statistics of various characters recorded. It is evident from the table that the mean height of progenies is 4.9 m and minimum height recorded was 2.0 m (Plant Number 304 from the cross Selection-2 x NRC-492). The highest yield of 3.58 kg/plant was recorded in plant number 308 i.e. progeny from Ullal-3 x Taliparamba cross and its height was 5 m which could not be classified under dwarf category. It appears that it is difficult to find an accession with dwarf stature and high yield in these progenies.

Table 1.6: Descriptive statistics of cashew hybrids generated by popular varieties and dwarf types crosses (N=190)

Character	Minimum	Maximum	Mean	SD	Kurtosis	Skewness
Plant Height (m)	2.0	7.75	4.90	0.89	1.04	-0.16
Canopy Spread (EW)	1.5	8.0	5.25	1.16	0.56	-0.10
Canopy Spread (NS)	1.0	8.25	5.19	1.15	0.82	-0.12
Stem Girth (cm)	23	114	68.96	14.71	0.66	-0.21
Yield (kg/plant) (N=182)	0.006	3.58	0.69	0.57	4.10	1.59

1.3 Genetic Analysis of mapping population through molecular markers for important traits in Cashew

In this project, Pistachio (9) and almond (21) SSR primers in parents were screened in the progenies of Ullal-3 x NRC-492 to confirm polymorphism (Fig 1.3). More number of SSR primers will be screened to generate molecular data (genotyping) in due course. The morphological parameters such as plant height, girth and canopy spread were recorded (phenotyping) on these 93 progenies (planted during 2009) along with the yield. The descriptive statistics of these characters are represented in the Table 1.7. The highest yield was observed in plant number 510 (4.34 kg/plant) with a height of 6.25 m. Overall, the yield levels were low.

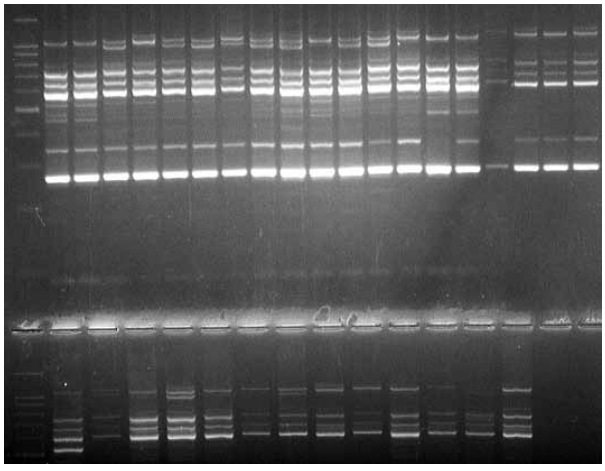


Fig 1.3: Polymorphism in progenies of Ullal-3 x NRC-492 with Almond SSR primer

Table 1.7: Descriptive statistics of F1 progenies (N=93)

Character	Minimum	Maximum	Mean	SD	Kurtosis	Skewness
Plant Height (m)	3.10	9.0	5.62	1.09	0.17	0.20
Canopy Spread (EW)	2.40	9.50	6.29	1.49	-0.21	-0.08
Canopy Spread (NS)	2.50	11.00	6.63	1.59	0.16	0.21
Stem Girth (cm)	30.0	123	67.68	16.34	0.99	0.41
Yield (kg/plant)	0.07	4.34	0.95	0.70	6.06	1.97

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

Growth observations such as plant height, girth and spread along with observations on yield were recorded on the hybrids planted during October, 2013 and presented in Table 1.8 to Table 1.11. Two promising plants include Plant number 46-2 from Madakkathara-2 x NRC-492 cross yielded 1.17 kg/ plant and it was having 4.25 m height, whereas Plant number 5-5 from Vengurle-4 x NRC-492 recorded the yield of 1.90 kg/plant and its height was 3.8 m.

Table 1.7: Descriptive statistics of direct and reciprocal crosses for plant height

S.No.	Cross	Plant Height (m)						
		No.of plants	Min	Max	Mean	SD	Kurtosis	Skewness
1	Vengurle-4 x NRC-492	138	1.0	5.5	3.94	0.82	2.25	-1.17
2	NRC-492 x Vengurle-4	9	2.5	4.3	3.52	0.53	0.47	-0.67
3	Vengurle-4 x Taliparamba-1	110	1.0	5.5	4.03	0.83	1.09	-0.77
4	Taliparamba-1 x Vengurle-4	6	4.0	5.1	4.85	0.41	5.81	-2.39
5	Priyanka x NRC-492	62	1.5	5.3	4.19	0.60	5.63	-1.18
6	NRC-492 x Priyanka	10	3.0	4.4	3.83	0.45	-0.35	-0.84

S.No.	Cross	Plant Height (m)						
		No.of plants	Min	Max	Mean	SD	Kurtosis	Skewness
7	Priyanka x Taliparamba-1	8	1.75	5.0	3.79	0.97	2.70	-1.40
8	Taliparamba-1 x Priyanka	6	3.0	5.1	4.05	0.67	2.14	-0.04
9	Dhana x NRC-492	55	1.5	5.1	4.14	0.66	5.16	-1.69
10	NRC-492 x Dhana	11	4.0	5.1	4.37	0.46	-1.37	0.75
11	Dhana x Taliparamba-1	56	2.9	6.1	4.16	0.68	1.04	0.56
12	Taliparamba-1 x Dhana	3	4.0	4.1	4.03	0.05	0.0	1.73
13	Madakkathara-2 x NRC-492	126	1.5	5.6	4.57	0.65	3.80	-1.51
14	NRC-492 x Madakkathara-2	7	3.0	5.5	4.12	0.73	3.01	0.71
15	Madakkathara-2 x Taliparamba-1	50	0.75	6.1	4.58	0.79	10.40	-2.42

Table 1.8: Descriptive statistics of direct and reciprocal crosses for stem girth

S.No.	Cross	Plant Height (m)						
		No.of plants	Min	Max	Mean	SD	Kurtosis	Skewness
1	Vengurle-4 x NRC-492	138	11	90	32.05	8.32	2.53	2.45
2	NRC-492 x Vengurle-4	9	28	40	32.33	4.03	0.49	1.21
3	Vengurle-4 x Taliparamba-1	110	17	51	35.30	7.15	-0.44	-0.18
4	Taliparamba-1 x Vengurle-4	6	34	48	42.16	4.95	0.45	-0.85
5	Priyanka x NRC-492	62	10	56	37.61	7.53	2.37	-0.59
6	NRC-492 x Priyanka	10	30	49	38.7	6.91	-1.17	0.23
7	Priyanka x Taliparamba-1	8	12	45	35.87	10.62	4.16	-1.91
8	Taliparamba-1 x Priyanka	6	38	47	42.5	3.93	-2.75	0.0
9	Dhana x NRC-492	55	17	49	38.10	6.30	1.33	-0.92
10	NRC-492 x Dhana	11	25	55	38.54	8.20	0.54	0.49
11	Dhana x Taliparamba-1	56	19	55	37.1	8.59	-0.69	0.08
12	Taliparamba-1 x Dhana	3	36	45	40.66	4.50	0.0	-0.33
13	Madakkathara-2 x NRC-492	126	18	62	39.50	6.36	1.60	0.18
14	NRC-492 x Madakkathara-2	7	34	51	41	5.41	1.43	0.94
15	Madakkathara-2 x Taliparamba-1	50	10	64	43.1	9.29	2.19	-0.75

Table 1.9: Descriptive statistics of direct and reciprocal crosses for Canopy Spread - EW

S.No.	Cross	Plant Height (m)						
		No.of plants	Min	Max	Mean	SD	Kurtosis	Skewness
1	Vengurle-4 x NRC-492	138	1.5	5.0	3.10	0.80	-0.59	0.25
2	NRC-492 x Vengurle-4	9	2.5	4.0	2.91	0.49	2.30	1.37

S.No.	Cross	Plant Height (m)						
		No.of plants	Min	Max	Mean	SD	Kurtosis	Skewness
3	Vengurle-4 x Taliparamba-1	110	1.0	5.0	2.64	0.68	0.72	0.49
4	Taliparamba-1 x Vengurle-4	6	2.1	4.3	3.27	0.77	-0.10	-0.22
5	Priyanka x NRC-492	62	1.0	5.0	2.91	0.78	0.81	0.33
6	NRC-492 x Priyanka	10	2.0	4.2	3.41	0.70	-0.01	-0.72
7	Priyanka x Taliparamba-1	8	1.7	4.1	3.35	0.79	1.39	-1.21
8	Taliparamba-1 x Priyanka	6	3.0	4.1	3.4	0.44	-0.73	1.03
9	Dhana x NRC-492	55	1.5	5.1	3.09	0.67	0.74	0.01
10	NRC-492 x Dhana	11	2.0	4.8	3.05	0.65	5.65	1.64
11	Dhana x Taliparamba-1	56	1.7	5.9	2.95	0.87	-0.53	-0.11
12	Taliparamba-1 x Dhana	3	3.1	9.1	3.03	0.05	0.0	1.73
13	Madakkathara-2 x NRC-492	126	1.3	4.5	2.67	0.62	-0.08	0.44
14	NRC-492 x Madakkathara-2	7	3.0	3.8	3.17	0.28	6.39	2.48
15	Madakkathara-2 x Taliparamba-1	50	0.5	5.1	3.56	0.91	1.38	-0.72

Table 1.10: Descriptive statistics of direct and reciprocal crosses for Canopy Spread - NS

S.No.	Cross	Canopy Spread - NS (m)						
		No.of plants	Min	Max	Mean	SD	Kurtosis	Skewness
1	Vengurle-4 x NRC-492	138	1.5	5.5	3.14	0.79	0.09	0.45
2	NRC-492 x Vengurle-4	9	2.5	4.0	3.20	0.45	-0.08	0.49
3	Vengurle-4 x Taliparamba-1	110	1.0	4.8	2.90	0.68	0.10	-0.03
4	Taliparamba-1 x Vengurle-4	6	3.0	4.1	3.35	0.54	-1.78	0.98
5	Priyanka x NRC-492	62	1.0	5.5	3.04	0.79	1.74	0.50
6	NRC-492 x Priyanka	10	2.1	4.1	3.19	0.59	0.59	0.04
7	Priyanka x Taliparamba-1	8	1.5	5.1	3.38	1.07	0.75	-0.18
8	Taliparamba-1 x Priyanka	6	2.9	5.0	4.11	0.75	0.28	-0.57
9	Dhana x NRC-492	55	1.5	5.0	3.28	0.69	0.53	-0.15
10	NRC-492 x Dhana	11	2.9	4.1	3.44	0.47	-1.83	0.52
11	Dhana x Taliparamba-1	56	1.7	4.3	3.00	0.68	-0.53	-0.11
12	Taliparamba-1 x Dhana	3	3.1	3.8	3.46	0.35	0.0	-0.42
13	Madakkathara-2 x NRC-492	126	1.2	5.5	3.06	0.67	1.08	0.12
14	NRC-492 x Madakkathara-2	7	3.0	4.5	3.59	0.57	-1.26	0.67
15	Madakkathara-2 x Taliparamba-1	50	0.5	5.2	3.77	0.99	1.45	-0.94

Table 1.11: Yield levels in different crosses during the year

S.No.	Cross	No.of plants	Yield (kg/plant)	
			Min	Max
1	Vengurle-4 x NRC-492	113	0.006	1.90
2	NRC-492 x Vengurle-4	4	0.040	0.15
3	Vengurle-4 x Taliparamba-1	68	0.005	0.87
4	Taliparamba-1 x Vengurle-4	6	0.104	0.85
5	Priyanka x NRC-492	51	0.006	0.99
6	NRC-492 x Priyanka	10	0.030	0.67
7	Priyanka x Taliparamba-1	4	0.040	0.09
8	Taliparamba-1 x Priyanka	9	0.006	0.42
9	Dhana x NRC-492	43	0.084	1.05
10	NRC-492 x Dhana	10	0.273	0.94
11	Dhana x Taliparamba-1	39	0.005	0.71
12	Taliparamba-1 x Dhana	3	0.440	0.55
13	Madakkathara-2 x NRC-492	116	0.025	1.17
14	NRC-492 x Madakkathara-2	7	0.320	0.89
15	Madakkathara-2 x Taliparamba-1	49	0.090	0.74

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

A total of 545 plants involving 471 back cross progenies and 74 parent plants were planted during October 2014 (Fig. 1.4). 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 were compiled on these progenies and the summary statistics of different characters in two back cross progenies are presented in Table 1.12 and Table 1.13.

The yield level ranged from 5 g to 760 g/ plant in Bhaskara back cross progenies and the height of the maximum yielding plant was 4.1 m (Plant Number: BDB-372-15). In Ullal-3 back cross progenies, it ranged from 5.0 g to 648 g/plant and the height was 2.8 m in the progeny (Plant Number: UDU-570-2). These two identified plants will be evaluated further in the ensuing years for their height and yield along with other progenies.

Fig 1.4 Panoramic view of back cross progenies block

Table 1.12: Descriptive statistics of (Bhaskara x NRC-492) x Bhaskara progenies (N=196)

Parameter	Minimum	Maximum	Mean	SD	Kurtosis	Skewness
Plant Height (m)	1.0	4.5	2.98	0.69	-0.30	-0.02
Stem Girth (cm)	11	47.0	27.74	5.93	0.68	0.23
Canopy Spread (EW)	1.0	5.0	2.81	0.78	-0.28	0.13
Canopy Spread (NS)	1.0	5.0	2.75	0.79	-0.46	0.24
Yield (g/plant) N=166	5.0	760	192.47	132.56	1.84	1.14

Table 1.13: Descriptive statistics of (Ullal-3 x NRC-492) x Ullal-3 progenies (N=275)

Character	Minimum	Maximum	Mean	SD	Kurtosis	Skewness
Plant Height (cm)	1.25	4.10	2.79	0.50	-0.15	-0.29
Stem Girth (cm)	11	41.0	26.03	4.99	0.75	-0.12
Canopy Spread (EW)	0.90	4.0	2.50	0.52	-0.06	-0.26
Canopy Spread (NS)	0.85	4.0	2.86	0.56	0.18	-0.24
Yield (g/plant) N=239	5.0	648	148.46	118.02	1.92	1.30

1.5.1 Establishment of open pollinated progenies

When cashew hybrids obtained from crosses involving dwarf types and popular tall cultivars were assessed for their height and yield, it was found that most of the progenies are falling under 'tall' category. Very few 'semi tall' progenies had lower yields. It appears that height and yield are positively correlated. However, in order to acquire dwarf/semi tall plants with high yield, open pollinated progenies from the dwarfest plants of tall x dwarf crosses were generated and planted along with parents in the field for further evaluation during the year 2016 (Fig 1.5). The details of the progenies planted are given in the Table 1.14.

Table 1.14: Open pollinated progenies from F_1 plants

Cross Combination (F_1 plants from which open pollinated seeds are collected)	Number of open pollinated progenies planted
Ullal- 3 x NRC 492	16
Bhaskara x NRC 492	86
Total	**102**

Fig 1.5: Establishment of open pollinated progenies from F1 plants

1.5.2 Generation of pre-breeding material

The interspecific hybrids generated at the Research Directorate are not useful per se due to their very low yields. Hence, in order to increase the yield of interspecific progenies, back cross was carried out wherein pollens from inter-specific hybrids were used to pollinate flowers in popular cultivated varieties. The details of the crosses and number of nuts collected are given in the table 1.15.

Table 1.15: Deatils of crosses and number of nuts collected for generating interspecific progenies

Cross combination	# of flowers pollinated	# of nuts collected
Bhaskara x (Bhaskara x A. *microcarpum*)	228	24
Ullal-3 x (Ullal-3 x A. *microcarpum*)	233	13
Total	**461**	**37**

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

The objective of this project is to assess cashew germplasm accessions for Cashew Nut Shell Liquid (CNSL) content and to identify promising accessions with very high or very low CNSL. Standard method of CNSL extraction using Hexane as solvent was followed and CNSL extracted from a total number of 110 accessions (Table 1.16). The work is under progress to evaluate remaining germplasm accessions.

Table 1.16: CNSL content of different cashew germplasm accessions

Sl. No.	NRC No.	CNSL (%)	Sl. No.	NRC No.	CNSL (%)	Sl. No.	NRC No.	CNSL (%)
1	110	35.78	38	200	20.33	75	190	16.19
2	354	31.59	39	19	20.27	76	395	15.91
3	88	30.9	40	270	20.22	77	78	15.74
4	130	28.45	41	72	20.16	78	348	15.6
5	391	27.51	42	301	19.88	79	345	15.51
6	120	27.23	43	87	19.8	80	95	15.46
7	H -126	27.22	44	278	19.7	81	33	15.38
8	160	25.42	45	48	19.63	82	98	15.26
9	280	25.36	46	291	19.5	83	124	15.12
10	276	25.27	47	365	19.43	84	240	14.9
11	61	25.25	48	80	19.35	85	221	14.88
12	195	24.97	49	379	19.19	86	310	14.66
13	180	24.85	50	119	19.12	87	363	14.55
14	30	24.83	51	176	19.07	88	59	14.18
15	175	24.51	52	171	19	89	244	14.15
16	20	24.27	53	1	18.78	90	241	14.13

Sl. No.	NRC No.	CNSL (%)	Sl. No.	NRC No.	CNSL (%)	Sl. No.	NRC No.	CNSL (%)
17	350	24.23	54	358	18.76	91	295	13.6
18	163	24.07	55	69	18.62	92	367	13.59
19	H- 125	23.79	56	44	18.6	93	370	13.57
20	35	23.64	57	85	18.56	94	279	13.43
21	99	23.63	58	26	18.52	95	89	13.19
22	109	23.32	59	243	18.37	96	274	13.17
23	300	23.3	60	209	18.33	97	27	13.06
24	349	22.9	61	371	18.12	98	193	13.06
25	362	22.66	62	18	18.01	99	299	12.77
26	112	22.64	63	208	17.85	100	145	12.19
27	359	22.16	64	351	17.68	101	88	11.98
28	39	21.76	65	186	17.58	102	29	11.95
29	128	21.71	66	292	17.55	103	10	11.87
30	346	21.7	67	193	17.39	104	65	11.58
31	83	21.59	68	23	17.25	105	202	10.92
32	67	21.54	69	257	17.19	106	40	10.62
33	267	20.85	70	86	17.08	107	108	10.43
34	353	20.77	71	77	17.05	108	55	8.05
35	81	20.5	72	368	16.85	109	198	7.65
36	56	20.48	73	21	16.79	110	199	6.53
37	365	20.39	74	355	16.79			

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

1.7.1 Morphological characterization of different cashew accession

Among the fourteen cashew apple accessions along with check (Vengrula-8) evaluated, it was observed that the maximum mean height (3.84 m) recorded in NRC 175 and NRC 389, while minimum height (2.44 m) found in Vengurla-8. Maximum girth (48.75 cm) and mean canopy spread (5.60 m) were recorded in NRC 112 and NRC 175 respectively, while minimum girth (29 cm) and mean canopy spread (4.16 m) recorded in Vengurla-8 (Table 1.17). Recording data on cashew apple characterization, apple and nut yield and biochemical analysis is under progress.

Table 1.17: Observation on morphometric parameters of different cashew accessions

Acc. Number	Growth parameters		
	Height (m)	Girth (cm)	Canopy spread (m)
NRC 75	3.58	47.53	4.64
NRC 111	3.52	46.03	4.80
NRC 112	3.73	48.75	5.25

Acc. Number	Growth parameters		
	Height (m)	Girth (cm)	Canopy spread (m)
NRC 120	3.24	40.53	5.34
NRC 140	3.14	43.00	4.75
NRC 144	3.23	40.17	4.71
NRC 175	3.84	44.67	5.60
NRC 176	3.40	40.25	4.53
NRC 183	3.07	38.69	4.49
NRC 189	3.37	41.17	4.86
NRC 270	3.61	47.78	4.94
NRC 301	3.54	45.17	4.77
NRC 389	3.84	47.31	5.30
NRC 493	3.63	46.25	4.86
V-8	2.44	29.00	4.16
Mean	3.41	43.09	4.87
SEd	0.234	2.872	0.42
CD (0.05)	0.48**	5.88**	NS

1.7.2 Incidence of insect pests on different cashew accessions

In general, pest incidence was very low during the year 2016 among the accessions during flowering and early fruiting stage. Filed observations revealed that TMB incidence was high on NRC 140, NRC 75 and NRC 111 with the damage grade of 1.70, 1.52 and 1.27, respectively during early flowering season and TMB incidence was very less (< grade 1) among other accessions. During early flowering stage, severe incidence of thrips on developing nuts was recorded on NRC 175 (1.23 %), NRC 189 (1.07 %) and NRC 140 (1.00 %). While, infestation (%) in harvested nuts by apple and nut borer (ANB) was less and varied between 0.00 and 1.00 among the accessions investigated (Table 1.18).

Pest infestation levels were recorded in the mid season harvested cashewnuts and found wide variation among accessions (Table 1.18). Incidence of TMB was more on NRC 270 followed by NRC 493 and NRC 120 with the grade of 1.15, 1.14 and 1.11, respectively. Incidence of thrips was maximum on NRC 189 (28.42 %), followed by NRC 140 (19.07 %) and NRC 176 (16.79 %), whereas it was low on NRC 111 (7.64 %) and NRC 144 (8.45 %). A maximum of 8.23 % infestation by ANB was recorded on NRC 183, whereas, less than 1 % infestation was noticed on NRC 176 and NRC 493.

Table 1.18: Pest incidence during flowering and early fruiting stage of the accessions

Accession no.	TMB*		Thrips[a]		ANB[a]	
	FFS	HRCN	FFS	HRCN	FFS	HRCN
NRC 75	1.52	0.78	0.49	14.23	0.04	5.25
NRC 111	1.27	0.20	0.74	7.64	0.12	3.36
NRC 112	0.38	0.01	0.59	11.90	0.03	2.69

Accession no.	TMB*		Thrips[a]		ANB[a]	
	FFS	HRCN	FFS	HRCN	FFS	HRCN
NRC 120	0.79	1.11	0.76	14.59	0.14	5.32
NRC 140	1.70	0.87	1.00	19.07	0.00	2.75
NRC 144	0.96	1.04	0.51	8.45	0.19	2.60
NRC 175	0.81	0.50	1.23	10.30	0.00	2.32
NRC 176	0.41	0.15	0.49	16.79	0.07	1.52
NRC 183	0.93	0.01	0.03	9.93	1.00	8.23
NRC 189	0.33	0.62	1.07	28.42	0.07	7.68
NRC 270	0.54	1.15	0.84	8.93	0.27	6.38
NRC 301	0.12	0.01	0.23	15.46	0.04	4.96
NRC 389	0.41	0.58	0.93	14.31	0.15	7.20
NRC 493	0.18	1.14	0.18	10.17	0.04	1.64
NRC V8	0.14	0.56	0.62	11.95	0.21	4.36

FFS: Flowering and fruiting stage; HRCN: Harvested raw cashewnuts

Mean of three replication * - on the grade of 0-4,

[a] - percent infestation under field conditions while developing nuts and apples.

1.7.3 Screening of cashew apple accessions against diseases under field condition

Fourteen accessions were screened for resistance against black spot and shoot die back/ twig rot/gummosis diseases during the year 2016 (Table 1.19). Disease was scored using 0-4 scale and % disease index (PDI) was calculated using standard formula. Among fourteen lines, NRC 301, NRC 493, and NRC 176 were resistant to black leaf spot disease. In case of shoot die back/ twig rot/gummosis, except NRC 183 (moderately susceptible) all were in moderately resistance or resistance. However, disease pressure during November 2016 was low and the maximum disease severity recorded was only 38.1%. Hence most of the apple accessions showed resistance/ moderately resistance reactions, but just opposite reactions observed during the previous year.

Table 1.19: Screening germplasm lines against black spot and shoot die back/twig rot/gummosis diseases under field conditions

Sl. No.	Accessions	Black leaf spot disease (%) / Reaction*	Die back of shoot/twig rot / gummosis (%) / Reaction*
1	NRC301	7.3(R)	12.5(MR)
2	NRC389	19.9(MR)	7.9(R)
3	NRC120	12.6(MR)	3.6(R)
4	NRC189	40.0(MS)	10.9(MR)
5	NRC175	22.3(MR)	8.3(R)
6	NRC493	6.8(R)	3.1(R)

Sl. No.	Accessions	Black leaf spot disease (%) / Reaction*	Die back of shoot/twig rot / gummosis (%) / Reaction*
7	NRC176	4.2(R)	17.3(MR)
8	NRC183	52.8(S)	38.1(MS)
9	NRC111	12.8(MR)	5.0(R)
10	NRC270	10.6(MR)	6.1(R)
11	NRC75	12.6(MR)	7.7(R)
12	NRC144	19.7(MR)	4.2(R)
13	NRC112	12.9(MR)	6.4(R)
14	NRC140	12.0(MR)	2.6(R)

*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).

1.8 Externally Funded Projects:

1.8.1 Development of morphological descriptors and DUS test guidelines for cashew

DUS test guidelines for cashew was finalized during the task force meeting held at this Research Directorate (Fig 1.6). This document contains both off-site and on-site testing procedures along with 6 grouping characters and 25 evaluation characters. Illustrations are also included for some characters to help in easy recognition of categories under each character.

Fig 1.6: Taskforce meeting of DUS guidelines on Cashew

1.8.2 Consortia Research Platform (CRP) - Agro biodiversity

Six cashew germplasm accessions which were planted during the year 2017, had been characterised and after evaluating five of them, pertinent data documented. Periodical maintenance was taken up as scheduled. A Decision Support System (DSS) for cashew germplasm data management was developed under this project.

In most crops, germplasm utilisation is rather limited due to non availability of proper characterisation and evaluation data on accessions. Even when they are available, it is quite difficult to select germplasm accessions having suitable combinations of characters for *per se* utilisation or in breeding programs owing to enormity of quantitative and qualitative data. Hence it is imperative to develop robust data management and retrieval systems for better utilization of germplasm resources.

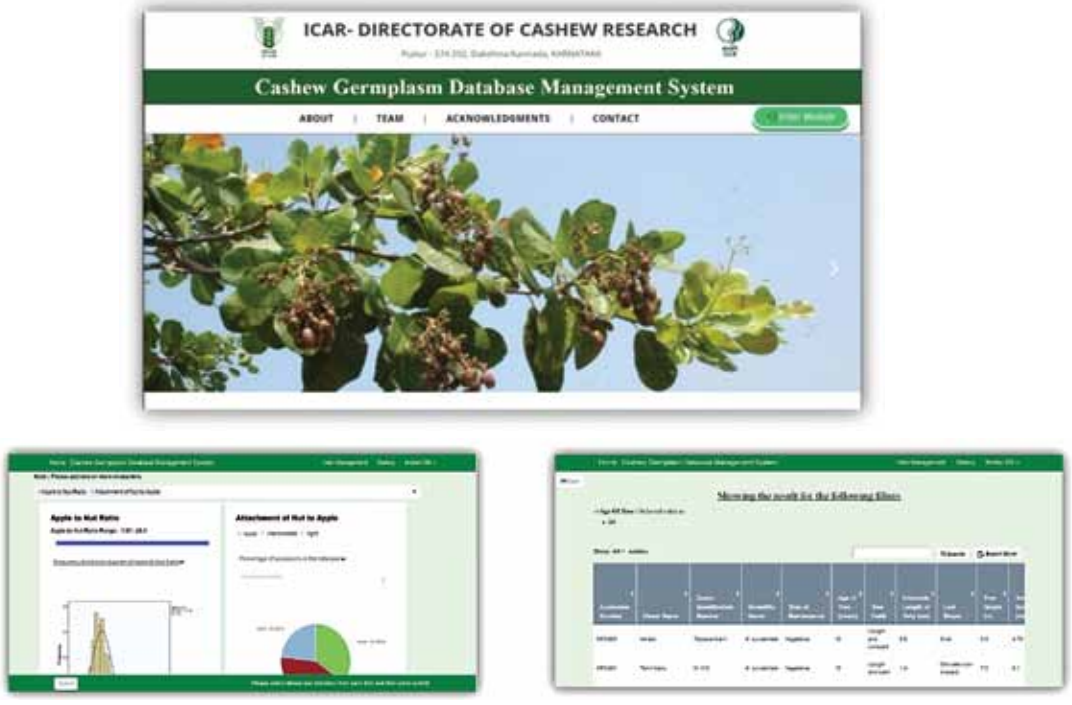


Fig 1.7: Web portal for decision support system in cashew germplasm

This research Directorate has the largest repository of cashew germplasm accessions in the country, in its National Cashew Field Gene Bank. A robust Decision Support System (DSS) has been developed to manage and utilise these germplasm resources. The module can be accessed now at www.mindstack.in/dcr/ (Fig.1.7). Currently the DSS system for cashew hosts data on 478 accessions with 68 evaluation characters (both vegetative and reproductive) in addition to 10 important fields from passport data. The database is open ended and it is possible to add any number of accessions with data and images.

The DSS aims at retrieval of accessions and related information at two levels i.e. General search and Search as per descriptor. The major difference between 'General search' and 'Search as per descriptor' sections is the way in which the option for selection is provided for quantitative characters. In 'General Search' the user can specify the required range of the character and get the accessions where as in 'Search as per descriptor', the categories of a character as per cashew descriptor will be displayed and user can select and get the accessions in that category. Images are also provided for each category of characters to facilitate the process of selection. Most importantly, it is possible to select one or many combination of characters and get the accessions in both search options. In the results, it is possible to retrieve images of different plant parts for each accession. The resultant data can also be exported to Microsoft excel sheet for further uses.

The DSS for cashew germplasm management helps in selection of accessions based on the requirement in the field of crop improvement, production, protection and post harvest technology. The frequency distribution patterns for quantitative characters give an idea of mean, standard deviation, skewness, kurtosis and variability patterns for a particular character. Whereas, pie diagrams for qualitative characters indicate the proportion of accessions for each character. This sort of information is crucial in deciding the novelty/worth of germplasm accessions during survey, collection and their subsequent inclusion in gene bank.

2. CROP MANAGEMENT

2.1. Organic Farming in Cashew

Organic manures caused increase in organic carbon content of soil over control.The treatments FYM to supply 500 g N/tree + rock phosphate to supply 125 g P_2O_5/tree and wood ash to supply 125 g K_2O/tree, poultry manure to supply 500 g N /tree and In situ composting using recyclable cashew biomass and weeds + Green manuring recorded high content of organic carbon whereas least was observed under control (Table 2.1).

Available nitrogen in soil under different treatments ranged from 301 to 464 kg/ha recording highest values in 'recommended NPK fertilizer' and 'FYM + Organic cakes + Recyclable cashew biomass + biofertilizer consortia' with minimum under 'control' and 'In situ composting using recyclable cashew biomass and weeds' (Table 2.2). Available soil micronutrients also showed variation under different organic and inorganic treatments. Available Fe of soil under different treatments varied from 15.0 to 21.2 ppm, available Mn varied from 6.0 to 9.0 ppm, available Zn varied from 0.74 to 0.92 ppm and available Cu ranged from 1.00 to 1.98 ppm.

Table 2.1: Influence of organic and inorganic sources of nutrients on organic carbon (%) content

Treatments	0-30 cm	30-60 cm	60-90 cm
T_1	1.50	1.41	1.33
T_2	1.50	1.41	1.33
T_3	1.89	2.01	1.50
T_4	1.83	1.65	1.38
T_5	1.53	1.30	1.12
T_6	1.95	1.80	1.59
T_7	1.77	1.62	1.56
T_8	1.68	1.38	1.33
T_9	1.65	1.44	1.35
T_{10}	1.50	1.33	1.18
T_{11}	1.18	0.97	0.85

Table 2.2: Influence of organic and inorganic sources of nutrients on Available N (kg/ha) content

Treatments	0-30 cm	30-60 cm	60-90 cm
T_1	413.952	363.776	426.496
T_2	401.408	351.232	401.408
T_3	413.952	426.496	464.128
T_4	401.408	413.952	388.864
T_5	338.688	426.496	401.408
T_6	376.320	401.408	326.144
T_7	388.864	363.776	351.232
T_8	439.040	451.584	376.320
T_9	413.952	363.776	376.320
T_{10}	401.408	426.496	363.776
T_{11}	376.320	301.056	376.320

2.1.1 Organic management of Tea Mosquito Bug

Pest management in the experimental field was carried out using sprays of biopesticide 'Nimbicidine' and also Beauvarria bassiana an entamopathogenic fungal culture at periodic intervals. Neem based insecticide and Nimbicidine @3ml/L were not effective to have a best control over TMB infestation. The fungal spray at two concentrations both @ 5ml/L and 10ml/L were tried but found less effective as compared to Nimbicidine spray. Reduvids, Sycanus sp. also tried in the field but found less effective as inundative

release of reduvids are required in large numbers for successful control over TMB.

2.2 Irrigation requirement of cashew under high density planting

Yield data showed variation among different plant densities and irrigation levels and varied from 2.84 to 4.51 kg under 5 × 4 m spacing, 3.23 to 4.96 kg under 6 × 4 m spacing. Variation in yield under 10 × 5m spacing was from 3.17 to 4.61 kg and no significant difference was observed in the yield with respect to different plant densities whereas significant difference was observed in yield with different irrigation levels (Table 2.3).

Table 2.3: Effect of plant densities and irrigation levels on nut yield of cashew var. Bhaskara

Irrigation (T) / Spacing (M)	T_1	T_2	T_3	T_4	T_5	T_6	Mean (M)
	Yield (kg/plant)						
M_1	3.33	3.25	4.51	4.27	2.84	3.12	3.55
M_2	3.89	4.55	3.91	4.96	3.37	3.23	3.98
M_3	4.08	4.05	4.41	4.61	3.85	3.17	4.03
Mean (T)	3.77	3.95	4.28	4.61	3.36	3.17	
Source	Main (M)	Sub (T)	Sub (T) x Main (M)		Main (M) x Sub (T)		
SE (d)	0.211	0.246	0.426		0.443		
LSD at 5%	NS	0.503	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 420 cashew orchards of 5 to 20 years old in Puttur (Karnataka), Vengurla (Maharashtra), Bhubaneswar (Odisha), Bapatla (Andhra Pradesh), Pilicode (Kerala) and Vridhachalam (Tamil Nadu) 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, Bhubaneswar, Bapatla, Pilicode and Vridhachalam under AICRP on 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. Seventy soil samples collected at a depth of 0-30 cm from different cashew orchards of these AICRP centres were analysed for selective physico-chemical characteristics and soil analysis of samples collected from Vridhachalam, Tamilnadu is underway.

Seventy soil samples collected from different cashew orchards in Bapatla region were analyzed for selective soil physicochemical properties along with macro, secondary and micronutrients. pH and EC of the all soil samples collected varied from 5.19-6.18 and found to be slightly acidic to neutral in reaction and 0.021-0.693 dS/m respectively. Organic carbon content of the samples ranged from 0.02-0.65 %. The available N and K content of the soils varied from 62.64 to 401.25 kg ha^{-1} and 47.41-929.94 kg ha^{-1} respectively. Exchangeable Ca and Mg content of the soils varied from 0.40-7.60 and 0.10-5.50 me/100g respectively.

Soil samples collected from cashew orchards of Bhubaneswar region were also analyzed for various physicochemical properties. The data

showed considerable variation w.r.t. orchards in soil properties. Available Potassium of soils ranged from 5.03-667.01 kg/ha while Ca and Mg ranged from 0.20-4.00 and 0.10-0.75 me/100g.

2.3.2 Spatial distribution of available micronutirents in cashew orchards of Bhubaneswar and Bapatla

Surface soil (0-30 cm) samples from Bhubaneswar and Bapatla were analyzed to assess the status and spatial distribution of available micronutrients viz., Fe, Mn, Zn and Cu. The selected cashew orchards cover entire range of management and yield level. The collected soil samples were processed and analyzed for DTPA extractable Fe, Mn, Zn and Cu as per standard methods described by Lindsay and Norvell (1978). The range and mean values of DTPA extractable micronutrient contents in soils showed wide variation among orchards (Table 2.4 and Table 2.7).

2.3.3 Micronutrient status in Bhubaneswar cashew orchard soils

Available Fe status in cashew orchard soils of Bhubaneswar region varied from 8.77 to 150.89 mg kg^{-1} with an average value of 31.76 mg kg^{-1} (Table 2.4). Critical limits Fe soil as suggested by Lindsay and Norvell (1978) is 4.5 mg kg^{-1}, accordingly Fe contents of cashew orchard soils of Bhubaneswar region are on the high side. The Mn content varied from 1.90 to 300.91 mg kg^{-1} with mean value of 73.58 mg kg^{-1}. As per critical limits of 2.0 mg Mn kg^{-1} soil as suggested by Lindsay and Norvell (1978), 87 % cashew orchard soils of Bhubaneswar are rich in Mn (Table 2.4).

Available Zn contents of the soils under study varied from one orchard to another. It varied from 0.27 to 5.71 mg kg^{-1} with mean value of 0.93 mg kg^{-1}(Table 2.4). According to critical limits of 0.6 mg Zn kg^{-1} (Lindsay and Norvell, 1978), 25 % of soil samples were deficient in available Zn. For DTPA-Cu contents of soil high values were recorded for about 57 % of samples. The Cu contents of the soils varied from 0.08 to 11.38 mg kg^{-1} with an average value of 1.19 mg kg^{-1}. The critical limits of Cu soil as suggested by Lindsay and Norvell (1978) is 0.2 mg kg^{-1}, based on that 17.14 % of soil samples were deficient in available Cu (Table 2.5).

Table 2.4: Available micronutrient content in different cashew orchards (N=70) of Bhubaneswar region of Odisha

Available micronutrient	Range (mg kg^{-1})	Mean (mg kg^{-1})	% samples deficient	% samples sufficient
DTPA-Fe	8.77-150.89	31.76	0	100
DTPA-Mn	1.90-300.91	73.58	5.71	94.29
DTPA-Zn	0.27-5.71	0.93	37.14	62.86
DTPA-Cu	0.08-11.38	1.19	8.57	91.42

Table 2.5: Frequency distribution of micronutrient availability of cashew orchards of Bhubaneswar region of Odisha

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	6	8.45	18	25.35	6	17.14
Medium	6	8.45	3	4.23	29	40.85	3	25.71
High	65	91.55	62	87.32	24	33.80	62	57.14

2.3.4 Micronutrient status in Bapatla cashew orchard soils

Soil samples collected from Bapatla cashew orchard showed a wide variation in the availability of micronutrients in surface soil (Table 2.6 and 2.7). Available Fe varied from 10.23 to 160.39 mg kg^{-1} with a mean value of 52.39 mg kg^{-1}. Frequency distribution showed that all samples recorded high value for available Fe. The Mn content of the orchard soils were in the range of 7.00 to 187.64 mg kg^{-1} with an average of 45.23 mg kg^{-1}. It was noticed that about 95 % soil samples studied were high in available Mn.

DTPA-Zn values of the study area varied from 0.02 to 155.36 mg kg^{-1} and mean value of 4.64 mg kg^{-1}. About 23 % of the soils under study were deficient in Zn content. Available Cu content of soils showed equal weightage in low, medium and high categories (Table 2.7). Cu values varied from 0.10 to 2.26 mg kg^{-1} with a mean value of 0.49 mg kg^{-1}.

Table 2.6: Available micronutrient content in different cashew orchards (70) of Bapatla region of Andhra Pradesh

Available micronutrient	Range (mg kg^{-1})	Mean (mg kg^{-1})	% samples deficient	% samples sufficient
DTPA-Fe	10.23-160.39	52.39	0	100
DTPA-Mn	7.00-187.64	45.23	0	100
DTPA-Zn	0.02-155.36	4.64	22.85	77.14
DTPA-Cu	0.10-2.26	0.49	32.86	67.14

Table 2.7: Frequency distribution of micronutrient availability of cashew orchards of of Bapatla region of Andhra Pradesh

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	15	21.43	23	32.86
Medium	0	0	3	4.29	18	25.71	23	32.86
High	70	100	67	95.71	37	52.86	24	34.28

2.3.5 Micronutrient status of cashew growing areas in terms of Nutrient Index

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 as 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, values between 1.5 -2.5 indicates medium and >2.5 as higher fertility status of the given area (Motsara, 2002). Based on the NI values for micronutrients, cashew orchard soils of all the four AICRP centers i.e. Puttur, Vengurla, Bhubaneswar and Bapatla

showed high NI values with respect to DTPA-Fe and DTPA-Mn (Table 2.8). Nutrient index value in case of DTPA- Zn was medium for all centers. Based on the nutrient index, cashew orchard soils of Vengurla and Bhubaneswar recorded high value whereas Puttur and Bapatla showed medium with respect to DTPA-Cu.

Table 2.8: Soil fertility index of cashew orchard soils

Soil parameter	% Frequency		
	Low <1.5	Medium 1.5-2.5	High >2.5
DTPA-Fe			2.81 : Puttur 2.74 : Vengurla 2.92 : Bhubaneswar 3.00 : Bapatla
DTPA-Mn			2.89 : Puttur 3.00 : Vengurla 2.79 : Bhubaneswar 2.96 : Bapatla
DTPA-Zn		1.74 : Puttur 2.19 : Vengurla 2.08 : Bhubaneswar 2.31 : Bapatla	
DTPA-Cu		2.40 : Puttur 2.71: Vengurla 2.01 : Bapatla 2.79 : Bhubaneswar	

2.4 Characterization of Physiological Responses of Cashew accessions to Salt and Drought

2.4.1 Stringent screening methodologies for evaluation of cashew varieties for salinity stress tolerance

Rigorous and stringent screening methodologies to select cashew varieties at both seedling and plant level under NaCl stress were developed. At seedling level, two screening strategies were standardized. One involved germination of nuts in plastic trays under green house in the presence of different NaCl (50-200 mM) treatments for 23 days and selection of tolerant cashew varieties based on germination and growth performance. The other involved growth of the established seedlings in poly bags by direct irrigation of different NaCl treatments (50-500 mM) for 20 days and scoring the salt induced leaf damage. Further, in vitro evaluation for stress tolerance involved a simple leaf senescence bioassay at plant level. Combination of the seedling and plant level screening strategies would result in the initial identification of promising cashew varieties for further analysis.

2.4.2 Screening at the seedling level by germination

Seed germination assays was the first level of screening. It was standardized for salt stress tolerance. Nuts of six cashew varieties were sown in plastic trays and irrigated with different NaCl concentrations (50-200mM) for 25 days. Four levels of salt treatments (50, 100, 150 and 200 mM) salt treatments were appiled with irrigation to sown nuts upto 24 days till the germination begin to cease. Differential germination of the cashew varieties observed in NaCl treatments (Fig. 2.1) after 15 days of salt application. The effect of the stress was high, evident from observations recorded on germination parameters viz., germination percentage (1B) and seedling vigor index (1C) after 15 and 24 days of salt application. Salt induced changes in terms of growth parameters viz., influence of salt levels on seedling morphology (A); on fresh and dry weight of leaf (B) and on fresh and dry weight of total seedlings (C) were also recorded after 24 days of NaCl treatments (50-200mM) (Fig 2.2).

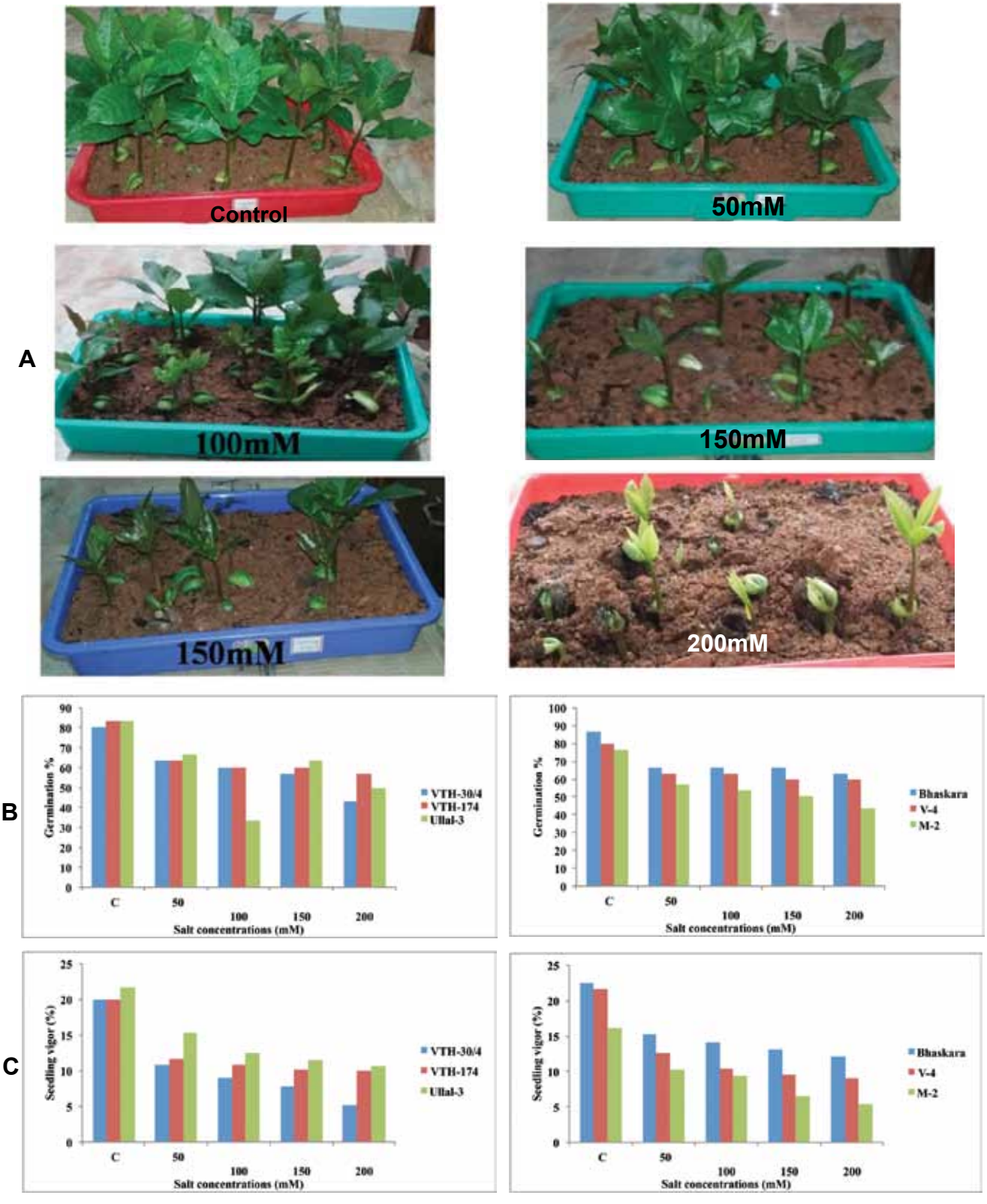


Fig.2.1 : Screening at the seedling level by germination

(A) Extent of seed germination of cashew varieties under different salt stress levels after 15 days of germination; (B) Germination precentage (%) and (C) seedling vigor index (%) of cashew varieties under salt levels after 24 days of germination.

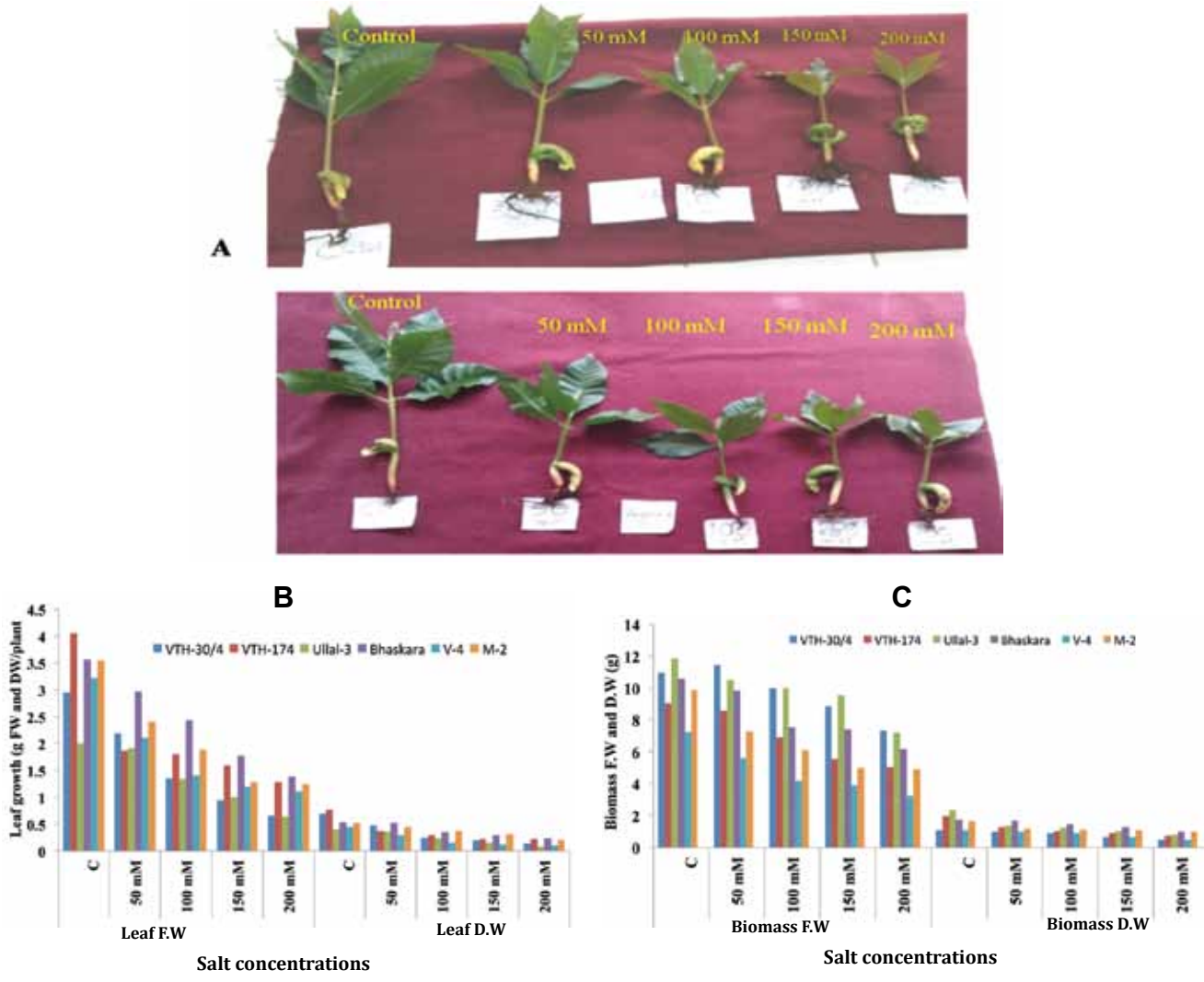


Fig. 2.2: Changes in growth parameters after 24 days of germination under varying salt levels. (A) Influence of salt levels on seedling morphology; (B) on leaf fresh and dry weight of leaf and (C) on total seedling fresh and dry weight.

Note: After 24 days of germination under varying NaCl stress levels (0, 50, 100, 150 & 200 mM), 6 seedlings per treatment per variety were removed and growth parameters were recorded. Data represent mean values (n=5).

2.4.3 Screening at the seedling level by irrigation

As an alternative another screening strategy was used involving direct irrigation of NaCl salts to growing seedlings. Two months old well established seedlings of cashew varieties were shifted to poly bags and irrigated with NaCl (50-500 mM). Significant difference observed in the growth of seedlings with continuous irrigation for 2 weeks (Fig. 2.3). The seedlings were green and fresh at lower salt treatments where as seedlings showed salt induced damages such as chlorosis and dead necrotic spots at higher salt treatment (500 mM) (Figure 3B). This observation corroborated with changes in growth and physiological parameters recorded with respect to changes in leaf dry weight (C); leaf area (D); relative water content (E) and percent membrane leakage (F) after 2 weeks of salt treatments (50-500 mM).

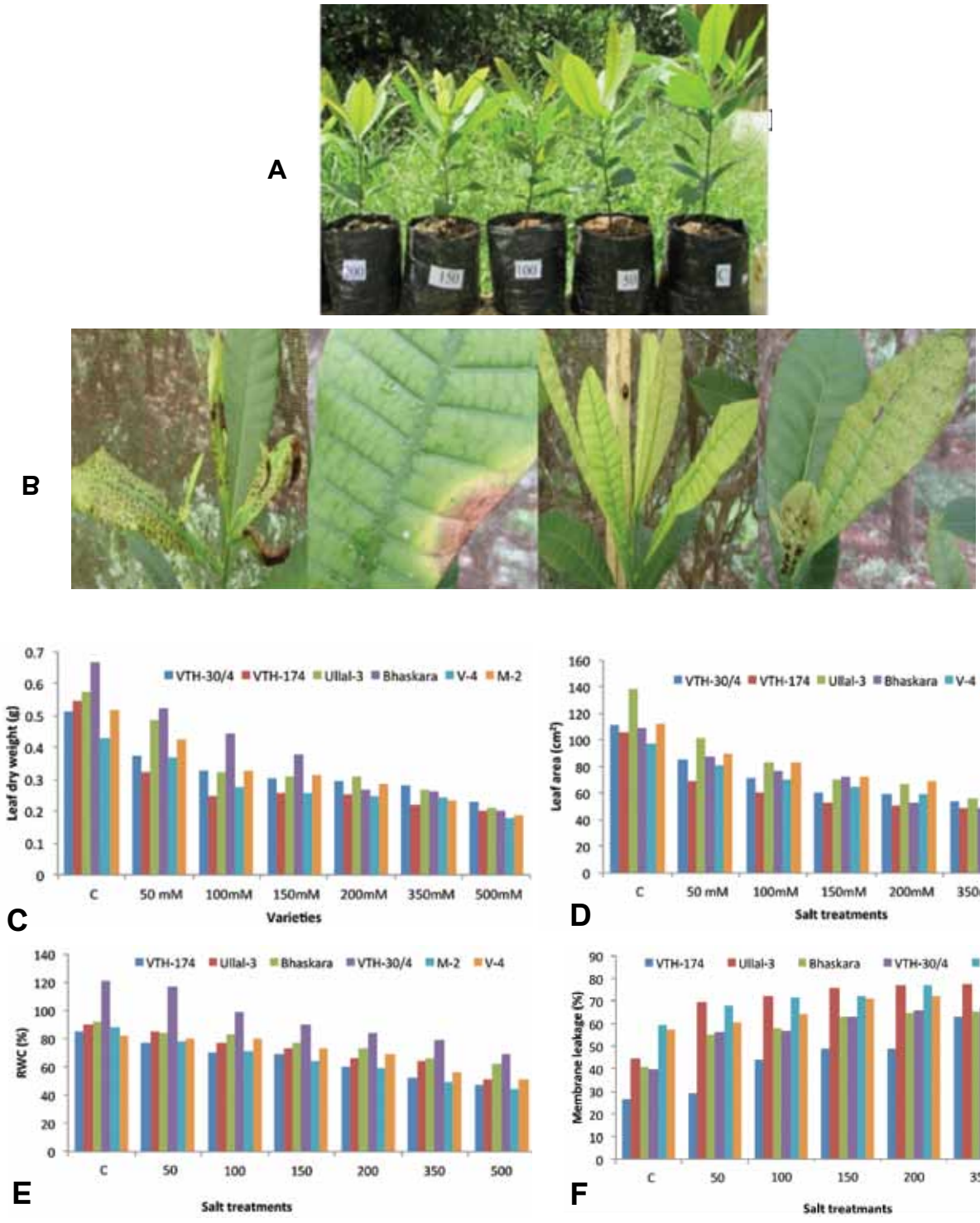


Fig. 2.3: Screening at the seedling level by irrigation.Differences in the growth of cashew varieties under different salt treatments

(A) and (B) ; salt induced leaf damage at 500mM salt treatment and (C) changes in growth and physiological parameters with respect to change in leaf dry weight ; (D) leaf area ; (E) relative water content and (F) percent membrane leakage after 2 weeks of salt treatments.

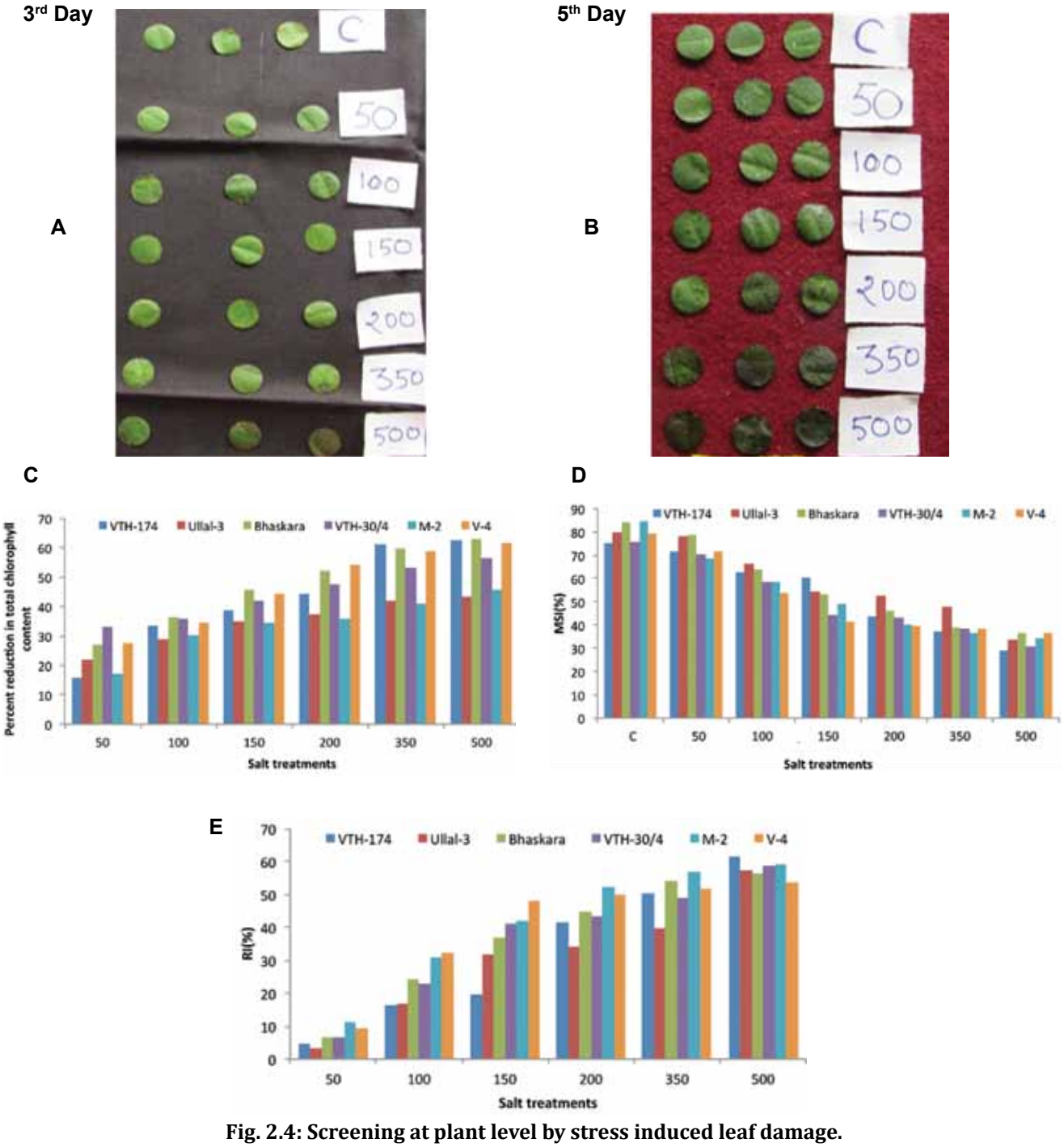


Fig. 2.4: Screening at plant level by stress induced leaf damage.

(A) & (B) Effects of salt treatments on leaf discs after 3 and 5 days of treatment; (C) Percent reduction in total chlorophyll content; (D) Membrane stability index and (E) Relative injury in leaf discs after 5 days of salt treatments.

2.4.4 Screening at plant level by stress induced leaf damage

Leaf discs from leaves of 2 months old seedlings of six cashew varieties were placed on filter paper dampened with different salt concentrations (50-500 mM). After 5 days of incubation on different salt concentrations, the extent of bleaching, chlorophyll loss and membrane leakage were determined. Leaf discs that were incubated at higher salt concentrations (350 and

500 mM) showed complete bleaching in terms of loss of chlorophyll content than other moderate salt treatments. The chlorophyll and membrane leakage estimation from these leaf discs after salt treatments corroborated with the response (Fig.2.4).

The present study, reveals that a few stringent screening strategies and presents an effective mode for the identification of cashew varieties for initial screening. All the strategies together could be used as an effective screening protocol, wherein the strategies one and two form the primary screening followed by the leaf bioassay which acts as the secondary screening. These screening protocols can then be followed by measurement of a number of traits that quantify stress response. These include measurement of growth and survival to assess the overall level of stress tolerance.

2.5 ICAR Network Project: Micronutrient Management in Horticultural Crops for Enhancing Yield and Quality – Cashew

2.5.1. Pot experiment

Studies on sand culture nutrient deficiency with young cashew seedlings (var. Bhaskara) were initiated in the polyhouse to determine the effects of nutrient deficiencies on the growth and vigour of cashew seedlings and document it. 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 pH, organic carbon and available N contents of acid washed sand were 6.8, 0.20% and 36 mg/kg, respectively while available K, Ca and Mg contents were negligible. The acid washed sand had pH of 6.7 whereas, the organic carbon content, available N, P, Ca and Mg contents were negligible and suitable for treatment applications.

Nutrient deficiency symptoms of cashew seedlings were identified (Fig. 2.5). Nitrogen (N), Phosphorus (P), Potassium (K) and Magnesium (Mg) being mobile elements inside the plant system, deficiency symptoms appeared in older/ lower leaves of the potted plants. Iron (Fe), Sulphur (S) deficiency symptoms developed in the younger leaves. Calcium (Ca) and Boron (B) deficiency symptoms developed in the terminal buds/ leaves. Zinc (Zn), Copper (Cu), Molybdenum (Mo) and Manganese (Mn) deficiency symptoms appeared in middle and upper leaves.

Plants deficient in nitrogen were showing stunted growth with reduced plant height, girth and number of leaves. Lower/older leaves were initially dark green in color, then changed to light green and finally to yellow, petiole also changed from green to reddish colour. Symptoms appeared 4-7 weeks after treatment imposition. Phosphorus deficient plants showed the symptoms very late. Leaves were dark green colour during initial 3-4 months, but lower leaves developed greenish yellow in the later stages, followed by yellowing of midrib to leaf margin between the veins. The symptoms of potassium deficiency appeared after three months of treatment imposition during which the lowest leaves turned yellow, starting from the apex and along the leaf margins.

The youngest/terminal leaves of Calcium deficient plants were chlorotic. Curling of top leaves occur, giving them an undulated appearance. Magnesium deficiency symptoms were interveinal yellowing of the lower leaves. Sulphur deficiency symptoms were quite similar to that of Nitrogen. Unlike the case of nitrogen deficient plants deficiency symptoms of sulphur appeared in terminal leaves. Terminal leaves became chlorotic, colour of leaves gradually changed from green to yellow and premature leaf drop also noticed in such terminal leaves. Iron deficiency appeared eight weeks after treatment imposition. When severe chlorosis of young leaves occurred, the whole leaf turned chlorotic except for the midrib and the main

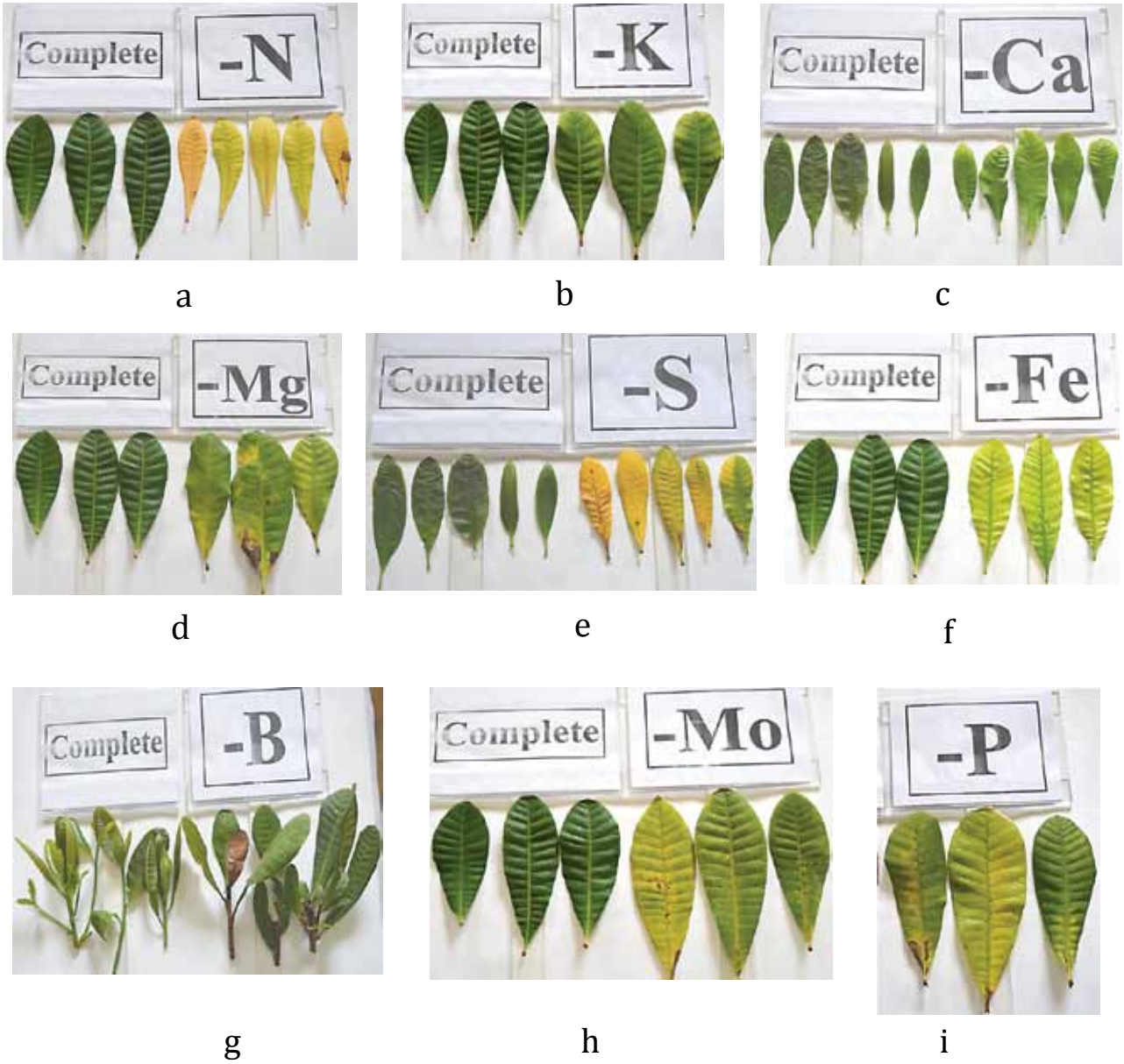


Fig. 2.5: Symptoms of mineral nutrient deficiencies in cashew seedlings

a, b, c, d, e and i nutrient deficiency symptoms develop first on old/ lower leaves on the plant whereas d, f, g symptoms develop on young/ terminal leaves. For boron (h) symptoms develop on terminal shoots and buds.

veins. Boron deficiency was visible in terminal buds/ emerging shoots characterized by dieback of twigs along with gummosis. This condition in turn led to development of more number of lateral shoots. In case of Molybdenum deficiency, lower leaves turned chlorotic then to greenish yellow with red to brown colored mottled spots on both sides of the leaves.

3. CROP PROTECTION

3.1 Cashew Stem and Root Borer (CSRB)

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

In continuation of the simulated pot experiments conducted earlier on soil survival and virulence of the coleopteran infecting EPN, field evaluations of all three EPN species for the above parameters was attempted in KCDC plantations of Alangar, Ramakunja and Sowthadka. The EPN suspensions having various concentrations of infective juveniles (IJs) i.e. 1LE/100ml, 4LE/100ml, 6LE/100ml and 10LE/100ml [LE = larval equivalent] were drenched in to the soil and gently raked upto 15–30 cm depth. Soil samples were collected at monthly intervals, brought to the laboratory and slightly moistened to activate the available IJs and the grubs of CSRB aged 45-90 days were allowed to crawl in these samples for 6 h. It was observed that all the three species of EPN applied into the soil displayed virulence and could induce mortality of more than 90 %, up to 180 days, when soil samples were baited with CSRB grubs. The mortality of CSRB grubs was generally less (< in soil samples treated with 1LE/100ml and 4LE/100ml of EPN suspension and further reduced after 30 days of treatment (Table 3.1 and 3.2). Another important observation was the higher survival of IJs obtained from such soils having more of organic matter and from shaded conditions in comparison to those samples of exposed soils.

Table 3.1: Mortality of CSRB grubs in the treated samples obtained from cashew ecosystem: *Heterorhabditis indica*

Location of soil samples collected	1LE/100ml	4LE/100ml	6LE/100ml	10LE/100ml
Ramakunja –ES	25	33.06	46.39	73.89
Ramakunja –SS	40.56	49.16	72.5	8
Alangar –ES	19.16	17.22	26.94	50
Alangar –SS	31.11	20.55	38.05	58.61
Sowthadka-ES	11.67	21.94	27.78	58.89
Sowthadka-SS	23.61	42.67	37.78	70.55

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

Table 3.2: Mortality of CSRB grubs in the treated samples obtained from cashew ecosystem: *Steinernema carpocapsae*

Location of soil samples collected	1LE/100ml	4LE/100ml	6LE/100ml	10LE/100ml
Ramakunja –ES	8.61	12.5	28.33	66.94
Ramakunja –SS	11.67	18.89	30.83	73.05
Alangar –ES	15.55	17.22	15.17	76.67
Alangar –SS	16.39	18.88	31.66	78.05
Sowthadka-ES	11.67	21.66	46.66	79.44
Sowthadka-SS	21.11	26.66	55.56	92.5

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

During the field surveys natural mortality of CSRB grubs and pre-pupae noticed during late August till October. Mortality of these CSRB stages was generally noticed in severely attacked cashew trees and was on incubation under laboratory conditions it was confirmed to be due to infection by the entomopathogenic fungus; *M.anisopliae*. The cadavers were incubated and the aqueous spore suspension (10^3 spore /µl) could induce 100 % mortality of CSRB grubs on topical application and through feed for more than 60 days and induced lower mortality of 60 % during 120 days after sporulation.

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

The virgin females of TMB did not elicit response from the males of TMB in field condition during the initial few days after emergence. Hence, the TMB virgin females were evaluated for confirming their "calling age" in days. It was found that TMB virgin females of 4 - 5 days after emergence had higher response from the males under field condition (Fig. 3.1 and 3.2)

Fig. 3.1: Delta sticky traps baited with live TMB females installed in cashew canopy

Fig. 3.2: Males of TMB trapped within 1hr of trap placement

Presently, it has been confirmed that virgin TMB females could elicit response in live condition. To confirm the activity of the sex pheromone compounds in vitro the virgin females aged 4-5 days were stunned by placing in a freezer and macerated in Eppendorf tubes with di-Chloromethane / n-hexane or methanol. The extracts when used as baits in sticky traps could elicit similar response compared to live virgin TMB females under field conditions.

A field trial was done to confirm the activity of pheromone release by the Tea mosquito bug females during different durations of the day. Number of TMB males trapped during different time of the day was recorded and it was found that maximum catches occurred between 10.30 h to 12.30 h as well during the afternoon between 15.30 h and 16.30 h (Fig 3.3). This can be an indication about the duration for extraction of sex pheromone from the virgin females for further analysis as well as the most suitable time of the day for installing the sex-pheromone baited traps to avoid rapid vaporization of the pheromone from the septa.

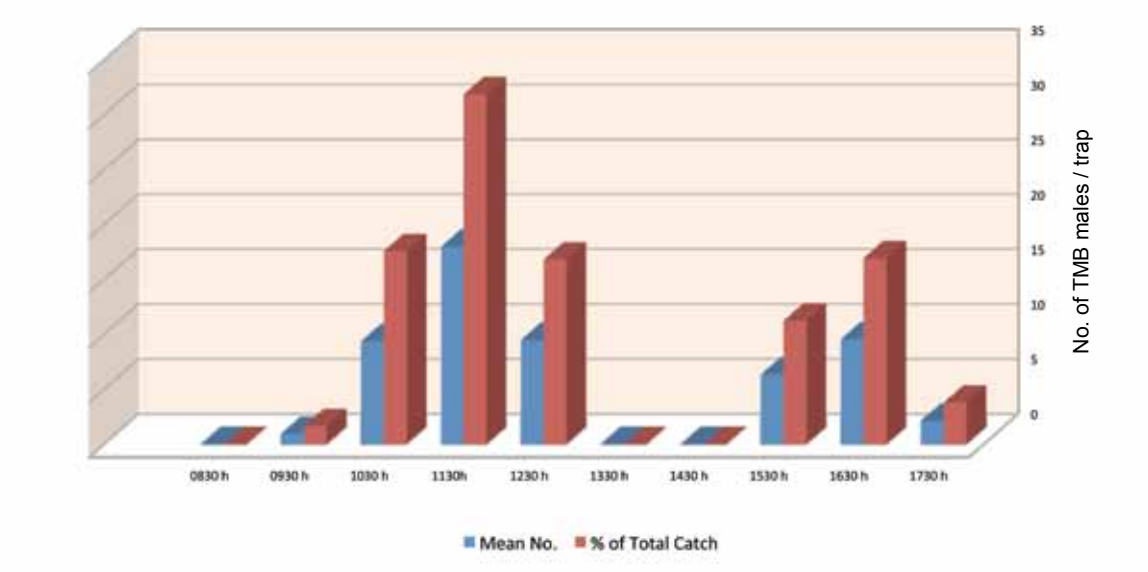


Fig. 3.3: Trap catches of TMB males during different times of the day

Fresh frass collected from infested cashew trees was assessed for its efficacy as bait using sticky traps. However, no trap catches of CSRB beetles were obtained possibly due to lower adhesiveness of these traps. Hence, a physical-trapping mechanism has to be devised to confirm the attractiveness of various baits under field conditions.

3.1.3 Consortium Research Platform on borers of horticultural crops

During the current year, the cashew plantations owned by state owned plantations and private farmers located in Odisha and Andhra Pradesh were surveyed for the level of incidence of CSRB. The number of CSRB grubs per infested plant could not be recorded due to paucity of time and hardness of the soils. The initial and moderate external symptoms of infestation were considered for identifiying the pest infested trees.

The intensity of CSRB in coastal regions of Odisha was recorded from infested cashew trees in Nimapada, Begunia, Gop, Nadia Coconut farm, Talbania and was lower than 2.0 %. Infestation of *Plocaederus* as well as one tree infested with *Batocera* spp. was observed in these plots. However, the pest incidence was about 4.0 to 5.0 % in the cashew plots surveyed at Shankarpur, Padalpur, Mahishapat, Kapilas, and Bhapur. All infested trees had infestation only by *Plocaederus* spp. in these areas.

Incidence of CSRB in cashew growing tracts of West Godavari and Vizianagaram districts was recorded by roving surveys. The incidence of CSRB was lesser than 1.0 % in the cashew plantations observed at Narasipatnam, Tallepalem, Manivalasa and Kotavurtla, and Kothakota. The incidence of CSRB was slightly higher i.e. 2.0 to 3.0 % at Relli, Kothavalasa and Mudunoor as well as, Srungavarpukota, *en route* to Araku.

3.2 Tea Mosquito Bug (TMB)

3.2.1 ORP on sucking pests

Several innundative releases of the reduviid *S.galbanus* was made to understand their efficacy in establishing in the cashew plots. In spite of release of more than 1300 adults and nymphs over a period of 5 – 6 months, the predator could not establish even in the unsprayed cashew plot. Larger number of predator per release may be beneficial.

3.3 Biodiversity of arthropod fauna in cashew ecosystems

Random surveys were taken up at weekly intervals between April 2016 and January 2017 for various cashew pests and their natural enemies in the cashew plots of this Research Directorate. The documented insects were got identified time to time by consulting experts of field. So far 191 insect pest species and 123 natural enemies were documented in past five years (Fig.3.4). The insects were taxonomically grouped and the diversity indices were worked out. Family wise, the abundant insect order was Hemiptera with 19 families followed by Lepidoptera with 17 families. There were a total of 57 species documented in Lepidoptera followed by Coleoptera (53) and Hemiptera (41).

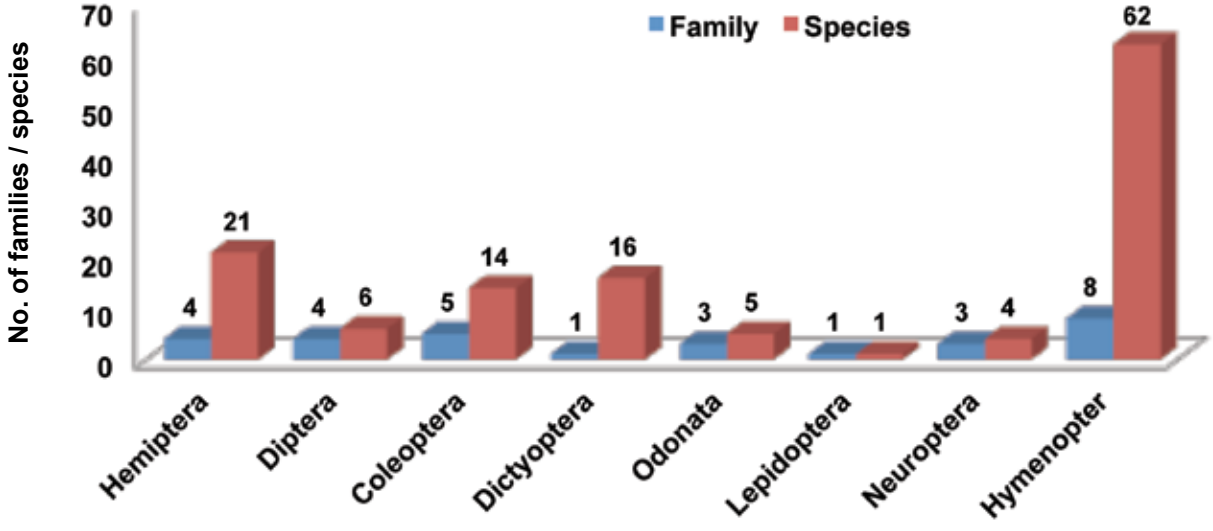


Fig. 3.4: Natural enemies recorded in cashew ecosystems

Among the natural enemies, dominant insect order was Hymenoptera followed by Hemiptera with 62 and 21 species, respectively. It should be noted that, the values may change if intensive study is made for some more years. The species richness was 191, and the Shannon index was 4.35 (Table 3.3). A total of 17, 282 insect specimens were observed under this study upon random surveys.

Table 3.3: Diversity indices of cashew pests

Sl. No.	Index	Value
1	Species richness	19
2	Simpson index	0.105
3	Dominance index	0.895
4	Shannon index	4.355
5	Berger-parker Dominance index	0.245
	Total no. of organisms	17, 278

Seasonwise most abundant insects were also grouped. *Monolepta longitarsus, Acrocercops syngramma* and *Neculla*(?) *pollinaria* were dominant during Jun-Aug, A. *syngramma, Toxopetra odinae* and *Helopeltis antonii* were abundant during Sep-Nov. During flowering period between Dec-May, thrips especially *Scirtothrips dorsalis* was most abundant followed by mealy bugs and aphids. Some species like slug caterpillars, tasar silk worm were seen only during rainy season (July-Nov). Similarly, *Drosophila* sp. and *Carpophilus* species were abundant during Mar-May (Table 3.4).

Table 3.4: Season wise most abundant insect species in cashew

Sl. No.	June-Aug	Sep-Nov	Dec-Feb	Mar-may
1	*Monolepta longitarsus J.*	*A. syngramma*	*Scirtothrips dorsalis Hood*	*S. dorsalis*
2	*Acrocercops syngramma Meyrick*	*Toxoptera odinae (van der Goot)*	*Ferrisia virgata Cockrell*	*Drosophila sp.*
3	*Neculla pollinaria*	*H. antonii*	*Toxoptera odinae*	*T. odinae*
4	*Deporaus marginatus Pasc.*	*Oenospila flavifuscata Walker*	*Frankliniella schultzei (Trybom)*	*F. virgata*
5	*Helopeltis antonii Signoret*	*Pachypeltis maesarum*	*Aphis sp.*	*Planococcus lilacinus Cockrell*
6	*Selenothrips rubrocinctus Giard*	*Orthaga exvinacea Hampson*	*H. antonii*	*Thylacoptila paurosema*
7	*Lypesthes sp.*	*Caloptilia tiselaea*	*Ceroplastes rubens Maskell*	*H. antonii*
8	*Pachypeltis maesarum Kirkaldy*	*N. pollinaria*	*A. syngramma*	*Carpophilus dimidiatus*
9	*Latoia lepida Cramer*	*Paria lefevrei Jacoby*	*Campylomma sp.*	*Frankliniella schultzei*
10	*Antheraea mylita Drury*	*Lamida (Macalla) moncusalis Walker*	*Hyposidra talaca*	*Hyalospila leuconeurella*

Influence of pest diversity *vs* plant density was also studied and found that there were non-significant differences in pest population especially leaf miner, apple and nut borer, flower thrips and flower beetles among four different plant densities *i.e.,* spacing (Table 3.5, 3.6 and 3.7).

Table 3.5: Effect of plant density on leaf miner incidence in cashew

Spacing	V-4	U-4	MDK-2	U-3	V-7	Bhaskara	Dhana	Sel-2	VRI-3	Mean
5 x 4	32	28	15	23	36	27	32	22	59	30.78
6.5 x 4	6	11	12	44	9	31	3	16	35	18.56
6.5 x 6.5	11	27	20	30	16	30	21	23	25	22.67
10 x 5	24	22	42	25	42	10	11	25	5	22.89
			F= 2.01				CD (s)	10.51 NS		
			P= 0.007 **				CD (v)	8.168 NS		
							S Vs V	18.57 **		

Table 3.6: Effect of plant density on apple and nut borer incidence in cashew

Spacing	V-4	U-4	MDK-2	U-3	V-7	Bhaskara	Dhana	Sel-2	VRI-3	Mean
5 x 4	0	8	6	8	2	3	4	2	4	4.11
6.5 x 4	12	11	2	6	10	0	2	5	4	5.78
6.5 x 6.5	4	4	3	2	5	1	0	3	3	2.44
10 x 5	3	0	6	2	1	0	4	0	10	2.89
							F= 1.25 NS		P= 0.209NS	

Table 3.7: Effect of plant density on flower thrips incidence in cashew

Spacing	V-4	U-4	MDK-2	U-3	V-7	Bhaskara	Dhana	Sel-2	VRI-3	Mean
5 x 4 m	26	38	10	32	16	29	30	25	18	24.89
6.5 x 4 m	16	2	9	16	12	0	10	29	32	14
6.5 x 6.5 m	14	10	3	12	15	2	9	26	18	12.44
10 x 5 m	17	4	14	8	5	13	31	14	43	16.56
		F= 5.67		P= 0.000 **				CD (s)	1.039 NS	
								CD (v)	0.834 **	
								S Vs V	1.878 P **	

3.3.1 Pest maps of TMB

Data was generated for developing pest maps. The pest population, latitude, longitude and altitude were recorded in selected spots of both Kemminje and Shantigodu regions. Pest maps of TMB incidence during 2015-16 was generated using ArcGIS software at CRIDA. Similarly, pest maps were generated for different parts of country as submitted by the AICRP centres (Fig. 3.5 and 3.6).

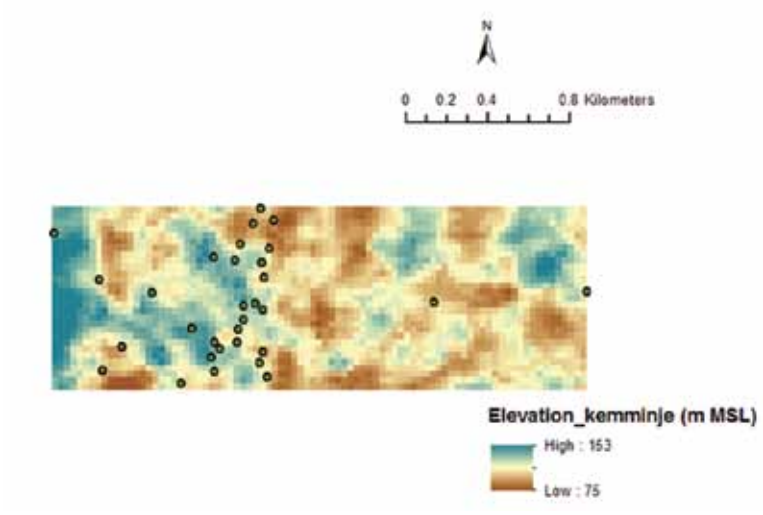


Fig. 3.5: Map showing elevation of cashew plantations at Kemminje, Puttur

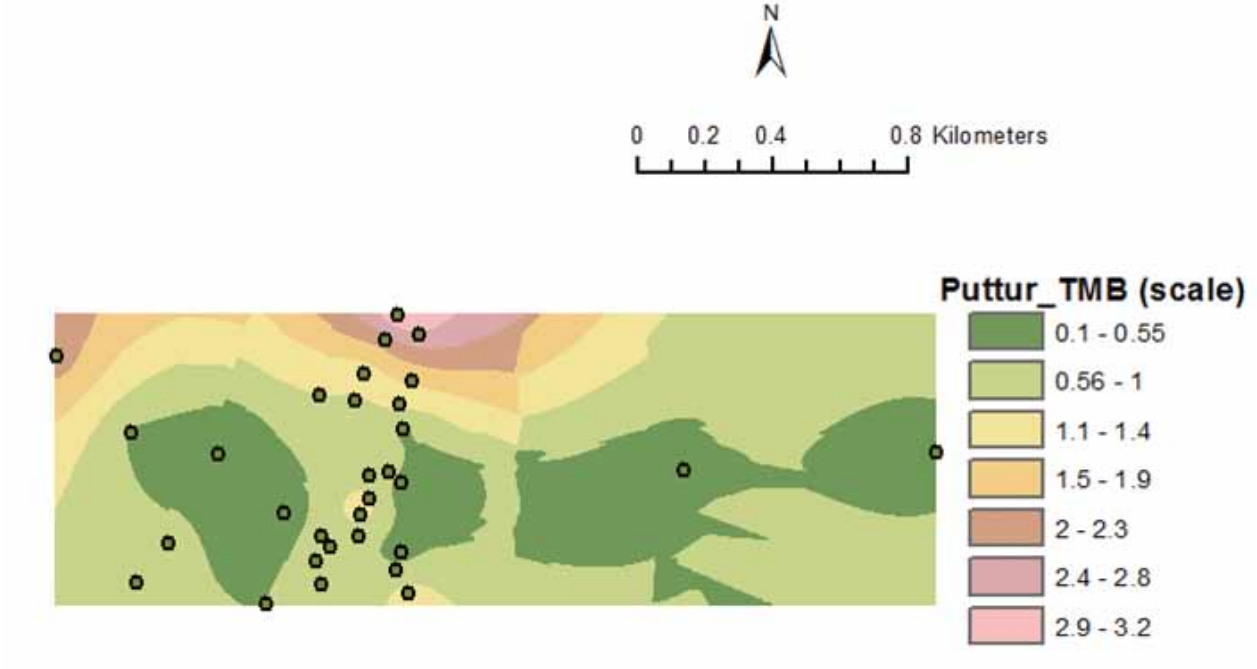


Fig. 3.6: Map showing status of TMB in Kemminje plots during 2015-16

3.3.2 Occurrence of inflorescence caterpillars

Yield reduction in cashew due to pests during the flowering season was generally attributed to incidence of tea mosquito bug (TMB), leaf and blossom Webbers (LBW) as well as, shoot borers. However, during the recent years occurrence of webbing in the inflorescence revealed that several micro-lepidopteran larvae were found to be feeding on the unopened buds and partially opened flowers by webbing together by several species of micro-lepidopteran larvae; which formed a niche for the pest complex (Table 3.8).

Table 3.8: Occurrence of micro-lepidopteran inflorescence caterpillars during the flowering season in different released cashew varieties:

Variety assessed	Mean percentage of laterals infested		
	2015	2016	Mean of 2 yrs.
Ullal-1	23.52	10.52	17.02
Ullal-2	16.67	10.56	27.23
Ullal-3	28.57	13.33	20.95
Ullal-4	20.00	16.67	18.33
Bhaskara	21.05	14.28	17.66
VTH30/4	18.75	17.64	18.19
VTH -174	25.00	6.67	15.83
V-1	20.00	23.07	21.5
V-3	21.42	15.78	18.60
V-4	23.89	11.76	17.82
V-7	22.22	16.67	19.45
Vri-3	23.07	18.75	20.91
Mdk – 2	20.00	21.05	20.52
H-32/4	21.43	17.64	19.53
Dhana	19.05	16.67	17.86
Kanaka	16.67	14.28	15.47
Priyanka	17.64	11.11	14.35
K-22-1	21.05	7.69	14.37
NRC-493	21.42	6.67	14.04

The occurrence of different species of inflorescence caterpillars (flower eating caterpillars) was noticed in several localized spots and pest density was found to vary from 3 – 14 larvae per inflorescence in different varieties. The pest incidence began during September and extended up to November / December in various experimental plots. The number of flowering laterals having incidence of inflorescence caterpillars was recorded for the main released cashew varieties.

3.4 Natural enemy complex of tea mosquito bug in cashew

3.4.1 Field release of reduviids

Among the natural enemies documented so far under the project namely, ants, spiders, praying mantids, reduviids, geocorids, anthocorids, pentatomids etc., reduviid bugs and manitds were found efficient against TMB and amenable for mass rearing in laboratory. Among the reduviid species, *Sycanus galbanus* was found highly suitable for

mass rearing with no cannibalism, high fecundity, high survival and more longevity. Inundative releases of *Sycanus galbanus* were taken up in organic plot of cashew between December 2016 and March 2017. A total of 956 adults were released at monthly intervals in 160 trees. But, the reduviids were hardly located after release, and the TMB population was not controlled in the plot. The study reveals that an inundative release of reduviids in large numbers is required to realize its biocontrol efficiency.

3.4.2 Record of a pentatomid predator - *Eocanthecona furcellata* in cashew plantations

Upon surveys, a pentatomid bug namely *Eocanthecona furcellata* was collected from cashew plantations which is a predator on soft bodied insects especially caterpillars. This species is also amenable for mass rearing using wax moth larvae. It multiplies very fast without any cannibalism except during moulting, having high fecundity and high survival. Biology of this bug upon rearing on wax moth larvae was studied. However, these bugs did not predate on TMB adults when provided as prey, but consumed the leaf feeding caterpillars by sucking the haemolymph.

3.4.3 Life cycle and laboratory rearing of mantids

3.4.3.1 Bark mantis *Humbertiella similis*

Biology of a common bark mantis, *Humbertiella similis* was studied under captive breeding using greater wax moth larvae as prey. The oothecae were dirty white in colour, and the incubation period lasted for 26 - 27 days. There were seven nymphal instars completed in 78-120 days. For lifecycle study, early instars were reared in test tubes, and grown up nymphs in glass bottles. Early instar nymphs managed well to feed on the tiny wax moth larvae and survived better unlike other mantid species. The early instars were dark chocolate brown with white patches on legs, while, the late instars develop white patches near thorax and abdomen. Cannibalism was not observed during nymphal stages when kept together with sufficient prey and found amenable for group rearing. Head corn becomes prominently visible in females and grows progressively; while of the males remain tiny. Male mantids were small (2.4±0.28 cm), thin with long antennae, compared to females (3.0±0.14 cm), with bulky abdomen and shorter antennae. Unlike most mantids, wings were lengthier extending beyond abdomen in both sexes. Adults expressed death-feigning pose upon disturbance. Longevity of the females was recorded up to 100 days, while that of males up to 127 days. The female laid its first ootheca after 27-28 days of emergence. Fecundity ranged from 6-8 oothecae/female and the oviposition interval was 6-17 days. Average number of nymphs emerged/ ootheca varied from 4-12. Oothecae laid without mating were infertile and did not hatch (Table 3.9).

Table 3.9: Developmental duration of *H. brunneriana*

Life stages	Duration in days (mean ± SE)	
	Male	Female
Incubation period	26.15 ± 0.10	
Nymphal stages		
1st instar	11.25 ± 0.89	11.62 ±0.88
2nd	14.5 ± 2.10	14.62 ± 1.03
3rd	9.08 ± 0.71	10.00 ± 0.7
4th	9.58 ± 0.58	9.97 ± 0.82
5th	12.67 ± 0.75	13.15 ± 0.46
6th	12.13 ± 0.48	12.91 ± 0.85
7th	18.46 ± 1.56	18.79 ± 1.33
Total nymphal stage	87.66 ± 1.01	91.06 ± 0.87
Nymphal survivability	90 - 95 %	
Adult longevity	71 ± 0.64	88.75 ± 0.76
Total life stage	158.66 ± 1.29	179.81 ± 1.54

The period of sexual maturity and the courtship behaviour of mantids were also studied. Duration of copulation varied between 5.30 - 5.45 hours. Though sexual cannibalism was not observed during or immediately after copulation, post mating cannibalism was seen (97% cases) in 1-2 days when the male was left in the same container after courtship. The studies found that these mantids can be reared successfully under captive breeding with high survival ability (75-80 %) using greater wax moth larvae as prey (Table 3.10).

Table 3.10: Reproductive parameters of *H. brunneriana*

Particulars	Duration/units
Period of sexual maturity	13-15 days
Pre oviposition period	10-15 days
Days to first oviposition	27-32
Oviposition period	35- 40 days
Duration of oviposition/ootheca	35-45 min
Frequency of oviposition	6-14 days
Post oviposition period	13-17 days
Fecundity	5-7 oothecae
Eggs/ootheca	8-16
Hatchability	85-90 %
Nymphal survivability	75-80 %

3.4.3.2 Parasitism in oothecae of *H. similis*

During September-November 2016, oothecae *H. similis* were found in large numbers in field conditions. It was noticed that these oothecae were being parastitized by undetermined parastioids in field conditions. Upon collection of oothecae, more than 50% parasitism of mantis eggs was observed in 60 - 70% of oothecae. The parasitoid could survive more than 10 days with 10 % honey in laboratory and parasitize the fresh oothecae provided. The parasitoids were preserved and submitted for identification at Calicut (Fig. 3.7 and 3.8).

Fig.3.7: Unidentified parasitoid species on ootheca of *Humbertiella similis*

Fig. 3.8: Life stages of *H. similis* (From left, top: oothecae and just emerged nymph, 3rd and 4th instar nymph, botton: 5th instar female nymph, adult male and female.

3.4.3.3 Life cycle and rearing of ant mimicking mantid, *Euantissa pulchra*

Similarly, life cycle of a common ant mimicking mantis was also studied. This mantid feeds on many cashew pests including tea mosquito bug, leaf beetles, aphids, leaf feeding caterpillars etc. The early instars of this mantid resemble black ants and hence called as ant mimicking mantids. Oothecae were laid on the leaves and up to seven nymphs were seen on a single cashew plant. The life cycle of the praying mantid was studied under captive breeding using greater wax moth larvae as prey. The oothecae were light yellow in colour, and the incubation period lasted for 9-10 days. There were six nymphal instars completed in 47-58 days. Though mortality was recorded during all nymphal stages, first instar nymphs were highly vulnerable resulting in high nymphal mortality. The early instars were black in colour with pink legs, while, the late instars turned into green with pinkish tinge. The wing buds became visible during the last nymphal stage.

Adults were green in colour and very active fliers. Male mantids were small (1.9 - 2.1 cm) and thin, compared to females (2.2 - 2.5cm). Healthy female mantids lived longer than males. Longevity of the females was recorded up to 158 days, while that of males was 86 days. The female laid its first ootheca after 12-20 days of emergence. Fecundity ranged from 8-15 oothecae/ female and the oviposition interval was 7-10 days. Average number of nymphs emerged/ootheca varied from 15-22. Oothecae laid without mating were infertile and did not hatch. The period of sexual maturity and the courtship behaviour of mantids were also studied using different pairs. Duration of copulation varied between 35-50 min, and multiple mating was seen (Tables 3.11 and 3.12). Though sexual cannibalism was not observed during or immediately after copulation, post mating cannibalism was seen in two-three days when the male was left in the same container after courtship. The studies found that these mantids can be successfully reared in laboratory using test tubes (for early nymphal instars) and glass bottles (final instar and adults) with greater wax moth larvae as prey.

Table 3.11: Survival percentage of different stages of Euantissa pulchra

Sl. No.	Stage	Mean Size (cm ± SE)	Survival percentage
1	Ootheca	0.93 x 0.45	Hatching percentage - 92
2	Nymphs		
a	1st instar	0.55 ± 0.09	31.74
b	2nd instar	0.81 ± 0.18	23.81
c	3rd instar	1.17 ± 0.15	19.05
d	4th instar	1.32 ± 0.08	12.69
e	5th instar	1.45 ± 0.12	11.11
f	6th instar	1.78 ± 0.13	11.04
3	Adult		
	Male	1.93 ± 0.08	9
	Female	2.22 ± 0.13	97

Table 3.12: Developmental duration, adult longevity and aspects of oviposition of E. pulchra

Sl. No.	Stage	Duration (days) (X= 83)
1	Eggs	9.38 ± 0.18
2	Nymphs	
	1st instar	11.54 ± 0.18
	2nd instar	7.08 ± 0.21
	3rd instar	8.62 ± 0.47
	4th instar	8.77 ± 0.23
	5th instar	10.08 ± 0.38
	6th instar	11.38 ± 0.71
3	Adult	
	Male longevity	85.15 ± 2.02
	Female longevity	97.62 ± 7.87
4	Period of sexual maturity	12 days (9-13)
5	Time for first egg laying	14 days (12-20)
6	Fecundity	12 Nos (8-15)
7	No. of nymphs emerged /ootheca	17 Nos (15-22)
8	Frequency of oviposition	8 days (7-10)

Some species visited cashew flowers for nectar alone, while many species visited for pollen as well as nectar, but a few only for extra floral nectarines. The active foraging period, foraging reward, number of flowers/ visit, pollen load/ insect after visit, time spent on each flower and age preference of the flower for the flower visitors were recorded (Table 3.14).

3.5 Diversity, bioecology of Pollinators of cashew and their role in increasing yield of cashew

In cashew plantations of Puttur, 64% of the insect species visiting cashew flowers belong to Apidae and Halictidae, while the rest comprised of megachilids, scolids, bombylids, syrphids, sciarids, calliphorids and butterflies. Among them, bees of apidae (9 species) and halictidae (5 species) provide real pollination service. Diversity indices of cashew pollinators have been worked out. Shannon diversity index was arrived as 2.3 (Table 3.13).

Table 3.13: Diversity indices of pollinators of cashew

Diversity indices	
Richness	13
Simpson index	0.11
Dominance index	0.89
Shannon Index	2.3
Berger parker index	0.21

In order to understand the pollination percentage in cashew, same day opened hermaphrodite flowers were collected during different time period of the day and observed for number of pollen deposited on flower stigma. It was noticed that around 42 % of the flowers were devoid of any pollen even at the end of the days showing that there is a definite pollination deficit

Table 3.14: Foraging behaviour of certain bees in cashew plantations

Bee species	Duration / flower	Foraging reward	No. of flowers/ visit	Pollen load/ insect (Max)	Preferred flower	Nesting site
Apis cerana	2 - 3 sec	Nectar	6 - 20	196	F+ 1-2 d	Hive
Pseudapis sp.1	6 -15 sec	Pollen	3 - 5	998	F	Soil, lateritic stone
Pseudapis sp.2	2 - 3 sec	EFN	2 - 5	4	F	Soil, lateritic stone
Braunsapis picitarsus	8 -12 sec	Pollen & nectar	3 - 6	924	F	Dried tiny sticks-tiny holes
Seledonia sp.	3-8 sec	Pollen & nectar	3 - 5	902	F + 1 d	Dried sticks
Tetragonula sp.	5-10 sec	EFN & pollen	2 - 3	156	F	Bamboo, cement/iron pipes, lamp posts
Ceratina sp.	2-5 sec	Nectar & pollen	3 - 5	134	F+ 1d	Dried sticks - holes
Apis florea	2-3 sec	Nectar & pollen	3 - 6	66	F	Hive

EFN = Extra floral nectaries located on leaf petiole/ lamina

in cashew. The mean number of pollen grains per stigma was 0.2 during 10-10.30 and, and 2.65 during the evening indicating that flowers are revisited by many bees during the day. A maximum of 21 pollen grains were observed on stigma of a single flower (Table 3.15).

Table 3.15: Pollen deposition in a cashew flower at different time period of a day

Period of flower observation	Mean % flowers without pollen grains	Mean No. of Pollen grains/stigma	Max. pollen grains / flower
10.00 -10.30 am	88	0.20	2
12.00 - 12.30 pm	48	2.73	16
2.00 - 2.30 pm	44	2.87	21
4.00 - 4.30 pm	42	2.65	13

Among the pollinator species visiting cashew flowers, *Braunsapis picitarsus* was the dominant (18 %), followed by *Pseudapis* sp. (16.7 %) and *Apis cerana* (15.1%). But the abundance of bees varies during different time period of the day. It was found that *Braunsapis* sp. was most abundant between 9 am - 1.30 pm, followed by *Pseudapis* sp, *A. cerana* and *Ceratina* sp. While in afternoon hours, *A. cerana* was only present but in less numbers (Fig. 3.9).

An experiment was controlled to understand the importance of period of bee visits on nut set of cashew. Results indicated that controlled exposure of bees during different periods on panicles have difference in nut set percentage. Nut set was more when flowers were exposed to bees during 11.30 A.M -1.30 P.M followed by 9.30 A.M to 11.30 A.M. There was no nut set in flowers exposed for insect visit after 4.00 pm. Similarly, no nut set was recorded in caged inflorescences, while maximum nut set was recorded under combined hand and open pollination confirming that increased pollination is required for cashew yield enhancement (Table 3.16).

Exposure of bees between T1 – 9.30 -11.30 am, T2- 11.30 am -1.30 pm, T3- 2.00 pm – 4.30 pm, T4- 4.30 pm – 9.00 am were allowed and T5- open pollination, T6- Caged throughout and T7- hand pollination.

Table 3.16: Nut set in cashew upon restricted bee visits

Rep	T1		T2		T3		T4		T5		T6		T7	
	♂:♀	INS %	♂:♀	INS%	♂:♀	INS%	♂:♀	INS%	♂:♀	INS%	♂:♀	INS%	♂:♀	INS%
1	1:0.19	10.64	1:0.27	10.26	1:0.42	4.08	1:0.23	1.82	1:0.30	47.06	1:0.29	0.02	1:0.30	41.18
2	1:0.29	15.49	1:0.23	9.30	1:0.10	5.88	1:0.23	0.00	1:0.37	30.95	1:0.28	0.01	1:0.27	46.15
3	1:0.38	12.73	1:0.18	22.86	1:0.23	5.66	1:0.35	0.00	1:0.30	39.34	1:0.67	0.00	1:0.29	40.68
4	1:0.13	14.71	1:0.28	12.96	1:0.34	4.44	1:0.31	2.63	1:0.30	40.74	1:0.25	0.00	1:0.32	50.00
5	1:0.28	7.69	1:0.19	4.23	1:0.20	2.04	1:0.14	0.00	1:0.35	29.69	1:0.31	0.00	1:0.20	51.02
Mean	1:0.25	12.25	1:0.23	11.92	1:0.26	4.42	1:0.25	1.11	1:0.32	37.56	1:0.37	0.01	1:0.28	45.8
FNS (%)	3.25		3.31		1.62		0		7.96		0		8.56	

Fig. 3.9: Pollen collection by *Tetragonula* sp. and *Pseudapis* sp.

Five cross-bred colonies of *Apis cerana* indica were bought from a progressive bee keeper at Irde, Puttur and established during cashew flowering season at Shantigodu. The colonies established well with broods and yielded ~ 2 liters of honey within one month period and further observations are in progress. Good activity of bees was noticed in cashew trees also nearby bee hives though other flora was also visited by bees. The observations revealed that bee keeping is an additional revenue source for cashew farmers besides increased cashew yield. But, care should be taken to ensure the availability of other pollen and nectar sources nearby throughout the bee rearing period. Nesting behaviour of few important bee species was studied. It was found that dried sticks of cashew in old trees serve as nesting sites for *Ceratina* sp. and *Braunsapis* sp and hence not to be removed so as to conserve bees (Fig. 3.10). Among the different artificial bee nests kept for monitoring and acceptance by bee species, drilled wooden block were accepted well by Megachilids in 4 out of 6 nests provided. It was found that flowering plants such as *Antigonon leptopus* and *Caesalpinia pulcherimma* attract lot of wild bees that pollinate cashew and hence, establishing such plants inside or around the borders of cashew plantations will help to increase bee pasturage in cashew also.

Fig.3.10: Nest of *Pseudapis* sp. in lateritic stone and nest of *Ceratina* sp. in twig.

3.5 Diversity, Survey and surveillance of important diseases of cashew

Observations made on diseases of cashew in the farms of this Research Directorate during 2015-16 indicated that seven diseases such as 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 prevailed at different stages of the crop. Based on intensity/ severity, black leaf spot, die back of shoot/twig rot/gummosis, inflorescence drying/die back and nut rot were reported as important diseases. Therefore, apart from recording occurrence of the important disease(s), basic and applied studies such as ascertaining association between tea mosquito bug (TMB, *Helopeltis antonii*) infestation and inflorescence drying/die back, and testing different fungicides against nut rot disease were also undertaken.

Fig. 3.11: Black spot disease infected NRC183 tree

3.5.2 Die back of shoot/twig rot/gummosis disease

The disease (considered to be caused by *Lasiodiplodia theobromae/Botryodiplodia theobromae)* was noticed in Apple evaluation and Showcasing plots during November. Scoring for severity of this disease in fourteen apple accessions recorded high infection in NRC 183 (38.1%) followed by NRC 176 (17.3%) and less infection in other lines (2-12%) (Fig 3.13).

3.5.1 Black leaf spot disease

Black mold disease caused by *Pilgeriella anacardii* was observed in Apple evaluation plot during September and the disease severity ranged from 5-50%. Disease severity for different germplasm lines indicated that the lines viz., NRC 301, NRC 493 and NRC 176 were less infected (<10.0%) while NRC 183 was severely infected (52.9%) (Fig. 3.11 and 3.12).

Fig. 3.12: Symptoms of black spot disease on NRC 183 leaves

Fig. 3.13: Severe infection of shoot die back in NRC183

3.5.3 Inflorescence drying/die back disease

Inflorescence drying/die back disease was observed during January to March and the disease severity ranged from 20-30%. Though the disease was observed in most of the germplasms/ varieties, four lines *viz.,* NRC 301, NRC 140, NRC 176 and NRC 175 showed severe infection. The disease is considered to be caused by fungal pathogen(s) in association with Tea mosquito bug (TMB). A field trial was initiated to ascertain the association between the TMB and disease by imposing 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, on four accessions *viz.,* NRC 301, NRC 140, NRC 176 and NRC 175. Observations were taken on disease severity at 10 and 40 days after treatment (Fig.3.14).

Results indicated that influence of fungal pathogen for causing disease was evident as in insecticide spray cum caging of inflorescence, caging of inflorescence and control showed similar infection while it was very less in fungicide treatment especially in NRC 176 and NRC 175 (Fig. 3.12). However, in other two lines (NRC 301 and NRC 140) no such results could be obtained invariably in all the treatments in both the lines. The disease severity was less (5-15%) probably due to flowering earlier than NRC 175 and NRC 176, and less number of flowers were present during disease scoring.

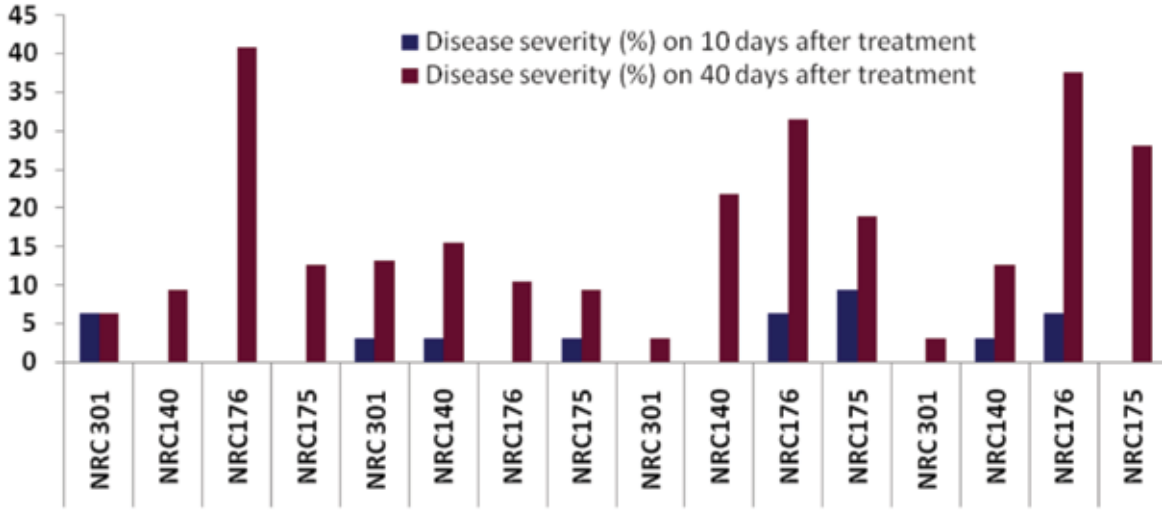


Fig.3.14: Ascertaining association between TMB and fungal disease in cashew accessions under field conditions.

5.3.4 Nut rot disease

The disease was severe (20-40%) in H-130 during February 2016 and a fungal pathogen was found upon isolation from the infected area. Hence to study effect of different fungicides on nut rot infection in H-130, a field trial involving different treatments *viz.,* Meteram 55%+Pyraclostrobin 5 WG (3 g/l), Copper oxy chloride 50% WG (0.24%), Streptocycline 100 ppm, Carbendazim 12%+Mancozeb 63 WP (0.15%), T5 Hexaconozole 4%+Zineb 68% WP (0.1%) and control, was initiated. Preliminary results indicated that among the treatments, Meteram 55%+Pyraclostrobin 5 WG (3g/l) recorded considerably less nut rot incidence in comparison to other fungicides and control and further observations on disease and yield are in progress.

4. POST-HARVEST TECHNOLOGY

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

4.1.1 Drying characteristics of raw cashewnuts under poly house solar tunnel dryer (PHSTD)

Cashew apple slices of different varieties viz., Dhana, Bhaskara, K 22/1, Ullal-3 and Madakkathara were dried under poly house solar dryer. Moisture ratio of cashew apple slices was computed and plotted against drying time (Fig. 4.1). Drying of cashew apple showed falling rate period of drying and the time required to reduce its moisture to desired level followed the same trend irrespective of varieties.

Depending on the initial moisture content of the cashew apple, total time required to bring down its moisture to 16% w.b ranged from 7 to 11 h. Increase in the relative humidity due to accumulation of moisture extended the time required for drying slices. Therefore, selection of the site and preventing the dryer from moisture accumulation are of paramount importance. In order to validate experimental results, drying experiment was carried for different released varieties (11 nos.) in PHSTD (Fig. 4.2) and compared with convention drying (CD) (Fig. 4.3). Constant temperature aids in diffusing the moisture progressively at a faster rate in the CD, but fluctuating air temperature influenced by change in relative humidity prolonged rate of drying in PHSTD. Surface colour characteristics of cashew apple powder obtained after PHSTD is comparatively better than powder generated after CD.

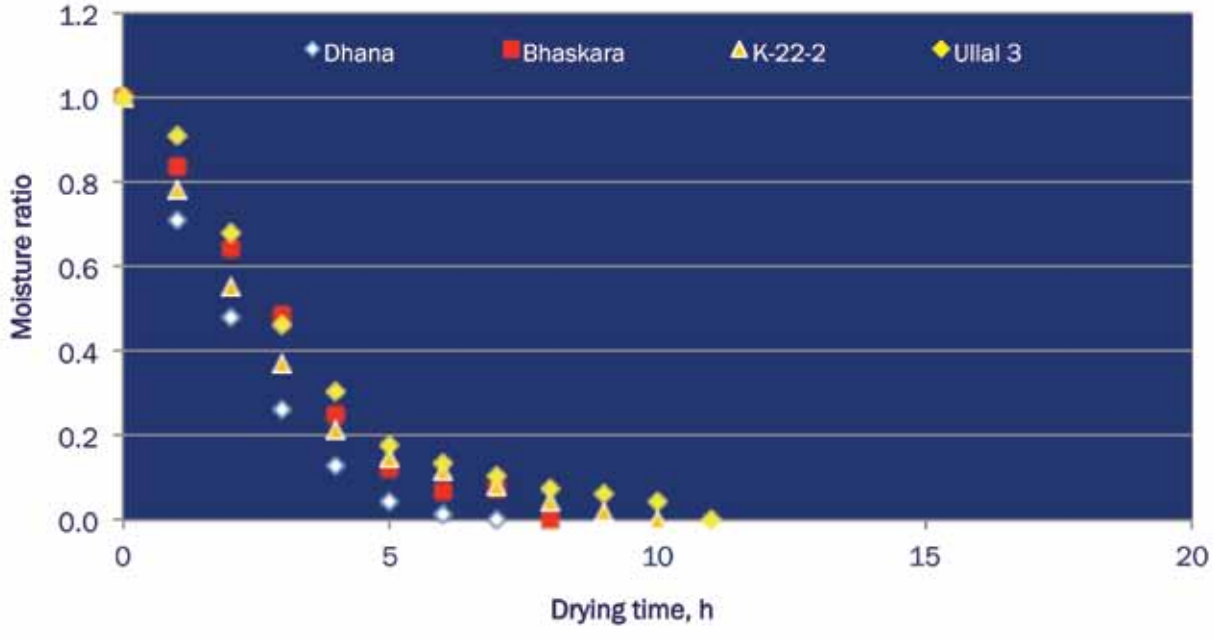


Fig. 4.1: Effect of cashew apple varieties on drying its slices in poly house solar tunnel dryer

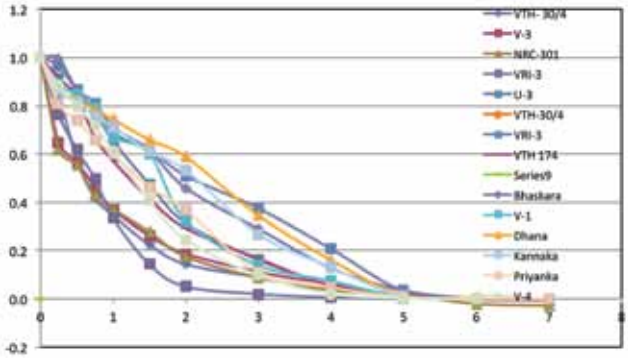


Fig. 4.2: Drying characteristics of CA slices of different varieties in CD

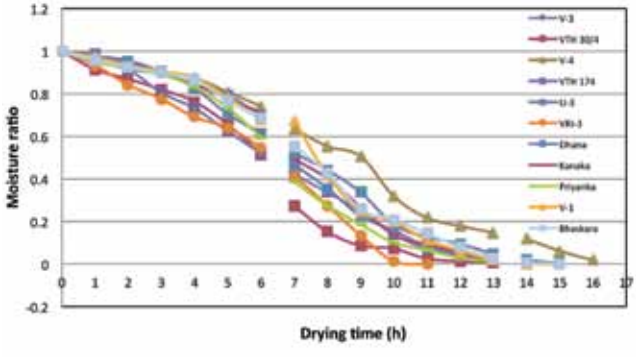


Fig. 4.3: Drying characteristics of CA slices of different varieties in PHSTD

4.1.2 Optimizing drying time of cashew apple slices

Cashew apple has free and bound moisture and moisture diffusion takes place at different rate. As it is evidenced from drying of cashew apple slices under PHSTD system, free moisture movement took place rapidly i.e. from 85% to 16.5% w.b and after reaching moisture below 16.5% w.b, prolonged drying process, probably due to fluctuating temperature inside drying chamber and binding nature of moisture within the material. Alternatively, it cannot be dried in CD due to economy of the process. Therefore, combination of both PHSTD and CD need to be worked out towards better quality CAP with lesser energy. In this regard, treated cashew apple slices i.e. NaCl (1%) and KMS for 2 min. were exposed in hot air environment generated in PHSTD in different batches for 9 to 25 h with 2 h interval between any two batches.

Table 4.1: Optimum period of drying in PHSTD for cashew apple slices

Period of drying (h)	Bone dry weight (g)	Initial moisture content of treated CA slices		Period of drying after STD using CD at 70°C (h)	Moisture content after specific period of drying under PHSTD	
		% d.b	% w.b		% d.b	% w.b
9	0.207	625.12	86.21	4.00	17.4	14.81
11	0.206	632.04	86.34	3.50	12.6	11.21
13	0.206	629.61	86.29	2.00	1.0	0.96
15	0.207	601.93	85.75	2.00	-9.7	-10.70
17	0.202	641.58	86.52	2.00	-9.4	-10.38
19	0.205	637.56	86.44	1.50	-10.7	-12.0
21	0.205	630.73	86.32	1.50	-10.7	-12.02
23	0.201	655.72	86.77	1.25	-12.4	-14.20
25	0.189	616.93	86.05	1.25	-14.3	-16.67

At the end of drying period, for example 9 h, the dried cashew apple slices were exposed in convection drying. At regular interval of 0.5 h interval, it was subjected to grinding to check pulverization. In the same manner, samples after drying for 11, 13, 15, 17, 19, 21, 23 and 25 h were ground and it quality assessed in terms of particle size and colour of the powder (Table 4.1). It was observed that moisture lost after 9 and 11 h of drying under PHSTD and 3.5 to 4 h of drying under

CD resulted with 12-17% M.C % w.b, becoming pulpy material rather than powder. In the case of cashew apple slices drying for 13 h in PHSTD and 2 h drying, yielded desire result of free flow CAP powder (Table 3). Beyond, 15 h change in the colour of the CAP noticed and it could be scorching due to over exposure to heating media.

4.1.3 Biochemical quality of cashew apple powder (CAP)

Comparison of certain chemical constituents' viz., tannin, ascorbic acid (Vit c), Protein and titratable acidity of CAP prepared by two different mode of drying for the selected varieties of cashew apples are depicted in fig. 4.4. Tannin content ranged from 0.39 to 0.55 ppm and 0.42 to 0.58 ppm for the CAP obtained by CD and PHSTD respectively indicating variation among the varieties and mode of investigated. As far as the vit c content of the CAP is concerned, Madakkathara-2 registered the lowest value of 188.3 mg per 100 g and 161.3 mg per 100 g and highest value of 407.0 mg per 100 g and 427.2 mg per 100 g of CAP resulted from CD and PHSTD respectively. During preliminary treatment of cashew apple slices with NaCl solution primarily for reducing the tannin content, naturally some amount of ascorbic acid lost due to leaching effect. Radiation effect during drying process would have contributed for the loss of Vit C content. Value of Vit C content in CAP prepared using mixed varieties resulted in the value ranged between 147 and 372 mg per 100 g. Protein content of CAP found to be in the range of 3.18 to 5.54 % and 3.88 to 7.03 % in the case of CD and PHSTD respectively indicating higher protein retention in the later mode of drying. Fluctuating exposure temperature and prolonged drying process in PHSTD could be underlying factor for the protein retention in CAP. In the same manner, it is observed that titratable acidity, one of the important content in the juice making process, showed negligible difference between CD and PHSTD while preparing CAP ensuring this quality parameter is on par.

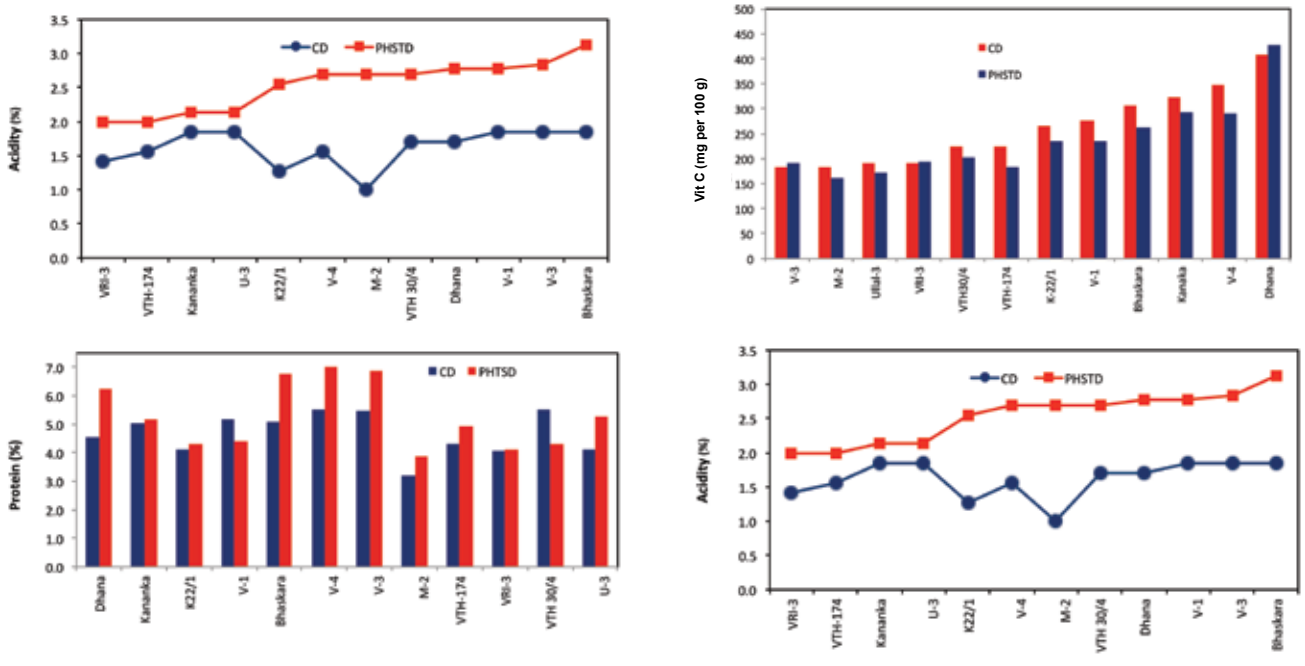


Fig. 4.4: Comparison of chemical constituents of CAP prepared by PHSTD and CD

4.1.4 Protocol for preparing cashew apple powder using PHSTD

- Harvest fully ripened cashew apples and wash it in running water to remove adhering dirt or other unwanted matter.
- Manually or mechanically slice cashew apples (2-3 mm thick with circular c/s) and treat it with NaCl (1%) solution for 5 min. Later the salt treated CA slices need to be immersed in KMS solution (0.1%) for about 2-3 min
- Drain excess water adhering to surface of CA slices by transferring to wire mesh tray.
- Drained CA slices are spread in a thin layer on the wire mesh tray, loaded on to the mobile trolley and shifted to Poly House Solar Tunnel Dryer (PHSTD).
- Change the position of the tray after every 2 h and turn partially dried CA slices after 4-5 h to ensure uniform drying.
- Dry under solar tunnel for 13- 14 h (End point: CA slices become crispy and appear shrivelled on its surface).
- Grind dried CA slices for size reduction (to enhance further drying) and dry under convection with its air temperature maintained at 60°C for 75 to 90 min.
- Pulverise the dried CA slices and sieve it to obtain uniform sized Cashew Apple Powder (CAP).

4.1.5 Lye peeling of cashew apples and drying characteristics of lye peeled cashew apple slices

Ultimate aim in peeling outer skin of the cashew apples was to reduce its tannin level. Various methods were employed viz., Immersing in the ice cube, NaOH treatment alone, and Hexane/ Ethanol immersion prior to NaOH treatment. Concentrations of lye solution (NaOH) and duration of treatment varied to optimize the process (Fig. 4.5 to 4.7). Cashew apples treated ethanol (2.5%) and NaOH (2.5%) yielded better results in terms of ease of peeling and peeling efficiency. Lye peeled cashew apples become somewhat hard facilitating slicing operation with minimum loss in juice content. Drying characteristics of peeled cashew apple slices treated with cold and hot caustic soda (NaOH) with or without salt is shown in Fig 4.8. NaCl treatments after slicing reduces the tannin further and enhance dehydration process. It is clear from the linear graph that the moisture ratio showed negligible variation with respect to time for the various treatments attempted. It was observed that more or less constant rate of drying took place during drying under poly house solar tunnel dryer.

Fig. 4.5: Freshly harvested cashew apple

Fig. 4.6: After ethanol treatment

Fig. 4.7: After NaOH (Lye) treatment

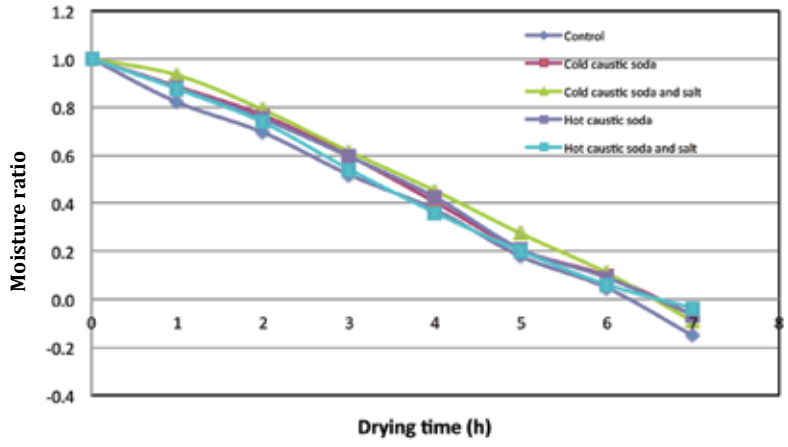


Fig. 4.8: Drying cahracteristics of peeled cashew apples in PHSTD.

4.1.6 Product preparation using cashew apple powder (CAP)

4.1.6.1 Reconstituted RTS

Like any other fruit powder reconstitution, CAP (50 g) was mixed with 300 ml of water and agitated thoroughly. After 4 h, it was filtered using whatman filter paper and using refractometer brix value was measured. As the filtrate had 9.5°B, sugar was added till it reached 10.5°B which is commercially acceptable for Ready-To-Serve (RTS) beverage. The quantity of sugar added to reach the desired brix value was around 35 g. Reconstituted juice prepared with CAP obtained by PHSTD and CD are depicted in Fig. 4.9. It was found that 'body' of RTS prepared from PHSTD is slightly higher than CAP obtained by CD. Sensory evaluation was conducted and found to be comparable with RTS prepared with fresh cashew apple juice.

4.1.6.2 Jam

In order to prepare jam using CAP, it was added to water in the ratio of 50g : 80 ml and mixed thoroughly so as to bring brix value to 10°B. Adding 130 g of sugar to the admixture, it contents were heated up. End point in preparing jam using CAP is to attain consistency with brix value of 65°B (Fig. 4.10). Later it was cooled and transferred to sterilized bottles leaving head space and closed air tight. Jam thus, stored could be stored under refrigerated condition for 180 days.

Fig. 4.9: Reconstitute juice from CAP of PHSTD and CD

Fig. 4.10: Jam prepared using CAP

4.1.6.3 Jelly

While preparing jelly using CAP, as a regular procedure, juice extracted from CAP by adding water and filtration. After checking its brix value, it was mixed with sugar in the ratio of 1:1.2 and contents were heated under controlled flame.

Fig. 4.11: Jelly prepared using CAP from PHSTD and CD

At regular interval its brix value need to be checked and once it reaches, 65°B, heating can be stopped and citric acid 0.25% and pectin 1g / litre were added. Citric acid and pectin were added in different proportion i.e. 1.0, 1.5, 2% and 1.0, 2.0, 3.0 respectively to check the consistency of the gel formed. (Fig. 4.11). No significant result indicated that citric acid and pectin can be added to the lowest proportion to reduce the cost.

4.1.6.4 Laddu

Products like burfi / cake and laddu (South Indian snack foods) can be prepared using CAP. In order to get better consistency and uniform texture of the end product, CAP obtained either by PHSTD or CD need to be sieved for uniform particle size. CAP and basin powder in equal ratio should be mixed and roasted at low flame to have control on scorching of materials. Once it reaches, light brown colour, roasting can be stopped and spread on clean plate for cooling. After cooling, sugar in amorphous form of same ratio can be added and mixed thoroughly. Water is sprinkled in such a way that the consistency is reached to make ball like structure manually (Fig 4.12). In the case of preparing laddu, in the above mentioned procedure, basin powder was replaced by coarse form of wheat. Rawa (75 g) was initially roasted for 10 min. in the presence of ghee (37.5 g) and later on CAP (75 g) added to prevent over roasting of principal ingredient. Later, sugar syrup prepared by adding 75 g of sugar in 50 ml of water was transferred to the admixture. After thorough mixing, it needs to be tested for ball consistency. Cooling the mixture in open air, laddu can be formed and decorated with a cashew kernel at the top centre (Fig. 4.12).

Fig. 4.12: Laddu using CAP in combination of Basin and Rawa

4.1.6.5 Burfi

While preparing burfi using CAP, coconut scraps need to be roasted for 15 min under controlled flame. Afterwards, CAP was added and roasting continued. Sugar and water were added to the mixture and continuously stirred to avoid clod formation. Once the forth appears on the periphery of the mixture in the vessel, heating can be stopped and transferred to SS plate coated with ghee. After cooling, the burfi can be cut in to desired size and shape. In order to make CAP and basin burfi, water should be boiled in the presence of sugar till it reaches 'string' consistency. Bengal gram powder (basin) and CAP of required quantity will be mixed thoroughly in the presence of ghee and dough is prepared. Later, this dough was added the sugar syrup and stirred continuously. Formation of froth from sides, or hole formation in the mixture is the end point (Fig. 4.13). Cardamom powder sprinkled on the surface to add flavour and scouring need to be done in a slightly warm condition to get desired shape and size of burfi.

CAP Laddu		CAP Burfi	
Ingredients	**Quantity**	**Ingredients**	**Quantity**
CAP	38 g	CAP	25 g
Basin	113 g	Bengal gram powder	100 g
Sugar	75 g	Sugar	500g
Ghee	38 g	Ghee	100 ml
		Water	100 ml

Fig. 4.13: Burfi using CAP in combination of Basin and Coconut

4.1.6.6 Cookies

Cookies were prepared by substituting the principal ingredient 'Maida' with 'cashew apple powder (CAP) to the extent of 5, 10 and 15 % as higher proportion of CAP made low consistency of dough with many cracks which is undesirable while preparing cookies. This may lead to poor quality of cookies with inferior surface texture. Recipe for the CAP based preparation of cookies is given below. By trial and error method, the baking time for the preparation of cookies standardized at baking temperature of 140°C for 15-18 min. Depending on the composition of CAP, it was observed cookies prepared using SS plate developed slight scorching on the periphery of the product which is not desirable. While using non-sticky plates, the problem was rectified. Cookies prepared using different admixture of Maida and CAP are shown in Fig. 4.14.

Ingredients	Quantity
Maida	212.5 g
CAP*	37.5 g
Sugar	100 g
Fat	150 g
Milk	5 ml
Baking powder	2.5 g

*CAP substitution is 15%

4.1.6.7 Bio-ethanol

In order to prepare bio-ethanol using CAP, it is initially sieved through commercially available tea filter, added to water to the ratio of 1: 3 and 1: 5.7. Baker yeast (1%) was added as inoculum to the mixture and after through agitation, the container was closed air tight allowing for anaerobic fermentation for 48 h. Later, it was distilled using 'Dean and stark' method to determine quantity of alcohol and its concentration by alcohol meter. Experimental data revealed that bio-ethanol could be extracted to the extent of 130 ml with 20% concentration from 50 g of CAP. This end product on further distillation yielded 100 ml of alcohol having 38% concentration (Fig. 4.15).

Fig. 4.14: CAP based cookies (5%), (10%) and (15%)

Fig. 4.15: CAP- Bio ethanol with 20% and 38%

4.1.7 Cost of drying raw cashewnuts under PHSTD

Cost of production of cashew apple powder (CAP) using PHSTD and cost of drying unit weight of raw cashew nuts (RCN) with necessary assumptions are presented in table 4.2 and 4.3.

Table 4.2: Cost of drying unit weight of raw cashewnuts

Assumptions		
Cost of fabrication and installation	50,000	
Economic life of PHSTD (Years)	10	
Capacity of solar dryer	375	
Production per season	4500	
Fixed cost		
Depreciation	10%	5000
Repair and maintenance	5.0%	2500
Interest	7.0%	3500
Total Fixed cost		11000
Variable cost		
Electricity (Exhaust) @ Rs 6/- per kWh	2 units per batch	1440
Labour (Loading and unloading @ Rs 300/- per head	1 person per batch	30000
Total variable cost		31440
Total cost for drying RCN		42440
Cost of drying per unit weight		0.94

Table 4.3: Cost of production of cashew apple powder

Assumptions	
Cost of fabrication and installation (PHSTD)	50,000
Economic life of PHSTD (Years)	10
Capacity of solar dryer	500
Production of CAP per batch (Seasonality)	75
Production per season	4500
Fixed cost	
Depreciation (10%)	5000
Repair and maintenance (7.5%)	3750
Interest (7.36 %)	3800
Total Fixed cost	12550
Variable cost	
Electricity (Dryer, Exhaust and Grinder) @ Rs.8/- per Kwh ≈3 units per batch	1440
Labour (Harvest, washing, slicing, spreading, drying, grinding and packaging @ Rs.300/- per head (≈ 4 personnel)	72000
Total variable cost	73440
Total cost for production of CAP	85990
Cost of production per kg	19.11
Rounded off	20

4.2 Developing quality standards for raw cashewnuts

4.2.1 Heterogeneity in raw cashewnuts

Spatial dimension of raw cashewnuts such as length, width, thickness representing the size and weight of nuts of certain varieties viz., Vengurla-1, Vengurla-3, Vengurla-4, Ullal-3, Bhaskara, Dhana and VTH 174, harvested from cashew farm, Puttur were determined and depicted in Fig 4.16. Data, thus obtained were correlated to corresponding kernel size in terms of length, width, thickness and weight in order to assess the nut quality based on spatial dimension. It is confirmed from resultant data that there was no strong correlation between nut and kernels characters for all the varieties examined except weight which is having correlation coefficient of 0.76. Same trend is observed for the nuts imported from Africa viz., CDJKL, Guinea Bissau, Gambia, Ivory coast, Indonesia and Tanzania (Fig. 4.17). This indicates that heterogeneity exits in raw cashewnuts even for the nuts grown in the same region. Significant difference observed in density with all other physical parameters assessed and it may not be used as quality indicator. Therefore, floating test which is in vogue to assess the quality should serve as preliminary indicator and not a confirmatory test.

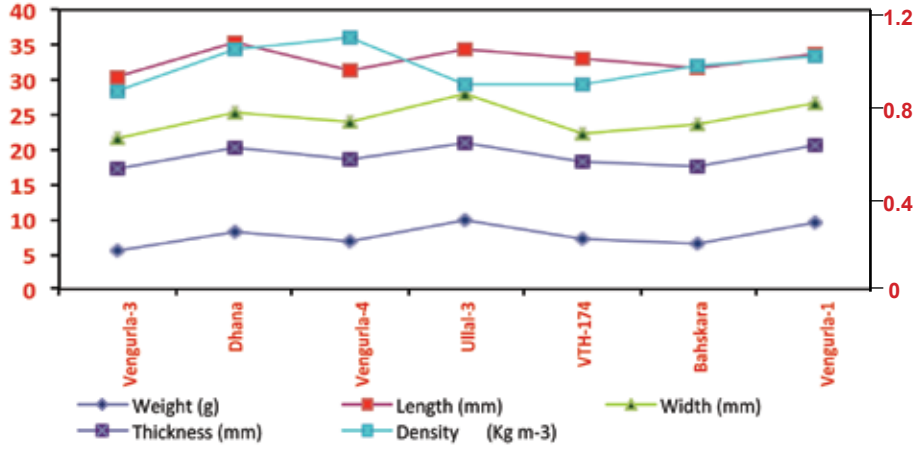


Fig. 4.16: Heterogneneity in spatial dimesion of raw cashewnuts (Domestic)

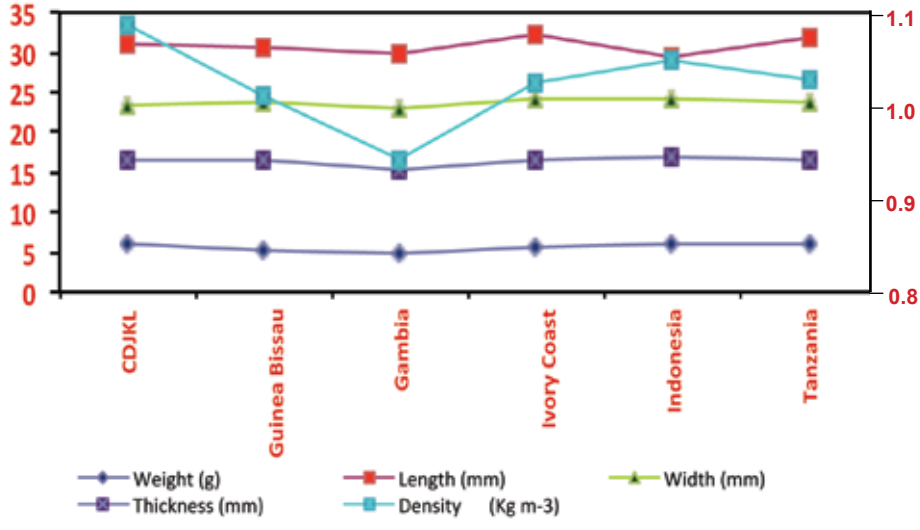


Fig. 4.17: Heterogneneity in spatial dimesion of raw cashewnuts (Imported)

4.2.2 Quality assessment based on nut counts

Nut count is one of techniques followed to assess the quality of raw cashewnuts in terms of size / weight. Random samples of raw cashewnuts obtained from different origins viz., Burkino faso (2 no. of samples imported in different time), Benin (2 no. of samples imported in different time), Ivory Coast, Tanzania and Zambia were segregated in to small, medium, large and very large based on its effective width using rotary sieve grader. Nuts, thus graded were counted and expressed per unit weight (Fig. 4.18). In the same manner, graded nuts were also weighed and expressed to the total quantity analyzed (Fig. 4.19). It is evident from the bar charts depicted on nut count and corresponding weight that there was no significant difference, indicating nut size has high correlation with its weight. Majority of the nuts of imported origin showed that proportion of the medium size nuts representing W240 and W320 grades of kernel as end product i.e. edible kernel quality had higher proportion followed by small, large and very large irrespective of nuts count or weight. Probably, this may be the underlying factor for considering W 320 as bench mark grade to assess the quality which is in vogue. Therefore, nut size or nut weight could serve as technique to assess the quality of the nuts at preliminary level. In this regard, grading gadget suitable for gading samples size of one kilo is essential.

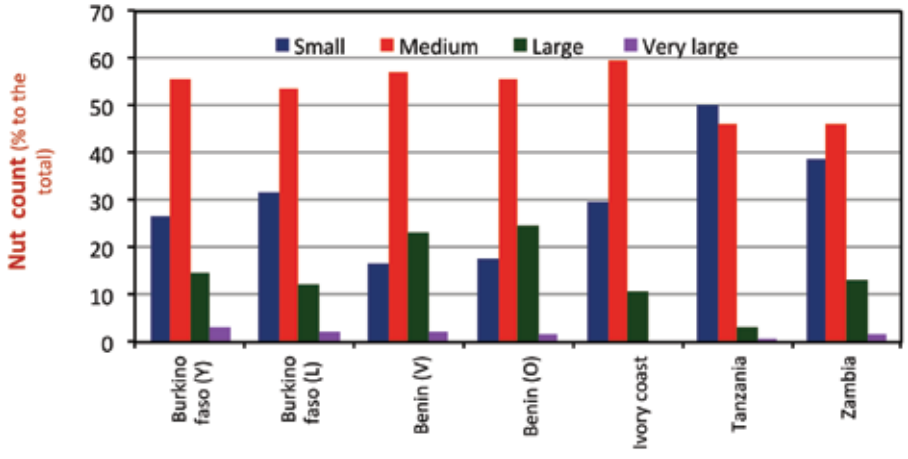


Fig. 4.18: Quality of raw cashewnuts (Imported) basd on nut count

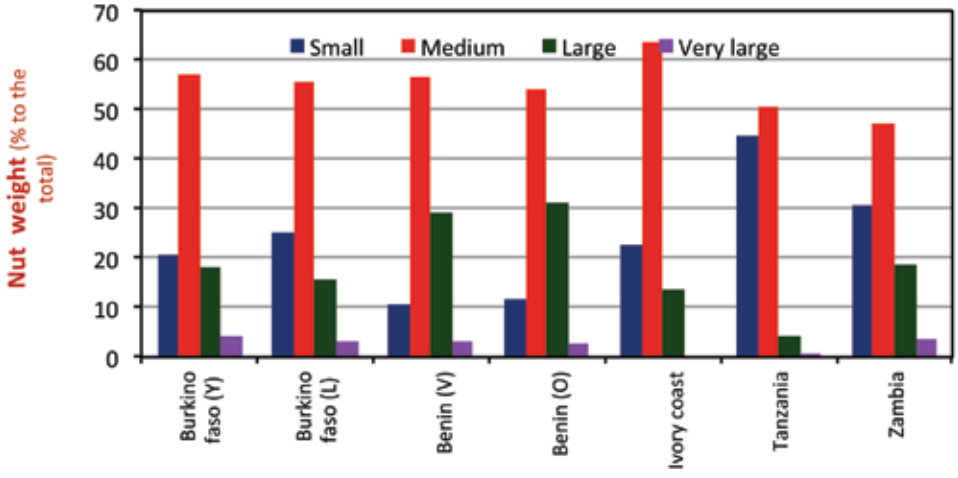


Fig. 4.19: Quality of raw cashewnuts (Imported) basd on nut weight

4.2.3 Variation in quality of freshly harvested nuts from cashew farms

In order to invetigate the changes in the quality in terms of entomological parameters viz., Healthy, Thrips, Apple and Nut borer (ANB), Tea mosquito bug (TMB) affected and other infested nuts of freshly harvested nuts from cashew farm located at kemminje and Shantigodu were collected and analysed for three different seasons i.e. Season I (Before 15th March); Season II (Between 15th March to 15th April) and Season III (After 15th April). Season-wise quality analysis indicated that proportion of the healthy nuts recorded an increasing trend from the commencement to the end of the harvesting season. Of course, there was no clear trend in the insect infestation of nuts during the three season investigated (Fig. 4.20). Among the insect infestation observed, thrips and apple and nut borer are two major pests infested the nuts to the tune of 75%, lowering its quality. TMB affected nuts are found to be negligible and timely spray of pesticide must have controlled the nut infestation. Among the three important pests infesting the quality of the nuts, thrips and TMB were inferred based on the external apperance. Quantitative and qualitative affect of infestation on the kernel characters needs exhaustive investigation to understand the changes in the economic part of cashew.

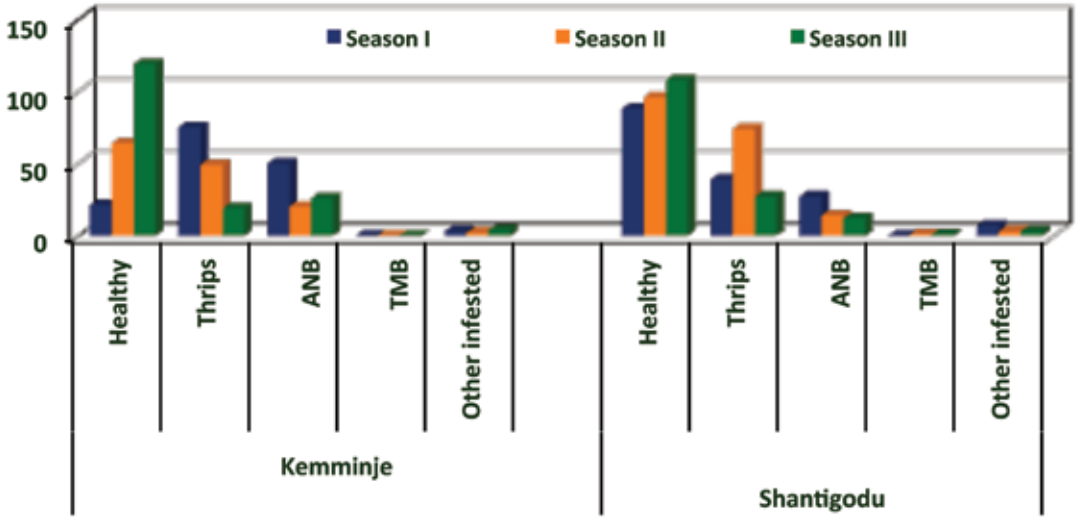


Fig. 4.20. Seasonal variation in the nut quality based on kernel characteristics

4.2.4 Assessment based on kernel quality

The end produce after processing raw nuts is the kernels and predominantly its quality is assessed at industrial level based on three factors viz., wholesomeness, size and surface colour. Wholesomeness is related to skill of the labourer engaged with the task or the efficiency of the processing machine. Change in surface colour is primarily due to control on the thermal treatment for the nut conditioning (Steaming or roasting) and kernel drying (ease peeling). Nuts, if stored for a certain period, surface colour changes are imminent due to bio chemical reaction. Considering the quality system requirements for kernels, it was assessed in terms of good kernels, brown patches, shriveled kernels, black spots and fully spoiled. Raw cashewnuts harvested from two different cashew farms of this Directorate during three seasons explained elsewhere in the document were de-shelled and the unpeeled kernels dried

under convective environment to ease peeling. Peeled cashew kernels were carefully assessed for its quality based on the surface characteristics (Fig. 4.21 and 4.22). Proportion of good kernels in the lot registered maximum of 92 % for the nuts harvested during the 2nd season from Shantigodu farm. On the other hand, good kernel recorded as 49% for the nuts harvested from the same farm. In the case of good kernels obtained for the harvested nuts from Kemminje farm varied from 71 to 84 %. Variation in the nut quality in the cashew farm of different location, confirms heterogeneity exists in the nut characters reflecting its quality. Although, thrips or ANB infested nuts yield good kernels to the tune of 18 to 83%, this infestation is the major cause for brown patches, shriveled kernels and black spots. In order to develop energy efficient and cost effective system of processing, these infected

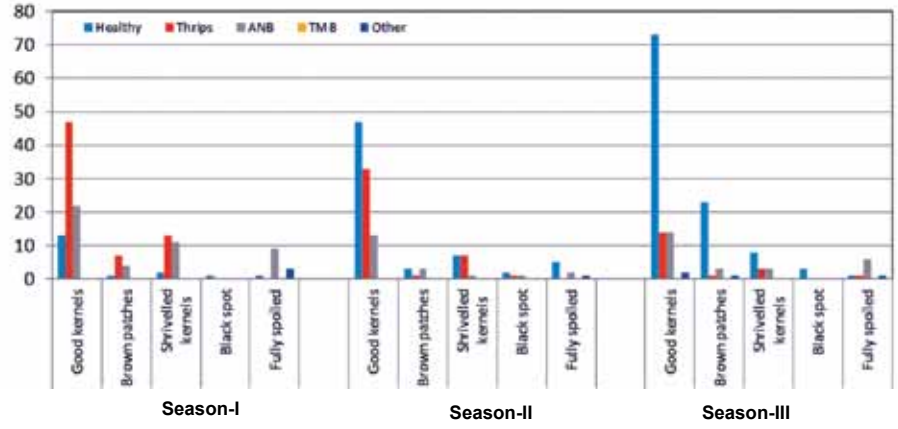


Fig. 4.21: Variation in quality of cashew kernels in DCR- cashew farm located in Kemminje

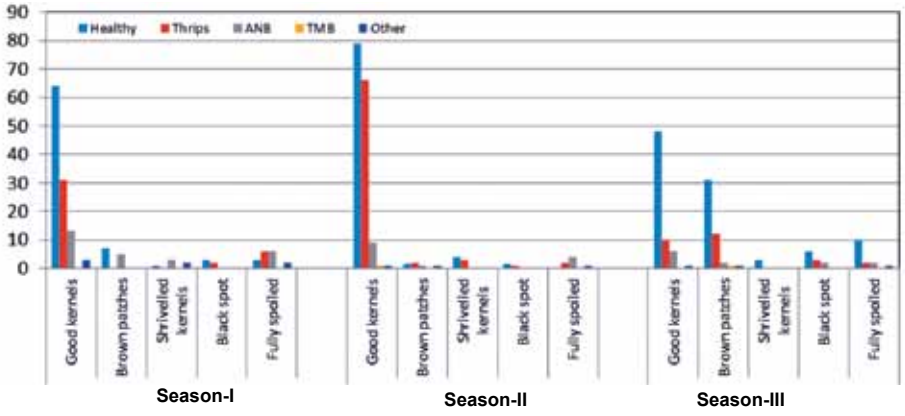


Fig. 4.22. Variation in quality of cashew kernels in DCR- cashew farm located in Shatigodu

nuts should be sorted out by manual or mechanical means in advance.

4.3 Design and development of mechanical slicer for cashew apples

4.3.1 Size distribution and firmness of cashew apples

Major axis dimension of cashew apples (N=100) harvested from cashew farm of the Research Directorate which plays important role in the development of mechanical slicer was analyzed. The largest dimension of the apple varied between 32 to 120 mm showing the wide range in the size. Maximum diameter of the cashew apples ranged between 23 to 78 mm at the full maturity i.e. when the surface colour, changes to bright with increased softness. Normal distribution of cashew apples size in terms of major axis dimension is shown in

Fig. 4.23. It indicates that majority of the cashew apples falls in the size category of 56-60 mm in the longitudinal direction.

4.3.2 Design and development of Multi-disc mechanized cashew apple slicer

A DC motor operated multi disc cashew apple slicer is designed and developed (Fig. 4.24). It consists of power transmission, slicing mechanism, slice regulator and outlet assembly. About 9-disc blades are mounted on a central shaft with space between discs provided by

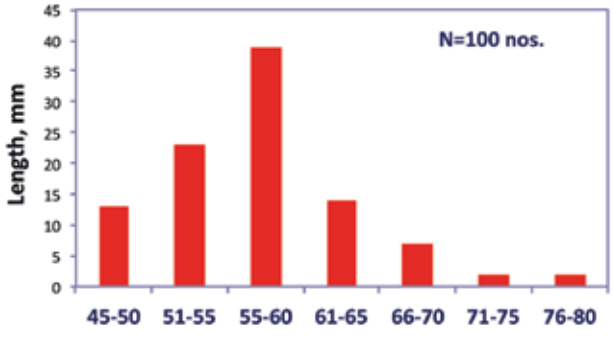


Fig. 4.23: Distribution of cashew apple based on major axis dimension

spacer having thickness of 2.5 mm. Sequentially arranged blades are held tightly to avoid distortion during slicing operation. Disc assembly rests on the metal stand having bearing at both ends and coupled to electrically operated motor for power transmission. A slice removing mechanism is provided at the rear side of the slicer adhering to the disc blades due to centrifugal force and high moisture content. Outlet is designed to in such a way that all slices are regulated to get collected at rear end. During the process of slicing, cashew apples are fed longitudinally i.e. perpendicular to disc blades so as to shear apples to obtain slices of circular cross section. Trials are conducted to optimize the rotational speed of the blades to shear cashew apples and avoid breakage of slices due to centrifugal force. Experimental results of its performance evaluation revealed that while feeding the apple in the beginning, the total disc load acted on the fruit body crushing it rather than shearing, losing some quantity of juice. Moreover, in a continuous run, due to lower strength of disc blades i.e. 0.7 mm thick, improper slice happened by distortion of blades.

In order to overcome the problms encountered in the horizontal feed veritical shearing mechanism, a commercially available vertical feed and horizontal slicing system (Fig. 4.25) available with a private firm in Coimbatore was tsted for its performance to slice cashew apples. Blades are fitted to 10 mm thick aluminium

Fig. 4.24: Mchanical slicer for cashew apple (Multidisc vertical shearing mechanism)

disc radially separated by 120 deg. Disc is mountd on a central shaft, which in turn linked to motor pulley to drive motion from a motor. Cashew apples can be fed vertically through inlet provided to shear and transfer the cut slices downwards by centrifugal force. These cut slices are regulated to the outlet by wivel action below cutting disc.

Fig. 4.25: Mechanical slicer for cashew apple – Disc and blade horizontal shearing mechanism

4.3.3 Performance evaluation of commercial slicer for cashew apple

Trials were conducted for slicing cashew apples with vertical feed horizontal shearing mechanism. Although slicing of cashew apple fruit was proper in the beginning, when the height of the fruit is reduced to 1/10th of its total, due to the centrifugal force of the rotating disc, the fruit was carried interior, blocking the gap between knife and disc, thus reducing its qualitative efficiency. Influence of disc speed, design and number of shearing blade, bevel and shear angle of blades, gap between shearing blade and top cover having feed chute etc., have to be investigated to improve the mechanical slicer. Further trials were conducted with banana central stem slicer available with the same firm to find out the suitability of slicer for cashew apples. In this machine, the vertical feed chute is reciprocated against rotating disc blade. During operation, projected apples in the feed chute is sheared by high speed disc blade in the forward motion. Influencing factors viz., bevel edge of the blade, rotational speed of the blade, reciprocating action of the feed chute, gap between the rotating disc and reciprocating chute have to be optimized for better qualitative and quantitative efficiency.

4.4 Studies on cashew apple pulp preparation and its shelf life

As recommended by RAC, an experiment was taken up to investigate on changes in physic-chemical quality of stored cashew apple pulp. Freshly collected cashew apples i.e. Accession no.301 were ground in to a slurry consistency without addition any other ingredient externally. Later, this pulp was transferred in to HDPE pouches and stored in a freezer maintained at temperature below -100°C (Fig. 4.26). Data recorded for the physico chemical changes of fresh and stored cashew apple pulp for a period of six months. It was observed that even after the completion of six months time of storage the pulp retained most of the biochemical compositions viz., tannin, phenols and total soluble solids and the changes are statistically non-significant (Table 4.4). But in the case of Vitamin C content, 16 % reduction had taken place after 6 months storage i.e. from 338 to 282 mg/100ml.

Fig. 4.26: Frozen cashew apple pulp

Table 4.4: Changes in the cashew pulp during storage

Biochemical parameters	Color	TSS (°Bx)	Vitamin C (mg/100ml)	Tannins (mg/100ml)	Phenols (%)
Storage Time (Months)					
March	Orange Red	11.5	338	394	0.36
April	No Change	11.6	330	390	0.32
May	No Change	11.3	316	395	0.34
June	No Change	11.4	310	398	0.34
July	No Change	11.5	290	394	0.35
August	No Change	11.5	282	396	0.37

4.5 Varietal screening for product preparation

Every processed product has its own raw material requirement to stand excellent as far as its quality is concerned. Keeping that in view, ten released varieties were analyzed for their physic chemical parameters and presented in table 4.5.

Table 4.5: Physico-chemical characteristics of cashew apples (N=3)

Variety	Colour	Mean apple weight (g)	Juice content (%)	TSS (°B)	Tannin (mg/g)	Vitamin C (mg/100g)	Acidity (g/100ml)
Bhaskara	Red	68.5	61.5	8.5	0.60	73.24	0.43
Madakkathara - 2	Red	79.0	63.5	10.0	0.51	NA	0.59
Ullal-3	Red	70.0	60.0	10.5	0.39	NA	0.29
Vengurla -4	Red	73.5	58.0	9.5	0.48	NA	0.37
NRCC-301	Red	132.0	69.5	9.0	0.50	NA	0.27
NRCC Selection-2	Red	71.0	65.0	11.0	0.68	63.80	0.48
Dhana	Yellow	73.0	61.0	9.0	0.63	59.72	0.40
Priyanka	Yellow	113.0	69.0	10.5	0.39	87.37	0.41
VTH-174	Yellow	79.0	48.0	11.5	0.66	NA	0.52
Kanaka	Yellow	63.0	50.0	12.0	0.58	63.28	0.39
Vengurla-3	Yellow	72.0	56.0	10.5	0.41	----	0.40

NA- Not analysed

4.6 Value Added Products from Cashew Apple

4.6.1 Cashew Apple- Lime blend RTS

Out of eleven varieties selected for study, five varieties viz., Vengurla-3, Accession-301, Dhana, Bhaskara and Ullal-3 found to be suitable for the preparation of RTS beverage in terms of overall acceptability through organoleptic evaluation and biochemical composition. Experiments were carried out to assess the palatability and overall acceptance of blended RTS prepared using cashew apple juice and lime juice varying its concentration levels and it was compared with RTS prepared with cashew apple juice alone.

Comparative nutrional value and functional properties of the CA-Lime blended RTS and commercial lime RTS is presented in Table 4.6. It is clearly understood that the RTS prepared from the selected combination of juices found to be superior to RTS prepared using cashew apple juice only. Moreover, the product could retain maximum ascorbic acid (75.9 mg/100ml),

total phenolics (0.06%) and tannin content (86.62mg/100ml) of the product was found below threshold level of sensation of astringency (≤0.1%) which confirms that at this concentration the product do not give an astringent taste. Presence of sufficient amount of ascorbic acid, tannins and phenolics made the product more functional than the traditional one, DPPH Scavenging activity of the selected combination was greater (281.6 µmoles/15min/100 µl juice) than the product prepared only from cashew apple juice (203.8 µmoles/15min/100 µl juice). This is attributed to additional antioxidants in the product due to the presence of 3% lime juice unlike the control.

Table 4.6: Nutritional value and functional properties of the CA-Lime Blend RTS compared with fresh juice and RTS without lime juice (N=3)

Sl.No.	Parameter	Raw Juice	RTS Without Lime Juice	Cashew Apple- Lime Blend RTS	Commercial Lime RTS
1.	TSS (^{0}Bx)	11.5	10.0	10.0	10.0
2.	Ascorbic acid (mg/100ml)	330.0	68.0	75.9	13.2
3.	Tannin (mg/100ml)	289.0	90.86	86.62	3.7
4.	Total phenol (%)	0.28.0	0.04	0.06	0.02
5.	DPPH Scavenging Activity (µmoles/5min/100 µl juice)	1184.2	203.8	281.6	117.0
6.	Acidity (%)	0.48	0.33	0.38	0.46

4.6.2 Cashew Apple Cider

Cashew apple Cider was prepared from four different varieties individually and mixed juice. The alcohol content of the product was estimated in the range of 3.5-5.5 % v/v. Based on the preliminary sensory evaluation, the cider prepared from mixed juices of different varieties found to be better than the individual varieties. Analysis of polyphenols and other antioxidants as in the case of grape wine is underway. The cider prepared was observed for its stability with respect to biochemical changes viz., Toatl soluble solids, Vitamin C, Total phenols and Antioxidants activity occurred during storage (Table 4.7). It was observed that around 22 % of reduction in antioxidant activity of the product over a period of six months. The DPPH radical scavenging activity declined from 2883 to 2254 µmoles/15min/100µl of product, but the product could retain maximum ascorbic acid (75.9 mg/100ml). Other parameters assessed remained least affected, while darkening of juice observed which was attributed to photo oxidation due to the use of transparent bottle as a packaging material. It is observed that the product below 3.5 % residual sugar content do not undergo significant change in its sensory and chemical attributes whereas if residual TSS is more than 4 %, surface scum formation and darkening were evident.

Table 4.7: Changes in the biochemical quality of cider during storage (N=3)

Month	Colour	TSS (°Bx)	Vitamin C (mg/100ml)	Phenols (%)	DPPH Rad Scav. Activity (µmoles/15min/100µl juice)
March	Golden Yellow	2.1	640	0.984	2883
April	No Change	2.2	546	0.980	2789
May	No Change	1.9	452	0.983	2656
June	Little dark yellow	2.1	456	0.980	2357
July	Little dark yellow	2.3	435	0.973	2263
August	Little dark yellow	2.0	450	0.960	2254

4.7 Tannin Reduction in cashew apple

Fresh cashew apple juice was treated to reduce its tannin content in a synergistic way. Cashew apple juice was treated with food grade tannin reducing agents viz., sago and Defatted meal at concentration level of 2%, maintaining its temperature at 40^{0}C followed by filtration and no filtration (just decantation leaving sediments at the bottom) and compared with control. It was observed that filtered juice after treatment showed four to five fold decrease in the tannin content (Table. 4.8). It is mainly attributed to precipitatation of tannin-protein or tannin-starch on the filter bed.

Table 4.8: Synergetic effect of treatments on tannin reduction of cashew apple juice (N=3)

Treatments		Absorbance	Tannin Reduction (%)
Control	Fitered	0.1943	4.80
	Unfiltered	0.1995	0.00
Sago (2 %)	Fitered	0.1778	28.60
	Unfiltered	0.1905	6.70
Defatted Soybean meal (2 %)	Fitered	0.1755	29.20
	Unfiltered	0.1947	5.40

Note: Juice filtered / unfitered @ 40^{0}C

5. TRANSFER OF TECHNOLOGY

5.1 Transfer of Technology Programme in Cashew

5.1.1 Adoption of Cashew Production Technologies by FLD and Non-FLD farmers

Adoption status of demonstration farmers with respect to recommended cashew production technologies were found to decline after period of financial support (3 years) and the Adoption Index of major cashew production technologies among these farmers were recorded as 48 against 40 in case of check farmers (Table 5.1). Majority (36%) of FLD farmers belonged to High adoption category while majority of check farmers (44%) belonged to medium adoption category.

Table 5.1: Adoption 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

5.1.2 Relationship between adoption and socio-personal profile of FLD farmers

Twelve socio-personal variables were studied for their relationship with adoption of cashew production technologies by cashew farmers. The results revealed that three variables; experience in farming (years) (0.456**), experience in cashew farming (years) (0.336**) and Extension participation (0.360**) had significant relationship with adoption of technologies by FLD farmers (Table 5.2).

Table 5.2: Relationship between adoption and socio-personal profile of FLD farmers (n=54)

Sl. No.	Socio-personal variables	'r' value
1.	Age	0.262 NS
2.	Level of Education	-0.112 NS
3.	Primary Occupation	-0.104 NS
4.	Experience in farming	0.456**
5.	Experience in cashew farming	0.336**
6.	Extension contact	0.238 NS
7.	Extension participation	0.360**
8.	ICT usage	-0.116 NS
9.	Cosmopoliteness	0.148 NS
10.	Land used for cashew	0.469**
11.	Land used for other crops	-0.007 NS
12.	Distance of cashew plot from home	0.131 NS

NS – Non-Significant, ** - Significant at 1 % level, * - Significant at 5 % level

5.1.3 Relationship between adoption and economic profile of FLD farmers

Ten economic variables were studied for their relationship with adoption of cashew production technologies by cashew farmers (Table 5.3). The results revealed that six variables; Importance given to cashew (0.453**), No: of yielding cashew trees (0.443**), Yield of Cashew/tree (0.458**), Expenditure in agriculture (0.396**), Net income from agriculture (0.312*) and Net income from cashew farming (0.380**) had significant relationship with adoption of technologies by FLD farmers.

Table 5.3: Relationship between adoption and economic profile of FLD farmers (n=54)

Sl. No.	Economic variables	'r' value
1	No: of crops grown	-0.160 NS
2	Importance given to cashew	0.453**
3	Farm size	0.123 NS
4	Cultivable land available	-0.062 NS
5	No: of yielding cashew trees	0.443**
6	Yield of Cashew/tree	0.458**
7	Expenditure in agriculture	0.396**
8	Net income from agriculture	0.312*
9	Expenditure in cashew farming	0.191 NS
10	Net income from cashew farming	0.380**

NS – Non-Significant, ** - Significant at 1 % level, * - Significant at 5 % level

5.1.4 Socio-economic factors predicting adoption of FLD farmers

Stepwise regression was used to identify predictors and select models explaining the adoption behavior of FLD cashew farmers. In this analysis, three models were tested to examine the variation in adoption among the FLD farmers (Table 5.4). Model 3 was found explaining up to 47 per cent of variability in adoption using the predictors; land available for cultivation (0.429**), production of cashew (0.354**) and importance given to cashew (0.293**).

Table 5.4: Socio-economic factors predicting adoption of FLD farmers

Model		Unstandarized Coefficients		Standardized coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	42.464	2.382		17.829	0.000
	NONCLTV	5.129	1.339	0.469	3.829	0.000
2	(Constant)	37.282	2.414		15.443	0.000
	NONCLTV	5.019	1.167	0.459	4.302	0.000
	CSWPDN	0.007	0.002	0.447	4.193	0.000
3	(Constant)	31.917	2.996		10.653	0.000
	NONCLTV	4.694	1.105	0.429	4.250	0.000
	CSWPDN	0.005	0.002	0.354	3.338	0.002
	IMPCSW	3.690	1.343	0.293	2.748	0.008

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.469a	0.220	0.205	13.6934512
2	0.648b	0.420	0.397	11.9234265
3	0.704c	0.496	0.466	11.2243249

a. Predictors : (Constant), NONCLTV

b. Predictors : (Constant), NONCLTV, CSWPDN

c. Predictors : (Constant), NONCLTV, CSWPDN, IMPCSW

5.1.5 Technology correlates of cashew production under FLD

Eight technology packages were studied for their relation and contribution towards cashew production under FLD (Table 5.5). Four technology packages; Planting and Aftercare (0.310**), Soil and Water Conservation (0.452**), Intercropping (0.383**) and Harvesting and Post Harvest technologies (0.311*) were found to have a significant relationship with present level of cashew production achieved by FLD cashew farmers.

Table 5.5: Socio-economic factors predicting adoption of FLD farmers

Sl. No.	Technologies	'r' value
1	Varieties	0.183NS
2	Planting and Aftercare	0.310*
3	Soil and Water Conservation	0.452**
4	Manures and Fertilizers	0.168 NS
5	Pruning and Training	0.137 NS
6	Plant Protection	0.215 NS
7	Intercropping	0.383**
8	Harvesting and Post Harvest	0.311*

NS – Non-Significant, ** - Significant at 1 % level, * - Significant at 5 % level

5.1.6 Technology determinants of cashew production under FLD

Stepwise regression was used to identify technology predictors and select models explaining the cashew production of FLD cashew farmers. In this analysis, two models were tested to examine the variation in cashew production among FLD farmers (Table 5.6). However the models were found explaining only up to 24 per cent of variability in cashew production using the predictors; soil and water conservation and intercropping thus making them unviable in predicting the determinants with accuracy.

Table 5.6: Technology determinants of cashew production under FLD

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.452a	0.204	0.189	913.1424090
2	0.522b	0.273	0.244	881.5123882

a. Predictors : (Constant), SWC AI

b. Predictors : (Constant), SWC AI, IC AI

5.1.7 Socio-economic factors predicting cashew production under FLD

Stepwise regression was used to identify predictors and select models explaining the cashew production of FLD cashew farmers. In this analysis, seven models were tested to examine the variation in production among the FLD farmers (Table 5.7). Among the models, model no 7, was found explaining up to 98 per cent of variability in production using the predictors; income from cashew, number of yielding cashew trees, yield of cashew, net income, expenditure incurred in farming, area under cashew and other crops grown. The analysis reveals that economic factors are most important predictors of cashew production under FLD and manipulating these factors can lead to better cashew production in the region.

Table 5.7: Socio-economic factors predicting cashew production under FLD

Model		Unstandarized Coefficients		Standardized coefficients	t	Sig.
		B	Std. Error	Beta		
7	(Constant)	-672.190	71.243		-9.435	0.000
	CSHWINC	0.005	0.001	0.392	4.367	0.000
	CSHWTRS	3.172	0.203	0.782	15.594	0.000
	CSHWYLD	104.108	9.613	0.223	10.830	0.00
	NET INC	-0.003	0.001	-0.235	-2.853	0.00
	FRMNGEXP	4.089	1.381	0.053	2.961	0.005
	CSHWAREA	80.596	32.482	0.042	2.481	0.01
	CRPSGRWN	21.891	9.190	0.041	2.382	0.021

a. Dependent Variable: CSWPDN

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.957	0.917	0.915	295.2769882
2	0.971b	0.943	0.941	246.0484436
3	0.989c	0.978	0.977	153.9268162
4	0.991d	0.982	0.981	140.4065330
5	0.992e	0.985	0.983	132.5867205
6	0.993f	0.986	0.985	125.8466944
7	0.994g	0.988	0.986	120.0200946

a. Predictors : (Constant), CHSWINC

b. Predictors : (Constant), CHSWINC, CSHWTRS

c. Predictors : (Constant), CHSWINC, CSHWTRS, CSHWYLD

d. Predictors : (Constant), CHSWINC, CSHWTRS, CSHWYLD, NET INC

e. Predictors : (Constant), CHSWINC, CSHWTRS, CSHWYLD, NET INC, FRMNGEXP

f. Predictors : (Constant), CHSWINC, CSHWTRS, CSHWYLD, NET INC, FRMNGEXP, CSHWAREA

g. Predictors : (Constant), CHSWINC, CSHWTRS, CSHWYLD, NET INC, FRMNGEXP, CSHWAREA, CRPSGRWN

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

5.2.1 Impact of cashew varieties on cashew area in Maharashtra

Study on impact of various varieties on coverage of total cashew area in Ratnagiri and Sindhudurg districts of Maharashtra showed that highest area under cashew is covered by the variety Vengurla-4 (57%) followed by variety Vengurla-7 (27%). Varieties Vengurla-8 and Vengurla-6 covers 6 percent each of rest of the area while Vengurla-1 (4%) has low impact on total cashew area. Variety wise impact on area is given in Fig.5.1.

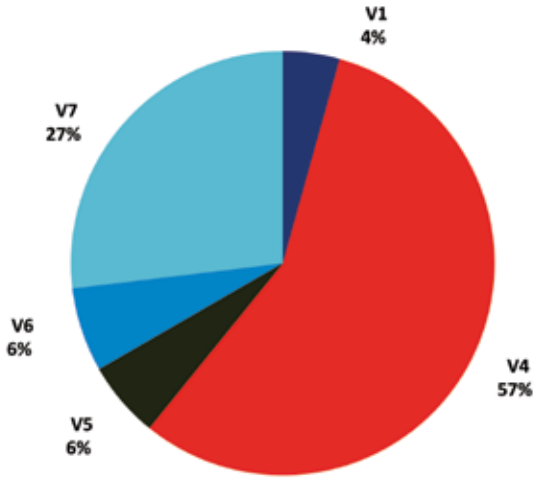


Fig: 5.1. Impact of cashew varieties on cashew area in Maharashtra

5.2.2 Impact of cashew varieties on cashew production in Maharashtra

Analysis of variety wise impact on production showed that farmers realized highest yield from variety Vengurla-4 (7.74 kg/tree) followed by Vengurla-7 (7.05 kg/tree). This was followed by Vengurla-8 (6.60 kg/tree) and Vengurla-1 (5.10 kg/tree). Variety wise impact on production is presented in Fig.5.2.

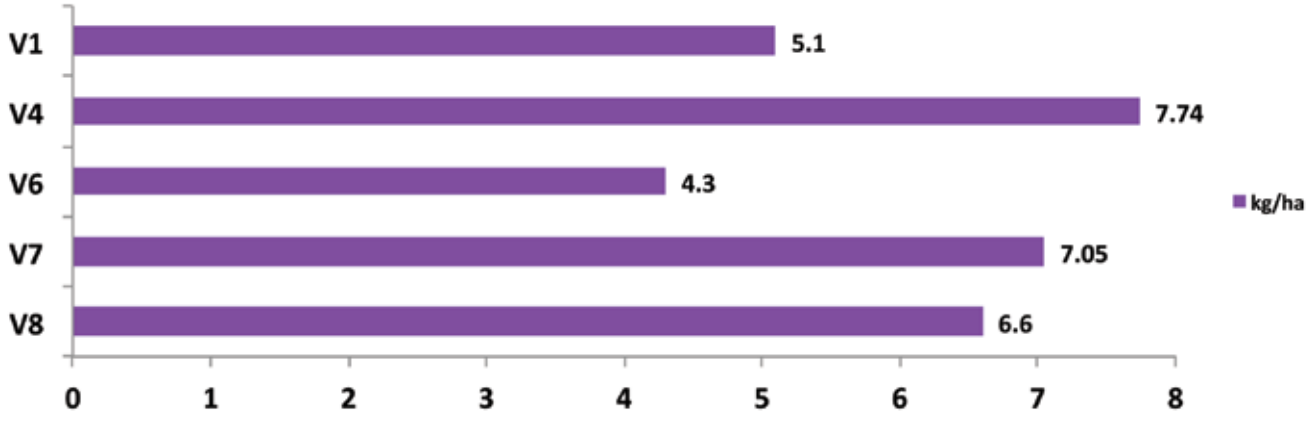


Fig. 5.2. Impact of cashew varieties on cashew production in Maharashtra

5.2.3 Impact of cashew varieties on cashew productivity in Maharashtra under normal density

Analysis of variety wise impact on productivity under normal density planting showed that farmers realized highest yield from variety Vengurla-4 (511 kg/ha) followed by Vengurla-7 (458 kg/ha). This was followed by Vengurla-8 (436 kg/ha) and Vengurla-1 (316 kg/ha). Variety wise impact on production is presented in Fig. 5.3.

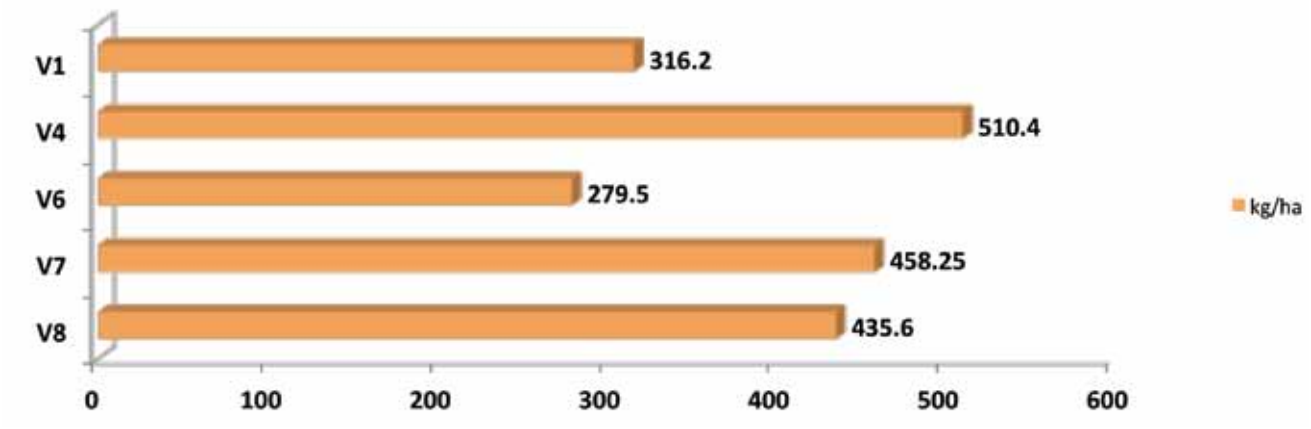


Fig. 5.3. Impact of cashew varieties on cashew productivity in Maharashtra under normal density

5.2.4 Impact of cashew varieties on cashew productivity in Maharashtra under high density

Analysis of variety wise impact on productivity under high density planting showed that farmers realized highest yield from variety Vengurla-4 (1254 kg/ha) followed by Vengurla-7 (1142 kg/ha). This was followed by Vengurla-8 (1049 kg/ha) and Vengurla-6 (688 kg/ha). Variety wise impact on production is presented in Fig. 5.4.

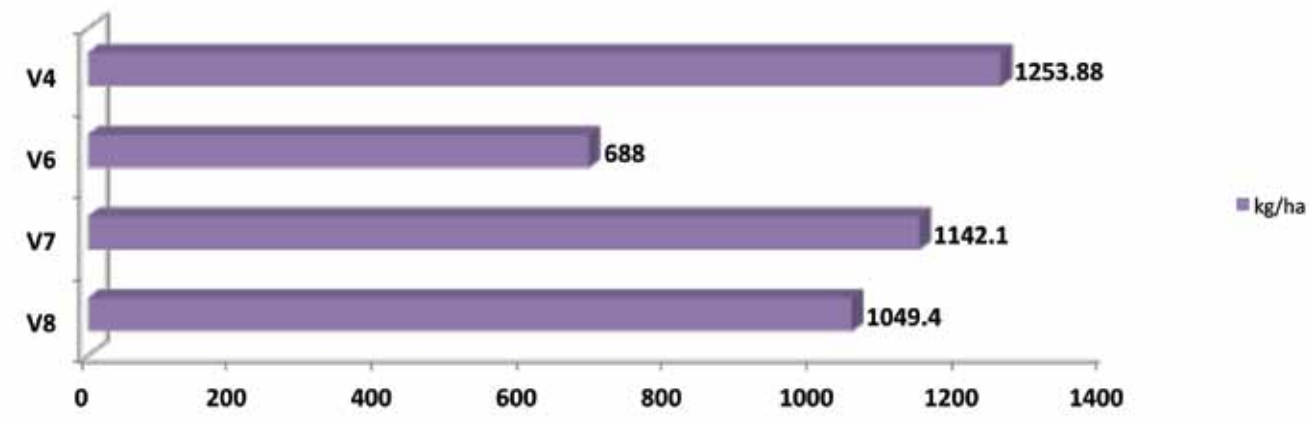


Fig. 5.4. Impact of cashew varieties on cashew productivity in Maharashtra under high density

5.2.5 Yield gap among major cashew varieties in Maharashtra

Yield gap in 6 major varieties grown in Maharashtra was studied and found to be very high. The yield gap was lowest in case of Vengurla-4 with avg. yield of 17.2 kg/tree and yield gap of 9.46 kg/tree. Highest yield gap was recorded for variety Vengurla-1 (13.9kg/tree) followed by Vengurla-6 (12.3kg/tree), Vengurla-7 (11.45kg/tree) and Vengurla-7 (10.9kg/tree) respectively (Fig. 5.5).

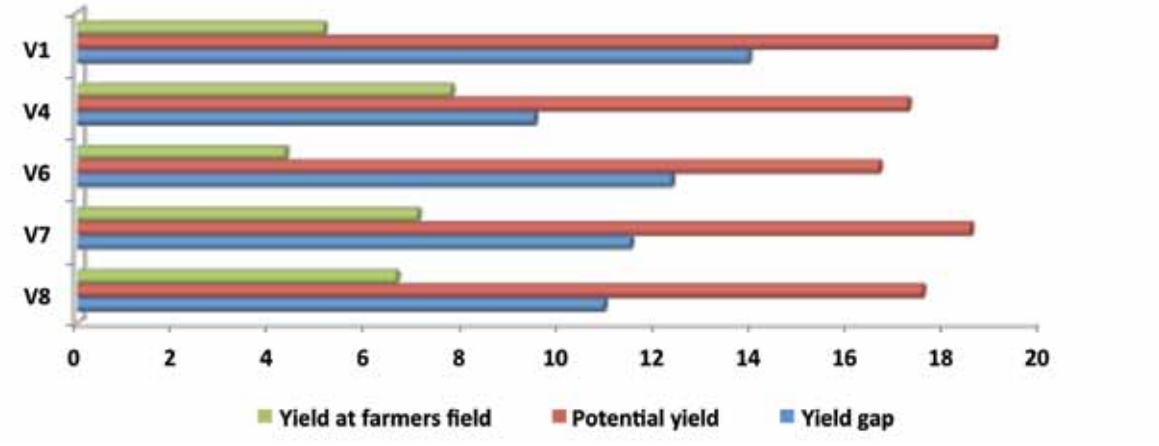


Fig. 5.5. Yield gap among major cashew varieties in Maharashtra

5.2.6 Technology utilization status of cashew farmers in Maharashtra

Technology utilization status of cashew farmers in Konkan region of were found to decline with years of planting and the Adoption Index of major cashew production technologies among these farmers were recorded as 39. Adoption was very high for recommended varieties (98) followed by planting and after care techniques (73) while technologies like soil and water conservation (15) and intercropping (11) fared very poorly in field. Majority (41%) of Konkan cashew farmers belonged to medium adopter category (Fig.5.6).

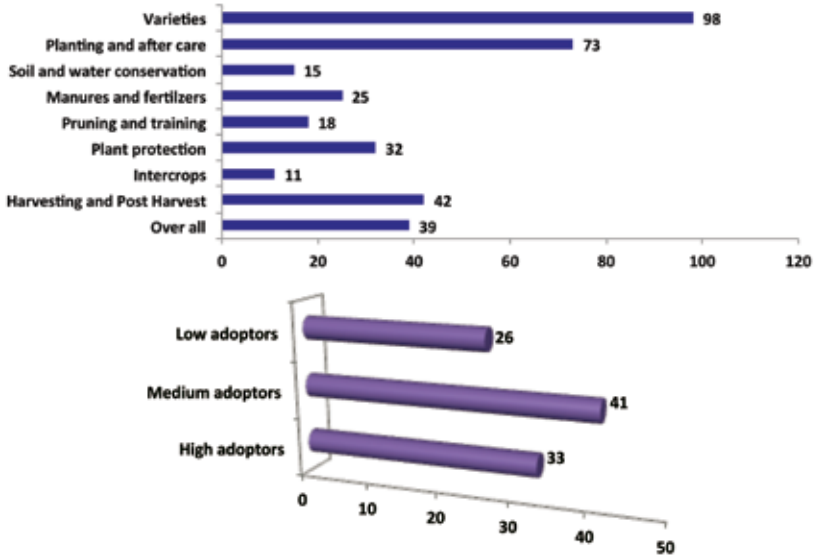


Fig. 5.6. Technology utilization status of cashew farmers in Maharashtra

5.2.8 Technology utilization status of cashew farmers in Maharashtra in comparison with Kerala and Karnataka

Comparative study of adoption of recommended cashew production technologies by cashew farmers of Maharashtra (Konkan region), Karnataka (South Canara) and Kerala (North Kerala) revealed that cashew farmers in all these states registered poor adoption. While Karnataka (40) and Maharashtra (39) farmers had slightly better adoption levels, cashew farmers of Kerala registered very low Adoption Index (30). While

majority cashew farmers in Maharashtra (41%) and Karnataka (44%) belonged to medium adopter category, majority (43%) of cashew farmers in Kerala belonged to low adopter category. Comparative analysis of technology wise adoption is presented below in Fig. 5.7.

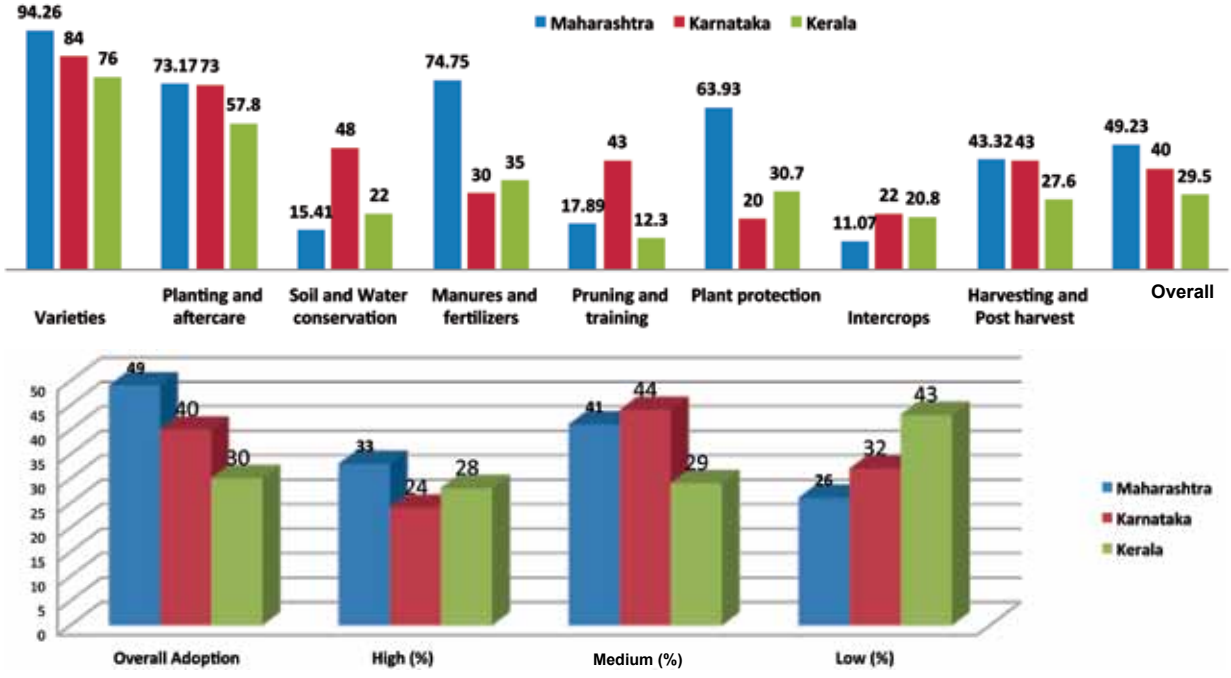


Fig. 5.7. Technology utilization status of cashew farmers in Maharashtra in comparison with Kerala and Karnataka

5.3 Exhibitions organized

The Directorate arranged four exhibitions on cashew production technology and extension during 2016-17. The Directorate put up two off-campus exhibitions at UAHS, Shivamogga and ICAR-CPCRI, Kasaragod and two on campus itself.

5.3.1 DCR Exhibition at Krishi Mela of UAHS, Shimoga

DCR set up exhibition at Krishi Mela of UAHS, Shimoga during 21-10-16 to 24-10-16. More than 2 lakh people representing various districts of Karnataka visited the DCR stall on the four days of exhibition. Scientists from various organizations also visited the stall and necessary information was provided. Non availability of quality planting material of latest varieties in Shimoga and nearby districts was a great concern echoed by most farmers. Other issues were non availability of good varieties for sale from UAHS, Shimogga campus, poor marketing facilities, poor price provided by agents in villages, non availability of proper information on cashew cultivation from line departments in and around Shimogga etc.

5.3.2 DCR Exhibition at ICAR-CPCRI, Kasaragod

The Directorate put up an exhibition during the Centenary exhibition and Kisan Mela held at ICAR-CPCRI, Kasaragode during 10-13, December, 2016. Around 1, 00,000 farmers representing various districts of Kerala and Karnataka visited the ICAR-DCR stall during the exhibition. 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 of the farmers. The DCR team won the best exhibition stall (III Prize) at the event.

5.4 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. A total of 30 FLD plots established in Puttur, Sullia and Bantwal taluks of Dakshina Kannada district were visited during the year and technical advice provided to the farmers on pest management, pruning, fertilization and marketing aspects.

Fig. 5.8: Extension team in PTD plots

5.5 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 and technical advice was given and feedback was collected. (Fig. 5.8).

5.6 E-extension in Cashew

E-extension was strengthened in cashew through Social Media during 2016-17. Under the project, a Facebook page for dissemination of latest cashew information and technical knowledge has been developed [ICAR-DCR PUTTUR] (Fig. 5.9). The page has been regularly edited, updated and uploaded with relevant content. All HRD

Fig. 5.9: Facebook page of DCR, Puttur

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, 202 organizations/stakeholders are actively following DCR Facebook page for updates.

5.7 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 organized

6.1.1 Foundation Day of ICAR-DCR: Innovative Cashew Farmers Meet: 2016

Directorate of Cashew Research, Puttur celebrated its 30th foundation day on 18-06-2016. On this occasion 'Farmers Meet-2016' was also organized in which more than 150 progressive cashew farmers participated besides nursery men, representatives of ICAR Institutes, KVKs, development departments, NGOs and scientists. Dr. K.L. Chadha, former DDG [Horticulture], ICAR, New Delhi, was the Chief Guest of the programme and Dr. M.G. Bhat, former Director, DCR, Puttur was the Guest of Honour. The Director, DCR, Puttur, Prof. P.L. Saroj presided over the inaugural session.

Felicitation to innovative farmer

After the inauguration, three selected innovative farmers were felicitated before the audience. Dr. L.C. Soans, innovative horticulturist from Moodbidri, Karnataka was felicitated for the various horticultural innovations made in his highly appreciated 'Soans Farm'. Sri. Somappa Rai of Darbethadka, Puttur was felicitated for adopting innovative high density planting on a large scale with variety VRI-3. Sri. Sashi Kumar Rai from Karnoor was felicitated for demonstrating high density technique with a yield of 28 Quintals from 1200 trees. The awardees also shared their experiences.

Dr. K.L. Chadha, Chief Guest of the function, congratulated the past and present leadership of DCR for establishing the best infrastructure for cashew research. He highlighted the major technology contributions of DCR as Softwood Grafting Technique, improved varieties and High Density Planting method. He called for adopting latest technologies to combat low productivity in Cashew. He gave the road map for doubling farmers' income in cashew. Dr. M.G. Bhat, Guest of Honour, congratulated cashew farmers and scientists and stressed on the need for better productivity and income from cashew farming. He appreciated the adoption of latest technologies by innovative farmers.

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. T.N. Raviprasad, Principal Scientist (Ento.), DCR welcomed dignitaries and participants and highlighted the importance of sharing farmer's innovations for facilitating farmer to farmer learning. On this occasion two extension pamphlets were 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 and Vote of thanks by Dr. D. Balasubramanian, Principal Scientist of the Directorate.

6.1.2 Cashew farmers fair

To provide technology backstopping to farmers on frontline cashew production technologies, Directorate of Cashew Research, Puttur celebrated Cashew Farmers' Fair on 11-03-2017. More than 200 cashew farmers participated besides nursery men, representatives of KVK, development departments, NGOs and Scientists. Sri. S.R. Satishchandra, President CAMPCO was the Chief Guest of the programme and Dr. W.S. Dhillon, ADG (Hort-I), ICAR, New Delhi and Sri. Achutha Moodithaya, Progressive Cashew Farmer were the Guests of Honour. Dr. M.G. Nayak, Director (Acting), DCR, Puttur, presided over the inaugural function.

Inauguration of the programme

A view of participants

Sri. S.R. Satishchandra, President, CAMPCO in his inaugural address stressed on the revolutions in Indian Agriculture and how the country is presently forging ahead in all the areas including agriculture. He stressed that cashew farmers should not be left behind and should benefit from this revolution. He appreciated the research achievements of DCR, Puttur and called for wider outreach of the technologies in collaboration with development departments. He informed that CAMPCO will also look into the possibilities of procuring cashew crop directly from farmers.

Chief Guest addressing the farmers

Address by Guest of Honour

Sri. Achutha Moodithaya, progressive cashew farmer addressed the gathering and highlighted the importance of farming as the noblest profession. He stressed upon sustainability in yield and income from cashew farming and shared his success in cashew farming with all other farmers.

Address by ADG (Hort-I)

Director, DCR addressing the farmers

In his address, Dr. W.S. Dhillon, ADG (Hort-I) stressed upon the importance of horticultural crops in providing nutritional security to the country. He opined that productivity of cashew has to be raised to world level and new varieties in cashew need to be immediately released from DCR. He called to focus upon bridging the big gap in production of quality planting material and technology transfer.

In his presidential address, Dr. M.G. Nayak, 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.

Release of publications

Sharing success story by the farmer

Earlier, Dr. T.N. Raviprasad, Principal Scientist (Ento.), DCR welcomed dignitaries and participants and highlighted the work done by DCR since inception. He also conducted farmers' scientist interaction session and replied various queries by farmers. 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 there by gaining much exposure to latest cashew production technologies. Earlier decisions support system for cashew germplasm and two extension bulletins viz., 'Cashew cultivation practices' and 'Sudharitha geru besaya' were released by the dignitaries. A folder on 'Unique cashew decision support system for cashew germplasm' was also released on this occasion. Progressive cashew farmers also shared their views on cashew cultivation during the programme. The programme concluded with vote of thanks by Dr. Sajeev, M.V, Senior Scientist and Coordinator of the programme.

6.1.3 Awareness programme on Cashew cultivation

About forty Farmers of Punacha Cooperative Society in Dakshina Kannada attended a programme on 'Cashew Cultivation' organised at this Directorate on 21-02-2017. During the programme, information about varieties, cultivations aspects, planting material and subsidies available for farmers were shared to the participants. Dr. Vanitha, Scientist (Entomology) delivered lecture on 'Insect pests of cashew and their control'.

Farmers from Punacha co-operative society at ICAR-DCR, Puttur

6.1.4 Cashew Day - training program by Karnataka State Cashew Development Corporation at this Directorate

A training program on different aspects of cashew cultivation, varieties and insect pest management was organised by Karnataka State Cashew Development Corporation in association with this Directorate on 04-03-2017. About 180 farmers from Kundapur and Udupi participated in the program. Field visit to cashew orchards of this Directorate and progressive farmers was also arranged for the farmers to promote cashew cultivation.

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

6.2.1 Report on NEH programme

Under the NEH scheme, surveys were taken up to identify the suitable locations for area expansion of cashew through establishing fresh cashew plantation in Nagaland. Based on the good response and existence of old cashew plots, two villages of Ghotovi and Mhainamtsi, Jalukie Dist. have been identified for taking up new cashew plantations. A total of 8 cashew farmers have been identified by the Nagaland University and cashew plantation has been established in their respective plots with the cashew grafts procured from the Central Institute of Horticulture, Medziphema. These newly established plots are being monitored by scientists of SASRD, Medziphema.

Further it was noticed that the cashew plots established earlier were not being properly maintained due to lack of processing facilities. In this connection several farmers expressed their desire to have a processing unit in the commercial centre at Dimapur. Hence, financial support has been provided to establish a cashew processing unit at Seithekima, Dimapur by the All Nagaland Cashew Growers' Association, Chumukedima. The infrastructure and machineries are being procured from Maharashtra and the unit is expected to be functional in the subsequent yielding season.

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

Under TSP program, 40 new FLD plots were established during 2016-17 in tribal farmer fields of Dakshina Kannada and Madikeri districts of Karnataka. 26 new FLD plots established during 2015-16 in tribal farmer fields of Dakshina Kannada district of Karnataka and Kasaragode district of Kerala were visited regularly by TSP team of DCR for provision of assistance during planting and aftercare and monitoring. Also, 25 FLD plots established under TSP programme during 2014-15 were also monitored regularly by TSP team comprising of Dr. M.G. Nayak, Dr. Sajeev M.V. and Dr. G.S. Mohan and technical advice was provided on aftercare, pest management and manuring. (Fig. x).

The students were exposed to the research and extension activities of the Directorate. The theme lecture of the programme was delivered by Dr. M.G. Nayak, Director (Acting), DCR in a student friendly manner where the scope of Agricultural Education was dealt in detail and as appreciable by students. The students were introduced to the importance of agriculture and vast opportunities in job market by the speaker. The programme generated immense curiosity and wide appreciation among the students and teachers.

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

On 5th December 2016 World Soil Day was celebrated at ICAR-DCR, Puttur. A team from ICAR-DCR visited the cashew farmers of nearby villages i.e. Kuriya, Mundur and Purusharakatte.

6.4 Agricultural Education Day celebrated at ICAR-Directorate of Cashew Research, Puttur

The ICAR-Directorate of Cashew Research, Puttur organized the 'Agricultural Education Day 2016' on 03-12-16 on the theme "Scope of Agricultural Education". The programme was organised in association with Sudana School, Puttur and Karnataka State Education Department. More than 1000 students and teachers from various schools of Puttur and nearby towns participated in the programme.

There, importance of soil testing and soil sampling methodology were explained to the farmers and method was demonstrated soil sampling in the farmers fields. Soil samples collected were taken to ICAR-DCR soil science laboratory. After analysis, soil health card will be prepares and distributed soon.

A soil test is essential to determine soil fertility levels and make good nutrient management decisions. A critical step in obtaining accurate soil tests is collecting representative samples in the field. A composite soil sample should represent a uniform field area. In general, sampling is done at the rate of one sample for every two hectare area.

6.5. Mera Gaon Mera Gaurav Programme

This Directorate has selected 15 villages of Puttur, Sullia and Bantwal taluks representing different agro-climatic zones. Most of the villages have cashew as a self –sown, seedling origin tree, while few farmers have recently adopted cashew cultivation using grafts. Due to inaccessibility from headquarters, the farmers face problem of transportation, frequent power cuts and crop losses due to damage by wild animals such as monkeys, squirrels, wild boars and deer. All the selected villages have ample unplanted areas which are suitable for cultivation of cashew. Efforts are being made to encourage farmers to plant region-specific recommended varieties of cashew in these vacant areas. As there are few cashew processing units in the vicinity, presently farmers are hesitant and undecided about expanding area under cashew; however few enterprising farmers have willing to undertake cashew cultivation adopting the good agricultural practices.

A farmers' meeting was held on 21.09.2016 in Amara Mudnoor village of Sullia taluk, for creating awareness about cashew cultivation in vacant lands owned by them. The farmers expressed interest in cashew crop as the current price of the raw cashew nuts was quite remunerative. Some of the farmers enquired about the varieties suitable to their area as the location is prone to low temperature and also occurrence of fog. During the discussions, the planting methods, systems of planting, suitable intercrops, canopy management, pest damage symptoms and their management as well as, correct harvesting stage and storage of collected raw cashew nuts ; etc. were explained to them.

A farmers' meeting was held on 31.12.2016 in Arayapu village of Puttur taluk, for knowing the problems faced by the farmers. The farmers expressed interest in growing forest trees and also enquired about micro-finance, crop insurance and reducing water table as well as, checking the crop losses due to damage by wild boars. During the discussion, the farmers expressed interest in cashew cultivation and enquired about pest infestation symptoms and management in cashew. They also evinced interest about homestead processing of raw cashewnuts.

Activities organised by ICAR- Directorate of Cashew Research, Puttur 574202 D.K., Karnataka under MGMG

Sl. No.	Name of activity	No. of activities	No. of farmers benefitted
1.	Visit to village by teams	2	150
2.	Interface meeting/ Kisan Goshties	2	150
3.	Literature support provided	1 (Pamphlet on CSRB management)	

6.6 Vigilance Awareness Week

The vigilance awareness week was orgnaized at this Directorate during first week of November 2016 as per directives of the Council. Vigilance awareness week was inaugurated by Smt. Rupa Shetty, Commissioner, Town Municipal Council, Puttur, Karnataka on 31st October along with concluding function of Swatcha Bharath Pakwada. During the programme, performing duties in an organization without any corruption was delivered by her. Dr. G.S. Rathod former ADG, ICAR, New Delhi and Vice Chancellor, Chaudhary Sarwan Kumar Himachal Pradesh Agricultural University, Palampur during inaugural address stressed upon positive thinking to bring down the corruption.

Closing ceremony of Vigilance Awareness Week

6.7 Swatch Bharath Abhiyan

The Swatch Bharath Abhiyan has been followed in this Directorate since the official communication from the Council. It is progressing in this Directorate sparing 2 hours every week on Friday to clean the surroundings of the institute and create awareness to the public. Besides, 'Swatcha Bharath Pakwada' was organized during 16th to 31st October 2016 and various programmes were under taken during the period. Certain activities which were taken up during 'Swatcha Bharath Pakwada' were cleaning canteen kitchen and laboratories, practicing yoga, creating awareness by delivering lecture on maintaining clean environment in the premises of public location.

Closing eremony of Swatch Bharath Abhiyan

7. CONCLUDED PROJECTS

7.1 Effect of Paclobutrazol on growth and yield of Cashew (*Anacardium occidentale* L.)

Project Leader : Dr. Ramkesh Meena (2009-10, 2012-15)
Dr. J.D. Adiga (2009-12)
Dr. Babli Mog (2015-17)

Project Associate : Dr. M.G. Nayak (2009-14)
Dr. J.D. Adiga (2012-15)
Dr. Janani P (2016-17)

Project Number : 2.18

Project Duration : 2009 – 2016

7.1.1 Introduction

Cashew (*Anacardium occidentale* L.), being a fast growing woody perennial, covers the allotted space under high density planting, within a short span of 6-7 years. Controlling excessive vegetative growth for increased or sustained productivity is the major principle of high density planting. In cashew, due to non availability of dwarf clones, dwarfing root stocks or a pruning technology for the management of vigorous canopies, use of growth retarding chemicals assumes significance. Treatments with growth retardants like Paclobutrazol was found effective in reducing the growth of fruit crops like pear, peach, lemon, apple, litchi, apricot, plum and mango. The reduction in growth was observed in cashew when Paclobutrazol was applied to young grafted plants at nursery stage. Therefore, an investigation is proposed to study the effect of application of Paclobutrazol on growth and yield of cashew to know its effect in detail and to manipulate the plant growth to suit for high density planting system.

7.1.2 Objectives

- To study the efficacy of Paclobutrazol (PBZ) in inducing dwarfism
- To study the effect of PBZ on growth, flowering, fruiting and yield of cashew
- To evaluate quality parameters in PBZ treated cashew

7.1.3 Material and Methods

The experiment was conducted at Experimental Station of the Directorate of Cashew Research, Karnataka, India. The experimental site is situated at 12.25 º N latitude, 75.4 º E longitude 90 m above mean sea level. The experimental soil was lateritic and having a slightly acidic soils pH 6.0 with low soluble salts (EC dSm-1), organic carbon 0.14-1.68, and base saturation of 26-31 %. The mean annual temperature is 27.6 °C and mean maximum and minimum temperature are 36°C and 20°C respectively. The study area lies along the West Coast region of India where the climate is seasonally wet, hot and humid, with distinct dry seasons (from January to May) during which the cashew development takes place. The average annual rainfall of the study area is 3500 mm and is distributed from late May to November. The trade name of the chemical used inthe study was Cultar 23% flowable concentration of Paclobutrazol. The three year old trees of variety Ullal-3 spaced at 3m x 3m were selected for the study. The experimental design was Split plot with five replications. Paclobutrazol was applied before vegetative flushing in the month of October. The main plot represented doses of paclobutrazol viz, 0.0 (Control) 1.0, 2.0 and 3.0 g. a. i. per plant as soil drench. The sub plots consisted of duration of PBZ application, viz., annual, biennial and triennial. The plant canopies were made uniform with required height and spread by pruning during the month of May after harvesting of the crop. The PBZ at required concentration was dissolved in the water and applied in 10-15 cm deep trench at 60 cm away from the plant trunk and covered with soil.

7.1.3.1 Observations recorded

Observations on plant height, canopy spread, number of flushes, girth of collar region and intermodal length, nut weight and nut yield per plants were recorded. The height of the tree was measured vertically from the ground to the tip of the tree and expressed in centimeter. The tree girth was measured at 30 cm above from the base and expressed in centimeter. The diametric length of the ground space occupied by the tree was measured in two directions and the canopy spread was recorded as "North-South and "East-West directions. The numbers of flushes were counted in all the four directions of plant and mean of them was expressed as the number of flushes. The intermodal length was measured vertically from the base to the tip of branches and recorded in centimeters. Mean intermodal length was calculated by measuring intermodal length of twenty shoots in all the directions of the tree.

7.1.3.2 Statistical analysis

Data generated from the experimental plot were analyzed by using the SAS statistical program (SAS Institute Inc, 2011). The analysis of variance (ANOVA) was performed by using PROC GLM. Means were separated using Fisher's protected least significant difference (LSD) test at the probability level of $p \leq 0.05$.

7.1.4 Results and Discussion

7.1.4.1 Effect of PBZ treatment on growth parameters

The PBZ application reduced the growth of plants with respect to parameters like plant height, canopy spread and intermodal length while the number of flushes increased with the application of PBZ. The height of plant among PBZ treated plants ranged from 411 to 554 cm in different doses and frequency of application, while in untreated plants, plant height was found to be 558 to 562 cm. The stem girth among PBZ treated plants ranged from 38.13 to 40.80 cm, while the untreated plants had 40 to 42 cm. The internodal length of PBZ treated plants ranged from 12.9 to 16.0 cm, while the untreated plants recoded 18.1 to 18.6 cm indicating the role of PBZ in reducing the plant vigor (Table 7.1.1). The canopy spread in E-W direction among PBZ treated plants ranged from 366 to 416 cm, while the untreated plants it was 413 to 423 cm. The canopy spread in N-S direction among PBZ treated plants ranged from 387 to 429 cm, while in untreated plants it was 435 to 439 cm. The mean ground coverage among four directions among PBZ treated plants varied from 377 to 422 cm, while in untreated plants it was 424 to 431 cm (Table 7.1.2). The total number of new flushes among PBZ treated plants ranged from 186.0 to 199.3, while the untreated plants produced 155 to 174. The number of floral and non-floral lateral among PBZ treated plants ranged from 65.0 to 71.7 and 121.0 to 127.7, respectively while the untreated plants had 46 to 59 and 109 to 115 cm, respectively (Table 7.1.3).

7.1.4.2 Effect of PBZ treatment on flowering parameters

The PBZ application was found effective in increasing sex ratio, number of panicles per plant while, the length and width of panicles and flowering duration got reduced. The number of male and hermaphrodite flowers per panicle in PBZ treated plants varied from 316.4 to 348.2 and 44.6 to 58.4 respectively, while the untreated plants it varied from 326.0 to 332.4 and 43.8 to 47.2, respectively. The sex ratio ranged from 0.15 to 0.20 % in treated plants while in untreated plants it was 0.13 to 0.14 % (Table 7.1.4).

The number of rachis per flower ranged from 7.30 to 7.95 in treated plants while in untreated plant it was 7.40 to 7.60. The length of flower panicles ranged from 14.0 to 15.7 cm and width 18.70 to 21.80 cm in treated plants while, in untreated plants the length and width varied from 18.40 to 21.60 cm and 25.80 to 27.20 cm, respectively (Table 7.1.5).

7.1.4.3 Effect of PBZ treatment on nut parameters

Of the frequency of PBZ application, annual application of PBZ was found significantly effective in reducing the nut length, width and thickness. The minimum length (29.2 mm), width (22.7 mm) and thickness (17.4 mm) of nut was recorded under the treatment @ 3 g a.i. per plant which was associated with annual application of PBZ as compared to control (length: 33.4 mm, width: 26.1 mm and thickness: 19.6 mm) (Table 7.1.6). The reduction of these parameters might be due to the increased percentage of flowered branches in PBZ-treated which intern lead to lower expenditure of tree reserves to the vegetative growth parameters leading consequently to no assimilate limitations.

7.1.4.4 Effect of PBZ treatment on yield parameters

The PBZ application increased the yield per plant but the nut weight got reduced. The highest nut yield (2.89 kg/plant) and minimum nut weight (6.2 g) was associated with annual application of PBZ @ 3 g a.i. per plant. This could be attributed to higher fruit set and fruit retention in the PBZ treated plants over untreated plants (Table 7.1.7).

Table 7.1.1: Effect of PBZ on plant height, stem girth and internodal length

Time of Application	Plant height (cm)			Mean	Girth (cm)			Mean	Inter nodal length (cm)			Mean
PBZ levels	Y1	Y2	Y3		Y1	Y2	Y3		Y1	Y2	Y3	
PBZ@1g a.i./pl	500	530	554	527.80	39	41	43	40.80	14.8	15.8	17.6	16.0
PBZ@2g a.i./pl	461	497	511	489.30	37	41	41	39.67	11.7	13.2	16.4	13.8
PBZ@3g a.i./pl	411	464	508	460.93	35	39	40	38.13	10.8	11.6	16.4	12.9
Control	558	561	562	560.30	40	42	42	41.27	18.1	18.6	18.6	18.4
Mean	482	513	533		38	41	42		13.8	14.8	17.2	
Source	L	T	L xT		L	T	LxT		L	T	Lx T	L
SEm±	14.28	12.37	24.73		0.79	0.68	1.37		0.23	0.10	0.40	
LSD (p<0.05)	40.71	35.25	NS		NS	NS	NS		0.65	0.57	NS	

Y1 = Application of PBZ every year; Y2 = Application of PBZ once in two years; Y3 = Application of PBZ once in three years

Table 7.1.2: Effect of PBZ on canopy spread

Time of Application	East & West (cm)			Mean	North & South (cm)			Mean	Ground coverage (cm)			Mean
PBZ levels	Y1	Y2	Y3		Y1	Y2	Y3		Y1	Y2	Y3	
PBZ@1g a.i./pl	407	419	421	415.53	424	426	438	429.27	416	422	429	422.40
PBZ@2g a.i./pl	366	380	403	382.90	379	416	420	405.10	372	398	412	394.00
PBZ@3g a.i./pl	346	366	387	366.20	353	402	406	386.80	349	384	396	376.50
Control	413	423	423	419.80	435	438	439	437.33	424	431	431	428.60
Mean	383	397	409		424	426	438		390	409	417	
Source	L	T	L xT		L	T	LxT		L	T	Lx T	
SEm±	19.29	11.09	26.36		14.16	15.20	28.58		14.80	9.97	22.01	
LSD (p<0.05)	42.03	22.42	NS		30.86	NS	NS		32.26	20.31	NS	

Y1 = Application of PBZ every year; Y2 = Application of PBZ once in two years; Y3 = Application of PBZ once in three years

Table 7.1.3: Effect of PBZ on number of flushes, flower laterals and non-flower laterals

Time of Application	Total no. of flushes			Mean	Flower laterals			Mean	Non flower laterals			Mean
PBZ levels	Y1	Y2	Y3		Y1	Y2	Y3		Y1	Y2	Y3	
PBZ@1g a.i./pl	192	187	179	186.0	68	66	61	65.0	124	121	118	121.0
PBZ@2g a.i./pl	208	192	186	195.3	76	73	65	71.3	132	119	121	124.0
PBZ@3g a.i./pl	212	196	190	199.3	78	72	65	71.7	134	124	125	127.7
Control	174	155	160	163.0	59	46	48	51.0	115	109	112	112.0
Mean	196.5	182.5	178.8		70.25	64.25	59.75		126.3	118.25	119	
Source	L	T	L xT		L	T	LxT		L	T	Lx T	
SEm±	3.88	3.02	6.28		1.97	1.42	3.05		2.72	2.28	4.61	3.88
LSD (p<0.05)	8.46	6.16	NS		4.29	2.90	NS		5.94	4.64	NS	8.46

Y1 = Application of PBZ every year; Y2 = Application of PBZ once in two years; Y3 = Application of PBZ once in three years

Table 7.1.4: Effect of PBZ on flower parameters

Time of Application	No. of male flowers			Mean	No. of female flowers			Mean	Sex ratio			Mean
PBZ levels	Y1	Y2	Y3		Y1	Y2	Y3		Y1	Y2	Y3	
PBZ@1g a.i./pl	352.4	338.4	316.4	335.7	54.2	50.4	48.6	51.1	0.17	0.15	0.14	0.15
PBZ@2g a.i./pl	366.4	358.4	348.2	357.7	58.2	57.2	48.6	54.7	0.19	0.18	0.16	0.18
PBZ@3g a.i./pl	364.2	352.6	341.4	352.7	66.4	58.2	54.2	59.6	0.23	0.20	0.17	0.20
Control	332.4	328.4	326.0	328.9	47.2	43.8	44.6	45.2	0.14	0.13	0.14	0.14
Mean	353.9	344.5	333.0		56.5	52.4	49.0		0.18	0.17	0.15	
Source	L	T	L xT		L	T	LxT		L	T	Lx T	L
SEm±	15.78	9.97	22.01		4.63	3.81	7.75		0.02	0.01	0.03	15.78
LSD (p<0.05)	NS	NS	NS		10.10	7.76	NS		0.033	NS	NS	NS

Y1 = Application of PBZ every year; Y2 = Application of PBZ once in two years; Y3 = Application of PBZ once in three years

Table 7.1.5: Effect of PBZ on flower parameters

Time of Application	Number of rachis per flower			Mean	Length of flower panicles (cm)			Mean	Width of flower panicles (cm)			Mean
PBZ levels	Y1	Y2	Y3		Y1	Y2	Y3		Y1	Y2	Y3	
PBZ@1g a.i./pl	7.2	7.40	7.40	7.30	13.20	16.2	17.8	15.7	21.6	21.80	22.00	21.80
PBZ@2g a.i./pl	8.2	7.80	7.60	7.95	13.10	15.6	16.0	14.9	18.6	19.40	19.60	19.00
PBZ@3g a.i./pl	8.0	7.80	7.00	7.60	12.60	13.8	15.6	14.0	16.8	19.20	20.20	18.70
Control	7.40	7.40	7.60	7.50	18.40	21.0	21.6	20.3	25.8	26.80	27.20	26.30
Mean	8.0	7.60	7.40		14.30	16.7	17.8		20.7	21.80	22.30	
Source	L	T	L xT		L	T	LxT		L	T	Lx T	
SEm±	0.33	0.02	0.60		1.96	0.84	2.40		1.29	0.74	1.66	0.33
LSD (p<0.05)	NS	NS	NS		4.27	NS	NS		2.46	1.51	NS	NS

Y1 = Application of PBZ every year; Y2 = Application of PBZ once in two years; Y3 = Application of PBZ once in three years

Table 7.1.6: Effect of PBZ on length, width and thickness of nut

Time of Application	Nut thickness (cm)			Mean	Nut length (cm)			Mean	Nut Width (cm)			Mean
PBZ levels	Y1	Y2	Y3		Y1	Y2	Y3		Y1	Y2	Y3	
PBZ@1g a.i./pl	2.0	2.1	2.1		3.22	3.41	3.35	3.3	2.56	2.66	2.66	2.6
PBZ@2g a.i./pl	1.9	2.0	2.0		3.10	3.19	3.39	3.2	2.43	2.51	2.64	2.5
PBZ@3g a.i./pl	1.9	2.0	2.0		2.99	3.16	3.27	3.1	2.43	2.56	2.69	2.6
Control	2.0	2.1	2.1		3.45	3.50	3.51	3.5	2.73	2.76	2.78	2.8
Mean	1.9	2.0	2.0		3.2	3.3	3.4		2.5	2.6	2.7	
Source	L	T	L xT		L	T	LxT		L	T	Lx T	
SEm±	0.03	0.02	0.04		0.04	0.02	0.05		11.6	10.10	20.20	0.05
LSD (p<0.05)	0.07	0.03	NS		0.08	0.05	0.011		25.41	20.58	42.11	0.11

Y1 = Application of PBZ every year; Y2 = Application of PBZ once in two years; Y3 = Application of PBZ once in three years

Table 7.1.7: Effect of PBZ on nut weight and yield

Time of Application	Nut weight (gm)			Mean	Nut yield (kg/plant)			Mean
PBZ levels	Y1	Y2	Y3		Y1	Y2	Y3	
PBZ@1g a.i./pl	7.4	7.6	7.7	18.7	2.78	2.57	2.50	2.62
PBZ@2g a.i./pl	6.3	6.4	6.7	17.7	3.01	2.86	2.53	2.80
PBZ@3g a.i./pl	6.0	6.0	6.5	17.4	3.08	2.96	2.63	2.8
Control	8.3	8.4	8.4	19.6	2.44	2.44	2.47	2.45
Mean	7.0	7.1	7.3		2.83	2.71	2.54	
Source	L	T	L x T		L	T	L x T	
SEm±	0.16	0.14	0.28		0.269	0.039	0.078	
LSD (p<0.05)	0.46	NS	NS		0.128	0.111	0.230	

Y1 = Application of PBZ every year; Y2 = Application of PBZ once in two years; Y3 = Application of PBZ once in three years

7.1.5 Conclusion

Soil application of PBZ at pre-flushing stage was found to be effective in reducing the plant height, canopy spread, intermodal length and yield increment (51%) per plant over control.

7.1.6 Publication

R K Meena, J D Adiga, M G Nayak, P L Saroj and D Kalaivanan. Effect of Paclobutrazol on growth and yield of Cashew (*Anacardium occidentale* L.). VEGETOS. 27 (1): 11-16 2014.

7.2 Performance of high yielding varieties of cashew in different high density planting system

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Dr. R. Rejani (2010-12)
Dr. J.D. Adiga (2012-16
Dr. Janani, P (2016-17)

Project Associate : Dr. J.D. Adiga (2007-12)
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Dr. D. Kalaivanan (2012-15)
Dr. Babli Mog (2015-17)

Project Number : 2.11

Project Duration : 2006-2017

7.2.1 Introduction

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
Year of planting	:	2006

7.2.2 Objectives

- Determine optimum plant density for achieving higher yield and profit for the first ten years.
- To recommend suitable variety for achieving highest yield and profit for the first ten years under high density planting.

7.2.3 Observations

An experiment was conducted at ICAR-Directorate of Cashew Research, Puttur, Karnataka during 2006-2017 to find the suitable variety and plant density for cashew cultivation along West Coast. All the growth and yield parameters during the period of investigation were recorded. The recommended dose of fertilizer (RDF) was applied to the plants. The RDF during first year after planting (YAP) is 1/5th, 2nd YAP is 2/5th, 3rd YAP is 3/5th, 4th YAP is 4/5th and fifth year onwards is full dose of fertilizers. The RDF (full dose) for a matured cashew plant is 500g N and 125g P_2O_5 and 125g K_2O per plant per year. Shape pruning was done every year to maintain the canopy.

7.2.3.1 Effect of plant density and varieties on growth and yield of cashew

Plant height was found to vary significantly among the different spacing as well as different varieties; however, their interactions were not significant (Table 7.2.1). The plant height ranged from 4.13 (VRI-3 planted at 6.5m x 6.5m) to 8.42 m (Madakkathara-2 planted at 6.5m x 6.5m spacing). Among the varieties, Madakkathara-2 recorded significantly higher plant height (7.95m) followed by Bhaskara (6.97m) and least plant height was recorded in VRI-3 (4.68 m).

Plant girth exhibited significant differences among the different varieties. The stem girth ranged from 73.08 cm (Madakkathara-2) to 53.79 cm (VRI-3). However, the differences among the spacing and their interactions did not attain the level of significance (Table 7.2.2). Canopy spread did not exhibit significant effect among the varieties, spacing and their interactions (Table 3). The average spread of canopy ranged from 5.83 m (VRI-3 planted at 6.5m x 4m) to 8.35m (Dhana planted at 6.5m x 6.5m) (Table 7.2.3). The data on percent ground coverage by canopy presented in Table 7.2.4 was found to vary significantly among the spacing however, varieties and their interactions were not significant. The ground coverage data indicates that under wider density, still 23% of space is available for canopy growth indicating the potential of realizing higher yield in subsequent harvests too. Whereas, under the high density planting system, the trees have out grown the allotted space by additional 85%, indicating the non-sustainability over long period of time(i.e., by 10th year).

Cashew yield (kg/tree) was influenced by the spacing, varieties and their interactions (Table 7.2.5). Among the varieties, Bhaskara showed higher yield (5.80) followed by Ullal-3 (5.22), Madakkathara-2 (5.16) while the lowest yield was observed in VRI-3 (3.93) followed by NRCC Selection -2 (4.17) which were on par with each other. With respect to yield per plant in the 8th harvest, density of 200 plants/ha (10m x 5m spacing) recorded highest annual yield of 7.18 kg/tree, while the highest density of 500 plants/ha (5m x 4m spacing) recorded the lowest yield of 2.39 kg/tree, indicating drastic reduction in per plant yield when planted under high density, though per hectare yield was highest under High density planting system (5m x 4m spacing). In respect of the Spacing x Variety interaction, among the varieties, Bhaskara and Ullal-3 recorded significantly higher yield (8.49, 8.05) under 10m x 5m spacing, while the lowest yield was recorded by Ullal-1 (2.05).

The data on yield (t/ha) presented in Table 7.2.6 was found to vary significantly among the varieties as well as spacing; however, their interactions were not significant. Among the varieties, Bhaskara and Ullal-3 recorded significantly the higher yield (t/ha) (1.65 and 1.48) than rest of the varieties. When compared to spacing, closer spacing treatments could substantially reduce yield from 1.44 (10m x 5m) to 1.20 (5m x 4m). The performance of cashew varieties 'Bhaskara' (7.90 t/ha) and 'Ullal-3' (7.42 t/ha) were found to be better measured in terms of Cumulative yield (8 years data). Among the different plant densities, density of 500 plants/ha (5 x 4m) with a cumulative yield of 8.86 t/ha is found to be the best (Table 7.2.7).

7.2.3.2 Effect of plant density and varieties on light interception (Leaf Area Index and Light extinction *coefficient*)

Leaf area index did not vary among planting densities at 10 years after planting, though it varied in the previous years. This could be due the reason that the canopies have over grown the allotted space in the high density leading to overlapping with canopies of adjacent canopies resulting in LAI which is on par with normal density. The varietal differences in LAI could be attributed to canopy architecture of each of the varieties which is genetically controlled (Table 7.2.8). Neither the varieties nor the spacing had any influence on K value (light extinction coefficient). It indicates that all the varieties are equally potential in intercepting the light and spacing did not have any influence on light interception of different varieties under trial (Table 7.2.9).

7.2.3.3 Nutrient content of soil and leaf under different plant densities

The soil samples and leaf samples were analysed for nutrient content. The organic carbon content of the soil varied from 0.50 to 0.57 percent (0-30 cm) (medium) and 0.37 to 0.52 percent (31-60 cm) (low to medium), the available nitrogen content of the soil varied from 74.4 to 81.3 kg ha^{-1} (low), the available of P_2O_5 ranged from 19.5 to 25.1 kg ha^{-1} (0-30 cm) and 14.1 to 19.7 kg ha^{-1} (31 to 60 cm), the available K2O content varied from 108.8 to 168.8 kg ha^{-1} (0-30 cm) and 64.6 – 91.1 kg ha^{-1} (31-90 cm). A slight increase in the levels of available N, P_2O_5, K_2O content the soil with high density planting system was obtained due to the increased biomass by falling leaves. No significant variation in the minor and micronutrients content was noted. The build-up of major nutrients in the soil under high density planting system due to higher quantity of litter output per unit area is one of the notable characteristic features of cashew. No significant variation in N, P, K, Ca, Mg, Cu, Zn, Fe and Mn content in the leaf with plant density was noted. Nutrient content in the leaf varied with plant variety. Analysis of soil sample indicated that as plant spacing increases, the soil N availability also increased significantly, but no predictable trend with respect to other parameters, except a noticeable increase in the organic carbon with the decrease in plant density.

Table 7.2.1: Effect of planting density and varieties on plant height (m) (10th year)

Varieties / Treatments-plants/ha	VRI-3	Ullal-3	V4	Bhaskara	Madakka Thara-2	Sel-2	V7	Ullal-1	Dhana	Mean
S1-200	4.33	6.58	5.50	6.33	7.25	4.75	5.92	6.54	5.50	5.86
S2-236	**4.13**	6.96	7.33	6.75	**8.42**	5.54	6.74	6.92	6.50	6.59
S3-384	4.58	7.50	6.00	7.29	8.13	6.46	7.21	6.63	6.79	6.73
S4-500	5.68	6.71	5.46	7.50	8.00	6.17	7.46	7.54	7.60	6.90
Mean	**4.68**	**6.94**	**6.07**	**6.97**	**7.95**	**5.73**	**6.83**	**6.91**	**6.60**	**6.52**
					SEd				CD (0.05)	
	S				0.16				0.39	
	V				0.44				0.88	
	S X V				0.85				NS	

Table 7.2.2: Effect of planting density and varieties on stem girth (cm) (10th year)

Varieties / Treatments-plants/ha	VRI-3	Ullal-3	V4	Bhaskara	Madakka Thara-2	Sel-2	V7	Ullal-1	Dhana	Mean
S1-200	50.83	69.83	60.83	68.83	71.50	59.00	64.00	65.83	70.50	64.57
S2-236	52.67	65.83	57.33	63.17	68.00	57.50	61.33	62.00	72.17	62.22
S3-384	50.67	67.33	56.17	65.83	79.67	58.17	65.83	69.83	69.33	64.76
S4-500	61.00	64.33	54.83	65.50	73.17	61.67	61.67	60.00	64.33	62.94
Mean	**53.79**	**66.83**	**57.29**	**65.83**	**73.08**	**59.08**	**63.21**	**64.42**	**69.08**	**63.63**
					SEd				CD (0.05)	
	S				2.20				NS	
	V				3.30				6.58	
	S X V				6.60				NS	

Table 7.2.3: Effect of planting density and varieties on canopy spread (m) (10th year)

Varieties / Treatments-plants/ha	VRI-3	Ullal-3	V4	Bhaskara	Madakka Thara-2	Sel-2	V7	Ullal-1	Dhana	Mean
S1-200	6.16	7.74	6.78	6.92	6.23	6.62	7.41	7.39	7.14	**6.93**
S2-236	6.58	7.92	7.21	7.89	7.71	6.42	7.1	6.96	**8.35**	**7.35**
S3-384	**5.83**	6.79	7.02	6.94	6.31	6.25	7.31	6.98	6.58	**6.67**
S4-500	6.88	6.79	7.02	6.88	7.02	6.46	7	6.38	6.87	**6.81**
Mean	**6.36**	**7.31**	**7.01**	**7.16**	**6.82**	**6.44**	**7.21**	**6.93**	**7.24**	**6.94**
					SEd				CD (0.05)	
	S				0.23				NS	
	V				0.44				NS	
	S X V				0.87				NS	

Table 7.2.4: Effect of planting density and varieties on the ground coverage by canopy (%) (10th year)

Varieties / Treatments-plants/ha	VRI-3	Ullal-3	V4	Bhaskara	Madakka Thara-2	Sel-2	V7	Ullal-1	Dhana	Mean
S1-200	**59.68**	99.19	72.48	75.51	61.31	71.93	86.98	86.04	80.23	**77.04**
S2-236	81.05	116.94	98.50	118.76	114.08	80.41	95.60	90.71	132.67	**103.19**
S3-384	103.98	139.81	156.17	148.44	120.91	118.34	163.44	147.78	134.80	**137.08**
S4-500	187.28	198.36	190.96	189.32	193.79	166.34	**193.80**	160.78	188.50	**185.46**
Mean	**108.00**	**138.58**	**129.53**	**133.01**	**122.52**	**109.25**	**134.95**	**121.33**	**134.05**	**125.69**
					SEd				CD (0.05)	
	S				7.79				19.06	
	V				16.29				NS	
	S X V				31.70				NS	

Table 7.2.5: Effect of planting density and varieties on yield (kg/tree) (10th year)

Varieties / Treatments-plants/ha	VRI-3	Ullal-3	V4	Bhaskara	Madakka Thara-2	Sel-2	V7	Ullal-1	Dhana	Mean
S1-200	5.45	8.05	7.45	8.49	7.96	6.15	7.87	6.55	6.65	**7.18**
S2-236	4.54	6.14	5.94	7.25	5.98	4.78	5.75	5.79	5.42	**5.73**
S3-384	3.47	4.12	3.75	4.56	4.25	3.54	3.94	3.98	3.86	**3.94**
S4-500	2.25	2.56	2.77	2.90	2.45	2.19	2.24	2.05	2.11	**2.39**
Mean	**3.93**	**5.22**	**4.98**	**5.80**	**5.16**	**4.17**	**4.95**	**4.59**	**4.51**	**4.81**
					SEd				**CD (0.05)**	
	S				0.07				0.17	
	V				0.12				0.24	
	S X V				0.25				0.49	

Table 7.2.6: Effect of planting density and varieties on yield (t/ha) (10th year)

Varieties / Treatments-plants/ha	VRI-3	Ullal-3	V4	Bhaskara	Madakka Thara-2	Sel-2	V7	Ullal-1	Dhana	Mean
S1-200	1.09	1.61	1.49	1.70	1.59	1.23	1.57	1.31	1.33	**1.44**
S2-236	1.07	1.45	1.40	1.71	1.41	1.13	1.36	1.37	1.28	**1.35**
S3-384	1.33	1.58	1.44	1.75	1.63	1.36	1.51	1.53	1.48	**1.51**
S4-500	1.13	1.28	1.39	1.45	1.23	1.10	1.12	1.03	1.06	**1.20**
Mean	**1.15**	**1.48**	**1.43**	**1.65**	**1.47**	**1.20**	**1.39**	**1.31**	**1.29**	**1.37**
					SEd				CD (0.05)	
	S				0.026				0.065	
	V				0.047				0.095	
	S X V				0.094				NS	

Table 7.2.7: Effect of planting density and varieties on cumulative nut yield (t/ha) (2008-2016)

Varieties / Treatments-plants/ha	VRI-3	Ullal-3	V4	Bhaskara	Madakka Thara-2	Sel-2	V7	Ullal-1	Dhana	Mean
S1-200	3.64	5.35	5.12	6.02	5.30	4.36	5.26	5.22	4.47	**4.97**
S2-236	4.26	5.59	6.72	6.05	5.34	4.59	5.18	5.61	5.41	**5.42**
S3-384	7.11	8.31	6.98	9.14	8.13	9.13	8.00	8.10	8.80	**8.19**
S4-500	7.68	10.43	9.25	10.39	8.45	8.72	8.19	8.53	8.15	**8.86**
Mean	**5.67**	**7.42**	**7.02**	**7.90**	**6.81**	**6.70**	**6.66**	**6.86**	**6.71**	**6.86**

Table 7.2.8: Effect of planting density and varieties on Leaf Area Index (LAI)

Varieties / Treatments-plants/ha	VRI-3	Ullal-3	V4	Bhaskara	Madakka Thara-2	Sel-2	V7	Ullal-1	Dhana	Mean
S1-200	1.46	1.36	1.34	1.47	1.75	1.38	1.62	1.36	1.80	**1.50**
S2-236	1.46	1.55	1.52	1.59	1.67	1.54	1.53	1.47	1.48	**1.53**
S3-384	1.46	1.46	1.57	1.70	1.89	1.30	1.73	1.50	1.55	**1.58**
S4-500	1.69	1.53	1.63	1.57	1.65	1.59	1.44	1.58	1.63	**1.59**
Mean	**1.52**	**1.48**	**1.52**	**1.58**	**1.74**	**1.45**	**1.58**	**1.48**	**1.61**	**1.55**
					SEd				CD (0.05)	
	S				0.049				NS	
	V				0.075				**0.115**	
	S X V				0.150				NS	

Table 7.2.9: Effect of planting density and varieties on K (Light extinction coefficient)

Varieties / Treatments-plants/ha	VRI-3	Ullal-3	V4	Bhaskara	Madakka Thara-2	Sel-2	V7	Ullal-1	Dhana	Mean
S1-200	0.88	0.90	0.84	0.94	0.95	0.82	0.89	0.83	0.85	**0.88**
S2-236	0.84	0.94	0.84	0.92	0.91	0.83	0.85	0.83	0.90	**0.87**
S3-384	0.91	0.79	0.87	0.83	0.90	0.82	0.90	0.91	0.93	**0.87**
S4-500	0.84	0.83	0.90	0.86	0.84	0.89	0.81	0.83	0.86	**0.85**
Mean	**0.87**	**0.86**	**0.86**	**0.89**	**0.90**	**0.84**	**0.86**	**0.85**	**0.89**	**0.87**
					SEd				CD (0.05)	
	S				0.013				NS	
	V				0.021				NS	
	S X V				0.043				0.088	

7.2.4 Conclusion

On the basis of results of 10 years experimental study, individual effect of tree density, individual effect of varieties and interaction effect of both recorded during 2007-2016 showed significant results with respect to growth and yield parameters.

- Lower plant density (200 plant ha^{-1}) with different varieties recorded higher yield (kg/tree) than other plant densities in the later years of orchard life.

- However, with respect to cumulative yield, higher density was associated with higher yield. Among the different varieties tried, under lower plant densities revealed that yield per plant in the 8th harvest was higher in Bhaskara (8.49 kg/tree) and Ullal-3 (8.05 kg/tree). But significantly higher cumulative nut yield ha-1 (8.86 t/ha) was observed in high density planting accommodating 500 plant ha^{-1} with Bhaskara (10.39 t/ha) and Ullal-3 (10.43 t/ha) over a period of 8 harvests in cashew under Puttur condition.
- Adoption of High Density Planting System is highly remunerative due to accommodation of more plants per unit area with higher nut yield, provided proper nutrient management; training and pruning operations, plant protection measures and other operations should be done at appropriate time.

7.3 Rootstock studies in cashew

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Project Associate : Dr. M.G. Nayak (2007-17
Dr. D. Kalaivanan (2012-15

Project Number : 2.15

Project Duration : 2007 – 2017

7.2.1 Introduction

Design : Randomized complete Block Design (RBD)

Replication : 3

Treatments : 12

- The rootstocks comprised of dwarf types like NRC 492 and Taliparamba-1 along with control (rootstock V-4).
- The scion varieties comprised of popular cultivars like Ullal-3, VRI-3, NRCC Selection-2 and Vengurla-4 (V-4).

Year of planting : 2008

7.2.2 Objectives

- Screening of rootstocks for dwarfness and to find out the influence of different stionic combinations on growth and yield parameters of popular cashew cultivars.

7.2.3 Results

7.2.3.1 Influence of rootstocks for grafting success in vigorous cashew cultivars

The experiment was initiated with nursery trial in 2007 at Experimental Station of Directorate of Cashew Research (DCR), Puttur, Dakshina Kannnada District, Karnataka, India (12.45°N latitude, 75.4°E longitude and 90 m above MSL). The seeds of rootstock varieties, namely Vengurla-4 (control), NRC 492 (Brazil dwarf) and Taliparamba-1 were sown in nursery bags filled with equal proportion of soil, sand and FYM. Observations on morphological characters of seedlings of less vigorous and vigorous root stock were recorded.

The two month old seedlings of dwarf rootstocks (NRC 492 and Taliparamba-1) were screened for dwarfness based on visual observations for plant height and intermodal length, as the seedlings of dwarf types segregated for plant height. The two month old seedlings from variety V-4 and the dwarf types were used for soft wood grafting (wedge-cleft method) involving scion varieties like Ullal-3, VRI-3, NRCC Selection-2 and Vengurla-4 (V4). There were 12 different stionic combinations involving three types of rootstocks and 4 scion varieties. Grafting was done during July and August months. Grafting success among different stionic combinations were recorded.

The study indicated that all the stionic combinations, except the one which involved Taliparamba-1 as rootstock, recorded nearly cent percent grafting success. The stionic combinations involving Taliparamba-1 as rootstock recorded around 50 % grafting success (Fig 7.3.1). The stionic combination of V-4 on NRC 492, VRI-3

on V-4, NRCC Selection-2 on V-4 and V-4 on V-4 recorded 100 % grafting success. This clearly indicates the suitability of either V-4 or NRC 492 as rootstock in obtaining higher grafting success at nursery stage. This could be because the rootstocks with different genetic makeup may have influence on compatibility of scion materials. About 210 successful grafts obtained from 12 different stionic combinations have been field planted in a replicated trail.

7.2.3.2 Effect of different stionic combinations on growth and yield of cashew

In the field established plants, observations on plant height, girth of stem below (rootstock portion) and above (scion portion) the graft union, internodal length, canopy spread, flowering, non-flowering laterals and yield per plant were recorded. The field performance of different stionic combinations indicated that the influence of rootstocks on growth and yield performance of popular scion cultivars of cashew.

The stomatal density was significantly influenced by stionic combinations (Fig.7.3.2). The various stionic combinations, rootstocks and scion cultivars were compared for stomatal density. Among the stionic combinations, NRCC Selection-2 as well as V-4 grafted on Taliparamba-1 rootstock recorded the highest stomatal density. The combination of Ullal-3 on grafted on NRC 492 rootstock recorded least stomatal density. Among the rootstocks, Taliparamba-1 had highest stomatal density and V-4 had least density of stomata. Among the scion varieties, VRI-3 had highest stomatal density compared to other varieties.

The bark percentage in shoots of field planted cashew varied among different stionic combinations (Fig.7.3.3). The highest bark percentage was associated with the stionic combination of Ullal-3 grafted on V-4. The graft percentage was reduced when Ullal-3 was grafted on either NRC 492 or Taliparamba-1 rootstock. Similarly Taliparamba-1 as a rootstock reduced the bark percentage in scion variety V-4 compared to V-4 grafted on its own root stock. This suggests that the association between bark percentage and tree vigour as well as the role of rootstocks in altering the bark percentage of scion varieties in cashew.

Different stionic combinations did not have any significant effect on canopy spread, girth below and above graft union at 7 year after planting. The plant height, internodal length, flowering and non-flowering laterals was found to vary significantly among the different stionic combinations. The plant height was least (4.60 m) in stionic combination of VRI-3 upon Taliparamba-1 rootstock. The plant height was highest (7.15 m) in stionic combination of Ullal-3 grafted on NRC- 492 rootstock. This indicated that vigour reduction by dwarf rootstocks is variable depending on stionic combination and is not uniform among different stionic combinations. Among different stionic combinations, Taliparamba-1 could reduce the vigour of V-4, VRI-3 and NRCC Selecion-2. No dwarf rootstocks were found to reduce the vigor of vigorous type Ullal-3 (Table 7.3.1).

The stem girth and canopy spread were not significantly affected by different stionic combinations. Among the stionic combinations, Ullal-3 grafted on NRC 492 rootstock recorded highest canopy spread (8.10 m) and least canopy spread (6.26 m) was observed VRI-3 grafted on Taliparamba-1 rootstock. However, stionic combination of NRCC Selection -2 grafted upon Taliparamba-1 rootstock recorded least stem girth below and above the graft union (49.52cm and 41.92cm). The highest stem girth below the graft union was recorded in stionic combination of Ullal-3 grafted on NRC 492 rootstock (68.28 cm and 62.62 cm). The stock: scion ratio ranged from 1.07 (NRCC Sel-2 / NRC-492) to 1.19 (NRCC Sel-2 / Taliparamba-1). The internodal length was least (0.82 cm) in VRI-3/V-4 and highest (1.23 cm) in Ullal-3/ Taliparamba-1 (Table 7.3.1).

The flowering laterals and non-flowering laterals were significantly influenced by different

stionic combination. The stionic combination of VRI-3 grafted on V-4 rootstock recorded highest number of flowering laterals (12.75) followed by VRI-3 grafted on NRC 492 rootstock (10.25). The stionic combinations which involved NRC 492 (dwarf type) as rootstock recorded lesser flowering laterals compared to other rootstocks. The stionic combinations of Ullal-3 grafted on V-4 rootstock recorded highest number (8.17) of non-flowering laterals, closely followed by stionic combinations of Ullal-3 grafted on NRC 492 rootstock (7.92) (Table 7.3.2).

The different stionic combinations significantly influenced the yield of cashew in the fifth harvest. The highest nut yield (4.83 kg/ plant) was associated with a combination of V-4 grafted on NRC 492 and lowest yield was recorded stionic combination of VRI-3 grafted on V-4 (3.11 kg/plant). The stionic combination of VRI-3/ NRC 492 was associated with highest cumulative nut yield (16.77 kg/plant) over 5 harvests (Fig.7.3.4). The yield performance of popular varieties varied based on the rootstocks. This clearly indicates the effect of rootstocks on yield of different in cashew varieties.

7.2.3.2.1 Root growth and distribution pattern

Cashew tree has an extensive root system spread over an area of 300 cm laterals around the tree and 200 cm vertically from the soil surface. The root dry weight of tree during eight year ranged from 6.90 to 3.48 kg. Ninety five percent of cashew roots occur within 100 cm laterally around the plant. The proportion of thick roots and fine roots was 75.28 % and 24.72 %, respectively.

7.2.3.2.2 Vertical distribution of roots

In different rootstocks, root penetration was observed up to 100 cm (Taliparamba-1), 150 cm (Brazil dwarf), 200 cm depth in v-4 and the top 0-50 cm of soil column had nearly 60 percent of the total roots. The root at lower depth from 50-100 cm was ranging from 23.23-38.72 percent of the total roots. Least percentage of total roots was found at depth from 100 cm to150 cm, 150 cm to 200 cm ranging from 3.16-1.29 percent (Fig. 7.3.5).

7.2.3.2.3 Lateral distribution of roots

In the present study, maximum root spread was observed up to 300 cm from the trunk in Vengurla-4 rootstock but beyond this distance there were no roots available. In dwarf rootstocks, more than 80 percent of the roots were found within 100 cm radius from the trunk of the tree. Whereas, Thalibaramba-1 recorded more than 94.25 percent of the total roots were found within 100 cm radius from the trunk of the tree and the remaining 5.75 % occurs in 200-300 cm radius around the trunk. In Brazil dwarf, more than 85 percent of the total roots occurred at 0-100 cm distance of the trunk and the remaining 15 percent occurred at 100-200 cm radius around the trunk. The thick roots were found between 0-100 cm distances from stem and it was 54.10 percent of the total fine roots in trees whereas, medium roots (21.18 %), thin roots (13.02 %) and feeder roots (11.70 %) of total roots (Fig.7.3.6). The root spread study conducted in the present trial indicated that two times increases in the total root production in vigorous rootstock (V-4) increased effective root volume compared to dwarf rootstocks.

7.2.4 Conclusion

Based on the study it can be concluded that these dwarf rootstocks hold promise in reducing the vigour of popular vigorous cultivars of cashew. Utilizing the selected dwarf rootstocks in reducing plant height, leaf area and internodal length, the vigour of scion varieties can be reduced.

- Taliparamba-1 when used as rootstock, it reduced the vigour of cashew varieties viz., V-4, VRI-3 and NRCC Selecion-2 up to 10-20%.
- Among the root stock utilized, NRC 492 showed better results and aisded in realizing higher nut yield from scion cultivars in the initial years of plantation.

Table 7.3.1: Growth parameters in different stionic combinations in cashew (2015-2016)

Stionic combination (scion/rootstock)	Plant height (m)	Canopy spread (m)	Girth below union (cm)	Girth above union (cm)	Stock:scion ratio	Internodal length(cm)
Ullal-3/ V-4	5.94	6.84	55.06	49.75	1.12	0.91
VRI-3/V-4	4.63	6.27	50.33	46.44	1.09	0.82
Sel-2/V-4	4.99	6.88	49.88	46.25	1.08	1.02
V-4/V-4	6.42	7.69	60.47	56.07	1.08	1.16
Ullal-3/ NRC 492	7.15	8.10	68.28	62.62	1.09	1.14
VRI-3/ NRC 492	5.07	7.06	59.14	52.93	1.12	1.16
Sel-2/ NRC 492	5.80	6.71	57.66	53.84	1.07	1.1
V-4/ NRC 492	5.74	6.95	54.53	49.14	1.11	0.93
Ullal-3/ Taliparamba-1	6.18	7.15	56.11	52.22	1.08	1.23
VRI-3/ Taliparamba-1	4.60	6.26	50.00	45.53	1.10	1.05
Sel-2/ Taliparamba-1	4.74	6.52	49.52	41.92	1.19	0.94
V-4/ Taliparamba-1	5.34	6.80	55.88	49.88	1.13	1.2
Mean	5.55	6.93	55.57	50.54	-	1.06
SE(d)	0.503	0.74	6.99	7.27	-	0.044
CD@5%	1.04	NS	NS	NS	-	0.092

Table 7.3.2: Flowering parameters and yield in different stionic combinations in cashew

Stionic combination (scion/rootstock)	FL	NFL	Yield (Kg/plant)	Cumulative yield (5 harvests)
Ullal-3/ V-4	7.50	8.17	3.48	10.46
VRI-3/V-4	12.75	5.42	3.11	11.76
Sel-2/V-4	9.25	7.00	4.79	11.03
V-4/V-4	8.00	6.67	4.68	13.80
Ullal-3/ NRC 492	8.17	7.92	4.49	14.53
VRI-3/ NRC 492	10.25	6.42	4.69	16.77
Sel-2/ NRC 492	7.17	6.03	4.26	12.50
V-4/ NRC 492	9.17	6.17	4.83	13.59
Ullal-3/ Taliparamba-1	7.92	4.00	4.45	13.26
VRI-3/ Taliparamba-1	9.92	6.58	4.66	11.19
Sel-2/ Taliparamba-1	8.75	5.17	3.15	7.84
V-4/ Taliparamba-1	8.38	5.63	4.13	11.74
Mean	8.93	6.26	4.22	
SE(d)	0.719	0.737	0.547	
CD@5%	1.491	1.530	1.135	

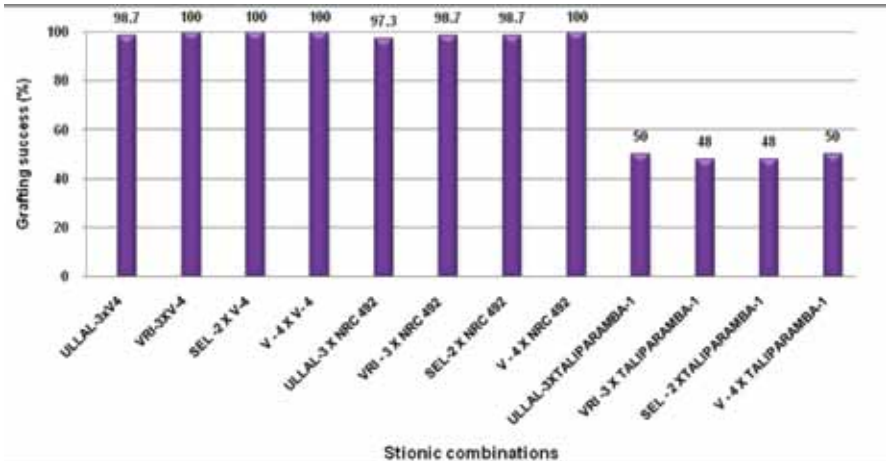

Fig. 7.3.1: Grafting success in various stionic combinations

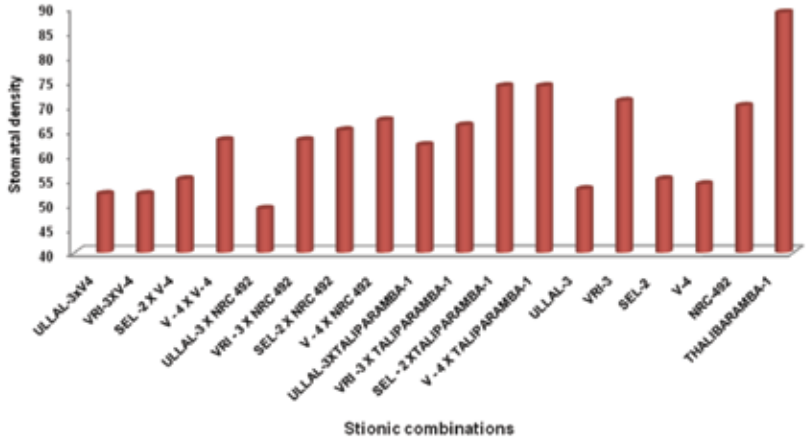

Fig. 7.3.2: Stomatal density in various stionic combinations (including rootstock and varieties)

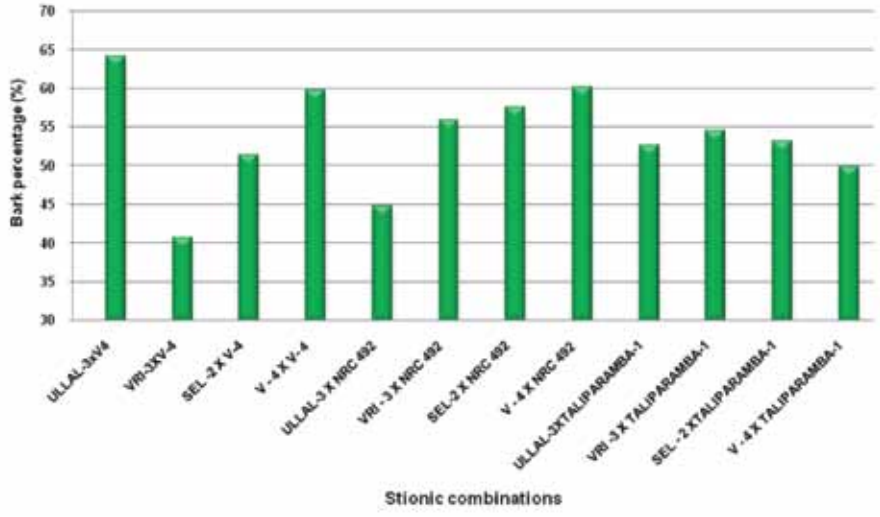

Fig.7.3.3: Bark percentage among different stionic combinations

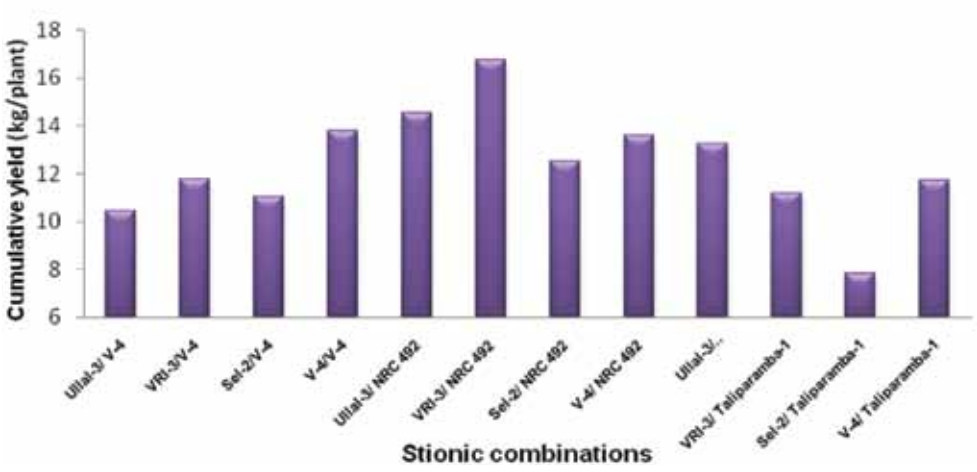

Fig. 7.3.4: Cumulative nut yield (kg/plant) of different stionic combinations

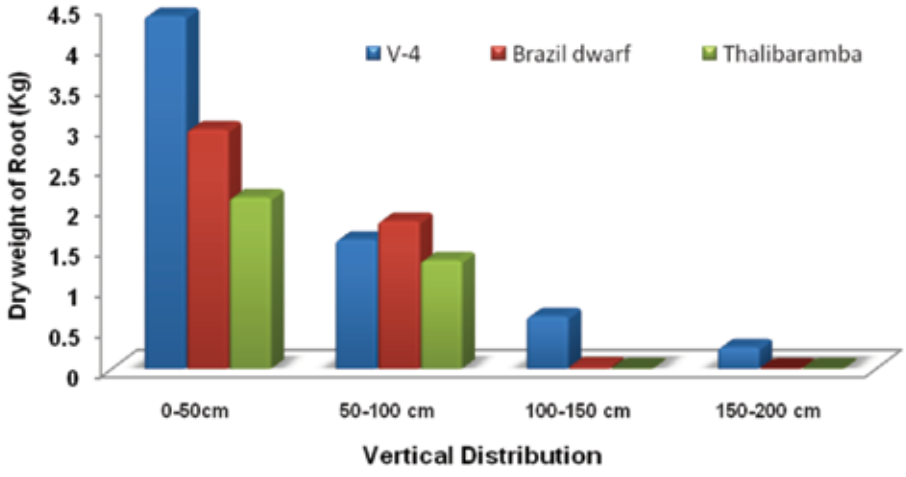

Fig. 7.3.5: Effect of rootstocks on vertical distribution of roots

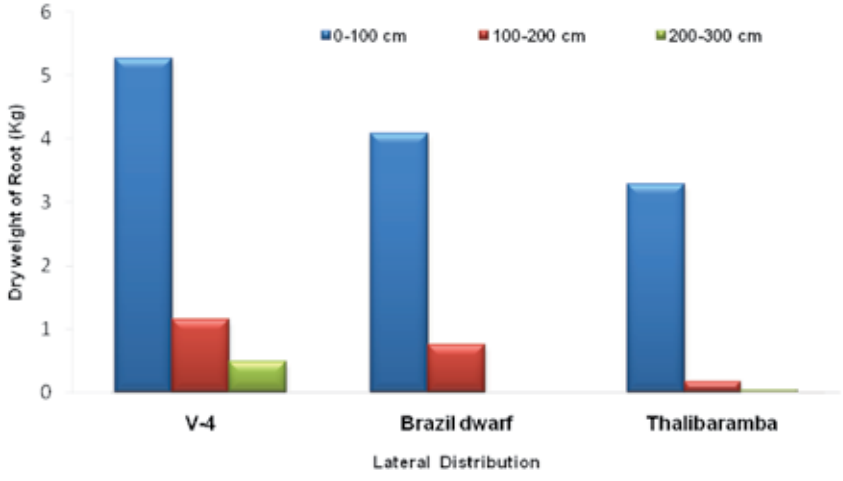

Fig.7.3.6: Effect of rootstocks on lateral distribution of roots

ADDITIONAL INFORMATION

8. LINKAGES / COLLABORATION

Organization	Area of collaboration
ICAR-National Bureau of Agriculturally Important Insects (NBAII), Bengaluru	Identification of kairomones/ pheromones of major pests of cashew.
ICAR-Indian Institute of Horticultural Research (IIHR), Bengaluru	Biosystematics of tea mosquito bug and natural enemies.
University of Agricultural Sciences (UAS), GKVK, Bengaluru	Identification of arthropod fauna associated with cashew.
ICAR-Indian Agricultural Research Institute (IARI), New Delhi	
Directorate of Cashewnut and Cocoa Development (DCCD), Kochi	Training programmes for farmers and frontline demonstrations.
ICAR-Central Institute of Agricultural Engineering, Bhopal	Development of post harvest technology machinery
Department of Horticulture, Karnataka. Horticultural Research Station, Ullal, Mangalore. Zonal Agricultural Research Station, Brahmavar, Udupi district, Karnataka.	Training programmes for farmers and Krishi Melas.
KVK, Mangalore. Achal Industries, Mangalore. UAHS, Shimoga. CPCRI, Kasaragod. KCMA, Mangalore.	Transfer of technology
AICRP-Cashew Centres located in SAUs / ICAR institutes	Multilocational testing, exchange of research findings/germplasm/planting material.
IARI-Indian Type Culture Collection, New Delhi	Identification of plant pathogens
ICAR-Central Plantation Crop Research Institute, Kasaragod, Kerala	Evaluation of EPN species in cashew ecosystem and with
ICAR-NBAIIR, Bengaluru	Identification of the kairomone components and their activity in attracting mated females of CSRB.
ICAR-DMARP	Identification and synthesis of organic components in the whole body extracts (WBE) of virgin females of TMB.

9. TRAINING AND CAPACITY BUILDING

Training programmes attended by Scientist		
Janani, P	Participated in one day training programme on "Application of statistical methods and software for plantation crop research" held at CPCRI, Vittal, Karnataka	20 June, 2016
Janani, P	Participated in winter school training programme on "Designing and analysis of cropping system experiments" held at IASRI, New Delhi,	7-27 September, 2016
Prabha Susan Philip	Attended one day training programme on 'Application of Statistical Methods and Software for Plantation Crops Research' held at CPCRI, Regional Station, Vittal , Karnataka	20 June, 2016
Vanitha, K.	Attendded basic hands-on training on usage of ArcGIS at ICAR-Central Research Institute for Dry land Agriculture, Hyderabad	8 -9 September, 2016
D Balasubramanian	Awareness/ Sensitisation on IPR for MSME held at Indian society of International Law, New Delhi	4 - 5 November, 2016.
Rajkumar A. Dagadkhair	Competency enhancement program for effective implementation of training functions for HRD Nodal Officers held at ICAR-NAARM, Hyderabad	13-15 February, 2017
Training programmes attended by Technical staff		
Bhojappa Gowda	Agrometerological data collection, analysis and management at ICAR - CRIDA, Hyderabad	25 July - 6 August, 2016
Vijay Singh	Advanced Training in Soil Testing, Plant Analysis and water Quality Assessment held at ICAR- IARI, New Delhi.	29 November to 19 December, 2016
P.G. Bhat	Competancy Enhancement Training Program on Motivation and Positive thinking, held at ICAR-NAARM	30 November to 9 December, 2016
R. Arulmony	Regional Training and Awareness Workshop on J-Gate and CeRA by KVAFS University, Bidar at Bengalore	27 January, 2017
Training programmes attended by Administrative staff		
V. Raghuraman	Reservation in post and service at ICAR-NAARM Hyderabad	27-29 April, 2016
	Implementation of NIC's e- procurement solution through CPP portal held at ICAR-IASRI, New Delhi	22-23 March, 2017
O.G. Verghese	Enhancing Efficiency and Behavioural Skills held at ICAR-NAARM Hyderabad	24-30 November, 2016

Training programme organized by ICAR-DCR, Puttur		
Topic	**No. of participants**	**Duration**
Coordinated the training program on "Insect pest management in cashew" for 40 farmers from Punacha cooperative society, Puttur	40	21 February, 2017
Conducted World Soil Day programme in farmers' field (Mundur, Kuriya and Purusharakatte) and demonstrated method of soil sampling	100	5 December, 2016
Awareness cum training programme on PPV & FR at Kadamajalu, Puttur, Karnataka	600	18 March, 2017
Training Programme Cashew Production Technology to the farmers sponsored by KCDC, Mangalore and DCCD, Kochi at ICAR-DCR, Puttur	200	04 March, 2017
Farmers training programme on Cashew Day cum Farmers Fair conducted at ICAR-DCR, Puttur	150	11 March, 2017

Status of Budget (2016-17) for training and capacity building

Allocation : Rs. 2.0 lakhs **Utilization : Rs. 1.35 lakhs**

Budget (Approx.) proposed for training (2017-18): Rs. 2.0 lakhs

10. PUBLICATIONS

9.1 Research Publications

9.1.1 International

Saroj, P. L. and G.S. Mohana, 2016, Cashew Improvement in India: retrospect and prospects. *International Journal of Innovative Horticulture*. 5(1):14-22.

Vanitha, K., Bhat, P.S., Raviprasad, T.N. and Srikumar, K.K. 2016. Biology and behaviour of purple boxer mantis, *Ephestiasula pictipes* (Hymenopodidae: Mantodea) under captive breeding. *International Journal of Pest Management* 62: 4, 308-318.

9.1.2 National

Balasubramanian, 2016. Moisture sorption characteristics of cashew kernels. *Journal of Plantation Crops*. 44(1):38-45.

Eradasappa, E. and Mohana, G.S. 2016. Role of pollination in improving productivity of cashew- A review. *Agricultural Reviews* 37 (1):61-65.

Nitin, K.S., Bhat, P. S., Raviprasad, T.N. and Vanitha, K. 2017. Biology, Behaviour and predatory efficiency of sycanus galbanus distant. (Hemiptera: Reduviidae: Harpactorinae) recorded in Cashew plantations. *Journal of Entomology and Zoology Studies* 2017; 5(2): 524-530.

Nitin, K.S., Bhat, P.S., Raviprasad, T.N. and Vanitha, K. 2017. Biology, behaviour and predatory efficiency of *Sycanus galbanus* Distant. Hemiptera: Reduviidae: Harpactorinae recorded in cashew plantations. *Journal of Entomology and Zoology Studies,* 5(2): 524-530.

Prabha Susan and R K Kaleeswari. 2015. Impact of nutrient management on nutrient uptake and yield in lowland rice. *Agric. Res. J.* 52 (4): 44-47.

Sajeev, M.V. and Meera Manjusha, A.V. 2016, Decline of Cashew (*Anacardium occidentale*) Cultivation in North Kerala: An Analysis of the Impact, its Determinants and Constraints. *Indian Research Journal of Extension Education,* 16(3): 25-32.

Thimmappaiah, Shobha, D., Mohana, G.S., Dinakara Adiga, J. and Bhat, P.G. 2016, Fingerprinting of Released Varieties of Cashew based on DNA Markers, *Vegetos*. 29(4): 89-95.

Thimmappaiah, Shobha, D., Santhosh, W.G., Melwyn, G.S., Mohana, G. S. and Nayak, M. G. 2016. Identification of unique subset of cashew germplasm using DNA marker analysis. *Indian Journal of Biotechnology.* 15: 363-37.

Vanitha, K. and Santhosh Sreevihar. 2016. First report of egg parasitism in Tropical tasar silkworm (*Antheraea mylitta* Drury) occurring on cashew. *Journal of Threatened Taxa.* 8(7):9045-9047.

Vanitha, K., Bhat, P.S., Raviprasad, T.N. and Srikumar, K.K. 2016. Biology and behaviour of purple boxer mantis, *Ephestiasula pictipes* (Hymenopodidae: Mantodea) under captive breeding. *International Journal of Pest Management* 62: 4, 308-318.

Vanitha, K., Javali, U.C. and Bhat, P.S. 2017. Rearing success of tasar silkworm on cashew- Its ecorace, biology and comparative silk properties. *Journal of Applied and Natural Science,* 9 (1): 150 -155.

9.2 Papers presented in Symposia/ Workshops/Seminars

Balasubramanian, 2017. Cashew processing, Value addition and Machinery of Cashew. In. Workshop on Agro-Food-Fruit processing Industries Opportunities conducted by Office of the Joint Director, District Industry Centre, Department of Industry and Commerce, Shivamogga, Karnataka at Shivamogga, Karnataka on 13-15 March, 2017.

Balasubramanian, 2017. Cashewnut Processing in India– An overview. Guest lecture delivered to students of College of Horticulture, Bidar, Karnataka on 21 March, 2017.

Balasubramanian, 2017. Harvest, Collection and Processing of Cashew. In. Seminar on Advanced Cashew Production Technology on Cashew conducted by College of Horticulture, Bidar, Karnataka in association with Directorate of Cashew and Cocoa Development, Cochin, Kerala at Bidar, Karnataka from 20-21 March, 2017.

Balasubramanian, 2017. Status of Cashewnut Processing and Utilization of Cashew apple in India. In. Women Self Help Group Training on Harvest, Protection and Processing of Cashew. conducted by College of Horticulture, Bidar, Karnataka in association with University of Horticultural Sciences, Bagalkot, Karnataka at Bidar, Karnataka on 21 March, 2017.

Balasubramanian, D. 2016. Design development and performance evaluation of drum roasting machine for raw cashewnuts. In. PLACROSYM 22 conducted at ICAR-Central Plantation Crop Research Institute, Kasargod, Kerala from 15 -17 December, 2016.

Balasubramanian, D. 2016. Status and researchable issues for engineering intervention in Cashew. In. Brain Storming Session-cum-Interaction Meet on Engineering Interventions for Production and Processing of Horticultural Crops conducted at ICAR-Central Institute of Agricultural Engineering, Bhopal, Madhya Pradesh on 24-25 October, 2016.

Janani, P., Dinakara Adiga, J. and Nayak, M.G. 2016. Can dwarf rootstocks influence growth and yield of cashew (*Anacardium occidentale* L.)? In: Seventh Indian Horticulture Congress- Doubling Farmers Income through Horticulture, conducted at ICAR-IARI, Pusa, New Delhi during 15 – 18 November, 2016.

Kaleeswari, R.K. and Prabha Susan. 2016. Optimization of elevated CO2 levels and nutrient management for lowland rice ecosystem. Poster Presentation In: International Conference on Contaminated Site Remediation CleanUp India 2016, held at TNAU, Coimbatore during 13-15 December, 2016.

Mohana, G.S. 2016. Deployment of Advanced M Strategy with Heuristic Approach for Developing Core Collection in Cashew (*Anacardium occidentale* L.). In. PLACROSYM -22 at ICAR-CPCRI, Kasaragod, Kerala, during 15-17, December 2016.

Mohana, G.S. Nayak, M.G. and Saroj, P. L. 2016, Cashew germplasm exchange: Problems and Prospects. Poster presentation. In. First International Agrobiodiversity Congress at ICAR-IARI, New Delhi during 6-9 November 2016.

Mohana, G.S., Adiga J.D., Eradasappa, E. and Saroj, P.L. 2016. Current Strategies in Cashew Breeding: Problems and prospects. In. National Conference on Fruit Breeding in Tropics and Subtropics - An Indian Perspective at ICAR- IIHR, Bengaluru during 27-29 April, 2016.

Nayak, M.G. 2016. Enhancement of Cashew Production through Improved Production Technologies. In. Golden Jubilee Conference on Cashew and Cocoa by DCCD, Cochin held at Goa during 6-7 October, 2016.

Raviprasad, T.N. 2016. Pest and disease management in cashew including biological control. In. National Conference on Cashew "Cashew and Cocoa: Production to marketing" conducted by DCCD at Hotel Fidalgo, Panjim, Goa during 7 - 8 November 2016.

Raviprasad, T.N. 2016. Progress report of CRP on Borers- Cashew Stem and Root borers. In the Annual Review Meeting of ICAR Consortia Research Platform on Borers, held at ICAR-IIHR Bengaluru on 06 October 2016.

Sajeev M.V. and P.L. Saroj. 2016. A critical analysis of technology utilisation in cashew pest management in relation to their perceived

attributes and socio-economic determinants in South Karnataka. In. PLACROSYM -22 at ICAR-CPCRI, Kasaragod, Kerala, during 15-17, December 2016.

Saroj, P.L. and Sajeev, M.V. 2016. Technology options for doubling farmers income in cashew cultivation. In: 7th Indian Horticulture Congress, 2016, Souvenir. Horticultural Society of India, New Delhi.

Vanitha, K. and Bhat, P.S. 2016. Life cycle and behaviour of Indian unicorn boxer mantids, a predator in cashew plantations. In: 22nd Biennial Symposium on Plantation crops conducted at ICAR-CPCRI, Kasaragod during 15-17 December, 2016.

Vanitha, K. and Raviprasad, T.N. 2016. Diversity of bees and their pollination service in cashew. In. 22nd Biennial Symposium on Plantation crops, conducted at CPCRI, Kasaragod during 15-17 December, 2016.

9.3 Book Chapters/ Lecture Notes

Balasubramanian D and P L Saroj. 2017. Mechanization in cashew. Eds, A.C Mathew, M R Manikandan and P Chowdappa. In. *Mechanization in Plantation crops.* Westville Publishing House, New Delhi. P:155.

Balasubramanian, D. 2017. Cashewnut Processing as Microenterprise. In Cashew: *Improvement, Production and Processing.* Daya Publishing House. A Division of Astral International Pvt. Ltd., New Delhi, pp. 451-464.

Balasubramanian, D. 2017. Mechanization in India Cashew Processing. In Cashew: *Improvement, Production and Processing.* Daya Publishing House. A Division of Astral International Pvt. Ltd., New Delhi, pp. 433-450.

Balasubramanian, D. and Saroj, P. L. 2017. Cashew Apple Feni. In Cashew: *Improvement, Production and Processing.* Daya Publishing House. A Division of Astral International Pvt. Ltd., New Delhi, pp. 465-480.

Balasubramanian, D. and Saroj, P. L. 2017. Processing of Cashew: International and National Scenario. In Cashew: *Improvement, Production and Processing.* Daya Publishing House. A Division of Astral International Pvt. Ltd., New Delhi, pp. 45-92.

Balasubramanian, D. 2016. Cashewnut Processing-Perspectives and Challenges in India. In *Cashew Production Technology*. Eds. Sreenivasan, N. Pub., Horticultural Research Station, Bidar, Karnataka. pp. 88-97.

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

Bhat, P. S., Raviprasad, T.N., Vanitha, K. and Srikumar, K.K. 2017. Tea Mosquito Bug and its Management in Cashew. In: Cashew-Improvement, Production and Processing. Eds. Saroj, P.L. Daya Publishing House. A Division of Astral International Pvt.Ltd., New Delhi. pp. 347- 366.

Bhat, P.S., Raviprasad, T.N., Vanitha, K. and Srikumar, K.K. 2017. Tea Mosquito Bug and its Management in Cashew: Improvement, Production and Processing. Eds. Saroj, P.L. Daya Publishing House. A Division of Astral International Pvt.Ltd., New Delhi, pp. 347-366.

Bhat, P.S., Vanitha, K., Raviprasad T.N. and Srikumar, K.K. 2016. Arthropod communities in cashew: A perennial reservoir of species assemblages. In: Economic and ecological significance of arthropods in diversified ecosystems-sustaining regulatory mechanisms. Eds. A.K. Chakravarthy and S. Sridhara. Springer Science. pp 299-319.

Bhat, P.S., Vanitha, K., Raviprasad, T.N. and Srikumar, K.K. 2016. Arthropod communities in cashew: A perennial reservoir of species assemblages. In: Economic and ecological significance of arthropods in diversified ecosystems-sustaining regulatory mechanisms. Eds. Chakravarthy, A.K. and Sridhara, S. Springer Science.pp 299-319.

M.G. Nayak & Sajeev M.V. 2016. Enhancement of cashew production through improved production technologies. In: Cashew and Cocoa: Production to marketing. Souvenir of National Conference on Cashew and Cocoa. P: 7.

Malhotra, S.K., Hubballi, V.N. and Nayak, M.G. 2016. Production, Processing and Marketing of Cashew. Published by Directorate of Cashew and Cocoa development, Cochi, Kerala P:150.

Mohana, G.S., Saroj, P.L. and Eradasappa, E. 2017, Genetic Resources in India. In: Cashew: Improvement, Production and Processing. Eds. Saroj, P.L. Daya Publishing House. A Division of Astral International Pvt.Ltd., New Delhi. pp 105-122.

Nayak M G. D.Balasubramaian and M Loganathan. 2017. Cashew Research in India: Current status and Strategies towards sustainability. In: Souvenir. International Symposium on Plantation Crops. Eds Chowdappa, P, Hebbar, K.B. and K. Samsudeen. ICAR-Central Plantation Crop Research Institute, Kasaragod, Kerala. pp.158-169.

Rajkumar A. Dagadkhair. and Saroj, P.L. 2016. Nutritional and Nutraceutical Aspects of Cashew. In: *In Cashew Production Technology.* Eds. Sreenivasan, N. Pub., Horticultural Research Station, Bidar, Karnataka. pp 60-62.

Sajeev M.V. and P.L. Saroj. 2017. Impact Analysis of Production Technologies: Approaches and Outcomes. In: Cashew: Improvement, Production and Processing, Eds. Saroj, P.L. Daya Publishing House. A Division of Astral International Pvt.Ltd., New Delhi. pp. 565-594.

Sajeev M.V. and Saroj. P.L. 2017. Indigenous Technical Knowledge on Cashew. In: Cashew: Improvement, Production and Processing, Eds. Saroj, P.L. Daya Publishing House. A Division of Astral International Pvt.Ltd., New Delhi. pp. 535-550.

Sajeev, M.V. and M.G. Nayak. 2017. Dissemination of Production Technologies: Approaches and Methods. In: Cashew: Improvement, Production and Processing, Eds. Saroj, P.L. Daya Publishing House. A Division of Astral International Pvt.Ltd., New Delhi. pp. 481-494.

Saroj, P.L., Adiga, J.D. and Mohana, G.S. 2017, Crop Improvement and Varietal Wealth. In Cashew: Improvement, Production and Processing. Eds. Saroj, P.L. Daya Publishing House. A Division of Astral International Pvt. Ltd., New Delhi. pp.123-148.

Srikumar, K.K., Bhat, P.S., Raviprasad, T.N. and Saroj, P.L. 2017. Climate Change and Cashew Pests in Cashew: Improvement, Production and Processing. Eds. Saroj, P.L. Daya Publishing House. A Division of Astral International Pvt. Ltd., New Delhi. pp 595-624.

Srikumar,K.K., Bhat, P.S., Raviprasad,T.N., Rajmohana, K. and Vanitha, K. 2016. Studies on Egg Parasitoids of *Helopeltis* spp. (Hemiptera: Miridae. In: Biopestides: Innovations and Practices. Eds. Sahayaraj and Selvaraj. First edition. Smith and Franklin. Pp 158- 165.

Vanitha, K., Bhat, P.S., Raviprasad T.N. and Sundararaju, D. 2017. Minor Pests and their Management in Cashew: Improvement, Production and Processing Eds. Saroj, P.L. Daya Publishing House. A Division of Astral International Pvt.Ltd., New Delhi. pp. 377-394.

Vanitha, K., Bhat,P.S., Raviprasad, T.N. and Sundararaju,D. 2017. Minor Pests and their Management. In.: Cashew-Improvement, Production and Processing. Eds. Saroj, P.L. Daya Publishing House. A Division of Astral International Pvt. Ltd., New Delhi. pp 377-394.

9.4 Technical Reports / Compendia

Annual Report, 2015-16. ICAR-Directorate of Cashew Research, Puttur, p. 138 (Ed: M.Loganathan).

Annual Report, 2015-16. All India Co-ordinated

Research Project on Cashew. ICAR-Directorate of Cashew Research, Puttur, p. 213 (Ed: Mohana, G.S.).

Cashew News, 2016. ICAR-Directorate of Cashew Research, Puttur, Vol. 21 (1), p. 12 (Ed: M.V. Sajeev).

Cashew News, 2016. ICAR-Directorate of Cashew Research, Puttur, Vol. 21 (2), p. 12 (Ed: M.V. Sajeev).

9.5 Extension Bulletins / Pamphlets

Balasubramanian, 2016. Post Harvest Technologies for Commercialization. Published by Director, ICAR-Directorate of Cashew Research, Puttur, Dakshina Kannada, Karnataka. DCR - Leaflet. P: 4.

Mohana, G.S. and Nayak, M.G., 2017, Improved varieties of Cashew for Karnataka (in Kannada) Leaflet. Published by Director, ICAR-Directorate of Cashew Research, Puttur , Dakshina Kannada, Karnataka. DCR Leaflet.P:4.

Nayak, M.G. and Sajeev, M.V. 2017. 'Sudharitha Geru Besaya' (Kannada), Published by by Director, ICAR-Directorate of Cashew Research, Puttur, Dakshina Kannada, ICAR-DCR Extension Bulletin. P: 6.

Nayak, M.G. Raviprasad, T.N., Prabha Susan and Sajeev, M.V. 2017.Cashew cultivation practices. Published by by Director, ICAR-Directorate of Cashew Research, Puttur, Dakshina Kannada, ICAR – DCR Extension Bulletin, P:8.

Nayak, M.G., Bhat, P.S.and Raviprasad T.N. 2017. Geru maragala punahschetana taantrikategalu. Rejuvenation techniques for cashew. (in Kannada). Published by by Director, ICAR-Directorate of Cashew Research, Puttur, Dakshina Kannada, ICAR – DCR Extension Bulletin, P:6.

Nayak, M.G., Raviprasad, T.N., Prabha Susan and Sajeev, M.V. 2017. Cashew Cultivation Practices (English). Published by by Director, ICAR-Directorate of Cashew Research, Puttur, Dakshina Kannada, ICAR – DCR Extension Bulletin, P:8.

Raviprasad, T. N. 2016.. Geru kaanda haagu beru koraka – gerina ondu pramukha keeta. Cashew stem and root borers – a major pest of cashew (in Kannada). Published by by Director, ICAR-Directorate of Cashew Research, Puttur, Dakshina Kannada, ICAR – DCR Extension Bulletin, P:6.

9.6 Technical / Popular Articles

Mohana, G.S. Nayak, M.G. and Saroj, P.L. 2016, Cashew germplasm exchange: Problems and Prospects. Proceedings of the First International Agrobiodiversity Congress 6-9 November 2016, New Delhi, India. p 272.

Mohana, G.S., Adiga J.D., Eradasappa, E. and Saroj, P.L. 2016, Current Strategies in Cashew Breeding: Problems and prospects. Proceedings of the National Conference on Fruit Breeding in Tropics and Subtropics – An Indian Perspective, 27-29 April, 2016.,ICAR-IIHR, Bangalore. p 158.

Mohana, G.S., Nayak, M.G. and P.L. Saroj, 2016, Deployment of Advanced M Strategy with Heuristic Approach for Developing Core Collection in Cashew (*Anacardium occidentale* L.) Proceedigns of the 22nd Plantation Crop Symposium, 15-17, December 2016, at CPCRI, Kasaragod, Kerala. P. 37

Rajkumar A. Dagadkhair and Sajeev, M.V. 2016. Cashew apple lime blend RTS: A functional beverage In: Cashew News, 21(1). pp 3-5.

Sajeev M.V. and M.G. Nayak. 2016. Impact of Frontline Demonstrations (FLD) in Cashew. In. Cashew News, 21(2). p: 3.

11. राजभाषा कार्यान्वयन एवं प्रगति

राजभाषा कार्यान्वयन समिति

1.	प्रो. पी.एल. सरोज	अध्यक्ष (31.09.16 तक)
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 निदेशालय में निदेशक महोदय की अध्यक्षता में गठित राजभाषा कार्यान्वयन समिति की बैठक नियमित रूप से आयोजित की जा रही है। इस बैठक को हर तिमाही में एक बार आयोजन की जा रही है।

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

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

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

राजभाषा के प्रति जागरुकता पैदा कराने हेतु राजभाषा विभाग की ओर से जारी किए गए वार्षिक कार्यक्रम के अनुसार इस निदेशालय में 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 पखवाडा के समापन समारोह में पुरस्कार भी वितरण किया गया है। इसके अतिरिक्त सरकारी काम काज में हिंदी का अधिकाधिक प्रयोग करनेवाले अधिकारियों एवं कर्मचारियों को इस अवसर पर मुख्य अतिथि द्वारा प्रोत्साहन योजना के अधीन नकद पुरस्कार वितरण किया गया है।

इस वर्ष हिन्दी पखवाडा समापन समारोह के अवसर पर श्रीमती नागरत्ना, प्राध्यापिका, हिन्दी विभाग, युनिवर्सिटी कालेज, मंगलुरु, मुख्य अतिथि के रूप में उपस्थित थी । डॉ आनंद, प्रधान, सी पी सी आर आई प्रादेशिक केन्द्र, विट्टल विशेष अतिथि थे।

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

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

वेबसाइट का प्रदर्शन :

निदेशालय की वेबसाइट संपूर्ण द्विभाषा में प्रदर्शित करने के लिए कोशिश जारी है। राजभाषा से संबंधित सभी गतिविधियों का विवरण वेबसाइट पर दिया जाता है।

हिंदी कार्यशाला

सरकारी काम काज में हिंदी का प्रयोग बढ़ाने एवं हिंदी कार्य का उपयोगी ज्ञान प्राप्त कराने हेतु निदेशालय में कुल चार कार्यशालाओं को आयोजन किया जा रहा है। इस वर्ष भी अनुभवी मार्गदर्शकों की मार्गदर्शन में मसौदा लेखन, टिप्पण, अनुवाद एवं राजभाषा नियम, अधिनियम पर हिंदी कार्यशाला आयोजित की गई और उन्हें अभ्यास भी कराया गया है।

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

पुत्तूर नगर राजभाषा कार्यान्वयन समिति

पुत्तूर नगर और आस पास के केन्द्र सरकारी कार्यलयों में राजभाषा हिन्दी का कार्यान्वयन सुनिश्चित करने की दृष्टी से पुत्तूर और विट्टल में स्थित केंद्रीय सरकार के कार्यालय, उपक्रम, बैंक सहित 22 सदस्य कार्यालय सम्मिलित नगर राजभाषा कार्यान्वयन समिति (नराकास) का घटन किया गया है। पुत्तूर नराकास की 29वीं और 30वीं अर्धवीर्षिक बैठक दिनांक 26.07.2016 को और दिनांक 27.01.2017 को निदेशक महोदय की अध्यक्षता में आयोजित की गई।

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

निदेशालय में निम्नलिखित रिपोर्ट हिंदी में प्रकाशित किया गए:

1. निदेशालय का वार्षिक प्रतिवेदन (वर्ष 2015-16) पूर्ण रूप से हिंदी में।
2. अखिल भारतीय समन्वित काजू अनुसंधान परियोजना की वार्षिक प्रतिवेदन सारांश (वर्ष 2015-16)।
3. काजू समाचार में हिंदी समिती की गतिविधियों के बारे में प्रतिवेदन।
4. दैनंदिन प्रयोग में आने वाले प्रपत्रों का हिंदी रूपान्तरण।

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

12. AWARDS / RECOGNITIONS

Individual/Team

Awards

Mohana, G.S, Senior Sciuentist (Genetics and Cytogenetics) and M G nayak, Principal Scientist (Horticulture) were awarded Peerless oral presentation during the National Conference on Fruit Breeding in Tropics and Subtropics – An Indian Persepective held ta ICAR- IIHR, Bengaluru during 27-29 April, 2016.

Mohana, G.S, Senior Sciuentist (Genetics and Cytogenetics) bagged the Best Poster presentation award - First International Agrobiodiversity Congress – Sceince - Technology, Policy and Partnership during 6-9 November 2016.

Recognitions

Nayak, M. G, Director (Acting) was honoured by the **Durga Parameshwari temple,** Mugeru, Katukakke Post, Kasaragod district during temple festival on 14 March 2016 in recognition of his services rendered to the cashew growers.

13. RAC / IMC / IRC / IJSC MEETINGS

12.1 Research Advisory Committee (RAC)

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, R.T. Nagar, PO Bangalore-560 032	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. W.S. Dhillon, ADG (H-I), ICAR, KAB-II, Pusa, New Delhi-110 012	Member
Shri. Vishnu Vasanth Bhandarakara, Post- Karki, Honnavara Taluk, Uttara Kannada district	Non-Official Member
Sharada R. Rai, Shreya, Mogarodi, Kaniyooru post , Belthangadi Taluk, Dakshina Kannada district	Non-Official Member
Dr .G.S. Mohana, Member Secretary, Sr. Scientist, Directorate of Cashew Research, Puttur	Member Secretary

The second meeting of 7th RAC was held during 30th September to 1st October, 2016. Progress of research work at this Directorate was presented the scientists under major programmes operated at this Directorate viz., Crop Improvement, Crop Management, Crop Protection and Post Harvest Technology during these two days. The RAC appreciated the efforts of scientists in various experiments and suggested specific points to improve the quality of research. Further, the committee encouraged the scientists to take necessary steps to implement research programmes through ICAR Extramural Research Project Funding and suggested to publish their research findings in International journals for peeer recognition. Supporting the concept of community clonal banks in cashew, committee also suggested obtaining IPRs for cashew varieties/hybrids through PPV-FRA. Besides, it also recommended that the Scientists of ICAR-DCR should be deputed to cashew research institutes in other cashew growing countries such as Brazil, Australia and African countries for scientific exposure and germplasm collection. The RAC committee visited the demonstration plot of cashew varieties, cashew field gene bank, showcasing block and cashew apple experiments of ICAR-DCR.

RAC Meeting in progress

RAC Meeting in progress

Visit of RAC Members to cashew nursery of DCR

Visit of RAC Members to experimental field

12.2 Institute Management Committee

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

45th IMC meeting of this Directorate was held on 29th November 2016. During the meeting, nine members were replaced by the Council and the term of the new members commenced from August 2016 to August 2019. The proceedings of the 45th IMC was forwarded to council for approval and all the recommendations of the IMC were approved. No adverse remarks have been made by the council.

Progress of IMC meeting

12.3 Institute Research Committee

The 29th annual meeting of Institute Research Committee (IRC) of ICAR-DCR, Puttur was held on 13th and 14th October, 2016 under the Chairmanship of Dr. M.G. Nayak, Director (Acting). There were five technical sessions chaired by experts of the respective field. Dr. R. Desai, Senior Scientist (Fruit Science), ICAR-Central Coastal Agricultural Research Institute, Goa served as resource person for the technical session on "Crop Improvement". Dr. N. Yadukumar, Former Principal Scientist (Agronomy), ICAR-DCR, Puttur was the resource person for 'Crop Management' and 'Transfer of Technology' sessions. Session on "Crop Protection" was dealt by Dr.T.Shivashankar Dean, College of Agriculture, Mandya (UAS, Bengaluru) and Dr. Hebbar, K.B., Principal Scientist, Head (Plant Physiology, Biochemistry & Post Harvest Technology), ICAR-Central Plantation Crops Research Institute, Kasaragod, Keralserved as the resource person for the technical session on "Post Harvest Technology". In each session, the results of various ongoing projects and two new project proposals were presented by scientists of this Research Directorate and deliberated to finalize the technical programme of all the on going research projects for the year 2017-18.

IRC meeting in progress

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.	Dr. M.G. Nayak	Chairman, IJSC
2.	Dr. M. Loganathan	Member (Official side)
3.	Sri. P. Abdulla	Member (Official side)
4.	Sri. V. Raghuraman	Member (Official side)
5.	Sri. R. Arulmony	Member (Official side)
6.	Sri. Rajkumar Arjun Dagadkhair	Secretary (Official side)
7.	Smt. Leela, M.	Member (Staff side)
8.	Smt. Reshma, K.	Member (Staff side)
9.	Sri. Ravishankar Prasad	Member (Staff side)
10.	Sri. K. Babu Poojary	Member (Staff side)
11.	Sri. K. Gopalakrishna	Member (Staff side)
12.	Sri. T. Padmanabha	Member (Staff side)

IJSC meetings were held at quarterly intervals during the year at this Directorate to discuss on issues for the welfare of staff. The tenure of IX IJSC was completed on 28th February, 2017 and X IJSC was constituted which is functioning since 01.03.2017.

ANNEXURES

Annexure - I

Ongoing Research Projects/Experiments

Sl. No.	Project	PI	Co-PI
Crop Improvement			
1	1.1. Collection, conservation, evaluation and documentation of cashew germplasm [1986 – Long term]	MG Nayak	Mohana, G.S. and Vanitha, K.
2	1.2. Genetic improvement of cashew for yield and quality traits [1986 – Long term]	Mohana GS	Nayak, M.G., P.L. Saroj and Rajkumar, A.D
3	1.2.1. Development of dwarf and compact cashew hybrids suitable for high density planting [2013 – 2023]	Mohana GS	Janani, P.
4	1.8. Genetic analysis of mapping population through molecular markers for important traits in cashew [2012 – 2018]	Mohana GS	Nayak, M.G.
5	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.
6	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
7	1.11 Identification and evaluation of cashew genotypes for Cashew Nut Shell Liquid content [2016-2024]	Mohana GS	Nayak, M.G. and Balasubramanian, D.
8	Development of morphological descriptors and DUS test guidelines for cashew (PPV & FRA) [2015-2018]	Nayak MG	Mohana, G.S. and Saroj, P.L.
9	CRP on Agro biodiversity [2015-2017]	Mohana GS	-
Crop Management			
1	2.11. Performance of high yielding varieties of cashew in different high density planting system [2006 – 2015]	P Janani	Babli Mog
2	2.15. Rootstock studies in cashew [2007 - 2016]	P Janani	Nayak, M.G.
3	2.18. Effect of Paclobutrazol (PBZ) on growth and yield of cashew [2009 – 2016]	Babli Mog	Janani, P. and Nayak, M.G.
4	2.19. Irrigation requirement for cashew under high density planting system. [2011 – 2015]	Prabha Susan Philip	Babli Mog

5	2.20.	Organic farming in cashew [2011 – 2016]	Prabha Susan Philip	Raviprasad, T.N.
6	2.21.	Establishment of nutrient diagnostic norms in cashew [2013-2018]	Prabha Susan Philip	Nayak, M.G.
7	2.22.	Characterization of physiological responses of cashew to salt and drought stresses [2015-2017]	Babli Mog	Prabha Susan Philip
8		Net work project Micronutrient Management in Horticultural Crops for Enhancing Yield and Quality – Cashew [2014-2017]	Prabha Susan Philip	-
9	2.23	Development of cashew based cropping system under rain fed condition of Karnataka [2016- 2019]	P Janani	Prabha Susan Philip
Crop Protection				
1	3.17.	Bio-diversity of arthropod fauna in cashew eco-system [2010- 2015]	K. Vanitha	Raviprasad, T.N.
2	3.19a and 3.19b were merged into 3.19 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]	T.N. Raviprasad	Vanitha, K. and Rajkumar (CPCRI, Kasargod)
3	3.21.	Diversity and bio-ecology of insect pollinators and their efficiency in increasing yield of cashew [2014-2019]	K. Vanitha	Raviprasad, T.N.
4	3.6	Survey and surveillance of important diseases of cashew [2015-2020]	Loganathan M.	Raviprasad, T.N.
5		Flag ship project Investigations on semio-chemicals for management of TMB and CSRB [2014-2019]	T.N. Raviprasad	Vanitha, K. and Bhaktavatsalam, N. (NBAIR, Bengaluru)
6		Net work project ORP on Management of sucking pests in Horticultural Crops (Network Project -ICAR funded through IIHR, Bangalore) [2012-2017]	T.N. Raviprasad	Vanitha, K.
7		CRP on Borers [2014-2019]	TN Raviprasad	-
8		New Project proposal: Evaluation of newer molecules for their efficacy against Tea Mosquito Bug (TMB) and Cashew Stem and Root Borers (CSRB)	T.N. Raviprasad	Vanitha, K.
9		New Project proposal: Investigations on inflorescence pests of cashew and their management	K. Vanitha	Raviprasad, T.N.

Post Harvest Technology				
1	4.15.	Design, development and evaluation of solar tunnel dryer for cashew apple [2012-16]	D. Balasubramanian	D Rajkumar Arjun Dagadkhair
2	4.16.	Developing quality standards for raw cashew nuts [2014-17]	D. Balasubramanian	
3	4.17.	Design and development of mechanical slicer for cashew apple [2014-17]	D. Balasubramanian	Vanitha, K.
4	4.18.	Reduction of tannins from cashew apple juice by using low cost food grade materials [2014-2017]	Rajkumar Arjun D.	Janani, P.
5	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				
1	5.1.	Transfer of Technology programmes in Cashew [1986 – Long term]	Sajeev M.V.	Nayak, M.G. and Balasubramanian, D.
2	5.2.	Impact of cashew production technologies on area, production and productivity of cashew [2011 – 2015]	Sajeev M.V.	Mohana, G.S.

Annexure -II

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

Balasubramanian, D.	Seminar on Advanced Cashew Production Technology on Cashew conducted by College of Horticulture, Bidar, Karnataka in association with Directorate of Cashew and Cocoa Development, Cochin, Kerala at Bidar, Karnataka.	20 March, 2017
Balasubramanian, D.	Seminar on Harvest, Protection and Processing of Cashew conducted by College of Horticulture, Bidar, Karnataka in association with University of Horticultural Sciences, Bagalkot, Karnataka at Bidar, Karnataka.	21 March, 2017
Balasubramanian, D.	Seminar on Agro-Food-Fruit processing Industries Opportunities conducted by Office of the Joint Director, District Industry Centre, Department of Industry and Commerce, Shivamogga, Karnataka at Shivamogga, Karnataka.	13-15 March, 2017
Balasubramanian, D. Nayak, M.G., Mohana G.S., Sajeev, M.V. and Vanitha K.	International Symposium on Plantation Crops (PLACROSYM XXII) conducted at ICAR-Central Plantation Crop Research Institute, Kasargod, Kerala.	15 -17 December, 2016
Balasubramanian, D and Nayak, M.G.	Brain Storming Session-cum-Interaction Meet on Engineering Interventions for Production and Processing of Horticultural Crops conducted at ICAR-Central Institute of Agricultural Engineering, Bhopal, Madhya Pradesh.	24-25 October, 2016
Nayak, M.G.	National Conference on Cashew and Cocoa – Production, Processing and Marketing of Cashew at Panaji, Goa	6-8 October, 2016
Nayak, M.G.	Sixth Indian Horticultural Science Congress organized at ICAR-IARI, New Delhi.	16-18 November, 2016
Nayak, M.G., Mohana G.S., and Loganathan M.	Annual Group Meeting of AICRP on Cashew at RRS Vridhachalam, Tamilnadu	27-29th December 2016
Nayak, M.G.	ISOCRAD organized by ICAR-CPCRI, Kasaragod on the occasion of Centenary Celebration of CPCRI, Kasaragod, Kerala.	10 December 2016
Nayak, M.G.	Vana Mahotsava programme organized by St. Bethany High School, Panglai, Darbe, Puttur, Karnataka.	1 July 2016
Nayak, M.G	Krishi Mela of ZARS, Brahmavar (University of Agril. & Horticulture), Shimogga, Karnataka	15 October 2016

Nayak, M.G.	Farmers seminar organized by SKDRDP, Dharmasthala at 'Kunjoor Panja' in Puttur taluk, Karnataka	16 October 2016
Nayak, M.G.	Regional Committee Meeting Zone VIII , New Delhi.	11 - 12 November, 2016
Nayak, M.G.	Meeting for the assessment of status of germplasm of horticultural crops held at NBPGR, New Delhi.	19 November, 2016
Nayak, M.G.	State Science Academy Annual Meet organized at Sudhana Residential School, Puttur, Karnataka	5 November, 2016
Nayak, M.G.	Karnataka State Co-ordination meeting on doubling of farmers income at UAS, Bangalore.	21 March, 2017
Nayak, M.G.	Meeting organized at Mangalore by CEPCI, Kollam for the improvement of cashew production in Karnataka	17 March, 2017
Nayak, M.G.	Meeting called by Principal Secretary, Cashew, Fisheries and Harbour Development, Govt. of Kerala for the improvement of rawnut production in Kerala.	10 February, 2017
Nayak, M.G.	Science forum day in the Department of Applied Botany, Mangalore University, Dakshina Kannada, Karnataka.	27 March, 2017
Nayak, M.G.	'Cashew Day' at Ullal Horticulture Station and delivered lecture on cashew cultivation.	11 February, 2017
Nayak, M.G.	Cashew Fair organized by Tumari Cashew Farmers Association.	7 March, 2017
Vanitha, K.	3rd National meet of Entomologists conducted at ICAR-IIHR, Bengaluru.	7-8 October, 2016
Vanitha, K.	3rd National Meet of Entomologists held at ICAR-IIHR, Bengaluru.	7-8 October, 2016
Mohana, G.S.	Training program on cultivation of cashew at ICAR- KVK, Bahmavar, Karnataka.	1 June, 2016
Mohana, G.S.	National Conference on Fruit Breeding in Tropics and Subtropics - An Indian Perspective, at ICAR-IIHR, Bengaluru.	27-29 April, 2016
Mohana, G.S.	First International Agrobiodiveristy Conference at New Delhi.	6-9 November, 2016
Mohana, G.S.	All India Coordinated Research Project on Cashew - Annual Workshop at RRS, Vridhachalam, Tamilnadu.	27-29 December, 2016
Rajkumar A. Dagadkhair	International Conference on Nutraceuticals and Functional Foods- The Challenges and Opportunities. Conducted at Anand Agricultural University, Anand, Gujarat	6-8 December, 2016

Raviprasad, T.N.	National Seminar on "Plantation based cropping system for improving livelihood security". ICAR-CPCRI, Kasaragodu, Kerala.	22-23 July, 2016
Raviprasad, T.N.	National Conference on Cashew "Cashew and Cocoa: Production to marketing" – Hotel Fidalgo, Panjim, Goa.	7 - 8 November, 2016
Raviprasad, T.N.	Annual Review Meeting of ICAR Consortia Research Platform on Borers, held at ICAR-Indian Institute of Horticultural Research, Hessaraghatta Lake Post. Bengaluru.	6 October, 2016
Raviprasad, T.N.	3rd National Meet of Entomologists, held at ICAR-National Bureau of Agriculturally Important Insects, Bengaluru.	7 - 8 November, 2016

Farmers' Day/Krishi Mela/Exhibitions/Campaigns

Name of Scientific/ Technical Personnel	Programme	Date
Sajeev, M.V. Nayak, M.G., Prabha Susan Philip, Bhojappa Gowda, M. and Raghuram Kukude	DCR Foundation Day and Innovative Cashew Farmers Meeting, DCR, Puttur, Karnataka	18 June 2016
	Krishi Mela at UAHS, Shivamogga, Karnataka	21 - 24 October, 2016
	Centenary Expo, ICAR-CPCRI, Kasaragod, Kerala	10 -13 December, 2016
	Cashew Day, DCR, Puttur, Karnataka	11 March, 2017

Annexure -III

Radio Talk / TV Programme

Nayak, M.G.	Delivered a TV interview on recent advances in cashew cultivation on DD1 channel and Chandana TV in Kannada	15 October 2016
Nayak, M.G.	Delivered a talk on recent cashew research cultivation by AIR, Mangalore.	6 December 2016
Nayak, M.G.	Delivered a talk on cashew research and achievements in cultivation practices broadcast by FM radio – Raida. Panchagauya, Puttur, D.K., and Manipal Radio network	16 March 2017

Annexure - IV

Services offered to farmers

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

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. V. Nache Gowda	Dean, College of Horticulture Kolar, Karnataka	2-5-2016
Dr. K.L. Chadha	DDG (Hort.), Rtd. ICAR, New Delhi	18-6-2016
Dr. G.S. Rathod	Dr. G.S. Rathod, Former ADG (ICAR) and Chaudhry Sarwan Kumar Himachal Pradesh Agricultural University, Palampur	4-11-2016
Dr. Ranveer Singh	Principal Scientist, (HS) Divsion, ICAR, New Delhi	29-11-2016
Dr. Mahabaleshwar Hegde	Professor, College of Horticulture, Hassan District, Karnataka	29-11-2016
Dr. D.V.S. Reddy	Principla Scientist, ICAR-Agricultural Technology Application Research Institute, Bangalore	29-11-2016
Dr. K. Bhanu Prakash	Principal Scientist, ICAR-IIHR, Bangalore	29-11-2016
Dr. N. Vijaya Kumari	Principal Scientist, ICAR-CCRI, Nagpur	29-11-2016
Dr. Ravi Bhatt	Head, Crop Production, ICAR-CPCRI, Kasaragod, Kerala.	29-11-2016
Smt. Sharada R. Rai	Non-official Member, IMC, ICAR-DCR, Puttur	29-11-2016
Dr. P. Das	Former DDG (Agri. Extn.), ICAR, New Delhi	4-12-2016
Dr. Trilochan Mohapatra	Secretary DARE & DG, ICAR, New Delhi	11-12-2016
Mr. Gurunath R. Odugoudar Hulkoti	Univ. of Agril. Sciences, Dharwad, Karnataka	24-12-2016
Dr. J.C. Katyal	Former DDG (Education), & Director NAARM, Hyderabad	26-1-2017
Haj B.H. Khader	Chairman, Karnataka Cashew Development Corporation	26-1-2017

Annexure -VI

Personnel

Staff Position as on 31.3.2017

Category	Sanctioned	Filled	Vacant
Director (RMP)	1	-	
Scientific	17	11	6
Technical	19	14	5
Administrative	15	9	6
Canteen staff	1	1	-
Skilled Support Staff	38	24	14
Total	**91**	**59**	**32**

Research Management Position

1. Prof. P.L.Saroj	Director (upto 1.10.2016)
2. Dr. M. Gangadhara Nayak	Director (Acting) from 1.10.2016 (AN)
Scientific	
1. Dr. T.N. Raviprasad	Principal Scientist(Agricultural Entomology)
2. Dr. D. Balasubramanian	Principal Scientist (Agricultural Structures and Processing Engineering)
3. Dr. J. Dinakara Adiga	Principal Scientist (Horticulture)
4. Dr. M. Loganathan	Senior Scientist (Plant Pathology) (up to 8.3.2017 – Transferred to ICAR-NRC on Banana, Trichirappalli, Tamilnadu)
5. Dr. Mohana G.S.	Senior Scientist (Genetics & Cytogentics)
6. Dr. Sajeev M.V.	Scientist (Agricultural Extension) (up to 16.3.2017– Transferred to ICAR – Central Institute of Fisheries Technology, Kozhikode, Kerala)
7. Sri Eradasappa E	Scientist (Plant Breeding) (on Study Leave)
8. Dr. (Mrs.) K. Vanitha	Scientist (Agricultural Entomology)
9. Sri. Rajkumar Arjun Dagadkhair	Scientist (Food Technology)
10. Dr. Babli Mog	Scientist (Plant Physiology)
11. Dr. Janani P	Scientist (Spices, Plantation, Medicinal and Aromatic Plants)
12. 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	Asst. Chief Technical Officer (Superannuated on 30.4.2016)
6	Sri. N. Manikandan	Sr. Technical Officer
7	Sri. Raghurama Kukude	Sr. Technical Officer
8	Sri. K.V. Ramesh Babu	Sr. Technical Officer
9	Sri. R. Muthuraju	Sr. Technical Officer
10	Sri. K. Seetharama	Technical Officer
11	Sri. M. Bhojappa Gowda	Technical Officer
12	Sri. Vijay Singh	Sr. Technical Assistant
13	Sri. Ravishankar Prasad	Sr. Technical Assistant
14	Sri. K. Babu Poojari	Sr. Technical Assistant
15	Sri. Honnappa Naik P.	Sr. Technician

Administration

1	Sri. V. Raghuraman	Administrative Officer
2	Sri. K.M. Lingaraja	Asst. Administrative Officer (Voluntary retirement on 3.8.2016)
3	Smt. M. Rathna Ranjini	Asst. Administrative Officer
4	Sri. O.G. Varghese	Private Secretary
5	Smt. Reshma K.	Personal Assistant
6	Ms. Winnie Lobo	Assistant
7	Smt. M. Leela	Assistant
8	Sri. Umashankar	Upper Division Clerk
9	Smt. K. Padminikutty	Upper Division Clerk
10	Sri. K. Balappa Gowda	Gestetner Operator

Promotions (Scientific)

- Dr. Mohana G.S., Senior Scientist (Genetics & Cytogenetics) has been promoted from RGP of Rs. 8000 to Rs. 9000 w.e.f. effect from 24.04.2015.
- Sri Eradasappa, E, Scientist (Genetics & Plant Breeding) has been promoted from RGP Rs. 6000 to 7000 w.e.f. 26.2.2013.

- Dr. K. Vanitha, Scientist, (Agricultural Entomology) has been promoted from the RGP Rs. 6000 to 7000 w.e.f. 21.4.2013.
- Dr. Ramkesh Meena, Scientist, (Horticulture – Fruit Science) has been promoted from the RGP Rs. 6000 to Rs. 6000 to 7000 w.e.f 6.6. 2012. (Transferred to ICAR- CIAH, Bikaner Rajasthan).
- Dr. D. Kalaivanan, Scientist (Soil Science) has been promoted from RGP of Rs. 6000/- to the RGP of Rs. 7000/- with effect from 28.4.2014. (Transferred to ICAR-IIHR, Bangalore).

Promotions (Technical)

- Dr. Lakshmipathi, Sr.Technical Officer, has been promoted to the next grade of Asst. Chief Technical Officer w.e.f. 24.8.2015 (Transferred to ICAR-IIHR, Bangalore).
- Sri Padmanabha Hebbar, Ex-Senior Technical Officer has been promoted to the next grade grade of Asst. Chief Technical Officer w.e.f. 01.01.2014.
- Sri R. Muthruraju, Technical Officer has been promoted to the next grade of Sr. Technical Officer w.e.f. 14.11.2014.
- Sri Ravishankar Prasad, Technical Asst. has been promoted to the next grade of Sr. Technical Asst. w.e.f. 28.7.2015.
- Sri K. Babu Poojary, Technical Asst. has been promoted to the next grade of Sr. Technical Asst. w.e.f. 20.7.2015.
- Sri.Vijay Singh, Technical Asst. has been promoted to the next grade of Sr. Technical Asst. w.e.f. 18.10. 2015.

Retirement

- Sri K.M.Lingaraja, Asst. Administrative Officer of this Directorate proceeded on Voluntary Retirement on 3.8.2016 (FN)
- Sri A. Padmanabha Hebbar, Asst. Chief Technical Officer superannuated on 30.4.2016

Annexure –VI

BUDGET 2016-17

Rs. in Lakhs

Sub Head	Plan		Non Plan	
	RE 2016-17	Expenditure	RE 2016-17	Expenditure
Establishment charges	-	-	506.00	474.33
Wages	–	–	–	–
OTA	–	–	-	–
TA	7.00	6.92	4.00	3.64
Other charges (Contigency)	84.00	100.62	114.64	110.56
HRD	1.39	1.35	–	–
Works	155.27	155.27	–	–
Equipment	2.26	2.26	1.00	0.93
Library	7.25	7.23	–	–
Vehicle	2.33	2.33	–	–
Information Technology	–	–	–	–
Furniture and fixture	–	–	–	–
Annual repair and maintenance	8.00	7.98	9.00	9.0
TSP	8.00	5.53	–	–
NEH	15.00	1.00	–	–
Total	**290.50**	**290.49**	**634.64**	**598.51**

Revenue generation (2016-17)

Particulars	Revenue generation (Rupees in Lakhs)
DCR	1.01 Crore

Annexure -VII

Meteorological Data (2016-17)

Month	Temperature		Humidity		Rainy	Rainfall	Mean wind velocity	Sunshine	Pan Evaporation
	(°C)		(%)		Days	(mm)	(Km/h)	Hours (h)	(mm)
	Max	Min	FN	AN					
April	35.0	25.6	69	48	1	6.6	3.0	8.8	5.3
May	36.1	25.0	79	58	8	98.5	2.7	7.0	3.7
June	30.2	22.8	90	84	25	836.7	2.1	1.8	2.2
July	29.3	23.6	86	81	26	933.6	2.7	1.4	2.3
August	29.2	23.3	89	78	26	434.7	2.5	2.6	2.7
September	30.5	23.9	86	74	21	193.5	2.1	3.1	1.8
October	30.7	23.7	82	61	5	59.1	2.1	6.1	3.0
November	31.3	22.0	78	49	0	0.0	1.5	7.1	3.0
December	34.0	21.5	80	45	4	35.8	1.6	7.7	3.1
January	33.8	19.4	78	38	0	0.0	2.1	8.2	3.5
February	35.7	20.7	72	36	0	0.0	2.4	8.3	3.6
March	33.6	22.7	83	48	0	2.0	2.7	8.0	4.3
					Total	**2600.5**	**27.5**	**70.1**	**38.5**

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

Annexure -VIII

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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