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काजू अनुसंधान निदेशालय
(भारतीय कृषि अनुसंधान परिषद्)
पुत्तूर - 574 202, कर्नाटक



Directorate of Cashew Research
(Indian Council of Agricultural Research)
Puttur - 574 202, Karnataka

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Prof. P.L. Saroj

Director

Directorate of Cashew Research

Puttur - 574 202, Karnataka

Tel No : 08251-231530 (O), 230992(R)

EPABX : 08251-230902, 236490

Fax : 08251-234350

E-mail : dircajures@gmail.com | dircajures@yahoo.com | dircajures@rediffmail.com

Website : <http://www.cashew.res.in>

Compiled and Edited by

Dr. P. Shivarama Bhat

Dr. T.R. Rupa

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Word Processing / Hindi Translation / Hindi Text

Mr. R. Muthuraju / Dr. Ramkesh Meena / Mr. Prakash G. Bhat

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काजू अनुसंधान निदेशालय
(भारतीय कृषि अनुसंधान परिषद्)
दर्बे पोस्ट, पुत्तूर - 574 202, दक्षिण कन्नड, कर्नाटक

प्रो. पी. एल. सरोज
निदेशक

Tel.: 08251-231530 (O)
Fax : 8251-234350
Email: dircajures@gmail.com

प्रस्तावना

मुझे काजू अनुसंधान निदेशालय, पुत्तूर, कर्नाटक की वार्षिक प्रतिवेदन 2013-14 को प्रस्तुत करने में खुशी हो रही है। निदेशालय द्वारा अनुमोदित तकनीकी कार्यक्रमों के तहत विभिन्न परियोजना के विभिन्न अवयवों जैसे फसल सुधार, फसल प्रबंधन फसल संरक्षण, कटाई उपरांत प्रधोगिकी एवं तकनीकी हस्तांतरण क्षेत्रों की उपलब्धियों को वार्षिक प्रतिवेदन में प्रस्तुत किया जा रहा है।

पादप अनुवंशिक संसाधन प्रबंधन के तहत राष्ट्रीय काजू जीन बैंक में संग्रहित 528 प्राप्तियों में से 478 का मूल्यांकन आई पी जी आर आई (IPGRI) मानक के अनुसार संपूर्ण किया जा चुका है। काजू के 17 प्राप्तियों का तुलनात्मक अध्ययन पूर्व विमोचित एवं विकसित किस्मों से 16 आई आई एस आर (IISR) मार्कर की सहायता से अभिलक्षित किया जा चुका है जिनमें अनुवंशिक विविधता बहुत कम पायी गयी है। काजू के द्वितीय एवं सूक्ष्म पोषक तत्वों (3 प्रतिशत urea + 0.5 प्रतिशत H_3PO_4 + 1 प्रतिशत K_2SO_4) और (0.5 प्रतिशत $ZnSO_4$ + 0.1 प्रतिशत Solubor + 0.5 प्रतिशत $MgSO_4$) का पर्णীয় छिड़काव कोपल, पुष्पन एवं गुठली वृद्धि अवस्था में करने से काजू उत्पादन में 16 और 30.5 प्रतिशत की बड़ोतरी चार वर्ष की संचय उपज में दर्ज की गयी है। विभिन्न अंतराल सघन पौध रोपण परीक्षण में 500 एवं 200 पेड प्रति हेक्टेयर रोपण से काजू उपजाता 1.91 एवं 0.73 टन प्रति हेक्टेयर अन्य सघन रोपण की तुलना में अधिक पायी गई है।

रेड्वीड्स की तीन प्रजातियों के जैविक अध्ययन से पता चला है कि इनको चाय मच्छर बग के जैविक नियंत्रण में उपयोग किया जा सकता है। काजू पारिस्थितिकी तंत्र में आइकोफायला स्मगदीना और एनोपलोलैपिस ग्रेसिलिपस की प्रचुरता अन्य कीट प्रजातियों की तुलना में अधिक पायी जाती है। काजू नमी उष्मा अवशोषणीय विधि के अध्ययन से ज्ञात हुआ कि इसका उपयोग गुठली नमी को कम कर संग्रहण क्षमता स्तर को बढ़ाने में किया जा सकता है। काजू अनुसंधान निदेशालय द्वारा तकनीकी हस्तांतरण कार्यक्रम के तहत प्रचलित अग्रिम पंक्ति प्रदर्शन को निरंतर वैज्ञानिक निगरानी में रखकर तकनीकी सलाह दी जा रही है। निदेशालय द्वारा आदिवासी किसानों को जागरूक एवं लाभान्वित करने के लिए जनजातीय विकास उपयोजना कार्यक्रम के माध्यम से विभिन्न परीक्षण कार्यक्रमों का आयोजन किया जा रहा है। किसान एवं कृषि विभाग के कर्मचारियों के लिए अभिनव किसान दिवस, गुठली गुणवत्ता मानक निर्धारण करने के लिए विचार विमर्ष बैठक, पौध संरक्षण एवं किसान अधिकार अधिनियम एक्ट, कृषि शिक्षा दिवस के रूप में जागरूकता सह प्रशिक्षण कार्यक्रमों का आयोजन किया गया है। निदेशालय द्वारा काजू ग्राहक मित्र समूहों के लिए उत्तम गुणवत्त की पैदा समग्री का उत्पादन एवं वितरण भी किया गया है।

मैं 2013-14 की वार्षिक प्रतिवेदन को संकलित करने के लिए निदेशालय के वैज्ञानिक, सभी कर्मचारियों एवं संपादकीय समिति के सदस्यों का बहुत आभारी हूँ।

स्थान : काजू अनुसंधान निदेशालय, पुत्तूर

दिनांक : 9 जून, 2014



(पी. एल. सरोज)

DIRECTORATE OF CASHEW RESEARCH

(Indian Council of Agricultural Research)

Puttur - 574 202, D.K., Karnataka

Prof. P.L. SAROJ

Director

Tel : 08251-231530 (O)

Fax : 8251-234350

E-mail : dircajures@gmail.com

PREFACE

I am pleased to present the Annual Report 2013-14 of Directorate of Cashew Research (DCR), Puttur (Karnataka). As per the approved technical programme, projects in the areas of Crop Improvement, Crop Management, Crop Protection, Post-Harvest Technology and Transfer of Technology have been taken up and the progress made during the period under report has been presented.

In genetic resource management, out of 528 accessions planted in National Cashew Field Gene Bank, 478 accessions have been evaluated as per IPGRI descriptors. Seventeen accessions of cashew comprising of germplasm, pre-release types and released varieties were characterized using 16 primers of ISSR which indicated low genetic diversity among the accessions. Foliar spray of 3% urea + 0.5% H_3PO_4 + 1% K_2SO_4 at flushing, flowering and nut development of cashew resulted in 16.1 per cent increase in nut yield whereas, 0.5% $ZnSO_4$ + 0.1% solubor + 0.5% $MgSO_4$ spray had 30.5 per cent higher nut yield over untreated trees. Of the different plant densities, plant density of 500 plants/ha was found to be superior in terms of higher nut yield (1.91 t/ha) than wider spacing with 200 plants/ha (0.73 t/ha). The biology of three species of reduviids was worked out which can be utilized for biological control of tea mosquito bug (TMB). Several species of ants were recorded in cashew ecosystem, of which, *Oecophylla smaragdina* and *Anoplolepis gracillipes* were most abundant. Moisture sorption isotherms of raw cashewnuts in relation to shelf life and safe level moisture were worked out. The Directorate strengthened its transfer of technology efforts and regularly monitored the frontline demonstration plots. The Directorate has taken up initiative in implementing Tribal Sub-Plan (TSP). Awareness cum training programmes were organized as a part of TSP for the benefit of the tribal farmers. Besides, Innovative cashew farmers' day, DCR-industry interactive interface meeting on quality standards for raw cashewnuts, Awareness cum training programme on protection of plant varieties and farmers' rights act and Agricultural education day were organized. This Directorate has taken a lead role in the production and supply of quality planting material to its clientele group.

I thank all the scientists for their research contributions and members of Editorial Committee for compilation and editing of the Annual Report 2013-14.

Place : DCR, Puttur

Date : 9 June, 2014

(P.L. Saroj)

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INTRODUCTION

Research on cashew was first initiated in the early 1950s. Indian Council of Agricultural Research (ICAR), sanctioned adhoc schemes for Research Centres located at Kottarakkara (Kerala), Ullal (Karnataka), Bapatla (Andhra Pradesh), Daregaon (Assam) and Vengurla (Maharashtra). In 1971, ICAR also sanctioned All India Coordinated Spices and Cashew Improvement Project (AICS and CIP) with its Headquarters located at CPCRI, Kasaragod. The CPCRI Regional Station, Vittal (Karnataka) was given the mandate to carry out research work on cashew while four Centres under University (Bapatla, Vridhachalam, Anakkayam and Vengurla) were assigned the research component on cashew under AICS and CIP. During the V and VI plan periods three more Centres (Bhubaneswar, Jhargram and Chintamani) came under the fold of AICS and CIP and with shifting of work of Anakkayam Centre to Madakkathara. The recommendations made by the Quinquennial Review Team (QRT) constituted by ICAR in 1982, working group on Agricultural Research and Education constituted by the Planning Commission for VII Plan Proposals and the Task Force on Horticulture constituted by ICAR resulted in the establishment of National Research Centre for Cashew at Puttur on 18 June, 1986 which was upgraded and renamed by ICAR in 2009 under XI Plan as Directorate of Cashew Research (DCR). Subsequent to the bifurcation of AICS and CIP, the Headquarters of All India Coordinated Research Project (AICRP) on Cashew was shifted to 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 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 have been established. Besides, Project Coordinated Cell of AICRP on Cashew, PME Cell, AKMU etc are also established.

The Directorate has got well-established library in the field of cashew research. The library is serving as an Information Centre on all aspects of cashew research and development in the country. The CD database viz., CABHORT, CABPEST, AGRICOLA, AGRIS, SOIL CD, CROP CD, PLANTGENE CD and TROPAG CD are also available in the library. The library has equipped with automation software and bar coding facility. The library has 1545 books and 1601 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

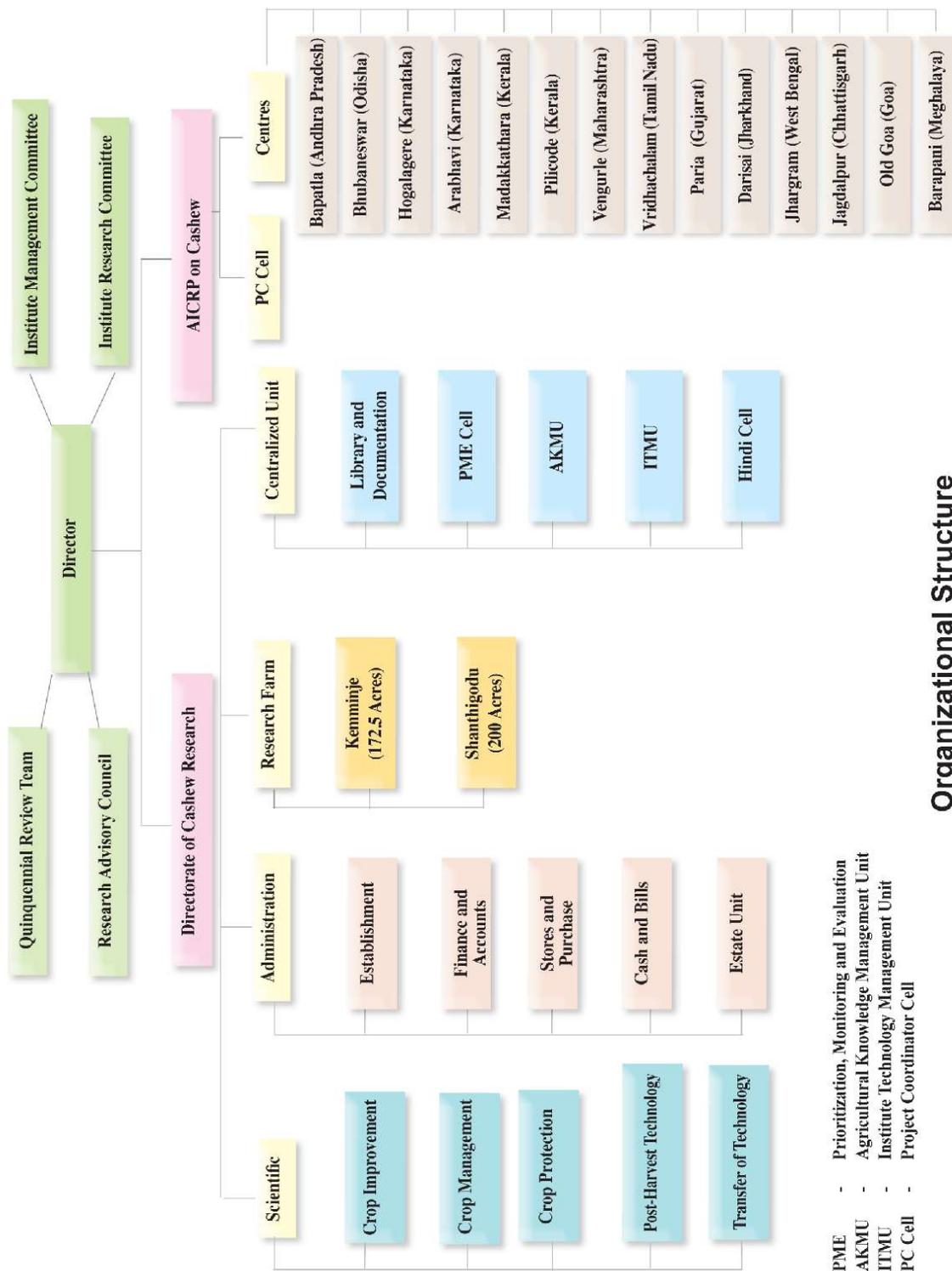
- To promote overall growth through enhancement of production and productivity in cashew.

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.



Directorate of Cashew Research



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

Organizational Structure

कार्यकारी सारांश

सन 2013-14 में काजू अनुसंधान निदेशालय, पुनूर, कर्नाटक में 6 परियोजनाओं के अंतर्गत एक, NAIP, ICAR नेटवर्क और DBT परियोजनाओं मिलाकर को कुल 29 परीक्षण का कार्य सतत प्रगति पथ पर अग्रसर है। वर्ष 2002-03 में रोपित 5 प्राप्तियों (जनन्द्रव्यो) का मूल्यांकन एवं विवेचन आई पी जी आर आई (IPGRI) वर्णक के अनुसार पौध वृद्धि, उपज एवं गुठली वर्ण के लिए किया चुका है। अब तक काजू क्षेत्रीय जीन बैंक में रोपित कुल 478 प्राप्तियों का मूल्यांकन सम्पूर्ण किया जा चुका है। लोकप्रिय एवं बौनी किस्मों के संकरण संयोजन से विकसित विभिन्न आशाजनक संकरों में से दो आशाजनक संकरों का चयन प्रति पेड उपजता (5.28 से 5.50 किलो) के आधार पर किया गया है। काजू की 17 प्राप्तियों का तुलनात्मक अध्ययन पूर्व विमोचित एवं विकसित किस्मों से 16 आई आई एस आर (IISR) मार्कर की सहायता से अभिलक्षित किया गया है जिनमें अनुवंशिक विविधता बहुत कम पायी गयी है। सतरह प्राप्तियों का गुच्छ विश्लेषण विधि की सहायता से 6 आणुविक समूह में विभाजित किया गया है। 2 संकरण संयोजन भास्कर x तालिपरम्ब और उळ्ळाल -3 x ब्रजिलीयन बौना जिनोटाईप्स के पूर्वजों का डी एन ए (DNA) का चयन आई आई एस आर (IISR) प्राईमर काजू (21) और संबन्धित प्रजातिया पिस्ता (25) अल्फा अल्फा (25), आम (25) और बदाम (35) की सहायता से किया गया है। पहले से चयनित बहुरूपी मर्कर का उपयोग F1 संतती की पहचान के लिए किया गया है। जैव उर्वरक एजोस्फिरिलम, एजोटोबैक्टर, फास्फोरस घुलनशील जीवाणु और ए एम एफ (AMF) टीके का अनुप्रयोग पौधे की 45 सेंटी मीटर परिधी में (50 ग्राम प्रति पेड) और शिफारित पैकेज 100 प्रतिशत (नाईट्रोजन 135 ग्राम, 39 ग्राम फास्फोरस, 34 ग्राम पोटैसियम और 5.6 किलो ग्राम गोबर की खाद चार पेडों की बीच खोदी गई आयाताकार खाई में डालने से पांच वर्ष पुराने वी आर आई-3 (VRI-3) और 12 वर्ष पुराने भास्कर किस्म के बागान से चार वर्ष की संचय उपज में 53 एवं 31

प्रतिशत की बढोतरी नियंत्रण की तुलना में अधिक पायी गयी है। मेग्नेसियम, जिन्क एवं बोरोन तत्वों की कमी वाले काजू बागान में (3 प्रतिशत urea + 0.5 प्रतिशत H_3PO_4 + 1 प्रतिशत K_2SO_4) और (0.5 प्रतिशत $ZnSO_4$ + 0.1 प्रतिशत Solubor + 0.5 प्रतिशत $MgSO_4$) तत्वों का वर्णीय छिडकाव कोपल, पुष्पन एवं गुठली वृद्धि अवस्था में करने से काजू उत्पादन में 16 और 30.5 प्रतिशत की वढोतरी चार वर्ष की संचय उपज में दर्ज की गयी है। काजू में (0.5 प्रतिशत Solubor) के पर्णीय छिडकाव से लाग लागत अनुपात (2.41) जबकि 0.1 प्रतिशत Solubor से (2.35) एवं 0.5 $ZnSO_4$ + 0.1 प्रतिशत Solubor + 0.5 प्रतिशत $MgSO_4$ (2.32) अनुसरित करती पायी गयी जबकि अन्य तत्वों के पर्णीय छिडकाव से काजू उत्पादन में नियंत्रण की तुलना में विविधता देखी गई है। काजू में वृद्धि अवरोधक हार्मोन पैक्लोब्युट्रजोल का अनुप्रयोग मिट्टी में @ 1.0 ग्राम, 2.0 ग्राम और 3.0 ग्राम प्रति पेड में करने से पौध वृद्धि, छत्रक फैलाव, पर्ण संधि वृद्धि में कमी पायी गई है जबकि पौध कलिकायन संख्या में बढोतरी दर्ज की गई है। वृद्धि अवरोधक हार्मोन उपजारित पौधों में पुष्पन लिंग अनुपात (0.34 से 0.95 प्रतिशत) जबकि नियंत्रण में (0.25 से 0.35 प्रतिशत) के बीच पाया गया है। विभिन्न अंतराल पर सघन पौध रोपण परीक्षण में 500 पेड प्रति हेक्टेयर से 5 वर्ष की संचय उपज 4.6 टन प्रति हेक्टेयर अन्य सघन रोपण की तुलना में अधिक पायी गयी है। इस परीक्षण के अध्ययन से पता चलता है कि सघन पौध रोपण से प्रारंभिक वर्षों में अधिक आय कमायी जा सकती है। इस परीक्षण में विभिन्न किस्मों की संचय उपज जैसे भास्कर (3.7 टन प्रति हेक्टेयर), उळ्ळाल -3 (3.47 टन प्रति हेक्टेयर), एन आर सी सी सलेक्शन -2 (3.27 टन प्रति हेक्टेयर), धना (3.11 टन प्रति हेक्टेयर) और उळ्ळाल -1 (3.01 टन प्रति हेक्टेयर) दर्ज की गयी है।

निदेशालय में काजू तना एवं जड छिद्रक कीट के लिए अर्ध संश्लेषित आहार के मानकीकरण का प्रयास

किया गया है और पता चला है कि संश्लेषित भोजन के साथ कैल्सियम का उपयोग करने से कीटों में प्यूपा (36.98 प्रतिशत) और युवा कीट (19 प्रतिशत) की संख्या अधिक पायी गई है। स्वदेश संग्रहित रोगकारक गोलकृमी स्पिसीज स्ट्रेनेमा फैल्टी, काजू तना एवं जड़ छिद्रक कीट में रोग जनक के रूप में पाया गया है। काजू पारिस्थितिकी तंत्र में पाया जाने वाले रेडविड्स एंडोचेस, एल्बोमोसच स्तेल, इपिडेस बाईकलर डी स्टेन्ट, युगोरस प्लेजियटस ब्युरोमिस्ट्र की जैविक प्रकृति का अध्ययन किया जिससे ज्ञात हुआ है कि यह सभी मकडिया चाय मच्छर बग कीट के जैविक नियंत्रण में उपयोग की जा सकती है। एक नया अन्डा परजीवी टेलोनोमस क्युस्पिसस (हाइमेनोप्टेरा : प्लेटिगेस्टर्ड) भारत एवं प्राच्य क्षेत्रों का लायरीकस स्पीसीज का संग्रहण है। काजू चाय मच्छर बग कीट को 10 खरपतवार और 2 सजावटी पौधों में वैकल्पिक आवास के रूप में आवासित पाया गया है। काजू पारिस्थितिकी तंत्र में चीन्टियाँ की 19 स्पिसीज में 5 उप परिवार ओकोपाइला स्मार्गडिना (फेबिकस) और एनोप्लोलेपिस ग्रेसिलेपिस की प्रचुरता अन्य कीट की अपेक्षा अधिक पायी जाती है जबकि कंपोनोटस कंप्रेसस और कंपोनोटस सेरिसस की प्रचुरता पूरी भारत वर्ष में पायी जाती है।

निदेशालय में अनुसंधान से पता चला है कि काजू गुठली की नमी (8.14 प्रतिशत) उष्मा अवशोषणीय विधि से कम करने पर गुठली की संग्रहण क्षमता और सुरक्षा स्तर को बढ़ाया जा सकता है। स्वदेशी काजू गुठली को भापीय विधि से प्रसंस्करण करने से गिरी सतह में विदेशी आयातित गुठली की तुलना में बहुत कम परिवर्तन देखा गया है। निदेशालय द्वारा किसानों के खेत में पहले से प्रचलित अग्रिम पंक्ति प्रदर्शन को निरंतर वैज्ञानिक निगरानी में रखकर तकनीकी सलाह दी जा रही है।

काजू अनुसंधान निदेशालय द्वारा किसानों एवं कृषि विभाग के कर्मचारियों को जागरूक एवं लाभान्वित करने के लिए अभिनव कृषक दिवस, गुठली गुणवत्ता मानक निर्धारण के लिए वैज्ञानिक विचार विमर्श संगोष्ठी, कृषि

शिक्षा दिवस, समन्वित कीट प्रबंधन, पौधा किस्म संरक्षण और किसान अधिकार अधिनियम एक्ट, काजू पौध संरक्षण, काजू सेव उपयोग आदि प्रशिक्षण कार्यक्रमों का आयोजन किया जा रहा है। किसान एवं कृषि विभागों के कर्मचारियों के लिए काजू अनुसंधान निदेशालय ने सी टी सी आर आई (CTCRI) तिरुवनंतपुरम में स्वर्ण जयंति अंतर्ष्ट्रीय सम्मेलन, बागलकोट कृषि विश्वविद्यालय द्वारा आयोजित कृषि मेला, भारतीय मसाला अनुसन्धान संस्थान द्वारा आयोजित संगोष्ठी और संत फिलोमिना कालेज द्वारा आयोजित कृषि प्रदर्शनी में काजू उत्पादन एवं प्रसंस्करण प्रद्योगिकी के विभिन्न पहलुओं को प्रदर्शित किया गया था।

काजू अनुसंधान निदेशालय ने इस वर्ष 1.5 लाख काजू पौध सामग्री का उत्पादन एवं वितरण किसान और कृषि विभागों में किया गया है। वर्ष 2013-14 में 24 शोध पर (09 अंतरराष्ट्रीय + 15 राष्ट्रीय), 6 पुस्तक अध्याय, 2 तकनीकी विवरणीका, 2 कृषि विस्तार विवरणीका, 2 लोकप्रिय लेख, 2 वैज्ञानिक समीक्षा पत्रों का प्रकाशन किया गया है। इसके अलावा 14 शोध पत्रों को विभिन्न सेमिनार एवं संगोष्ठियों में प्रस्तुत किया गया है। काजू अनुसंधान निदेशालय की प्रभावी गतिविधि निगरानी के लिए क्यू आर (QRT), आर ए सी (RAC), आई आर सी (IRC) और आई एम सी (IMC) बैठकों का समय समय पर आयोजन किया गया है। निदेशालय के वैज्ञानिकों ने अपने अपने क्षेत्र की विभिन्न संगोष्ठियों, सम्मेलनों और बैठकों में भाग लिया है। निदेशालय में कर्मचारी कल्याणकारी गतिविधियों पर भी विशेष ध्यान दिया जा रहा है। राजभाषा हिन्दी को बढ़ावा देने के लिए हिन्दी कार्यशाला एवं राजभाषा कार्यान्वयन समिति की विभिन्न बैठकों का आयोजन किया गया है।

इस वार्षिक प्रतिवेदन में काजू अनुसंधान परियोजना के परिणामों का ब्योरा प्रस्तुत किया गया है।

EXECUTIVE SUMMARY

During 2013-14, a total of 06 projects having 29 experiments along with one each NAIP, ICAR Network and DBT projects were in operation at Directorate of Cashew Research, Puttur (Karnataka). Five germplasm accessions planted during 2002-03 were evaluated and characterized as per IPGRI descriptors for their growth, yield and nut characters bringing the total number of accessions evaluated to 478. Among the hybrids generated from cross combinations of popular cultivars and dwarf types, two hybrid progenies were identified as promising semi-dwarf genetic stock with higher yield varied from 5.28 to 5.50 kg/plant. Seventeen accessions of cashew comprising of germplasm, pre-release types and released varieties were characterized using 16 primers of ISSR. The study indicated low genetic diversity existing among the accessions. The cluster analysis distinguished 17 accessions into six molecular groups. Parental DNA of two crosses namely Bhaskara x Taliparamba-1 and Ullal-3 x Brazil dwarf genotype were screened with SSR primers of cashew (21) and from other related species namely pistachio (25), alfalfa (25), mango (15) and almond (35). The identified polymorphic markers were selected for screening F1 individuals.

Application of biofertilizer consortia [*Azospirillum*, *Acetobacter*, Phosphate solubilizing bacteria and AMF inoculation both to the tree basin at a radius of 45 cm (50 g each/tree) and in the rectangular trenches taken in the middle of four trees (50 g each/tree)] and 100 per cent of recommended dose of nutrients (N: 135 g, P₂O₅: 39 g, K₂O: 34 g and FYM: 5.6 kg per tree

per annum) had resulted in increased cumulative nut yield for four years to the tune of 53 per cent and 31 per cent in young cashew (5 years old, VRI-3) and mature cashew (12 years old, Bhaskara) plantations, respectively as compared to control (no biofertilizer, fertilizer and irrigation). Foliar application of 3% urea + 0.5% H₃PO₄ + 1% K₂SO₄ at flushing, flowering and nut development of cashew increased nut yields by 16.1 per cent while, 0.5% ZnSO₄ + 0.1% solubor + 0.5% MgSO₄ spray had 30.5 per cent higher nut yield averaged over the four years (2010-2013) in soils deficient in Mg, Zn and B. Application of 0.5% ZnSO₄ + 0.1% solubor gave maximum B:C ratio (2.41) followed by 0.1% solubor (2.35) and 0.5% ZnSO₄ + 0.1% solubor + 0.5% MgSO₄ (2.32) which differed significantly from other foliar treatments including control. Application of paclobutrazol (PBZ) @ 1 g, 2 g and 3 g a.i./plant reduced the plant height, canopy spread and internodal length while the number of flushes increased. The sex ratio of flowers (0.34 to 0.95%) in PBZ treated plants was higher compared to untreated plants (0.25 to 0.35%). Among different plant densities, density of 500 plants/ha resulted in highest cumulative nut yield of 4.6 t/ha (2008-2013) indicating the potentiality of high density planting in cashew in the initial years of plantation. Among the varieties, Bhaskara recorded the highest cumulative nut yield of 3.7 t/ha followed by Ullal-3 (3.47 t/ha), NRCC Sel-2 (3.27 t/ha.), Dhana (3.11 t/ha) and Ullal-1 (3.01 t/ha).

Efforts for standardizing semi-synthetic diet (SSD) for cashew stem and root borer (CSRB) is being continued and highest pupation of 36.98

per cent was recorded in SSD fortified with CaSO_4 and adult emergence was also higher (19%) in this diet. The indigenously collected Entomopathogenic nematode species, *Steinernema feltiae* was found pathogenic to the grubs of CSRB. The biology of the reduviids *Endochus albomaculatus* Stal, *Epidaus bicolor* Distant, *Euagoras plagiatus* Burmeister was worked out which can be tried for biological control of tea mosquito bug (TMB). A new egg parasitoid *Telenomus cuspis* sp. nov. (Hymenoptera: Platygasteridae) on TMB has been described which is a new record of the laricis species group from India as well from the Oriental region. Twelve weed species and two ornamental plants belonging to 10 different families were recorded as alternate hosts of TMB during flushing period of cashew (September-October). Twenty nine species of ants of five sub-families were recorded in cashew ecosystem, of which, *Oecophylla smaragdina* (Fabricius) and *Anoplolepis gracillipes* Smith were most abundant, while *Camponotus compressus* and *C. sericeus* were found throughout the year.

Moisture sorption isotherms of raw cashewnuts in relation to shelf life and safe level moisture was worked out to be 8.14 per cent d.b. Changes in surface colour of cashew kernels with respect to various stages of processing (steaming) showed minimal changes for the indigenous nuts (Karnataka and Kerala) as compared to imported nuts (Nigeria, Benin and Ivory Coast).

The Frontline demonstration plots laid out previously in the farmers' fields were monitored and technical advice was offered by the group of scientists. Innovative cashew farmers' day, Interactive meeting on quality standards for raw cashewnuts and Agricultural education day were organized at DCR, Puttur. Training programmes

on Integrated pest management in cashew, Awareness cum training programme on protection of plant varieties and farmers' rights act, Pest management in cashew, Cashew production technology and Cashew apple utilization were organized for the benefit of farmers and officials from line departments. The Directorate participated in CTCRI Golden Jubilee International Conference and Exhibition held at CTCRI, Thiruvananthapuram, Horticulture Mela organized by UHS, Bagalkot, Symposium on Spices and Aromatic Crops – VII at Regional Station of Indian Institute of Spices Research, Cardamom Research Centre, Appangala, Karnataka and exhibition at St. Philomena College, Puttur, Karnataka and displayed various aspects of cashew production and processing technologies for the benefit of the farmers.

During the year, around 1.5 lakh cashew grafts were produced and distributed to farmers and development departments. During 2013-14; 24 research papers (09 International + 15 National), 06 book chapters, 05 technical reports, 02 technical bulletins, 02 extension bulletins, 02 popular articles and 02 scientific / teaching reviews were published. Besides, 14 papers were presented in different seminars and symposia. For effective monitoring of research and Directorate activities; the QRT, RAC and IMC meetings were organized timely. The scientists also participated in various seminars, symposia, conferences, meeting etc. in their respective fields. The staff welfare activities were also taken up in time. For promotion of Rajbhasha Hindi, the Hindi workshop and Town Official Language Implementation Committee (TOLIC) Meeting were also organized. In this Annual Report, the details of results of the on-going research projects are presented.

RESEARCH ACHIEVEMENTS

I. CROP IMPROVEMENT

1.1 Genetic Resources of Cashew

1.1.1 Germplasm survey and collection

During the fruiting season, a high yielding bold nut type was identified in Kolthige village of Puttur taluk, Karnataka for collection. The planting material of Jhargram-2, Vengurla-8 and Vridhachalam-5 (H-1) were collected from respective Centres of AICRP - Cashew for planting in National Cashew Field Gene Bank (NCFGB).

1.1.2 Germplasm evaluation

Five germplasm accessions planted during 2002-03 have been evaluated as per IPGRI descriptors for characterization and documentation. Among them, all the five were upright and open type with extensive branching habit. Four of them had obovate leaf shape and one had oval shaped leaves (Table 1.1). Young leaves were yellow red in colour in all the

accessions with mid season flushing and flowering behaviour having flowering period of 2-3 months. Three accessions had yellow coloured apple and other two accessions had yellow red apples. Four accessions had cylindrical shaped fruits while one had round shaped fruit. All of them had big apples (>59 g). Two accessions had bold nut (>7 g) and other three had medium sized nuts (5 - 7 g). Kernel weight in four accessions was intermediate (1.2 - 2.5 g) and higher (> 2.5 g) in one accession. The cumulative nut yield was low (<9 kg) in all the five accessions and the shelling percentage varied from intermediate to high.

1.1.3 Registration of germplasm

The indigenous collection (IC) numbers were obtained from NBPGR, New Delhi for 36 accessions (NRC No. 434 to NRC No. 473).

Table 1.1: Important features of germplasm accessions evaluated in 2013

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

		3	Green red	0
		4	Purple	0
28	Season of flowering	3	Early (Nov-Dec)	0
		5	Mid (Dec-Jan)	5
		7	Late (Jan-Feb)	0
31	Mature cashew apple colour	1	Yellow	2
		2	Red	0
		3	Yellow red	3
		4	Red purple	0
32	Shape of cashew apple	1	Cylindrical	4
		2	Conical-obovate	0
		3	Round	1
		4	Pyriiform	0
50	Attachment of nut to ashew apple	3	Loose	3
		5	Intermediate	1
		7	Tight	1
35	Nut weight	3	Low (<5 g)	0
		5	Intermediate (5-7 g)	3
		7	High (>7 g)	2
43	Weight of cashew apple	3	Low (<27 g)	0
		5	Medium (27-52 g)	0
		7	High (>52 g)	5
60	Flowering duration	3	Short (<60 days)	0
		5	Medium (60-90 days)	5
		7	Long (>90 days)	0
62	Apple to nut ratio	3	Low (<6)	0
		5	Medium (6-12)	5
		7	High (>12)	0
63	Shelling percentage	3	Low (<18%)	0
		5	Intermediate (18-28%)	2
		7	High (>28%)	3
64	Kernel weight	3	Low (<1.2 g)	0
		5	Intermediate (1.2-2.5 g)	4
		7	High (>2.5 g)	1
57	Shell thickness	3	Thin (<2.5 mm)	0
		5	Intermediate (2.5-4.0 mm)	5
		7	Thick (>4.0 mm)	0

65	Attachment of peel to kernel	3	Loose	1
		7	Tight	4
68	Cumulative yield per plant (6 annual sts)	3	Low (<9 kg)	5
		5	Medium (9-18 kg)	0
		7	High (>18 kg)	0

1.2 Genetic Improvement of Cashew

1.2.1 Performance of promising hybrids

Among hybrids, under replicated trial, planted in 2006, the plant height ranged from 3.76 m (H-

2452) to 5.16 m (Bhaskara), stem girth ranged from 42 cm (H-1250) to 55.30 cm (Bhaskara), while, the canopy spread ranged from 4.28 m (H-1250) to 5.40 m (Bhaskara) (Table 1.2).

Table 1.2: Growth parameters

Hybrid/ variety	Plant height (m)	Stem girth (cm)	Canopy spread (m)
H-43	4.20	42.33	4.56
H-66	4.40	44.30	4.70
H-68	4.86	53.76	5.50
H-125	3.90	46.30	4.63
H-126	4.50	49.86	4.83
H-1250	3.96	42.00	4.28
H-2452	3.76	42.26	4.43
H-2473	4.53	52.33	5.13
NRCC Sel-2 (check)	4.16	44.30	4.30
Bhaskara (check)	5.16	55.30	5.40

The promising hybrids varied for sex ratio. The sex ratio was the lowest in local check NRCC Sel-2

(0.06), while it was highest in H-2452 (0.51) (Table 1.3).

Table 1.3: Sex ratio

Hybrids / variety	No. of male flowers	No. of bisexual flowers	Sex ratio
H-43	482.5	113.75	0.24
H-126	524.3	111.5	0.21
H-2473	333.8	29.25	0.09

H-66	378.8	76.75	0.20
H-125	341.5	128.00	0.37
H-1250	276.3	84.25	0.30
H-2452	207.8	105.75	0.51
H-68	347.5	82.75	0.24
Bhaskara	302.3	45.75	0.15
NRCC Sel-2	233.3	13.75	0.06

1.2.2 Performance of hybrids (selected from closely planted block)

Three hybrids planted in 2008 at a spacing of

6 m x 6 m, were identified as promising genetic stock in the third harvest for nut weight and yield. The nut weight ranged from 7.5 to 9 g and yield ranged from 3.5 to 4.9 kg/plant (Table 1.4).

Table 1.4: Nut weight and yield of hybrids

Tree No.	Hybrid combination	Nut weight (g)	Yield (kg/plant) at 3 rd harvest
122	NRC-99 x NRC-185	7.5	3.71
130	NRC-100 x NRC-185	9.0	5.33
163	NRC-240 x NRC-194	8.5	4.89

1.2.3 Performance of hybrids (crosses between popular cultivars and dwarf types)

Among the hybrids generated from cross combinations of popular cultivars and dwarf types, the hybrids planted during 2008, at a spacing of 6 m x 6 m, two hybrid progenies were

identified as promising semi-dwarf genetic stock, as the plant height fell under semi dwarf category in the third harvest. These hybrids had medium to bold nut size with higher yield ranging from 5.28 to 5.50 kg/plant (Table 1.5).

Table 1.5: Performance of hybrids

Tree No.	Cross combination	Plant height (m)	Canopy spread (m)	Nut weight (g)	Yield (kg/plant) at 3 rd harvest
601	Ullal-3 x NRC-492	3.65	4.50	8.2	5.28
626	Bhaskara x NRC-492	3.00	3.25	8.1	5.50

1.2.4 Seedling selection in cashew

To find out the variability existing in cashew cultivars raised through seedlings, an experiment was laid out in 2007 by planting the seedling progenies of NRCC Sel-2, Vengurla-4, VRI-3, Bhaskara, VTH-174 and VTH-30/4. Growth parameters with respect to seedling progenies were recorded. The average plant height ranged from 4.69 to 5.80 m, the stem girth ranged from 45.19 to 60.19 cm, the canopy spread ranged from 4.93 to 6.26 m (Table 1.6). The

seedling progenies of Bhaskara exhibited highest values for plant height and stem girth, while the seedling progenies of VTH-174 exhibited highest canopy spread. The seedling progenies of VRI-3 recorded highest average yield of 1.51 kg per plant in the second harvest. The cumulative yield was also highest (3.83 kg) in the seedling progenies of VRI-3. One seedling progeny i.e., Tree No. 480 from VTH 30/4 was identified as a promising genetic stock as it recorded 5 kg nut yield and nuts fell under medium nut category.

Table 1.6: Growth and yield of seedling progenies

Variety	Plant height (m)	Stem girth (cm)	Canopy spread (m)	Yield (kg/plant) in 2013	Cumulative yield (kg/plant) of 2 harvests
NRCC Sel-2	4.69	45.19	4.93	0.33	1.31
Vengurla-4	5.22	58.81	5.89	0.57	2.02
VRI-3	4.88	53.81	5.45	1.51	3.83
Bhaskara	5.80	60.19	5.82	0.83	2.51
VTH-174	5.73	52.81	6.26	0.67	2.41
VTH 30/4	5.25	51.50	5.63	0.67	2.38

1.2.5 Development of dwarf and compact cashew hybrids

A total of 1010 hybrid seed nuts of 16 crosses were sown in polybags filled with fresh filling mixture during May, 2013. The 16 crosses include eight direct and eight reciprocal crosses made during 2012-13 involving four popular cultivars viz., Vengurla-4, Priyanka, Dhana, Madakkathara-2 and two dwarf / compact germplasm accessions viz., Brazil dwarf and Taliparamba-1. The hybrid seedlings were raised in the nursery at Kemminje campus. The number of germinated

seedlings were counted in each cross (Table 1.7). Observations on seedling growth parameters such as length from cotyledon to first leaf, stem girth, height, number of leaves and number of branches were recorded at 80 days after sowing. The data was analyzed to estimate the variability present in each cross for the mentioned traits and presented in Table 1.8. The hybrid seedlings of 15 crosses were planted in the field at a spacing of 4 m x 4 m during October, 2013 for evaluation along with parents and check hybrid (Vengurla-4) at Shantigodu Experimental Station. Observations on seedling growth parameters such as stem

girth, height, number of leaves and number of branches were recorded at 50 days after planting. The data was analyzed to estimate the variability present in each cross for the mentioned traits and presented in Table 1.9. The mortality of seedlings

was negligible in the crosses. The variability measures such as range, mean and coefficient of variation varied significantly in all the crosses for all the seedling parameters. The analysis revealed a good amount of variability for all the traits in all the 15 crosses.

Table 1.7: Germination percentage and planting of seedlings

Cross combination			No. of nuts sown	No. of nuts germinated	Germination (%)	No. of seedlings planted
Vengurla-4	x	NRC-492	204	177	86.76	177
Vengurla-4	x	Taliparamba-1	150	134	89.33	134
Priyanka	x	NRC-492	90	70	77.78	70
Priyanka	x	Taliparamba-1	22	10	45.45	10
Dhana	x	NRC-492	62	61	98.39	61
Dhana	x	Taliparamba-1	78	75	96.15	75
Madakkathara-2	x	NRC-492	170	151	88.82	150
Madakkathara-2	x	Taliparamba-1	129	62	48.06	62
NRC-492	x	Vengurla-4	16	10	62.50	10
Taliparamba-1	x	Vengurla-4	7	7	100.00	7
NRC-492	x	Priyanka	30	13	43.33	13
Taliparamba-1	x	Priyanka	11	8	72.73	8
NRC-492	x	Dhana	16	12	75.00	12
Taliparamba-1	x	Dhana	8	4	50.00	4
NRC-492	x	Madakkathara-2	15	10	66.67	10
Taliparamba-1	x	Madakkathara-2	2	0	0	0
SE						6.65
CV (%)						38.69



Table 1.8: Variability in seedling parameters at 80 days after sowing

Cross	Girth (cm)			Plant height (cm)			No. of leaves			LCFL (cm)			No. of branches							
	Range	Mean	SE	CV	Range	Mean	SE	CV	Range	Mean	SE	CV	Range	Mean	SE	CV				
Vengurla-4 x NRC-492	0.3-1.1	0.77	0.01	20.1	9-37	24.72	0.40	21.4	7-25	13.14	0.23	21.9	2-12	7.07	0.12	22.4	0-5	0.26	0.06	310.2
Vengurla-4 x Taliparamba-1	0.4-0.9	0.68	0.01	17.1	14.0-38.5	27.75	0.45	18.1	6-31	14.45	0.27	21.5	4-11	7.30	0.12	18.6	0-4	0.41	0.07	201.1
Priyanka x NRC-492	0.4-1.1	0.86	0.01	13.9	11-52	39.24	0.85	18.8	5-31	17.57	0.69	33.0	4-12	9.05	0.20	18.8	0-4	1.24	0.14	92.5
Priyanka x Taliparamba-1	0.4-1.1	0.77	0.08	32.4	15-40	29.15	2.38	25.8	5-18	11.90	1.23	32.8	7-11	9.15	0.42	14.6	0-4	1.10	0.41	117.0
Dhana x NRC-492	0.5-1.0	0.74	0.04	15.3	23.5-39.5	32.11	0.45	11.0	10-23	14.52	0.34	18.6	6-12	9.64	0.19	15.4	0-4	0.77	0.13	130.7
Dhana x Taliparamba-1	0.5-1.0	0.74	0.13	15.7	17-43	31.74	0.57	15.6	5-26	13.35	0.43	27.8	2-17	10.00	0.22	19.4	0-5	0.59	0.13	191.2
Madakkathara-2 x NRC-492	0.2-1.1	0.70	0.01	24.8	8.5-38	25.80	0.48	22.8	4-43	20.14	0.62	37.6	2-15	7.24	0.16	26.7	0-7	2.32	0.14	72.5
Madakkathara-2 x Taliparamba-1	0.3-1.0	0.73	0.02	18.7	9.0-37.5	27.09	0.80	23.3	6-35	17.61	0.82	36.9	2-11	7.16	0.26	29.0	0-5	1.84	0.22	93.5
NRC-492 x Vengurla-4	0.4-0.8	0.62	0.04	21.2	13-33	25.70	1.70	20.9	12-20	15.10	0.78	16.4	6-10	8.50	0.37	13.8	0-3	0.40	0.30	241.5
Taliparamba-1 x Vengurla-4	0.6-1.0	0.76	0.06	19.9	21-31	27.71	1.30	12.4	12-20	15.57	1.13	19.2	6-11	8.71	0.64	19.6	0-5	1.14	0.70	163.5
NRC-492 x Priyanka	0.5-0.8	0.59	0.03	16.2	21.5-33.0	26.77	0.92	12.4	12-27	17.46	1.31	27.0	3-11.5	9.77	0.60	22.1	0-5	2.23	0.42	68.9
Taliparamba-1 x Priyanka	0.7-0.9	0.77	0.04	13.4	28.0-43.5	33.50	2.07	17.5	10-17	13.62	0.80	16.6	10-13	11.62	0.42	10.2	0-3	1.00	0.42	119.5
NRC-492 x Dhana	0.5-0.8	0.61	0.03	16.3	14-37	26.67	1.71	22.2	9-16	13.17	0.76	19.9	6-14	9.96	0.64	22.3	0-4	0.33	0.33	349.9
Taliparamba-1 x Dhana	0.7-0.9	0.75	0.05	13.3	20-30	24.25	2.17	17.9	12-16	14.25	1.03	14.5	7-12	8.75	1.11	25.3	0-2	1.00	0.41	81.6
NRC-492 x Madakkathara-2	0.4-0.8	0.63	0.05	23.7	10.5-29.0	21.65	2.46	36.0	5-23	12.50	1.79	45.3	5.5-9.0	7.80	0.47	18.9	0-3	0.90	0.35	122.3

1-8= Direct crosses, 9-15= Reciprocal crosses,

ICFL = Length from cotyledon to first leaf



Table 1.9: Variability in seeding parameters at 50 days after planting

Cross	Girth (cm)			Plant height (cm)			No. of leaves			No. of branches						
	Range	Mean	SE	CV	Range	Mean	SE	CV	Range	Mean	SE	CV				
Vengurla-4 x NRC-492	0.4-1.6	0.97	0.02	25.3	8-68	36.36	0.87	31.8	2-39	17.27	0.51	39.0	0-9	1.44	0.11	105.8
Vengurla-4 x Taliparamba-1	0.6-1.8	1.04	0.02	23.7	14-83	46.46	1.25	31.0	7-41	20.02	0.59	34.2	0-6	1.96	0.14	83.5
Priyanka x NRC-492	0.5-1.8	1.13	0.03	21.9	10-81	56.43	1.64	24.2	5-38	16.78	0.69	34.3	0-6	2.10	0.18	71.7
Priyanka x Taliparamba-1	0.6-1.4	1.11	0.07	21.4	18-75	46.10	5.42	37.2	5-27	20.00	2.21	35.0	0-4	2.1	0.50	75.96
Dhana x NRC-492	0.7-1.4	1.07	0.02	13.2	29-61	43.00	0.91	16.5	10-33	17.20	0.64	29.3	0-7	2.51	0.21	67.3
Dhana x Taliparamba-1	0.6-1.6	1.15	0.02	19.2	22-81	55.93	1.64	25.5	9-38	23.83	0.78	28.3	1-8	3.57	0.20	45.3
Madakkathara-2 x NRC-92	0.3-1.6	1.01	0.02	20.5	13-83	46.68	1.01	26.3	5-44	18.92	0.46	35.0	0-7	2.27	0.12	65.1
Madakkathara-2 x Taliparamba-1	0.4-1.5	1.07	0.02	19.4	16-82	52.84	1.91	28.5	9-38	21.93	0.76	27.3	0-7	2.82	0.21	58.6
NRC-492 x Vengurla-4	0.8-1.2	1.05	0.04	11.2	25-58	38.7	2.77	22.6	13-28	20.00	1.47	23.3	0-2	1.2	0.20	52.7
Taliparamba-1 x Vengurla-4	1.0-1.2	1.07	0.03	7.0	36-45	40.71	1.42	9.3	18-26	22.71	1.04	12.1	0-3	2.28	0.42	48.7
NRC-492 x Priyanka	0.9-1.2	1.06	0.03	9.8	26-47	39.38	1.92	17.6	12-23	17.46	0.95	19.6	0-5	1.77	0.41	83.7
Taliparamba-1 x Priyanka	1.2-1.5	1.26	0.04	8.4	47-68	57.00	2.46	12.2	17-32	26.87	1.62	17.0	1-4	2.75	0.31	32.2
NRC-492 x Dhana	0.8-1.3	1.07	0.04	12.8	24-52	35.25	2.47	24.3	10-33	22.0	1.95	30.7	0-7	3.00	0.56	65.13
Taliparamba-1 x Dhana	1.1-1.4	1.27	0.06	9.8	38-51	44.00	1.03	43.4	23-32	27.00	1.96	14.5	2-7	4.75	1.03	43.4
NRC-492 x Madakkathara-2	0.6-1.5	1.05	0.08	25.9	17-57	37.30	3.97	33.7	13-24	21.80	2.47	35.8	0-5	2.80	0.53	60.2

1-8= Direct crosses, 9-15= Reciprocal crosses

1.2.6 Evaluation of cashew germplasm for cashew apple yield quality traits

In order to evaluate cashew germplasm for cashew apple yield and quality traits, 14 germplasm accessions and one check hybrid

were planted at a spacing of 7.5 m x 7.5 m in RBD with three replications in 2013 at DCR, Puttur. Observations on plant height, canopy spread, number of branches and trunk growth have been recorded at six months after planting (Table 1.10)

Table 1.10: Growth of different accessions

Accession	Plant height (cm)	Canopy spread (cm)	No. of branches	Trunk girth (cm)
NRC-301	93.0	77.2	7.3	2.3
NRC-493	81.4	71.9	7.0	2.0
NRC-140	72.1	69.2	6.6	1.9
NRC-111	83.7	63.9	7.0	1.9
NRC-75	69.5	56.4	6.3	1.8
NRC-389	86.7	81.7	6.6	1.8
NRC-120	79.4	71.0	8.0	1.8
NRC-176	82.2	69.6	8.0	2.0
NRC-270	56.5	40.6	5.8	1.4
NRC-112	79.4	75.1	7.8	2.1
NRC-144	73.8	68.9	7.1	1.9
NRC-189	81.8	59.0	7.0	1.6
NRC-175	101.5	95.7	6.8	2.0
NRC-183	83.4	67.9	7.1	2.1

1.2.7 Development of back cross progenies of promising hybrids for dwarf stature with high yield

Back crosses were made for two combinations with two trees in each combination viz., i) (Ullal-3 x NRC-92) x Ullal-3 and ii) (Bhaskara x NRC-492) x Bhaskara. The nuts collected were sown in polybags for further studies.

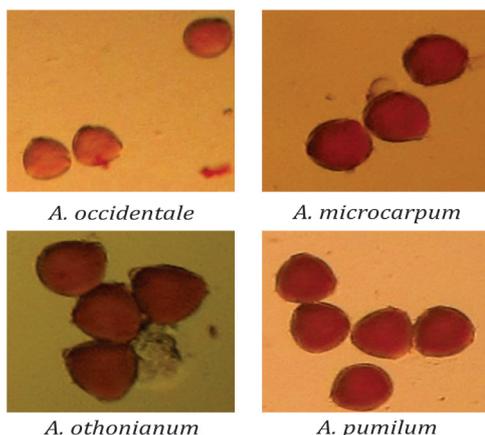
1.2.8 Pollen fertility in cultivated and wild species of cashew

The pollen fertility status of 20 varieties of cultivated species *Anacardium occidentale* L. and

three wild species viz., *Anacardium microcarpum* Ducke., *Anacardium orthonianum* Rizz. and *Anacardium pumilum* St.Hil (*A. humile*) was assessed using aceto-carmin staining method. The percentage data was transformed using arcsine degree transformation.

The arcsine transformed data on pollen fertility (%) was analyzed using SAS software (9.3 version). Further paired t-test analysis was carried out to compare the pollen fertility means between two kinds of flowers used in the study. The genotypic, phenotypic and environmental coefficients of variation, heritability and genetic advance were calculated for this trait.

The stained pollen grains were larger in size and tricolpate whereas the unstained pollen grains were smaller and round in shape in two kinds of flowers in all four species studied. There was significant difference among the varieties with pollen source from male as well as hermaphrodite flowers while wild species differed significantly only for pollen source from hermaphrodite flower (Table 1.11). The pollen fertility means within a variety from male and hermaphrodite flowers differed significantly in two varieties viz., K-22-1 and Madakkathara-2 and this was also true in case of wild species *A. pumilum*.



Pollen grains of four species of cashew stained with aceto-carmine (100 x)

The pollen fertility of varieties of cultivated species ranged from 53.10 per cent (Dhana) to 9.42 per cent (Ullal-3) with male flower as source of pollen whereas the fertility of pollens from hermaphrodite flowers ranged from 65.99 per cent in K-22-1 to 98.40 per cent in Kanaka. The pollen fertility in wild species ranged from 90.49 per cent in *A. othonianum* to 93.48 per cent in *A. pumilum* when the pollen source was male flower. But when the pollen source was hermaphrodite flower, *A. pumilum* showed the lowest pollen fertility of 47.68 per cent and *A. microcarpum* exhibited the highest pollen fertility of 97.19 per cent.

With regard to variability components, genetic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were found to be low for the pollen fertility from male flowers of both cultivated and wild species (Table 1.12) while it was moderate for the cultivated species and high for the wild species for the pollen fertility from hermaphrodite flowers. It means that variability of pollen fertility in cultivars and wild species is low in case of male flowers and it was moderate for perfect flowers. The heritability was found to be high for pollen fertility from male flowers and moderate for hermaphrodite flowers in cultivated species. It was low in pollen fertility from male flower and high for hermaphrodite flowers of wild species. The genetic advance was low for pollen fertility from male flower and high for hermaphrodite flowers of wild species. It was moderate for pollen fertility from two kinds of flowers of cultivated species. High heritability and high genetic advance observed for pollen fertility from hermaphrodite flower of wild species indicates that most likely the heritability is due to additive gene effects and selection may be effective at pollen level. Low heritability was accompanied with low genetic advance for the pollen fertility from male flower of wild species which indicates the pollen fertility is highly influenced by environmental effects and selection would be ineffective.

The study revealed the possibility of using both male and hermaphrodite flowers as pollen source for inter-varietal hybridization. However, for varieties with partial pollen fertility, large quantity of pollen grains needs to be collected during hybridization. Based on fertility values, it appears that in the variety K-22-1, pollen from male flowers should be used whereas in Dhana and Kanaka, pollen from hermaphrodite flowers should be used for better success of seed set in cashew. The study also revealed that all three wild species can be used as pollen donors in the inter-specific hybridization programme in which the male flowers of *A. pumilum* should be used as pollen source.

Table 1.11: Pollen fertility percentage from two sources of pollen in cultivated varieties and wild species of cashew

Variety	Source of pollen		Paired t-test
	Male flower	Hermaphrodite flower	
Ullal-3	96.42 (74.96) a	97.55 (82.00) ba	-1.99
Ullal-1	96.11 (74.43) a	96.08 (75.67) bac	-0.24
K-22-1	95.29 (72.95) ba	65.99 (41.34) h	10.88
Vengurla-7	94.68 (71.43) bac	92.18 (68.24) ebdgcf	0.66
VTH-174	94.55 (72.11) bac	84.42 (59.60) edgf	1.56
Vengurla-3	94.40 (71.10) bac	91.27 (71.95) ebdac	-0.08
Madakkathara-2	94.18 (70.91) bac	81.21 (54.75) hacgf	4.12
VTH 30/4	94.17 (71.11) bac	89.33 (69.73) ebdacf	0.19
Bhaskara	93.42 (69.43) bac	96.60 (80.59) ba	-2.18
Brazil dwarf	93.38 (69.56) bac	98.33 (85.29) a	-2.29
Ullal-2	93.21 (69.08) bac	96.16 (77.63) ba	-1.65
Ullal-4	93.17 (70.95) bac	86.41 (60.62) edgcf	2.63
Vridhachalam-3	92.28 (69.57) bac	84.47 (57.96) egf	2.63
Taliparamba-1	92.21 (67.57) bac	91.77 (71.92) ebdac	-0.48
NRCC Sel-2	92.04 (68.20) bac	97.70 (82.25) ba	-2.09
Vengurla-4	91.77 (67.67) bac	93.25 (72.41) ebd	-0.78
Purple mutant	90.43 (65.42) bdc	96.89 (78.88) ba	-2.23
Priyanka	89.28 (63.77) dc	94.18 (74.88) bdac	-1.45
Kanaka	85.12 (59.30) d	98.40 (83.49) ba	-3.27
Dhana	53.18 (32.23) e	74.99 (52.88) hg	-2.32
Mean	90.97	90.36	t (P<0.05): 2.77
SEm +/-	2.15	5.59	
CV (%)	6.50	17.83	
LSD (P<0.05)	6.05	15.75	
Species			
<i>A. pumilum</i>	93.84 (70.14) a	47.68 (28.54) c	16.71
<i>A. microcarpum</i>	92.27 (67.56) a	97.19 (76.61) a	-3.95
<i>A. occidentale</i>	90.97 (65.46) a	90.36 (64.63) b	0.89
<i>A. orthonianum</i>	90.49 (66.09) a	94.78 (76.13) a	-1.29
Mean	91.89	82.50	t (P<0.05): 2.77
SEm +/-	2.69	3.41	
CV (%)	8.92	12.41	
LSD (<0.05)	NS	10.52	

Values in parenthesis indicate arcsine transformed values
Means with same letter do not differ significantly

Table 1.12: Variability statistics for pollen fertility in cashew

Parameter	Varieties		Species	
	Male flower	Hermaphrodite flower	Male flower	Hermaphrodite flower
GCV (%)	9.69	15.08	3.6	45.19
PCV (%)	12.02	23.35	11.15	47.67
Heritability %	65.02	41.71	10.44	89.86
GA as % mean	11.94	15.30	0.24	87.39

1.3 Biotechnology

1.3.1 Molecular characterization of cashew

Seventeen accessions of cashew comprising of germplasm, pre-release types and released varieties were characterized using 16 primers of ISSR. The number of bands generated were 84, out of which 60 (75%) were polymorphic with 3.75 polymorphic markers per primer. The polymorphic information content varied from 0.177 to 0.353 with a mean of 0.244. Similarly, the markers index varied from 0.121 to 2.118 with a mean of 0.989. The genetic relatedness of accessions was assessed based on their coefficient of genetic similarity (Jaccard) which varied from 0.51 to 0.82 with a mean of 0.662 indicated low genetic diversity existing among the accessions. A lowest similarity of 0.51 observed between Ullal-3 and Bhuthnath indicated that these accessions were highly divergent. Similarly, a high similarity of 0.92 observed between hybrids H-66 and H-68 indicated that they were genetically similar. The cluster analysis made distinguished 17 accessions into six molecular groups based on similarity coefficient.

1.3.2 Identification of markers linked to economic characters

Parental DNA of two crosses namely Bhaskara x Taliparamba-1 and Ullal-3 x Brazil dwarf genotypes were screened with SSR primers of related species namely Pistachio (25), alfalfa (25), mango (15) and almond (35), and recorded polymorphic markers. DNA of all the F1 plants of Ullal-3 x Brazil dwarf genotype was isolated for markers segregation study.

DNA has been extracted from two parents and 42 F1 individuals of Ullal- 3 x Brazil dwarf following CTAB procedure. This population is taken because of contrasting characters of parents viz., Ullal-3 (vigorous, high yielding) and Brazil dwarf (dwarf and compact, low yielding). The parental polymorphism was assessed with 21 cashew SSR primers and 28 pistachio SSR primers. Of these, six cashew and six pistachio SSR primers were found to be polymorphic. These primers were further confirmed for their polymorphism and selected for screening F1 individuals. The phenotypic characters were recorded on parents and F1 individuals.

2. CROP MANAGEMENT

2.1 Foliar Spray of Nutrients on Cashew

The study was undertaken to evaluate the effect of foliar sprays of major nutrients (3% urea + 0.5% H_3PO_4 + 1% K_2SO_4) alone or combinations, and secondary and micronutrients (0.5% $ZnSO_4$ + 0.1% solubor + 0.5% $MgSO_4$) alone or combinations on cashew during 2009-2013 at experimental farm of DCR, Puttur. The treatments were as follows:

Experiment I: Foliar spray of major nutrients on cashew

1. Urea 3%
2. Orthophosphoric acid (H_3PO_4) 0.5%
3. K_2SO_4 1%
4. Urea 3% + H_3PO_4 0.5%
5. Urea 3% + K_2SO_4 1%
6. H_3PO_4 0.5% + K_2SO_4 1%
7. Urea 3% + H_3PO_4 0.5% + K_2SO_4 1%
8. Control

Experiment II: Foliar spray of secondary and micronutrients on cashew

1. $ZnSO_4$ 0.5%
2. Solubor 0.1%
3. $MgSO_4$ 0.5%
4. $ZnSO_4$ 0.5% + solubor 0.1%
5. $ZnSO_4$ 0.5% + $MgSO_4$ 0.5%
6. Solubor 0.1% + $MgSO_4$ 0.5%
7. $ZnSO_4$ 0.5% + solubor 0.1% + $MgSO_4$ 0.5%
8. Control

2.1.1 Impact of foliar spray of nutrients on nut yield and economics of cashew

Foliar nutrients were administered three times viz., flushing, flowering and nut development of cashew. The experimental plants were nine years old (During first year of study) of cashew variety NRCC Sel-2 spaced at 5 m x 5 m. The soil properties at the start of the experiment showed that acidic (pH 5.66 - 6.11) and non-saline in nature (EC = 0.018 - 0.034 dS m⁻¹), high in organic carbon (7.9 - 8.5 g/kg), low in Exch. Mg [0.45 - 0.58 cmol (p+) kg⁻¹], available N (172 - 182 kg/ha), available P (17.5-19.1 kg/ha), low to medium in available K (133.4 - 146.5 kg/ha), sufficient in DTPA-Fe (32.6 - 37.8 mg/kg), DTPA-Mn (22.2 - 25.0 mg/kg), DTPA-Cu (0.58 - 0.61 mg/kg), and deficient in DTPA-Zn (0.25 - 0.26 mg/kg) and available B (0.21 - 0.24 mg/kg) contents. The results showed that all major nutrient and, secondary and micronutrient applications individually and combinations increased cumulative nut yield (2009-13) over control (Tables 2.1 and 2.2). Of the major nutrient applications, significant yield increase was obtained with 3% urea + 0.5% H_3PO_4 + 1% K_2SO_4 (7.30 kg/tree), 0.5% H_3PO_4 + 1% K_2SO_4 (7.20 kg/tree) and 3% urea + 0.5% H_3PO_4 (6.93 kg/tree) as compared with the control (6.29 kg/tree). Of secondary and micronutrients, application of either 0.5% $ZnSO_4$ or 0.1% solubor individually resulted in a small but still significant increase in nut yield over control. Application of 0.5% $MgSO_4$, although superior to control, was less effective than either 0.5% $ZnSO_4$ or 0.1% solubor

supplied individually. The highest cumulative nut yield (2009-13) was obtained with combined application of 0.5% ZnSO₄ + 0.1% solubor + 0.5% MgSO₄ (8.18 kg/tree) followed by 0.5% ZnSO₄ + 0.1% solubor (8.01 kg/tree) and 0.5% ZnSO₄ + 0.5% MgSO₄ (7.79 kg/tree).

Table 2.1: Effect of foliar spray of major nutrients on nut yield

Treatment	Nut yield (kg/tree) (2013)	Cumulative yield (kg/tree) (4 years)	Shelling %
Urea (3%)	2.23	6.71	29.2
H ₃ PO ₄ (0.5%)	2.20	6.82	29.0
K ₂ SO ₄ (1%)	2.21	6.63	30.0
Urea + H ₃ PO ₄	2.25	6.93	27.8
Urea + K ₂ SO ₄	2.30	6.83	27.3
H ₃ PO ₄ + K ₂ SO ₄	2.34	7.20	28.5
Urea + H ₃ PO ₄ + K ₂ SO ₄	2.41	7.30	29.1
Control	2.15	6.29	27.9
CD (p=0.05)	0.18	0.64	ns

Table 2.2: Effect of foliar spray of secondary and micronutrients on nut yield

Treatment	Nut yield (kg/tree) (2013)	Cumulative yield (kg/tree) (4 years)	Shelling %
ZnSO ₄ (0.5%)	2.40	7.16	28.8
Solubor (0.1%)	2.34	7.29	28.1
MgSO ₄ (0.5%)	2.30	7.05	27.5
ZnSO ₄ + solubor	2.61	8.01	28.6
ZnSO ₄ + MgSO ₄	2.52	7.79	30.1
Solubor + MgSO ₄	2.46	7.40	28.5
ZnSO ₄ + MgSO ₄ + solubor	2.65	8.18	28.6
Control	2.23	6.27	27.5
CD (p=0.05)	0.21	0.83	ns

Foliar application of 3% urea + 0.5% H_3PO_4 + 1% K_2SO_4 increased the nut yield by 16.1 per cent while, application of 0.5% $ZnSO_4$ + 0.1% solubor + 0.5% $MgSO_4$ resulted in an increase of nut yield by 30.54 per cent averaged over the four years (2010–2013) in soils deficient in Mg, Zn and B. This study suggests that nut yield response to foliar spray of secondary and micronutrients was appreciably higher as compared to the foliar spray of major nutrients. Use of need based micronutrient fertilizers is highly cost effective in deficient situations, especially with foliar feeding. Shelling % of cashew was not affected by foliar spray of nutrients. Of major nutrient spray, 3% urea resulted in the highest B:C ratio (2.22) followed

by 3% urea + 0.5% H_3PO_4 (2.16) and 0.5% H_3PO_4 (2.14) (Table 2.3). Application of 0.5% $ZnSO_4$ + 0.1% solubor gave maximum B:C ratio (2.41) followed by 0.1% solubor (2.35) and 0.5% $ZnSO_4$ + 0.1% solubor + 0.5% $MgSO_4$ (2.32) respectively which differed significantly from other foliar treatments including control (Table 2.4). Foliar application of nutrients showed no effect on quality of cashew kernel measured in terms of protein (35.9 - 40.3 per cent), starch (36.6 - 41.8 mg/100 g) and sugars (9.55 - 10.2 mg/100 g). The results of the present study suggest that foliar application of secondary and micronutrients is not only augmenting the nut yield but also improve the economic status of cashew growers.

Table 2.3: Economic analysis of cashew as influenced by foliar spray of major nutrients (Mean of 4 years)

Treatment	Nut yield (kg/ha)	Cost of the treatment (₹/ha)	Gross income (₹/ha)	Net monetary returns (₹/ha)	B:C ratio
Urea (3%)	671	96,908	2,14,720	1,17,812	2.22
H_3PO_4 (0.5%)	682	1,01,834	2,18,240	1,16,406	2.14
K_2SO_4 (1%)	663	1,06,948	2,12,160	1,05,212	1.98
Urea + H_3PO_4	693	1,02,451	2,21,760	1,19,309	2.16
Urea + K_2SO_4	683	1,07,852	2,18,560	1,10,708	2.03
H_3PO_4 + K_2SO_4	720	1,13,610	2,30,400	1,16,790	2.03
Urea + H_3PO_4 + K_2SO_4	730	1,14,195	2,33,600	1,19,405	2.05
Control	629	95,300	2,01,280	1,05,980	2.11
CD (p = 0.05)	64	10,648	19,850	10,936	0.19

Table 2.4: Economic analysis of cashew as influenced by foliar spray of secondary and micronutrients (Mean of 4 years)

Treatment	Nut yield (kg/ha)	Cost of the treatment (₹/ha)	Gross income (₹/ha)	Net monetary returns (₹/ha)	B:C ratio
ZnSO ₄ (0.5%)	716	1,03,226	2,29,184	1,25,958	2.22
Solubor (0.1%)	729	99,121	2,33,152	1,34,031	2.35
MgSO ₄ (0.5%)	705	1,03,428	2,25,600	1,22,172	2.18
ZnSO ₄ + solubor	801	1,06,586	2,56,448	1,49,862	2.41
ZnSO ₄ + MgSO ₄	779	1,10,925	2,49,216	1,38,291	2.25
Solubor + MgSO ₄	740	1,05,185	2,36,832	1,31,647	2.25
ZnSO ₄ + MgSO ₄ + solubor	818	1,12,826	2,61,888	1,49,062	2.32
Control	627	95,232	2,00,608	1,05,376	2.11
CD (p = 0.05)	83	11,582	24,629	14,256	0.20

2.2 Maximization of Yield in Irrigated Cashew and sustaining Soil Productivity through Integrated Nutrient Management

Field experiments were carried out during 2009-13 at DCR, Puttur to develop a package of recommendation for young (Two years old cashew variety VRI-3 during first year of study) and mature (Nine years old cashew variety Bhaskara during first year of study) cashew plantations involving integrated nutrient management (INM) with the application of biofertilizers, organic manures and chemical fertilizers.

Treatments

(a) Main plot treatments (Method of biofertilizer application)

M1 : Control (No inoculation)

M2 : Biofertilizer (*Azospirillum*, *Acetobacter*, Phosphate solubilizing bacteria and AMF 50 g each/tree) inoculation around tree basin to a radius of 45 cm

M3 : Biofertilizer (*Azospirillum*, *Acetobacter*, Phosphate solubilizing bacteria and AMF 50 g each/tree) inoculation in the rectangular trenches taken in the middle of four trees

M4 : Combination of M2 + M3

(b) Sub plot treatments (Fertilizer levels)

T1 : Control (No application)

T2 : 50 % of recommended NPK through drip + FYM

T3 : 75 % of recommended NPK through drip + FYM

T4 : *100 % of recommended NPK through drip + FYM

T5 : Soil test based fertiliser recommendation through drip.

*100% of recommended dose: N 135 g : P₂O₅ 39 g : K₂O 34 g and FYM 5.6 kg per tree per annum.

2.2.1 Effect of INM strategies on nut yield and economics of cashew

The nut yield of cashew increased significantly due to various fertilizer levels and biofertilizer application over control (Tables 2.5 and 2.6). In young cashew plantation, inoculation of biofertilizer consortia both to the tree basin at a radius of 45 cm and in the rectangular trenches taken in the middle of four trees + 100% of recommended dose of nutrients (M4T4) resulted in the highest nut yield (10.15 kg/tree) which was at par with that of inoculation of biofertilizer consortia to the tree basin at a radius of 45 cm +100% of recommended dose of nutrients (M2T4) (9.84 kg/tree) and increased nut yield to the tune of 53.1 and 48.4 per cent over control, respectively. In case of mature cashew plantation, the higher nut yields, however, were obtained when 100% of recommended NPK + FYM (T4) (39.43 kg/tree), 75% of recommended NPK + FYM

(T3) (38.29 kg/tree) and soil test based fertilizer recommendation (T5) (38.11 kg/tree) were applied either with application of biofertilizer consortia both to the tree basin at a radius of 45 cm (50 g each/tree) and in the rectangular trenches taken in the middle of four trees (50 g each/tree) (M4) or application of biofertilizer consortia to the tree basin at a radius of 45 cm (50 g each/tree) (M2). It was found that there was a yield response of 31.1 per cent with the application of biofertilizer consortia both to the tree basin at a radius of 45 cm and in the rectangular trenches taken in the middle of four trees with 100% recommended dose of NPK + FYM (M4T4). The higher nut yields in different fertilizer levels, FYM and biofertilizer consortia were attributed to the beneficial effect of combined use of fertilizers, FYM and biofertilizer consortia as nutrient availability increased through enhanced microbial activity, conversion from unavailable to available forms and also due to improved soil quality.

Table 2.5: Effect of INM strategies on nut yield of young cashew plantation

	Yield (kg/tree) - 2013					Cumulative yield (kg/tree) - 4 years				
	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
M1	2.68	2.98	3.39	3.51	3.75	6.63	7.20	7.93	8.70	8.64
M2	2.85	3.25	3.86	4.12	4.00	7.17	7.57	8.88	9.84	9.41
M3	2.80	3.15	3.80	3.89	3.80	7.29	7.64	8.89	9.21	9.08
M4	2.90	3.45	3.96	4.20	3.95	7.70	8.69	9.61	10.15	9.37
CD (p = 0.05)	Main plot			0.342		0.697				
	subplot			0.396		0.735				

M1= No inoculation, M2= Biofertilizers inoculation around tree basin to a radius of 45 cm, M3= Biofertilizers inoculation in the middle of four trees and M4= M2+M3

T1= Control, T2= 50% of recommended NPK + FYM, T3= 75% of recommended NPK + FYM, T4= 100% of recommended NPK + FYM and T5= Soil test based fertilizer recommendation

Table 2.6: Effect of INM strategies on nut yield of mature cashew plantation

	Yield (kg/tree) - 2013					Cumulative yield (kg/tree) - 4 years				
	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
M1	7.02	7.55	8.31	8.52	8.44	30.08	30.43	32.64	34.58	33.29
M2	8.40	8.79	9.45	10.24	10.41	32.64	33.14	35.43	37.23	36.39
M3	8.01	8.15	8.59	8.55	8.45	30.81	31.64	33.89	36.06	34.08
M4	8.60	8.75	10.00	10.25	10.50	34.03	34.32	38.29	39.43	38.11
CD (p=0.05)	Main lot			0.933		2.81				
	subplot			0.965		2.98				

M1= No inoculation, M2= Biofertilizers inoculation around tree basin to a radius of 45 cm, M3= Biofertilizers inoculation in the middle of four trees and M4= M2+M3
 T1= Control, T2= 50% of recommended NPK + FYM, T3= 75% of recommended NPK + FYM, T4= 100% of recommended NPK + FYM and T5= Soil test based fertilizer recommendation

In young cashew plantation, of the different fertilizer levels, on an average, the highest cumulative nut yield was obtained under the 100% of recommended NPK + FYM (T4) (9.48 kg/tree) followed by soil test based fertilizer recommendation (T5) (9.13 kg/tree), but difference was non-significant. The average improvements in cumulative nut yield due to 50% of recommended NPK + FYM (T2), 75% of recommended NPK + FYM (T3), 100% of recommended NPK + FYM (T4) and soil test based fertilizer recommendation (T5) was by 8.1, 22.7, 31.7 and 26.8 per cent, respectively over control (T1). The effect of the different fertilizer levels on cumulative nut yield of mature cashew plantation also followed similar trend where the highest average yield was obtained under 100% of recommended NPK + FYM (T4) (36.83 kg/tree) followed by soil test based fertilizer recommendation (T5) (35.47 kg/tree) and 75% of recommended NPK + FYM (T3) (35.06 kg/tree). On an average, improvements in cumulative nut yield due to 50% of recommended NPK + FYM

(T2), 75% of recommended NPK + FYM (T3), 100% of recommended NPK + FYM (T4) and soil test based fertilizer recommendation (T5) was by 15.3, 9.9, 15.4 and 11.2 per cent, respectively over control (T1).

Method of application of biofertilizer consortia [*Azospirillum*, *Acetobacter*, Phosphate solubilizing bacteria and AMF) significantly influenced the nut yield. In young cashew plantation, on an average, there was a cumulative nut yield response of 9.64, 7.7 and 16.4 per cent with the application of biofertilizer consortia to the tree basin at a radius of 45 cm (50 g each/tree) (M2), application of biofertilizer consortia in the rectangular trenches taken in the middle of four trees (M3) and application biofertilizer consortia both to the tree basin at a radius of 45 cm (50 g each/tree) and in the rectangular trenches taken in the middle of four trees (50 g each/tree) (M4), respectively. In mature cashew plantation, the average improvements in nut yield were higher

by 8.6, 3.4 and 14.4 per cent in M2, M3 and M4 treatments respectively, over control.

Fertilizer levels and inoculation of biofertilizer consortia caused significant variations in net returns of cashew (Tables 2.7 and 2.8). In young cashew plantation, the maximum net returns (₹ 36,168/- per ha) with a B:C ratio of 2.06 were obtained with the application of biofertilizer consortia to the tree basin at a radius of 45 cm with 100% recommended dose of NPK + FYM (M2T4) which was significantly higher than

other treatments tested under this study. The treatment M2T4 increased net returns of cashew by 97 per cent over control. Among the fertilizer levels, the higher net returns (₹ 33,562/- per ha) were achieved with the application of 100% of recommended NPK + FYM (T4) followed by soil test based fertilizer recommendation (T5) (₹ 31,561/- per ha). The treatments 100% of recommended NPK + FYM (T4) and soil test based fertilizer recommendation (T5) were statistically at par with each other but were significantly superior to rest of the treatments.

Table 2.7: Economic analysis as influenced by the INM strategies in young cashew plantation (Mean of 4 years)

	Net monetary returns (₹/ha)					B:C ratio				
	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
M1	18,338	21,708	26,868	32,313	32,382	1.63	1.73	1.90	2.08	2.10
M2	17,910	20,066	29,367	36,168	33,596	1.54	1.59	1.86	2.06	2.00
M3	18,767	20,566	29,438	31,670	31,240	1.56	1.61	1.86	1.93	1.93
M4	17,410	23,779	30,295	34,098	29,026	1.46	1.62	1.79	1.89	1.77
CD (p=0.05)	Main plot			1658		0.185				
	Sub plot			2035		0.193				

M1= No inoculation, M2= Biofertilizers inoculation around tree basin to a radius of 45 cm, M3= Biofertilizers inoculation in the middle of four trees and M4= M2+M3

T1= Control, T2= 50% of recommended NPK + FYM, T3= 75% of recommended NPK + FYM, T4= 100% of recommended NPK + FYM and T5= Soil test based fertilizer recommendation

In mature cashew plantation, application of biofertilizer consortia both to the tree basin at a radius of 45 cm and in the rectangular trenches taken in the middle of four trees with 100% recommended dose of NPK + FYM (M4T4) resulted in significant increase in net returns (₹ 2,24,435/- per ha) with a B:C ratio of 4.93 but it was statistically at par with the application of

biofertilizer consortia to the tree basin at a radius of 45 cm with 100% recommended dose of NPK + FYM (M2T4) (₹ 2,13,011/- per ha). On an average, the net returns were higher by 25.1 and 31.8 per cent in M2T4 and M4T4 treatments respectively, over control. Among fertilizer levels, 100% of recommended NPK + FYM (T4) gave the highest net returns (₹ 2,10,119.3 per ha) followed by

soil test based fertilizer recommendation (T5) (₹ 2,01,214 per ha) and 75% of recommended dose (₹ 1,97,802.3 per ha) which were statistically at par with each other.

The results of the present study indicated that application of biofertilizer consortia [*Azospirillum*, *Acetobacter*, Phosphate solubilizing bacteria and AMF) at a radius of 45 cm along with 100% of recommended dose of nutrients (N 135 g :

P₂O₅ 39 g : K₂O 34 g and FYM 5.6 kg/tree/year) is found to be the best INM strategy for young cashew plantation. In mature cashew plantation, application of biofertilizer consortia [*Azospirillum*, *Acetobacter*, Phosphate solubilizing bacteria and AMF) at a radius of 45 cm along with 75% of recommended NPK + FYM is found to be the best INM strategy in terms of higher nut yield, net monetary returns and better soil health.

Table 2.8: Economic analysis as influenced by the INM strategies in mature cashew plantation (Mean of 4 years)

	Net monetary returns (₹/ha)					B:C ratio				
	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
M1	1,70,271	1,69,272	1,84,787	1,98,374	1,87,726	4.83	4.53	4.83	5.09	4.76
M2	1,84,266	1,84,338	2,00,424	2,13,011	2,08,541	4.78	4.53	4.81	5.03	5.07
M3	1,71,128	1,73,628	1,89,428	2,04,657	1,92,052	4.51	4.32	4.60	4.88	4.75
M4	1,89,906	1,88,479	2,16,570	2,24,435	2,16,537	4.58	4.33	4.81	4.93	4.90
CD (p=0.05)	Main plot			12158		0.30				
	Sub plot			13340		0.39				

M1= No inoculation, M2= Biofertilizers inoculation around tree basin to a radius of 45 cm, M3= Biofertilizers inoculation in the middle of four trees and M4= M2+M3

T1= Control, T2= 50% of recommended NPK + FYM, T3= 75% of recommended NPK + FYM, T4= 100% of recommended NPK + FYM and T5= Soil test based fertilizer recommendation

2.3 Irrigation Requirement of Cashew under High Density Planting System

In order to assess irrigation requirement in cashew planted at different spacings, a field experiment was laid out in split plot design with variety Bhaskara in 2011. The treatments are given below

Main plot treatments (Plant densities)

M1: 5 m x 4 m (500 plants/ha)

M2: 6 m x 4 m (416 plants/ha)

M3: 10 m x 5 m (200 plants/ha)

Sub plot treatments (Irrigation levels)

T1: 20% CPE

T2: 40% CPE

- T3: 60% CPE
 T4: Critical irrigation (once in 15 days)
 T5: Soil and water conservation technique (Modified crescent bund)
 T6: Control (without irrigation and soil and water conservation)

2.3.1 Plant density and irrigation levels on growth of cashew

The growth parameters *viz.*, plant height, girth and canopy spread (NS and EW direction) of

cashew plant was recorded under different plant density and irrigation levels (Table 2.9 and 2.10). The data was statistically scrutinized using SAS 9.3 software version. No significant difference was observed in growth parameters with respect to different plant densities and irrigation levels. However, the height of the plant ranged from 292.50 to 313.19 cm in different plant densities and 281.94 to 343.06 cm under different irrigation levels. Girth of the plant in different plant densities and irrigation levels varied from 23.42 to 24.72 cm and 22.61 to 26.11 cm, respectively.

Table 2.9: Effect of spacing and irrigation on plant height and stem girth

Irrigation (T) / Spacing (M)	T1	T2	T3	T4	T5	T6	Mean
	Plant height (cm)						
M1	354.17	271.67	287.50	300.00	258.33	283.33	292.50
M2	366.67	337.50	345.83	270.83	266.67	291.67	313.19
M3	308.33	329.17	295.83	329.17	320.83	275.00	309.72
Mean (T)	343.06	312.78	309.72	300.00	281.94	283.33	
Source	Main plot (M)	Sub plot (T)	Sub plot (T) x Main plot (M)		Main plot (M) x Sub plot (T)		
SE (d)	19.26	25.13	43.53		44.16		
LSD at 5%	NS	NS	NS		NS		
Stem girth (cm)							
M1	26.17	21.83	23.50	24.33	22.17	22.50	23.42
M2	27.33	25.00	26.33	23.00	22.67	24.00	24.72
M3	24.83	26.67	24.83	23.67	23.00	22.50	24.25
Mean (T)	26.11	24.50	24.89	23.67	22.61	23.00	
Source	Main plot (M)	Sub plot (T)	Sub plot (T) x Main plot (M)		Main plot (M) x Sub plot (T)		
SE (d)	1.06	1.41	2.45		2.47		
LSD at 5%	NS	NS	NS		NS		

Canopy spread in NS and EW direction of the cashew plant under different plant densities varied from 261.81 to 268.75 cm and 252.78 to 279.17 cm, respectively. Canopy spread with

respect to different irrigation levels ranged from 230.56 to 288.89 cm in NS direction and 236.11 to 281.94 cm under EW direction.

Table 2.10: Effect of spacing and irrigation on canopy spread

Irrigation (T)/ Spacing (M)	T1	T2	T3	T4	T5	T6	Mean
	Canopy spread N-S (cm)						
M1	325.00	241.67	233.33	304.17	254.17	225.00	263.89
M2	258.33	295.83	312.50	216.67	241.67	245.83	261.81
M3	283.33	295.83	279.17	262.50	270.83	220.83	268.75
Mean (T)	288.89	277.78	275.00	261.11	255.56	230.56	
Source	Main plot (M)	Sub plot (T)	Sub plot (T) x Main plot (M)		Main plot (M) x Sub plot (T)		
SE (d)	22.87	25.94	44.93		46.96		
LSD at 5%	NS	NS	NS		NS		
Canopy spread E-W (cm)							
M1	291.67	262.50	237.50	333.33	250.00	233.33	268.06
M2	270.83	270.83	287.50	233.33	220.83	233.33	252.78
M3	283.33	304.17	300.00	279.17	266.67	241.67	279.17
Mean (T)	281.94	279.17	275.00	281.94	245.83	236.11	
Source	Main plot (M)	Sub plot (T)	Sub plot (T) x Main plot (M)		Main plot (M) x Sub plot (T)		
SE (d)	23.36	30.87	53.46		54.11		
LSD at 5%	NS	NS	NS		NS		

2.4 Effect of Paclobutrazol on Cashew

Paclobutrazol (PBZ) was applied to the plants @ 1.0 g, 2.0 g and 3.0 g a.i. per plant as soil drenching in the month of September before vegetative flushes. The frequency of PBZ application was every year, once in two years and once in three years. The morphometric and flowering parameters have been recorded after the imposition of PBZ treatments.

2.4.1 Morphometric 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 326.0 to 423.8 cm in different doses and frequency of application, while in the untreated plants, plant height was

found to be 425.8 to 454.0 cm. The girth at collar region among PBZ treated plants ranged from 28.83 to 34.20 cm, while the untreated recorded 33.95 to 34.95 cm. The intermodal length of PBZ treated plants ranged from 8.1 to 12.2 mm, while the untreated plants recorded 17.4 to 18.4 mm indicating the role of PBZ in reducing the plant vigour (Table 2.11). The canopy spread in E-W direction among PBZ treated plants ranged from 260.0 to 360.0 cm, while in untreated plants, it was 380.8 to 410.0 cm in the same direction. The reduction in canopy spread in N-S direction among PBZ treated plants ranged from 327.3 to 369.8 cm, while in untreated plants it was 354.0 to 392.0 cm in the same direction. The mean ground coverage of the four directions ranged from 293.6 to 355.3 cm in PBZ treated plants, while in untreated plant it was 367.4 to 401.0 cm (Table 2.12).

Table 2.11: Effect of PBZ on plant height, girth and internodal length

Time of Application/ PBZ levels	Plant height (cm)				Girth (cm)				Internodal length (mm)			
	Y1	Y2	Y3	Mean	Y1	Y2	Y3	Mean	Y1	Y2	Y3	Mean
PBZ@1g a.i./pl	385.3	415.8	423.8	408.3	32.65	33.7	34.2	33.52	10.7	11.1	12.2	11.33
PBZ@2g a.i./pl	335.8	378.8	402.8	372.4	28.83	33.82	32.7	31.78	8.6	9.1	10.2	9.30
PBZ@3g a.i./pl	326.0	385.0	401.0	370.7	31.13	31.28	32.8	31.74	8.1	8.6	9.9	8.87
Control	442.8	454.0	425.8	440.8	33.95	34.95	34.15	34.35	17.4	18.3	18.4	18.03
Mean	372.4	408.4	413.3		31.64	33.44	33.46		11.20	11.78	12.68	
Source	L	T	L x T		L	T	L x T		L	T	L x T	
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 2.12: Effect of PBZ on canopy spread

Time of Application/ PBZ levels	East - West (cm)				North - South (cm)				Ground coverage (cm)			
	Y1	Y2	Y3	Mean	Y1	Y2	Y3	Mean	Y1	Y2	Y3	Mean
PBZ@1g a.i./pl	360.0	335.8	340.0	345.3	343.8	365.0	369.8	359.5	351.9	350.4	354.9	352.4
PBZ@2g a.i./pl	293.5	333.2	350.0	325.6	344.8	351.8	360.5	352.3	319.1	342.5	355.3	338.9
PBZ@3g a.i./pl	260.0	320.0	358.3	312.8	327.3	333.8	339.5	333.5	293.6	326.9	348.9	323.1
Control	400.0	380.8	410.0	396.9	380.3	354.0	392.0	375.4	390.1	367.4	401.0	386.2
Mean	328.4	342.4	364.6		349.0	351.1	365.5		338.7	346.8	365.0	
Source	L	T	L x T		L	T	L x T		L	T	L x T	
SEm±	0.12	0.11	0.21		0.12	0.10	0.20		9.11	7.89	15.78	
LSD (p<0.05)	0.34	NS	NS		NS	NS	NS		25.97	NS	NS	

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

The total number of new flushes among PBZ treated plants ranged from 100.0 to 237.0, while the untreated plants produced 132.0 to 150.0. The number of floral and non-floral laterals

among PBZ treated plants ranged from 54 to 92 and 46.0 to 146 respectively while the untreated plants had 38.0 to 56.0 and 94 to 98 respectively (Table 2.13).

Table 2.13: Effect of PBZ on number of flushes, flower laterals and non-flower laterals

Time of Application/ PBZ levels	Total no. of flushes				Flower laterals				Non-flower laterals			
	Y1	Y2	Y3	Mean	Y1	Y2	Y3	Mean	Y1	Y2	Y3	Mean
PBZ@1g a.i./pl	180.0	171.0	100.0	150.3	76.0	66.0	54.0	65.3	104.0	105.0	46.0	85.0
PBZ@2g a.i./pl	218.0	199.0	201.0	206.0	86.0	75.0	69.0	76.7	132.0	124.0	132.0	129.3
PBZ@3g a.i./pl	237.0	218.0	192.0	215.7	92.0	72.0	67.0	77.0	145.0	146.0	125.0	138.7
Control	150.0	140.0	132.0	140.7	56.0	42.0	38.0	45.3	94.0	98.0	94.0	95.3
Mean	196.3	182.0	156.3		77.5	63.8	57.0		118.8	118.3	99.3	
Source	L	T	L x T		L	T	L x T		L	T	L x T	
SEm±	3.79	3.28	6.56		1.67	1.44	2.89		3.21	2.78	5.57	
LSD (p<0.05)	10.80	9.35	18.71		4.75	4.11	NS		9.16	7.93	15.86	

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

2.4.2 Flowering parameters

The number of male and hermaphrodite flowers per panicle in PBZ treated plants varied from 152.4 to 292.8 and 80.9 to 179.2 respectively, while in untreated plants it varied from 219.0 to 259.5 and 60.3 to 89.8 respectively. The sex ratio of flowers ranged from 0.34 to 0.89 per cent in treated plants while in untreated plants it was 0.25 to 0.35 per cent (Table 2.14). The number of rachis per flower ranged from 7.5 to 8.3 in treated plants while in untreated plant it was 7.5 to 7.8. The length of flower panicles ranged from 12.4 to 16.1 cm and width 14.9 to 18.3 cm in treated plants while, in untreated plants the length and

width were 15.8 to 16.5 cm and 18.3 to 19.2 cm respectively. The study indicated that the PBZ



Profuse fruiting in PBZ treated tree

application was found effective in increasing sex ratio, number of panicles per plant while, the length and width of panicle and flowering duration got reduced. The number of rachis in flower panicles was unaffected by PBZ application (Table 2.15).

Table 2.14: Effect of PBZ on number of flowers and sex ratio

Time of Application/ PBZ levels	No. of male flowers				No. of female flowers				Sex ratio			
	Y1	Y2	Y3	Mean	Y1	Y2	Y3	Mean	Y1	Y2	Y3	Mean
PBZ@1g a.i./pl	216.5	231.8	292.8	219.3	157.6	86.3	98.9	114.3	0.73	0.37	0.34	0.48
PBZ@2g a.i./pl	222.7	198.2	261.6	207.9	179.2	80.9	100.9	120.4	0.81	0.41	0.39	0.53
PBZ@3g a.i./pl	152.4	179.7	223.3	244.9	135.5	149.0	96.3	126.9	0.89	0.83	0.44	0.72
Control	259.5	219.0	244.4	212.5	89.8	76.4	60.3	75.5	0.35	0.35	0.25	0.31
Mean	212.8	207.2	255.5		140.5	98.2	89.1		0.69	0.49	0.35	
Source	L	T	L x T		L	T	L x T		L	T	L x T	
SEm±	6.93	5.99	11.99		3.67	3.18	6.35		0.01	0.01	0.02	
LSD (p<0.05)	19.74	17.10	34.19		10.45	9.05	18.10		0.03	0.03	0.06	

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

Table 2.15: Effect of PBZ on number of rachis per flower, length width of flower panicles

Time of Application/ PBZ levels	Number of rachis per flower				Length of flower panicles				Width of flower panicles			
	Y1	Y2	Y3	Mean	Y1	Y2	Y3	Mean	Y1	Y2	Y3	Mean
PBZ@1g a.i./pl	8.1	7.8	8.3	8.1	14.3	15.7	16.1	15.4	17.2	18.2	18.3	17.9
PBZ@2g a.i./pl	7.8	7.8	8.0	7.9	12.9	15.1	16.1	14.7	14.9	16.1	17.2	16.1
PBZ@3g a.i./pl	7.5	7.7	7.8	7.7	12.4	13.4	14.8	13.5	14.9	15.1	16.7	15.6
Control	7.5	7.7	7.8	7.7	15.8	16.4	16.5	16.2	18.3	19.2	19.1	18.9
Mean	7.7	7.8	8.0		13.9	15.2	15.9		16.3	17.2	17.8	
Source	L	T	L x T		L	T	L x T		L	T	L x T	
SEm±	0.10	0.09	0.17		0.17	0.15	0.30		0.16	0.14	0.29	
LSD (p<0.05)	0.29	NS	NS		0.51	0.43	0.86		0.48	0.41	0.83	

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

2.5 Organic Farming in Cashew

A field experiment on organic farming in cashew has been initiated in 2012 with the following treatments.

- T1 : FYM to supply 500 g N/tree
- T2 : FYM to supply 500 g N/tree + biofertilizer consortia*
- T3 : FYM to supply 500 g N/tree + rock phosphate to supply 125 g P₂O₅/tree and woodash to supply 125 g K₂O/tree.
- T4 : Poultry manure to supply 500 g N/tree
- T5 : *In situ* composting using recyclable cashew biomass and weeds
- T6 : *In situ* composting using recyclable cashew biomass and weeds + Green manuring (Growing *Glyricidia* between two rows of cashew)
- T7 : Vermicomposting of recyclable cashew biomass
- T8 : FYM + organic cakes + recyclable cashew

biomass + biofertilizer consortia

T9 : Recommended NPK fertilizer**

T10: Recommended NPK fertilizer + 10 kg FYM/ tree

T11: Control.

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

**Fertilizer dose: 1st year of planting: 1/5th of recommended N, P and K per tree per year, 2nd year: 2/5th of recommended N, P and K per tree per year, 3rd year: 3/5th of recommended N, P and K per tree per year, 4th year: 4/5th of recommended N, P and K per tree per year and 5th year onwards full dose i.e. 500 g N, 125 g each of P₂O₅ and K₂O/ tree/year.

2.5.1 Effect of organic and inorganic sources of nutrients on growth parameters

Influence of different organic and inorganic sources of nutrients on growth of cashew is given in Table 2.16. The plant height and canopy height

Table 2.16: Effect of different organic and inorganic sources of nutrients on growth parameters

Treatment	Plant height (cm)	Girth (cm)	Canopy height (cm)	Canopy Spread (cm)	
				E-W	N-S
T1	212	16.5	123	203	215
T2	258	16.3	174	188	160
T3	246	17.3	165	201	198
T4	247	16.2	154	194	187
T5	245	16.3	160	218	192
T6	250	18.7	163	203	205
T7	248	16.8	158	177	178
T8	218	17.2	128	187	191
T9	250	16.5	157	194	188
T10	277	17.8	193	210	207
T11	226	16.7	138	185	156
SE(d)	14.4	1.26	13.7	24.2	29.5
LSD at 5%	30.1	NS	28.6	NS	NS

differed significantly with treatments and ranged from 212 to 277 cm and 123 to 193 cm, respectively. However, no significant difference was observed in other growth parameters *viz.*, stem girth and canopy spread with respect to different treatments. The stem girth varied from 16.2 to 18.7 cm. The canopy spread in N-S direction ranged from 156 to 215 cm and in E-W direction varied from 177 to 218 cm.

2.5.2 Effect of organic and inorganic sources of nutrients on soil properties

Soil samples at three different depths (0-30, 31-60 and 61-90 cm) were collected from the base of the plant at 1.5 m radius after imposing the treatments. The soil samples were analyzed for bulk density, particle density, per cent pore space, pH, electrical conductivity and organic carbon content. Bulk density and particle density of the surface soils under different treatments varied from 1.16 to 1.28 g cm⁻³ and 1.70 to 2.04 g cm⁻³, respectively. Pore space of the soils ranged from 31.5 to 38.5 per cent (Fig. 2.1).

2.6 Rootstock Studies in Cashew

The different stionic combinations planted in the field were compared for various growth parameters and yield. The various stionic combinations varied with respect to growth parameters. Among different stionic combinations, Ullal-3 grafted on NRC-492 recorded the highest plant height (4.13 m), while the lowest plant height (3.26m) was associated with stionic combination of VRI-3 / Taliparamba-1. The stem girth below the union ranged from 36.52 cm (VRI-3 / Taliparamba-1) to 52.85 cm (Ullal-3 / NRC-492). The stem girth above the union ranged from 31.91 cm (NRCC Sel-2 / Taliparamba-1) to 45.62 cm (Vengurla-4 / Taliparamba-1). The stock:scion ratio ranged from 1.09 (NRCC Sel-2 / Vengurla-4 and VRI-3 / Vengurla-4) to 1.18 (Ullal-3 / Vengurla-4, Ullal-3 / NRC-492, Vengurla-4 on Vengurla-4 and NRC-492). The canopy spread was the lowest (3.92 m) in NRCC Sel-2 / Taliparamba-1, while it was the highest (4.83 m) in Ullal-3 / NRC-492 (Table 2.17)

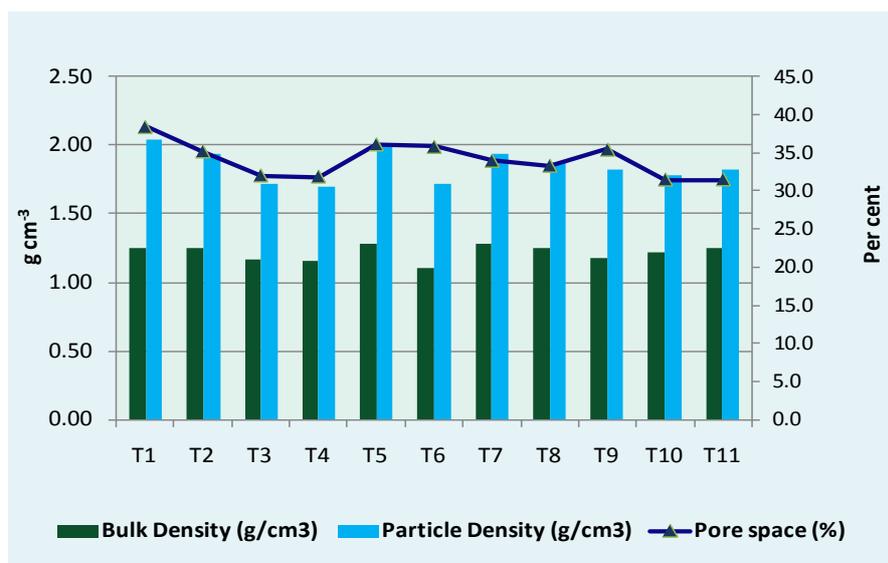


Figure 2.1: Influence of organic and inorganic sources of nutrients on soil physical properties

Table 2.17: Growth parameters and yield in different stionic combinations

Stionic combination (scion/rootstock)	Plant height (m)	Girth below union (cm)	Girth above union (cm)	Stock:scion ratio	Canopy spread (m)
Ullal-3 / Vengurla-4	3.61	41.34	35.06	1.18	4.04
VRI-3 / Vengurla-4	3.68	40.29	36.74	1.09	4.15
NRCC Sel-2 / Vengurla-4	3.58	38.91	35.41	1.09	3.89
Vengurla-4 / Vengurla-4	3.91	50.26	42.56	1.18	4.77
Ullal-3 / NRC-492	4.13	52.85	44.76	1.18	4.83
VRI-3 / NRC-492	3.82	49.20	41.93	1.17	4.72
NRCC Sel-2 / NRC-492	3.88	45.70	40.74	1.12	4.42
Vengurla-4 / NRC-492	3.80	44.58	37.94	1.18	4.50
Ullal-3/ Taliparamba-1	3.91	47.50	41.08	1.16	4.31
VRI-3/ Taliparamba-1	3.26	36.52	32.10	1.14	3.96
NRCC Sel-2 / Taliparamba-1	3.66	37.08	31.91	1.16	3.92
Vengurla-4 / Taliparamba-1	3.92	52.75	45.62	1.16	4.47

2.6.1 Performance of high yielding varieties of cashew

A field experiment was laid out in 2006 with grafts of nine varieties in four different spacings to find out the optimum plant density for different varieties of cashew so that the recommendation can go variety-wise to achieve highest yield and net profit for the first 10 years of orchard management. The main objective of the experiment is to determine optimum plant density for achieving the highest yield and profit 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 - Vengurla-7, T4 - Ullal-1, T5 - Dhana, T6 - Madakkathara-2, T7 -Ullal- 3, T8 - Vengurla-4, T9 - Bhaskara

Design: Split plot

Replications: 3

2.6.2 Observations on growth

The ground coverage of different varieties planted at different plant densities indicated that the plant density of 500 plants/ha. occupied highest available space (68.3%), followed by the plant density of 384/ha (62.0%). The ground coverage by plant canopy was the lowest (25.9%) under the plant density of 200 plants/ha. The ground coverage of canopy was not influenced by different varieties (Table 2.18).

Table 2.18: Effect of plant densities and varieties on ground coverage of canopy

Varieties/ plants/ha	VRI-3	NRCC Sel-2	Vengurla-7	Ullal-1	Dhana	Madakka thara-2	Ullal-3	Vengurla-4	Bhaskara	Mean
S1-200	16.3	22.9	29.6	27.9	26.5	24.2	27.8	23.6	35.0	25.9
S2-236	28.8	32.1	42.3	37.6	48.1	40.2	33.9	37.1	37.4	37.5
S3-384	48.5	63.1	66.8	70.7	62.0	67.9	67.6	55.8	55.6	62.0
S4-500	66.9	69.7	77.9	62.6	65.8	69.1	68.5	62.8	71.9	68.3
Mean	40.1	46.9	54.2	49.7	50.6	50.4	49.4	44.8	49.9	
CD for main plot (p=0.05)										14.91
CD for sub plot (p=0.05)										NS

Among plant densities, the density of 500 plants/ha was associated with highest annual yield of 1.91 t/ha and was superior over other plant densities. The yield increase under highest plant density (500 plants/ha) was to the tune of 2.6 times over the lowest plant density (200 plants/ha) which recorded a nut yield of 0.73

t/ha. Among different varieties, Ullal-1 recorded highest annual yield of 1.31 t/ha in the fifth harvest followed by Vengurla-7, Madakkathara-2, Vengurla-4 and Bhaskara. Ullal-1 planted at a plant density of 500 plants/ha recorded the highest yield of 2.45 t/ha (Table 2.19).

Table 2.19: Effect of plant densities and varieties on the nut yield (kg/ha) (2012-13)

Varieties plants/ha	VRI-3	NRCC Sel-2	Vengurla-7	Ullal-1	Dhana	Madakka thara-2	Ullal-3	Vengurla-4	Bhaskara	Mean
S1-200	366	786	872	806	658	806	204	658	784	726
S2-236	422	658	656	963	550	975	604	1890	762	696
S3-384	1110	1021	1436	1018	1079	1363	1164	783	1156	1125
S4-500	1390	1440	2045	2450	1610	1865	1855	1620	2210	1910
Mean	822	976	1252	1309	974	1252	957	1238	1228	
CD for main plot (p=0.05)										560.03
CD for sub plot p=0.05)										310.62

Among different plant densities, density of 500 plants/ha recorded the highest cumulative nut yield of 4.6 t/ha, followed by plant density of 384 plants/ha (3.9 t/ha). The plant density of 200 plants/ha was associated with lowest yield of 1.62 t/ha. Increase in yield to the tune of 2.8 times under the plant density of 500 plants/ha over

the plant density of 200 plants/ha indicate the potentiality of high density planting in cashew in the initial years of plantation. Among the varieties, Bhaskara recorded the highest cumulative nut yield of 3.7 t/ha, followed by Ullal-3 (3.47 t/ha), NRCC Sel-2 (3.27 t/ha), Dhana (3.11 t/ha) and Ullal-1 (3.01 t/ha) (Table 2.20).

Table 2.20: Effect of plant density and varieties on the cumulative nut yield (kg/ha) (2008-13)

Varieties/ plants/ha	VRI-3	NRCC Sel-2	Vengurla-7	Ullal-1	Dhana	Madakka thara-2	Ullal-3	Vengurla-4	Bhaskara	Mean
S1-200	1351	1511	1495	1878	1533	1466	1708	1414	2214	1619
S2-236	1751	1965	1736	2311	2461	2039	2054	3132	2208	2184
S3-384	3310	4887	3775	3718	4564	3458	4042	2731	4604	3899
S4-500	3628	4744	3953	4291	3877	4257	6068	4657	5858	4593
Mean	2510	3277	2740	3050	3109	2805	3468	2984	3721	

3. CROP PROTECTION

3.1 Cashew Stem and Root Borers (CSRB)

3.1.1 Evaluation of different calcium salts for enhancing cocoon formation

The lower level of normal / perfect cocoon formation was a main impediment in obtaining sufficient number of adult CSRB beetles using semi-synthetic diet (SSD) under laboratory conditions. With the intent of enhancing the perfect cocoon formation by the grubs of CSRB reared on SSD, the same was fortified using CaSO_4 , CaCl_2 and Ca(OH)_2 at 1.00 per cent on weight basis. All the SSD formulations fortified with the Ca salts supported normal feeding and development of CSRB grubs and could enhance the level of pupation. It was noticed that highest per cent pupation of 36.98 occurred in SSD with CaSO_4 followed by 31.57 per cent pupation in CaCl_2 in comparison to the unfortified control (18.74%). The per cent emergence of both females and males was maximum (18.89 and

18.05 respectively) in the CaSO_4 fortified diet (Fig. 3.1).

3.1.2 Evaluation of the virulence of indigenous entomopathogenic nematode (EPN) species against CSRB grubs

The indigenously collected EPN species, *Steinernema feltiae* was initially cultured on the wax moth larvae (*Galleria melonella*) and after emergence of the infective juveniles (IJs), the suspensions in R.O. water were used for evaluating their virulence against grubs of CSRB. The larvae were treated either by topical application of IJs suspension (1.0 ml for 10 CSRB grubs) or allowed to crawl in the frass mixed at 10 ml IJs suspension in 100 g of fresh frass, obtained from CSRB infested cashew trees. Only the CSRB grubs treated by adopting topical application of IJs suspension displayed 41.67 to 58.33 per cent mortality, while the grubs allowed to crawl in treated frass exhibited lower levels of mortality (8.33%) (Table 3.1).

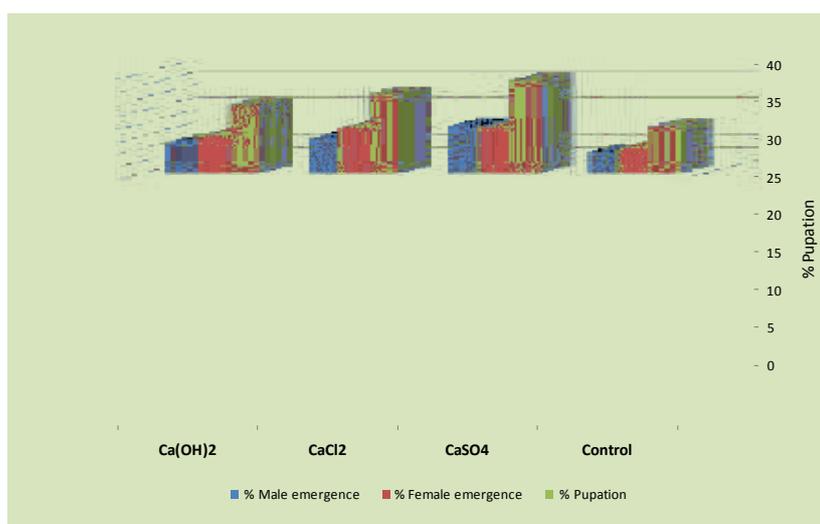


Fig. 3.1: Effect of Ca salt fortification of SSD on pupation and adult emergence

Table 3.1: Virulence of *S. feltiae* on CSRB grubs under laboratory conditions

Treatment	Mortality of CSRB after 'x' days of treatment (%)											
	5 DAT	7 DAT	9 DAT	Cum.	5 DAT	7 DAT	9 DAT	Cum.	5 DAT	7 DAT	9 DAT	Cum.
Topical application of IJs	0.0	16.6	25.0	41.6	0.0	33.3	25.0	58.3	0.0	0.0	50.0	50.0
Frass mixed with IJs	0.0	0.0	8.33	8.33	0.0	8.33	0.0	8.33	0.0	0.0	0.0	0.0
Untreated grubs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CD (P=0.05)				8.731				9.877				9.574

**CSRB grub infected by entomopathogenic nematode**

3.2 Studies on Black Spots on the Cashew Kernels

The raw cashewnuts were collected from the experimental plots during different months. These were dissected to find out occurrence of black spots if any, on the cashew kernels. It was noticed that no black spot occurred on the cashew kernels but a miniscule number of nuts showed damage on the testa portion. The raw nuts infested by tea mosquito bug and healthy nuts were dissected but there was no black spot development on the kernels in both the samples.

The TMB damage was restricted only to the outer shell portion.

3.3 Efficacy of Food Grade Repellents against *Ephestia Cautella* infesting Stored Cashew Kernels

The food grade repellents viz., clove oil and lemongrass oil were evaluated for their repellence to *E. cautella* by free choice method. The suspensions were prepared in absolute alcohol to obtain 250 ppm, 125 ppm, 60 ppm and 30 ppm concentrations. Filter discs (Whatman No.1/30 mm dia.) were dipped in these solutions; air dried and placed at the base of 500 ml glass bottles. Later, 100 g of whole cashew kernels were placed on top of these treated filter discs. Four pairs of mated *E. cautella* moths were released for oviposition for 48 h, into a net cage containing these bottles. Both the test food grade repellents could induce oviposition repellence only at 250 ppm and 125 ppm whereas, the treatments at 60 ppm and 30 ppm were at par with the untreated check (Table 3.2).

Table 3.2: Effect of food grade repellents on ovipositional repellence to *E. cautella*, infesting stored cashew kernels

Test repellents	Conc. (ppm)	Mean No. of larvae after 30 days	
		2013	2104
Clove oil	250	0.00 a	0.00 a
Clove oil	125	0.00 a	0.00 a
Clove oil	60	7.75 b	10.75 b
Clove oil	30	7.50 b	10.50 b
Untreated check		8.00 b	12.75 b
CD @ 0.05		0.871	2.311
Lemongrass oil	250	0.00 a	0.00 a
Lemongrass oil	125	0.00 a	0.00 a
Lemongrass oil	60	7.75 b	12.00 b
Lemongrass oil	30	9.50 b	12.50 b
Untreated check		9.25 b	14.75 b
CD @ 0.05		1.812	2.824

3.4 Bio-diversity of Arthropod Fauna in Cashew Ecosystem

The tea mosquito bug (TMB) incidence was noticed at moderate to high intensity. Among the four TMB species (Miridae: Hemiptera), *Helopeltis antonii* Signoret was found dominant followed by *H. theivora* Waterhouse, *H. bradyi* Waterhouse and *Pachypeltis maesarum* Kirkaldy. Incidence of minor pests like leaf miners, leaf folders, shoot tip caterpillars, leaf and blossom webbers was less, while, incidence of apple and nut borers was noticed up to 10 per cent during March, 2014. During South West monsoon, severe occurrence of *Monolepta longitarsus* Jacoby (Chrysomelidae: Coleoptera) was noticed. These beetles occurred immediately in large numbers after showers (June) and population increased steadily reaching the peak during third week of June which remained high till the end of July and abruptly

reduced during first week of August. Dispersion of this pest did not follow a consistent pattern and in groups 60-75 of these beetles were capable of causing complete drying of cashew shoots within 2-3 days and thus spread of damage was fast. Limb pruned cashew trees that had tender flushes were severely defoliated than unpruned trees and old trees.



A group of *M. longitarsus*



Feeding damage of *M. longitarsus*

For the first time, TMB was found to appear on an array of common weeds in cashew plantations. Fourteen weed species belonging to 10 different

families were found as alternate hosts of TMB during flushing period of cashew (September-October) for different species of TMB. Weeds observed to support TMB are *Terminalia paniculata*, *Getonia floribunda*, *Macaranga peltata*, *Chromolaena odorata*, *Melastoma malabathricum*, *Meremmia vitifolia*, *Solanum torvum*, *Cissus repanda*, *Strychnos nuxvomica*, *Ixora sp.*, *Lantana camera* and *Leea sp.* Besides, ornamental plants viz., *Acalypha hispida* and *Acalypha wilkesiana* were also seen as hosts for TMB species. Maximum TMB infestation was noticed during October on *C. odorata* (>30 % of weed population), *M. peltata* and *G. floribunda*. The number of weed species that support *H. antonii*, *H. bradyi*, *H. theivora* and *P. maesarum* are two, one, ten and seven species (Table 3.3).



H. antonii* on *T. paniculata



H. theivora* on *G. floribunda

Table 3.3: List of weed species recorded as alternate hosts of TMB

Family	Weed species		Species of TMB
	Common name	Scientific name	
Combretaceae	Kindal tree	<i>Terminalia paniculata</i> Roth	<i>H. antonii</i>
Combretaceae	Pelawas plant	<i>Getonia floribunda</i> Roxb. (Lamk.)	<i>H. theivora</i>
Convolvulaceae	Grape leaf wood rose	<i>Merremia vitifolia</i> (Burm. F.) Hallier F.	<i>H. theivora</i>
Verbanaceae	Wild sage	<i>Lantana camera</i> L.	<i>H. theivora</i>
Vitaceae	Pani Bel	<i>Cissus repanda</i> Vahl.	<i>P. maesarum</i>
Leeaceae	-	<i>Leea</i> sp.	<i>H. antonii</i>
Loganiaceae	Quaker buttons	<i>Strychnos nux-vomica</i> L.	<i>H. theivora</i>
Rubiaceae	West Indian Jasmine	<i>Ixora</i> sp.	<i>H. theivora</i>
Asteraceae	Siam weed	<i>Chromolaena odorata</i> L.	<i>P. maesarum</i> <i>H. theivora</i>
Melastomataceae	Malabar Melastome	<i>Melastoma malabathricum</i> L.	<i>P. maesarum</i> <i>H. theivora</i>
Solanaceae	Turkey berry	<i>Solanum torvum</i> Sw.	<i>P. maesarum</i> <i>H. theivora</i>
Euphorbiaceae	Copper leaf/ Jacob's coat	<i>Acalypha wilkesiana</i>	<i>P. maesarum</i> <i>H. theivora</i>
Euphorbiaceae	Chenille plant	<i>Acalypha hispida</i> Burm. F.	<i>P. maesarum</i>
Euphorbiaceae	Chandada plant	<i>Macaranga peltata</i> (Roxb.) Mueller	<i>P. maesarum</i> <i>H. theivora</i>

All the three parasitoids recorded earlier as the egg parasitoids of tea mosquito bug *viz.*, *Telenomus cuspis* Rajmohana and Srikumar, *Chaetostricha* sp. and *Erythmeles helopeltidis* occurred this year also. The general predatory fauna observed are an array of spiders, ants, reduviids, preying mantids, coccinellids, syrphids, geocorid bugs, anthocorid bugs, wasps and green lace wing bugs.

3.5 Tea Mosquito Bug (TMB)

3.5.1 Biosystematics of natural enemies of TMB

The molecular characterization of reduviids a major predator of TMB was done based on the

core principle of generating DNA barcode using mitochondrial cytochrome c oxidase 1 (COX1) gene. Total DNA was isolated from individual reduviid species such as *Endochus albomaculatus* Stal, *Euagoras plagiatus* Burmeister, *Panthous bimaculatus* Distant and *Rihirbus trochantericus* Stal var. luteous using modified CTAB method. The samples were ground with 1 ml of 2 per cent cetyl trimethyl ammonium bromide (CTAB), 100 mM Tris-HCl (pH-8.0), 1.4 M sodium chloride, 20 mM EDTA and 2 per cent of 2-mercaptoethanol. The suspension was incubated at 65°C for 1-2 h and then an equal volume of chloroform: isoamyl alcohol (24:1) solution was added.

The suspension was centrifuged at 6000 rpm for 15 minutes. The aqueous layer was transferred to the fresh 2 ml micro centrifuge tube taking care not to disturb the middle protein interface. DNA was precipitated by the addition of 20 μ l of 0.3 M sodium acetate and equal volume of ice-cold 95 per cent ethyl alcohol. The precipitated DNA was spun at 8000 rpm for 10 minutes and the resultant DNA pellet was washed with 70 per cent ethyl alcohol. This was centrifuged at 8000 rpm for 10 minutes and finally the pellet was dissolved in 50 μ l DNase, RNase free molecular biology water. The genomic DNA was visualized using 1 per cent agarose gel and diluted with sterile water to get a working solution of 20-25 ng/ μ l.

Polymerase chain reaction (PCR) was carried out in a thermal cycler (AB-Applied Biosystems) with the following cycling parameters: 94°C for 4 minutes as initial denaturation followed by 35 cycles of 94°C for 30 seconds, 47°C for 45 seconds, 72°C for 45 seconds and 72°C for 20 minutes as a final extension. The universal primer specific to mitochondrial cytochrome oxidase I (COX-I) used for the amplification resulted in approximately 700 bp fragment. PCR was performed in 25 μ l reaction volume containing 20 picomoles of each primer, 10 mM Tris-HCl (pH-8.3), 50 mM KCl, 2.5 mM MgCl₂, 0.25 mM of each dNTP and 0.5 μ l of Taq DNA polymerase (Fermentas Life Sciences). The amplified product was resolved in 1 per cent agarose gel and the remaining PCR product was eluted using Nucleospin Extract II according to the manufacturers protocol (MN, Germany) which is sequenced in an automated sequencer (ABI Prism 310; Applied Biosystem, USA) using M13 universal primer both in forward and reverse direction. The summary of the sequence and accession numbers of the reduviid samples deposited in NCBI (National Centre for Biotechnology Information)

are as follows:

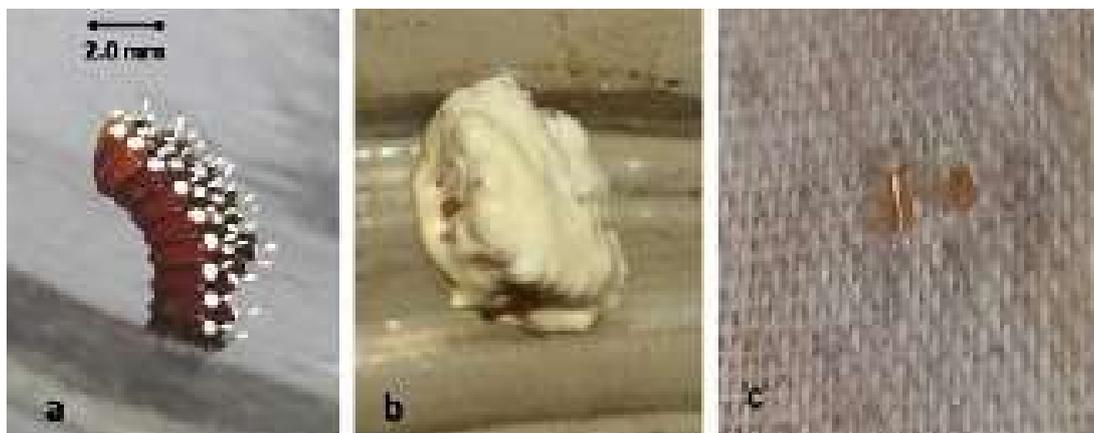
1. *Endochus albomaculatus* cytochrome oxidase subunit 1 (COXI) gene, partial cds; mitochondrial 658 bp linear DNA, KC834737.1 GI: 523588098
2. *Euagoras plagiatus* cytochrome oxidase subunit 1 (COXI) gene, partial cds; mitochondrial 658 bp linear DNA, KC834735.1 GI: 523588094
3. *Panthous bimaculatus* cytochrome oxidase subunit 1 (COXI) gene, partial cds; mitochondrial 658 bp linear DNA, KC834734.1 GI: 523588092
4. *Rihirbus trochantericus* cytochrome oxidase subunit 1 (COXI) gene, partial cds; mitochondrial 658 bp linear DNA, KC834736.1 GI: 523588096.

3.5.2 Biology of natural enemies of TMB

In addition to *Rihirbus trochantericus* and *Cydnocoris gilvus* another three species of reduviids viz., *Endochus albomaculatus* Stal, *Epidaus bicolor* Distant and *Euagoras plagiatus* Burmeister (Heteroptera: Harpactorinae) were recorded as potential predators of *Helopeltis* spp. These predators were reared in the laboratory (temperature 26-28°C; relative humidity 89-94%) on wax moth, *Galleria mellonella* Linnaeus (Lepidoptera: Pyralidae) larvae and their biology, mating and predatory behaviors were examined. The reduviids laid eggs in batches on the bottom of the rearing bottles, each egg vertically glued to the substratum. Morphology of eggs covering colour, shape, size, chorionic and opercular architecture nature and position of chorionic collar, sealing bar, opercular plate and chorionic notch showed considerable variation among species. Female laid a total of 214.4 ± 3.6 eggs

in 6.3 ± 0.4 batches (35.7 eggs/batch); 221.1 ± 8.8 eggs in $6.91 \pm$ batches (36.8 eggs/batch) and 65.08 ± 0.39 eggs in 9.03 ± 0.2 batches (1.3 eggs/

batch) and in the case of *E. albomaculatus*, *E. plagiatus* respectively (Table 3.4).



Eggs of (a) *Endochus albomaculatus*, (b) *Epidaus bicolor* and (c) *Euagoras plagiatus*

The egg hatching percentage was highest in *P. bimaculatus* (99.1%) and *E. bicolor* (97.7%). The

three species of reduviids laid eggs on the bottom and sides of the culture bottles and muslin cloth.

Table 3.4: Oviposition pattern of Three species of reduviids

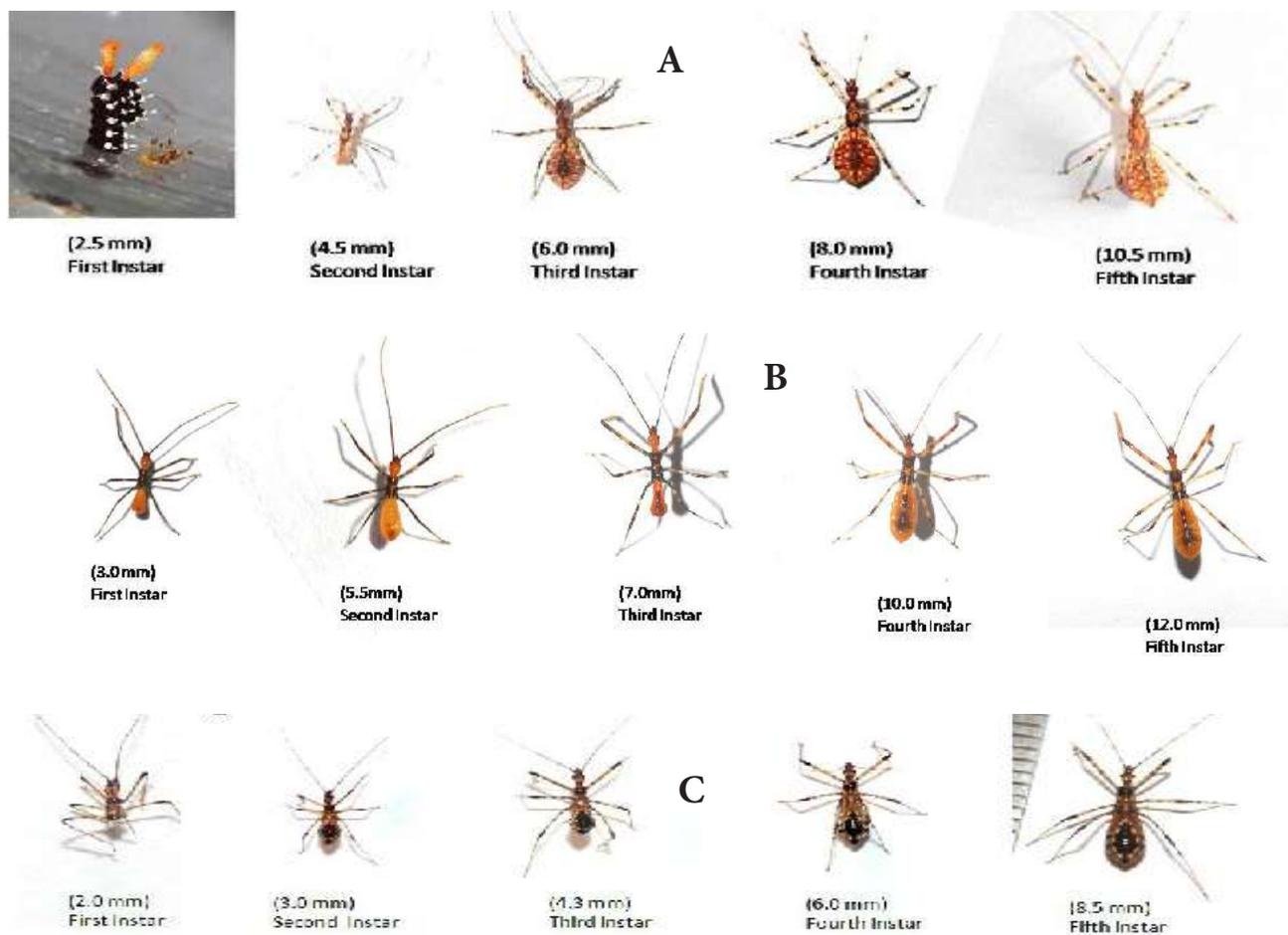
Reduviids	No. of eggs/ batch	Total no .of eggs laid	Incubation period	Per cent hatch
	(Mean \pm SE)			
<i>E. albomaculatus</i>	35.7 ± 0.2	214.4 ± 3.6	6.4 ± 0.2	95.8
<i>E. bicolor</i>	36.8 ± 0.1	221.1 ± 8.8	10.0 ± 0.2	97.7
<i>E. plagiatus</i>	1.3 ± 0.4	65.1 ± 0.39	5.4 ± 0.1	84.2

The total stadia periods were 58.3 ± 4.5 , 44.0 ± 1.2 and 36.8 ± 1.32 days for *E. albomaculatus*, *E. bicolor* and *E. plagiatus* respectively (Table 3.5). The developmental period for I and V instars were longest for all the three species of reduviids. The newly hatched nymphs were fragile and they

became tanned in 3 to 4 h after emergence and thereafter started feeding, showing preference to small and sluggish larvae. Nymphal instars of reduviids differ exceptionally in shape and size during their development.

Table 3.5: Developmental period of instars of different species of reduviids

Reduviids	Stadial period (days) (Mean ± SE)					Total
	I	II	III	IV	V	
<i>E. albomaculatus</i>	15.0 ± 0.8	10.8 ± 0.9	10.0 ± 0.6	9.5 ± 0.9	13.0 ± 1.7	58.3 ± 4.5
<i>E. bicolor</i>	8.8 ± 0.2	8.2 ± 0.2	7.6 ± 0.4	8.8 ± 0.2	10.6 ± 0.24	44.0 ± 1.2
<i>E. plagiatus</i>	5.2 ± 0.2	7.8 ± 0.2	7.0 ± 0.3	7.2 ± 0.2	9.6 ± 0.4	36.8 ± 1.3



A-C : First, second, third, fourth and fifth nymphal instars of *E. albomaculatus*, *E. bicolor* and *E. plagiatus*

The oviposition period and longevity of reduviids is given in Table 3.6.

Table 3.6: Oviposition periods and longevity of different species of reduviids

Reduviids	Pre-oviposition	Oviposition		Longevity (days)	
		Period (days) (Mean ± SE)	Post- oviposition	Male	Female
<i>E. albomaculatus</i>	12.67 ± 0.4	47.6 ± 1.9	10.7 ± 0.9	78.6 ± 11.5	85.0 ± 11.6
<i>E. bicolor</i>	14.50 ± 0.4	57.4 ± 2.1	7.7 ± 0.42	80.4 ± 7.1	94.8 ± 10.3
<i>E. plagiatus</i>	12.0 ± 0.4	28.8 ± 1.9	12.2 ± 0.5	57.4 ± 2.6	61.0 ± 1.4



Riding over and copulation in *E. bicolor*



Predation by *E. plagiatus*

The sequential acts of mating behaviour observed in the reduviids were arousal, approach,

riding over and copulation. The aroused male has approached by chasing the females with extended antenna movement. The males rode over the females with extended rostrum. They remained motionless during copulation and exhibited pterothorax rostral pinning. Drooping down of antennae by both the sex was observed at the termination of copulation and thereafter separation of mating partners. After separation both male and female moved away from the place of copulation. Post copulatory acts such as genitalia brushing, antennal grooming, cleaning the legs, wing beating were observed in both the sex partners. The successful completion of copulation was evidenced by the ejection of spermatophore capsule by female after termination of copulation.

The reduviids exhibited a pin and jab mode of predation in a sequence of acts. The sequential pattern of predatory behaviour was observed in 24 h prey deprived predators as follows: arousal - approach - capturing - rostral probing - paralysing - sucking - postpredatory behaviour.

3.5.3 Management of TMB

3.5.3.1 Screening of cashew varieties

The screenings of the varieties against the incidence of TMB were continued and the damage

due to the infestation of pest was recorded in 0-4 scale from first fortnight of November 2013 to March 2014 (Grade 0 = no damage, 1 = 1-3 necrotic lesions, 2 = 4-6 coalescing lesions, 3 = > 6 coalescing lesions and 4 = complete drying). During the period of 2013-2014, field screening revealed that varieties such as Dhana, Bhaskara, Ullal-3, Ullal-1 and Madakkathara-2 showed least damage scores (0.23, 0.24, 0.27, 0.30 and 0.30, respectively). The varieties NRCC Sel-2 and Vengurla-4 had higher damage score of 1.54 and 0.73, respectively (Fig. 3.2).

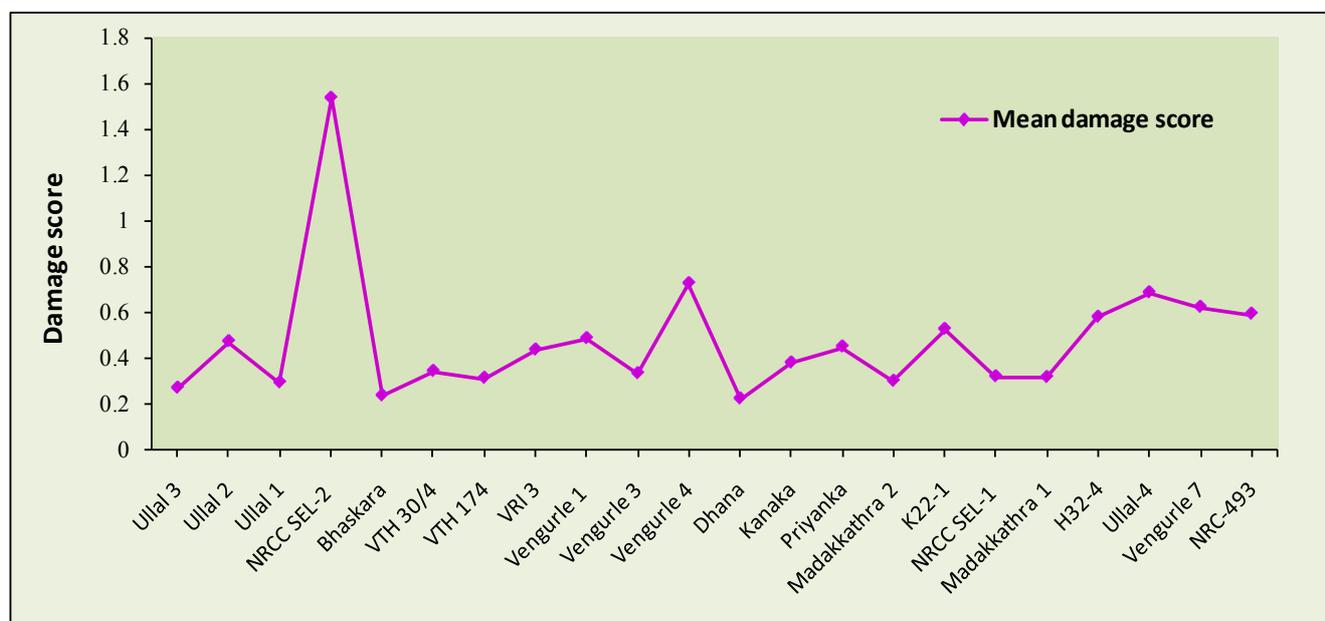


Fig. 3.2: Susceptibility of cashew varieties against TMB during 2013-14

3.5.3.2 Egg parasitoids of TMB

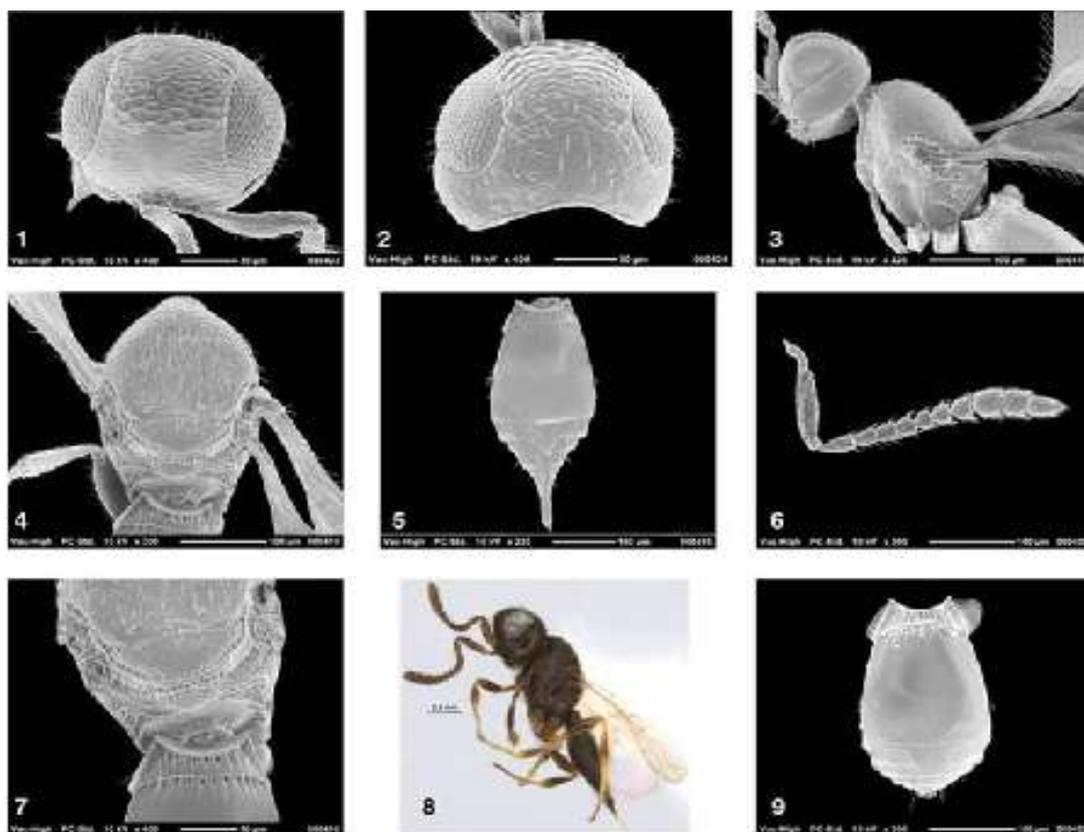
A new egg parasitoid *Telenomus cuspis* sp. nov. (Hymenoptera: Platygasteridae) of TMB *Helopeltis antonii* on cashew from India has been described. It was a new record of the laricis species group from the Oriental region. The taxonomic work was carried out at Zoological Survey of India, Calicut. Description of *Telenomus cuspis* sp. nov.

Rajmohana and Srikumar : Female (holotype). Head and body brownish black; legs including all coxae blackish brown, apical and tibiae towards apex and basal tarsal segments brownish yellow; terminal tarsal segments and claws brownish black; antenna including radicle, concolourous with coxae, with slight yellowish tinge on basal scape and apical pedicel; eyes and ocelli silvery; and wings hyaline with veins brown.

Male similar to female, differing only in shape of metasomal tip and in antennal characters; with A2 (pedicel) not as long as A3 (13:16); A3 $1.7 \times$ as long as wide; A4 $1.83 \times$ as long as wide and $1.7 \times$ as long as A3; only $0.76 \times$ as long as A12; A4 and A5 subequal; A6–A11 subglobular; A12 longest of all and $2.25 \times$ as long as wide. Tip of male metasoma not pointed; genitalia with laminae volsellares in the form of a narrow ventral plate, $1.2 \times$ as long as digiti; aedeagal lobe short, medially drawn, tapered (length of tapered part subequal to length of digiti) and truncate towards tip; laminae volsellares sclerotised; aedeago-volsellar shaft a little narrowed towards basal ring; with 3–4

digital small teeth.

Seasonality: A total of 2171 eggs of *Helopeltis* were sampled and reared and three species of egg parasitoids viz., *Telenomus cuspis* Rajmohana and Srikumar (Hymenoptera: Platygasteridae), *Chaetostricha* sp. (Hymenoptera: Trichogrammatidae) and *Ertymelus helopeltidis* Gahan (Hymenoptera: Mymaridae) emerged from *Helopeltis* spp. eggs. *T. cuspis* was the most abundant species with 6.85 per cent of mean parasitism, whereas *Chaetostricha* sp. and *E. helopeltidis* showed relatively low level of parasitism of 0.12 and 0.08 per cent respectively (Table 3.7).



T. cuspis sp. nov. female, 1 and 2, head: 1, anterior view; 2, dorsal view; 3, mesosoma, profile; 4, mesosoma, dorsal view; 5, metasoma dorsal view; 6, antenna; 7, lower mesosoma and basal metasoma; 8, body profile; 9, male metasoma.

Table 3.7: Egg parasitoids of TMB (2013)

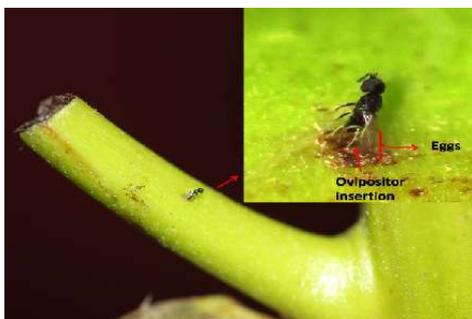
Month	No. of eggs of TMB	<i>T. cuspis</i>	<i>Chaetostricha</i> sp.	<i>E. helopeltidis</i>
January	104	6.73	0.00	0.00
February	224	10.27	0.89	0.00
March	343	0.00	0.00	0.00
April	121	0.00	0.00	0.00
May	144	1.39	0.00	0.49
June	137	7.35	0.49	0.49
July	142	12.79	0.00	0.00
August	67	11.94	0.00	0.00
September	192	1.56	0.00	0.00
October	144	10.50	0.00	0.00
November	361	11.91	0.00	0.00
December	192	6.77	0.00	0.00
Total	2171	6.85	0.12	0.08

Behaviour: Five different kinds of *T. cuspis* female behaviour viz., drumming, ovipositor insertion, marking, walking and resting were observed. Drumming was characterized by movement of antennae up and down over the exposed surface of the eggs, the female remained still or walked over the eggs. During drumming, the females didn't follow a definite direction, returning to the same egg many times. Subsequently, the female paused so that the egg was behind her

inclined body and inserted the ovipositor in the host egg when drumming stopped. From this moment on, she remained still, with no antennae movement and directed towards base, wings parallel to the body and hind legs firmly holding the extrachorionic process of host egg.

3.5.3.3 Salivary system of TMB

The salivary system in TMB consists of a pair of principal and accessory glands. The principal glands are quadrilobed, comprising anterior and posterior lobes. They extend from the thorax on either side of the gut to the abdomen region. The relative size and shape of the lobes varies in different species but the anterior lobe is always the smaller. Accessory glands are vesicular and looped over posterior lobe of principal salivary glands. The common opening of the duct lies in a salivary pocket at the base of the hypopharynx. It is modified for expelling the secretion of the glands.



T. cuspis parasitizing *H. antonii* egg



Salivary gland structure of *H. antonii* [al- anterior lobe, pl- posterior lobe, d- situated on dorsal side, v- situated on ventral side, ag- accessory gland, agr- accessory gland reservoir, pd- principal duct]

3.5.3.4 Other predators of TMB

Among the eight species of praying mantids noticed (Order: Mantodeae), *Euantissa pulchra*

(F.) and *Ephestiasula pictipes* Wood- Mason (Fam:Hymenopodidae) were common on cashew canopy, while, *Humbertiella* sp. (Fam: Liturgusidae) on bark region.



***Ephestiasula pictipes* - a common praying mantid**



***Tetraponera* sp. : An predatory ant**

Twenty nine species of ants (Fam: Formicidae) belonging to five subfamilies were recorded in cashew ecosystems of Puttur and Shantigodu

(Table 3.8) which have multiple roles like predators, pollinators, scavengers, extra floral nectarine feeders etc. Ants belonging

Table 3.8: Ant species in cashew eco-system

Scientific name	Occurrence
Sub family: Formicinae	
<i>Camponotus compressus</i> Fabricius	Very common
<i>Camponotus sericeus</i> Fabricius	Very common
<i>Camponotus angusticollis</i> (Jerdon)	Moderate
<i>Camponotus</i> sp.1	Less common
<i>Camponotus</i> sp.2.	Less common
<i>Oecophylla smaragdina</i> (Fabricius)	Very common
<i>Anoplolepis gracilipes</i> Smith	Very common
<i>Polyrhachis thrinax</i> Roger, 1863	Less common
<i>Polyrhachis lacteipennis</i> Smith, 1858	Less common
<i>Prenolepis naoroji</i> Forel	Moderate
Sub family: Myrmicinae	
<i>Catalaucus taprobanae</i> Smith	Less common
<i>Crematogaster</i> sp.1.	Moderate
<i>Crematogaster</i> sp. 2.	Less common
<i>Crematogaster</i> sp.3.	Less common
<i>Monomorium floricola</i> (Jerdon, 1851)	Common
<i>Monomorium</i> sp.1.	Moderate
<i>Monomorium</i> sp. 2.	Less common
<i>Monomorium</i> sp. 3.	Less common
<i>Meranoplus bicolour</i> Guerin	Moderate
<i>Pheidole</i> sp.	Less common
<i>Myrmicaria brunnea</i> Saunders, 1842	Moderate
<i>Pheidologeton</i> sp.1.	Common
<i>Pheidologeton</i> sp. 2.	Less common
Sub family: Pseudomyrmicinae	
<i>Tetraoponera</i> sp. 1.	Less common
<i>Tetraoponera rufonigra</i> Jerdon	Moderate
<i>Tetraoponera</i> sp.2.	Less common
Sub family: Ponerinae	
<i>Diacamma</i> sp.	Moderate
Sub family: Dolichoderinae	
<i>Dolichoderus</i> sp.	Moderate
<i>Tapinoma melanocephalum</i> Fabricius	Common

to Myrmicinae subfamily were dominant (13 species) followed by formicinae (10 species). Among the ant species, *Oecophylla smaragdina* (Fabricius) and *Anoplolepis gracillipes* Smith were most abundant, while *Camponotus compressus* and *C. sericeus* were found throughout the year. The activities of most ant species are predominant during flowering and fruiting period (November-

April) and pre monsoon period (May), while during heavy rain i.e., South West monsoon, activities of *Myrmecaria brunnea*, *C. sericeus*, *Prenolepis naoroji* and *C. angusticollis* were only seen (Fig. 3.3). In a single tree, foraging activities of maximum of seven species were found at a time especially during flowering and initial fruiting season.

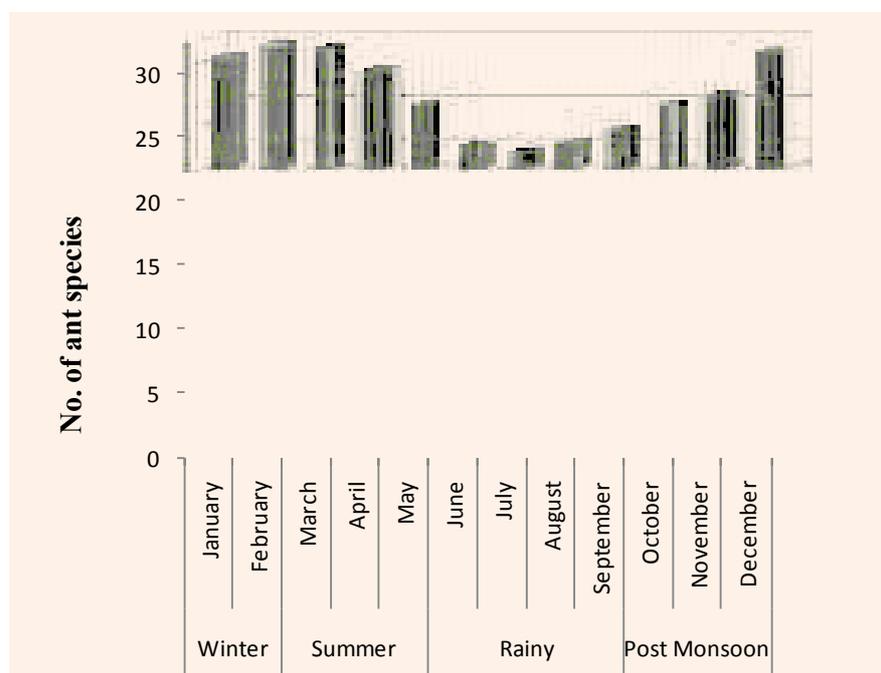


Fig. 3.3: Seasonal occurrence of ant species in cashew ecosystem

3.5.3.5 Spiders in cashew eco-system

Spiders are recorded as the most abundant natural predators of TMB. A total of 2629 individuals belonging to 117 species 63 genera and 18 families were collected during the study (Table 3.9). The families viz., Araneidae (26 species), Clubionidae (2 species), Corinnidae (1 species), Gnaphosidae (4 species), Herisilidae (1 species), Linyphiidae (1 species), Lycosidae

(1 species), Miturgidae (1 species), Nephilidae (4 species), Oxyopidae (6 species), Pholcidae (2 species), Pisauridae (2 species), Salticidae (35 species), Sparassidae (2 species), Tetragnathidae (6 species), Theridiidae (11 species), Thomisidae (10 species) and Uloboridae (1 species) were recorded. Of these, 30 species were classified as very common, 26 species common, 34 species rare and 27 species very rare.

Table 3.9: Genera and species distribution of spiders in cashew eco-system

Family	Guild	Genera	Species	No. of individuals	Status			
					VC	C	R	VR
Araneidae	Orb weavers	11	26	583	7	5	10	4
Clubionidae	Foliage runners	2	2	3	0	0	0	2
Corinnidae	Ground runners	1	1	4	0	0	0	1
Gnaphosidae	Ground runners	3	4	16	0	0	2	2
Herisilidae	Foliage runners	1	1	15	0	1	0	0
Linyphiidae	Sheet webs	1	1	42	1	0	0	0
Lycosidae	Ground runners	1	1	45	0	1	0	0
Miturgidae	Foliage runners	1	1	15	0	1	0	0
Nephilidae	Orb weavers	2	4	47	0	2	0	2
Oxyopidae	Stalkers	2	6	191	4	0	2	0
Pholcidae	Space builders	2	2	11	0	0	1	1
Pisauridae	Ambushers	2	2	17	0	1	0	1
Salticidae	Stalkers	16	35	1023	12	7	10	6
Sparassidae	Foliage runners	2	3	99	2	1	0	0
Tetragnathidae	Orb weavers	3	6	82	1	1	1	3
Theridiidae	Space builders	5	11	169	2	3	3	3
Thomisidae	Ambushers	7	10	266	4	2	2	2
Uloboridae	Orb weavers	1	1	1	0	0	0	1
Total		63	117	2629	30	26	34	27

VC = Very Common, C = Common, R = Rare, VR = Very Rare

Spiders exhibited seasonal variation in their occurrence. A total of 95 species were recorded during monsoon (June - October); 46 species during winter (November - February); 34 species during summer (March - May) and 12 species throughout the year.

Salticidae was the most predominant spider family, forming 29.91 per cent of the whole

collection. It was followed by Araneidae (22.22 %), Theridiidae (9.40 %), Thomisidae (8.55 %), Oxyopidae (5.13 %) and Tetragnathidae (5.13 %), Gnaphosidae (3.42 %) and Nephilidae (3.42 %) and Sparassidae (2.56 %). Families viz., Clubionidae, Corinnidae, Herisilidae, Lycosidae, Linyphiidae, Miturgidae, Pholcidae, Pisauridae, Uloboridae contributed below 2 per cent (Fig. 3.4).

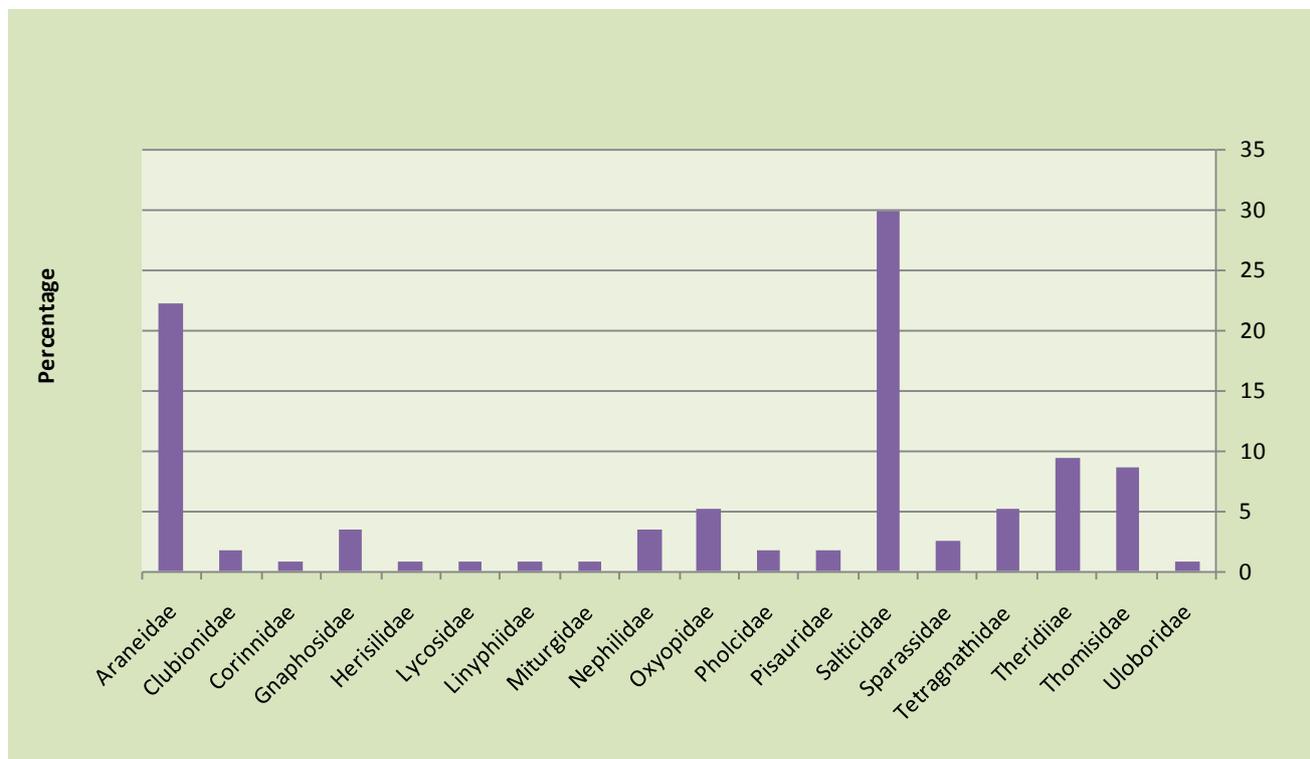


Fig. 3.4: Per cent distribution of spider families in cashew eco-system

The spiders sampled belonged to 7 functional groups (guilds) based on their foraging behaviour in the field. Stalkers (35 %) and orb weavers (32%)

were the dominant groups, subsequently space builders (11 %), ambushers (10%), foliage runners (6%), ground runners (5%) and sheet webs (1%) (Fig. 3.5).

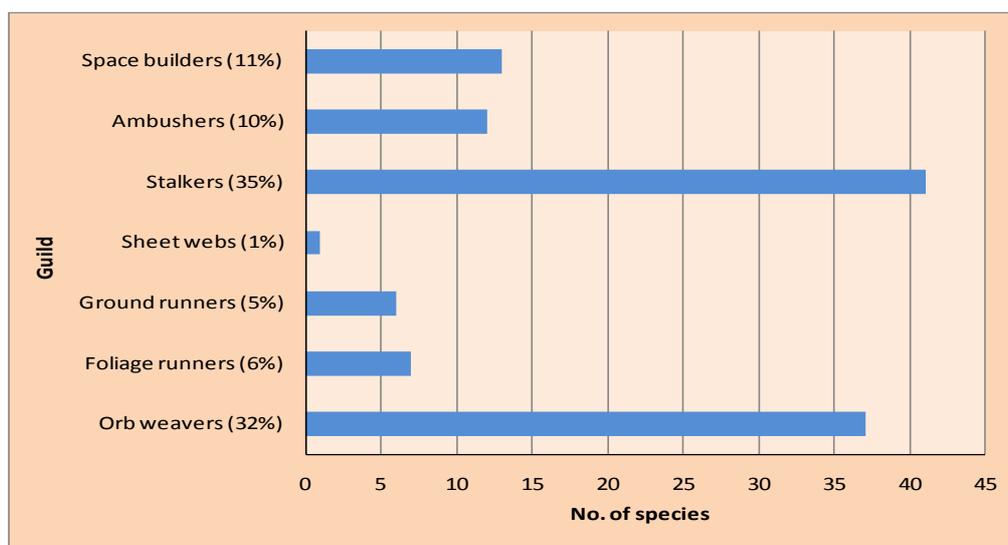


Fig. 3.5: Guild structure distribution of spider families

Field observation revealed *Telamonia dimidiata* and *Oxyopes shweta* were the major predators of *Helopeltis* spp. The spiders viz., *Argiope pulchella*, *Cyclosa fissicauda*, *Eriovixia laglazei*, *Neoscona muckerjeri*, *Nephila pilipes*,

Oxyopes sunandae, *Bavia kairali*, *Carrhotus viduus*, *Epocilla aurantiaca*, *Hyllus semicupreus*, *Achaearanea mundula*, *Camariacus formosus* and *Thomisus lobosus* were also recorded as important predators of *Helopeltis* spp. (Fig. 3.6).

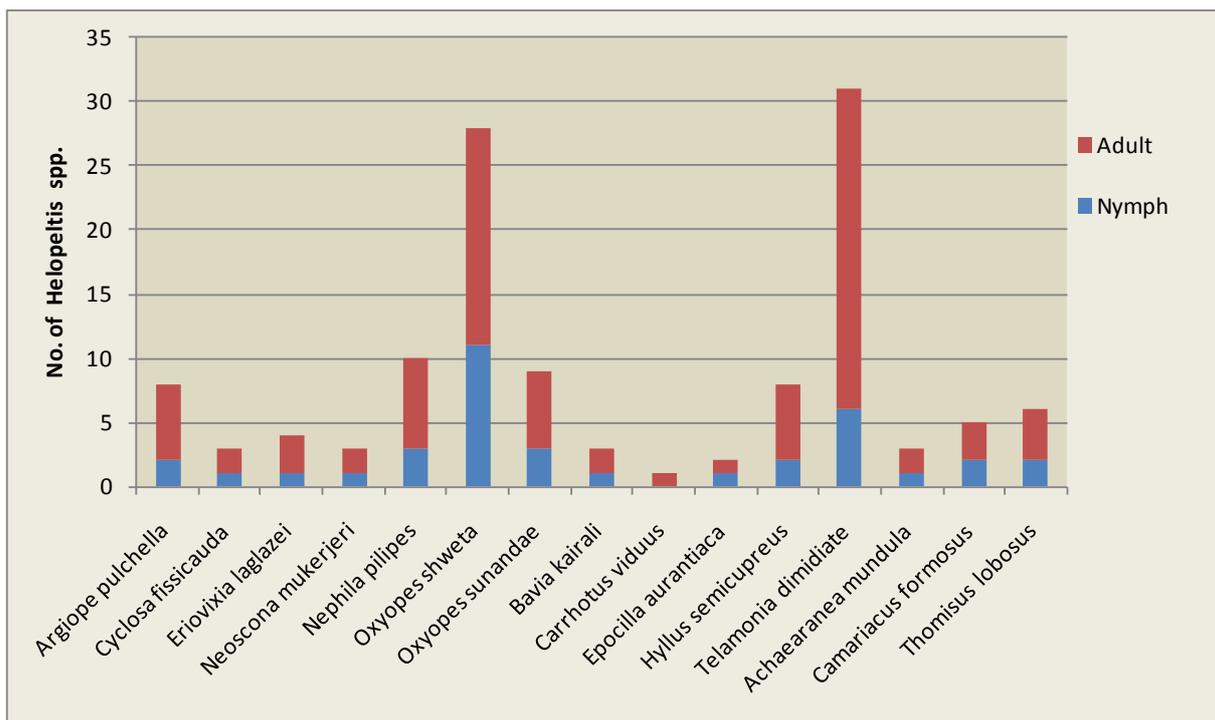


Fig. 3.6: Spider predation on Tea Mosquito Bug

4. POST-HARVEST TECHNOLOGY

4.1 Design Development and Evaluation of Solar Tunnel Dryer for Cashewnut and Apple

4.1.1 Drying characteristics of cashew apple

In order to study the drying characteristics of cashew apple certain varieties viz., Bhaskara, Ullal-3, Vengurla-4, Madakkathara-2 and VTH-30/4 were used. Freshly harvested cashew apples were cut in to slices of circular c/s with 2, 4 and 6 mm thickness and a vertical slice of 6 mm thickness were dried in thin layer using solar poly house (model), solar- cabinet (model), Electrical - convective air oven (40, 50 and 60°C). Weight loss of cashew apple samples (triplicate) were observed to work out the loss of moisture per unit time per unit weight of bone dry weight. Besides, total time required to reach bone dry condition was also worked out. Moisture available was determined by oven drying method and it was found to be 86.25 per cent, 85.99 per cent, 87.44 per cent, 86.00 per cent and 86.90 per cent on wet basis for the selected varieties respectively. Drying behaviour of cashew apple slices showed differential rate of drying irrespective of size of the sample or type of dryers. Rate of drying observed to be faster in the beginning i.e. 2-3 h indicating the diffusion of free moisture available. On an average, 2 mm cashew apple slices required 1-3 h to reduce to bone dry condition whereas drying time required ranged from 3-5 h and 8-11 h for 4 mm and 6 mm (circular or vertical) thick samples. Poly house dryer found to be on par with convective air oven maintained at 50°C in terms of rate of drying and time required for dryness equivalent to zero. Equilibrium Moisture Content (EMC) of cashew apple slices (Bhaskara)

was determined following static method through adsorption and desorption process at 30°C and 70 per cent RH and used for working out drying rate (g of water h⁻¹ g⁻¹ of BDW).

4.1.2 Prediction model for dehydration characteristics of cashew apple slices

Dehydration characteristics of cashew apple slices having thicknesses of 2, 4 and 6 mm exposed to different air temperatures i.e. 40, 50 and 60°C were investigated. Drying kinetics of cashew apple slices was primarily influenced by air temperature. Drying rate found to be faster at higher temperature owing to accelerated moisture migration within the cashew apple slice. Dehydration of cashew apple slices followed falling rate period of drying irrespective of air temperature and slice thickness indicating removal of free moisture in the beginning followed by bound moisture by diffusion. Apparently, increase in cashew apple thickness caused an increase in the drying time. Moisture migration distance and surface area for the given volume are the due reasons for the faster rate of moisture diffusion for reduced thickness of slice.

Non-linear regression analysis of fitting five different thin layer drying models to the experimental data and evaluation criteria used to compute the statistical validity of the fit viz., R², SEE, χ^2 , E_{MB} and E_{RMS}. All models gave a good fit to the experimental data with a value for R² greater than 0.90. But the Page model gave comparatively higher R² values in all the drying treatments (0.939 to 0.999), and also the SEE (0.009 to 0.076), χ^2 (0.081 to 0.670), E_{MB} (0.033 to 0.472) and E_{RMS} (0.008 to 0.024) values were lower. In view of good agreement between

experimental and predicted moisture ratios, the Page model may be assumed to represent the thin-layer drying behaviour of cashew apple slices. Moisture diffusivity (D_{eff}) for different drying treatments with R^2 are given in Table 4.1. Drying

at higher temperature gave highest D_{eff} values and ranged from 1.875×10^{-10} to $16.176 \times 10^{-10} \text{ m}^2\text{s}^{-1}$ for drying temperature between 40 to 60°C. It can also be seen that thickness of the cashew apple slice affected the moisture diffusivity.

Table 4.1: Effective moisture diffusivity of drying cashew apple slices

Drying temperature (°C)	Thickness of cashew apple slice (mm)	Moisture diffusivity, m^2s^{-1} ($\times 10^{-10}$)	Co-efficient of determination (R^2)
40	2	1.875	0.9901
	4	6.312	0.9326
	6	12.630	0.9222
50	2	2.039	0.9971
	4	7.498	0.9449
	6	14.008	0.9604
60	2	2.116	0.9893
	4	8.195	0.9758
	6	16.176	0.9539

4.1.3 Drying characteristics of raw cashewnuts

Raw cashewnuts were exposed in thin layer in convective air oven (40, 50 and 60°C) and solar dryers (model) viz., cabinet and poly house dryers. Initially, raw cashewnuts were sorted in to three different sizes based on major axis dimensions as large (>30 mm), medium (25 to 30 mm) and small (<25 mm) and used in the present investigation. Initial moisture content of raw cashewnut samples were determined by chemical distillation method and found to be 18.96 per cent, 16.80 per cent and 14.15 per cent d.b. for large, medium and small sizes respectively. Equilibrium moisture content of raw cashewnuts worked out to be 8.14 per cent d.b. and used for computing rate of drying. Differential rate of drying observed throughout drying process irrespective of type of drying system and size of the nuts. Time taken for drying raw cashewnuts of selected sizes was observed to be in the range of 9 to 14 h to reduce

to safer level which is on par with drying of raw cashewnuts under electrically operated cross flow dryer maintained at 50°C. Therefore, drying raw cashewnuts saves electricity to the tune of 9.5 kW. In comparison to direct solar drying, on an average 48 per cent of drying time is saved and drying took place in clean and controlled environment.

4.2 A Value Chain on Cashew for Domestic and Export Market (NAIP)

4.2.1 Parameters identified to assess the quality of raw cashewnuts

Certain physical parameters related to quality of raw cashewnuts were identified and its description is given below based on the discussion with processors, traders and farmers involved in cashew business chain towards developing empirical relationship among the quality parameter and price.

- Number of nuts: Counting of the number of nuts per kilogram and higher the number of nuts per kilogram, poorer is the quality.
- Extraneous matter: Dust, dirt, stones, chaff, straw and any other impurity mixed with the nuts are termed as extraneous matter.
- Void nuts: Nuts in which there are no kernels (Number/kg).
- Broken and damaged nuts: Nuts which are broken/internally damaged or discoloured affecting the quality (Number/kg).
- Cutting test: A random sample of one kg of raw nuts is taken from the bulk and cut open using hand-cutting tool. Based on the kernel in terms of surface colour i.e. white, shriveled, dotted or reject (spoiled), the percentage of good kernel is calculated and it has direct influence on quality of nuts.
- Floating test: One kilogram of sample is put in a vessel containing water, after continuous stirring floaters are collected and counted. Immature nuts due to low density than water, improperly filled nuts and deteriorated nuts floats. Higher the percentage of floaters, poorer is the quality of cashew nuts.
- Size: It is determined with the help of length, width, and thickness of the nut. Bigger the size, better is the quality.
- Moisture: The moisture (%) in cashew nuts inversely affects the price and grade.
- Kernel recovery: Out of one kg raw nuts with shell and without shell are weighed and percentage of nuts without shell is calculated. Higher the percentage, better the quality of cashewnuts. It is a factor contributing to higher price and better grade for cashewnuts.

4.2.2 Physico mechanical properties of cashew kernels

Physical and mechanical properties of primary grades (WW 180, WW 210, WW 240, WW 320, WW 450) and secondary grades (SW, SSW and DW) cashew kernels were determined as a function of moisture content in the range of 3 to 7 per cent d.b. Experimental data indicated that the mean values of length, width, thickness, effective width, sphericity and geometric mean diameter had linear correlation with moisture content. Sphericity and geometric mean diameter of cashew kernels in the specified moisture ranged from 65.76 to 69.51 mm and from 13.48 to 19.11 mm for primary grades and from 64.65 to 74.36 mm and from 15.12 to 15.91 mm for secondary grades of cashew kernels respectively. Positive correlation existed between one hundred kernel weight and moisture content and average value increased from 102.00 to 277.80 g for primary grades and from 154.20 to 187.00 g for secondary grades in the moisture range investigated. Negative linear relationship was observed for gravimetric properties *viz.*, bulk density, true density and porosity. Bulk density decreased from 544.35 to 494.46 kg m⁻³; True density from 1162.93 to 1024.69 kg m⁻³ and porosity from 58.72 to 41.14 per cent irrespective of grades of cashew kernels experimented. Angle of repose showed increasing tendency with moisture absorption, WW 180 registered maximum while DW grade showed the minimum value. Softening of surface texture of cashew kernels resulted in lower values of rupture force at higher moisture content. Glass as a surface for sliding offered the maximum friction followed by cardboard, mild steel and galvanized iron.

4.2.3 Geometrical properties of cashew kernels

Initial moisture content of untreated cashew kernel samples of various grades ranged from

2.26 to 2.85 per cent d.b. Average values of principal dimensions viz., length, width, thickness, effective width, geometric mean diameter and sphericity for various grades of cashew kernels were determined in the moisture range of 3 to 7 per cent d.b. In general, tri-axial dimension increased with increase in moisture content for all grades of cashew kernels. It was observed that expansion of cashew kernels more pronounced in intermediate axis followed by minor axis and major axis irrespective of the cashew kernel grades selected. Geometric mean diameter and sphericity of cashew kernels in the specified moisture linearly ranged from 13.48 to 19.11 mm and from 65.76 to 69.51 mm for primary grades and from 15.12 to 15.91 mm and from 64.65 to 74.36 mm for secondary grades of cashew kernels respectively. Mean values showed that increase in geometric mean diameter and sphericity found to be 2.86 per cent and 1.29 per cent for primary grades and 2.55 per cent and 0.88 per cent for secondary grades respectively when moisture increased from 3 to 7 per cent d.b.

4.2.4 One hundred kernel mass

It was evident that the increase in mass could result from the addition of moisture and primary grade of cashew kernels recorded an average increase of 5.41 per cent while secondary grade kernels observed to be 3.20 per cent in the specified range of moisture tested. Hardening of kernels owing to high temperature during processing and uneven surface could be the contributing reasons lowering infusion of moisture for the secondary grade cashew kernels.

4.2.5 True density, bulk density and porosity

Variation in true density, bulk density, and porosity of cashew kernels with moisture content is depicted in Fig. 4.1. Bulk density decreased from 544.35 to 494.46 kg m⁻³; True density from 1162.93 to 1024.69 kg m⁻³ and porosity from 58.72 to 41.14 per cent irrespective of primary or secondary grade of cashew kernels in the moisture range tested. Empirical relationship between gravimetric properties of cashew kernels and moisture is given in Table 4.1.

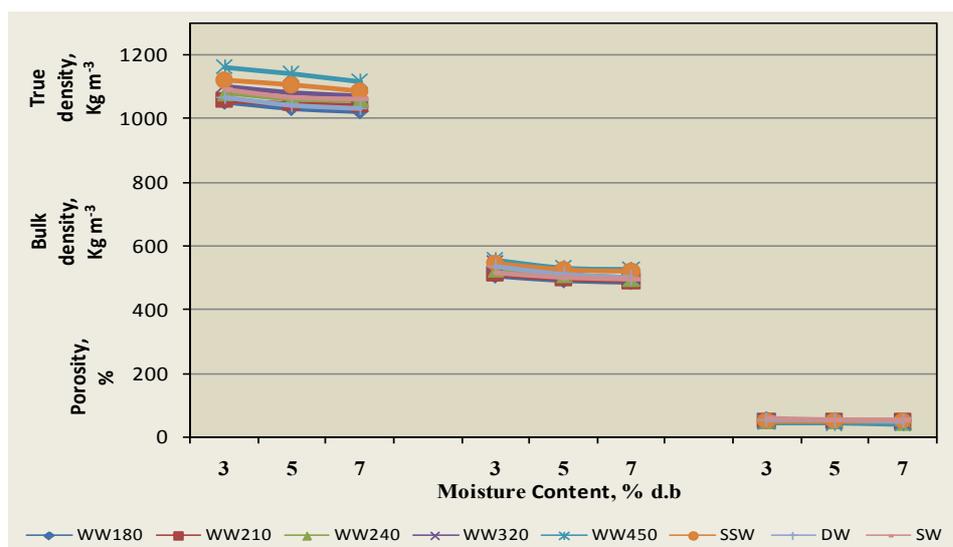


Fig. 4.1: True density , bulk density and porosity of cashew kernel

Table 4.1: Empirical relationship representing gravimetric properties of cashew kernels and moisture content

Grades	True density	R ²	Bulk density	R ²	Porosity	R ²
WW 180	$y = -14.31x + 1065$	0.946	$y = -10.16x + 514.8$	0.965	$y = -2.430x + 55.77$	0.985
WW 210	$y = -16.95x + 1081$	0.966	$y = -9.996x + 519.5$	0.983	$y = -1.868x + 53.19$	0.913
WW 240	$y = -9.881x + 1087$	0.847	$y = -15.94x + 543.0$	0.983	$y = -1.588x + 51.44$	0.906
WW 320	$y = -15.15x + 1115$	0.976	$y = -21.66x + 562.6$	0.932	$y = -1.933x + 50.05$	0.996
WW 450	$y = -22.26x + 1184$	0.998	$y = -13.61x + 565.7$	0.850	$y = -1.738x + 46.49$	0.981
SSW	$y = -17.81x + 1139$	0.993	$y = -14.45x + 559.3$	0.873	$y = -0.818x + 52.11$	0.964
DW	$y = -8.750x + 1067$	0.959	$y = -19.17x + 554.2$	0.952	$y = -2.513x + 58.53$	0.960
SW	$y = -16.14x + 1107$	0.883	$y = -11.83x + 528.8$	0.975	$y = -2.579x + 60.77$	0.891

High value of coefficient of determination indicates the strong bearing of moisture content on gravimetric properties. The decrease in true density with increase in moisture content could be attributed to relatively higher kernel volume as compared to corresponding mass attained due to absorption of moisture. Porosity of different food and agricultural material respond differently to

changes in moisture and these changes could be attributed to their morphological properties.

4.2.6 Angle of repose

The experimental values of angle of repose of cashew kernels at various moisture levels are illustrated in Fig. 4.2. Mean values of angle of repose increased from 0.51 to 0.59 for the

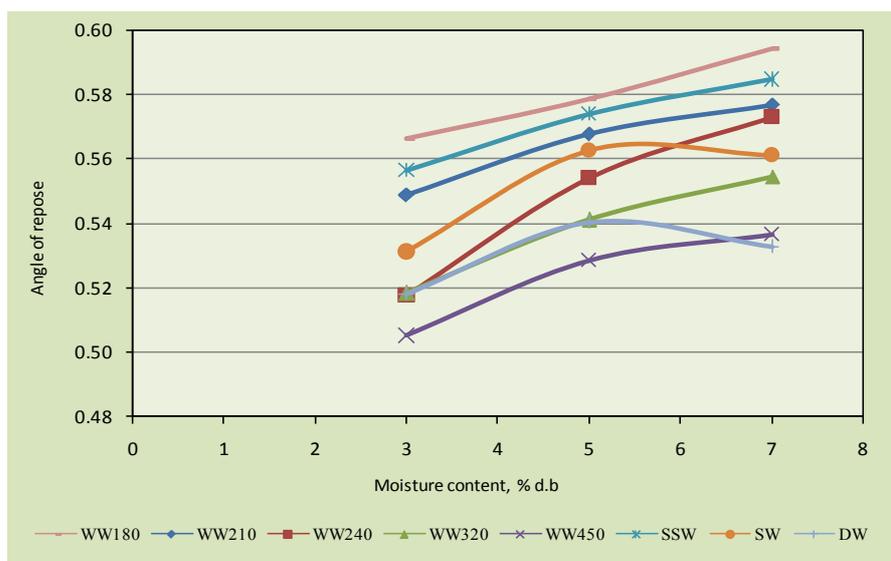


Fig. 4.2: Angle of repose of cashew kernels

primary grades whereas it increased from 0.52 to 0.58 for the secondary grade of cashew kernels with the increase in moisture content from 3 to 7 per cent d.b. Experimental data of angle repose revealed that WW 180 recorded highest value of 0.59 at 7 per cent d.b and value of DW observed to be the lowest of 0.52 at moisture content of 3 per cent d.b. Owing to the presence of carbohydrate in cashew kernels and its reaction with moisture during absorption process developing adhesiveness, offered resistance to sliding of kernels.

4.2.7 Rupture force

Force required to developing rupture in the cashew kernel while employing uni axial compression load is presented in Fig. 4.3. It was evident that the rupture force was negatively correlated and decreased as the moisture content increased from 3 to 7 per cent d.b. Rupture force value ranged between 2.63 to 5.30 kg for the primary grades and ranged from 4.19 to 5.13 kg for the secondary grade in the specified moisture level. Softening of surface texture of cashew kernels irrespective of grades investigated resulted in lower values of rupture force at higher moisture content.

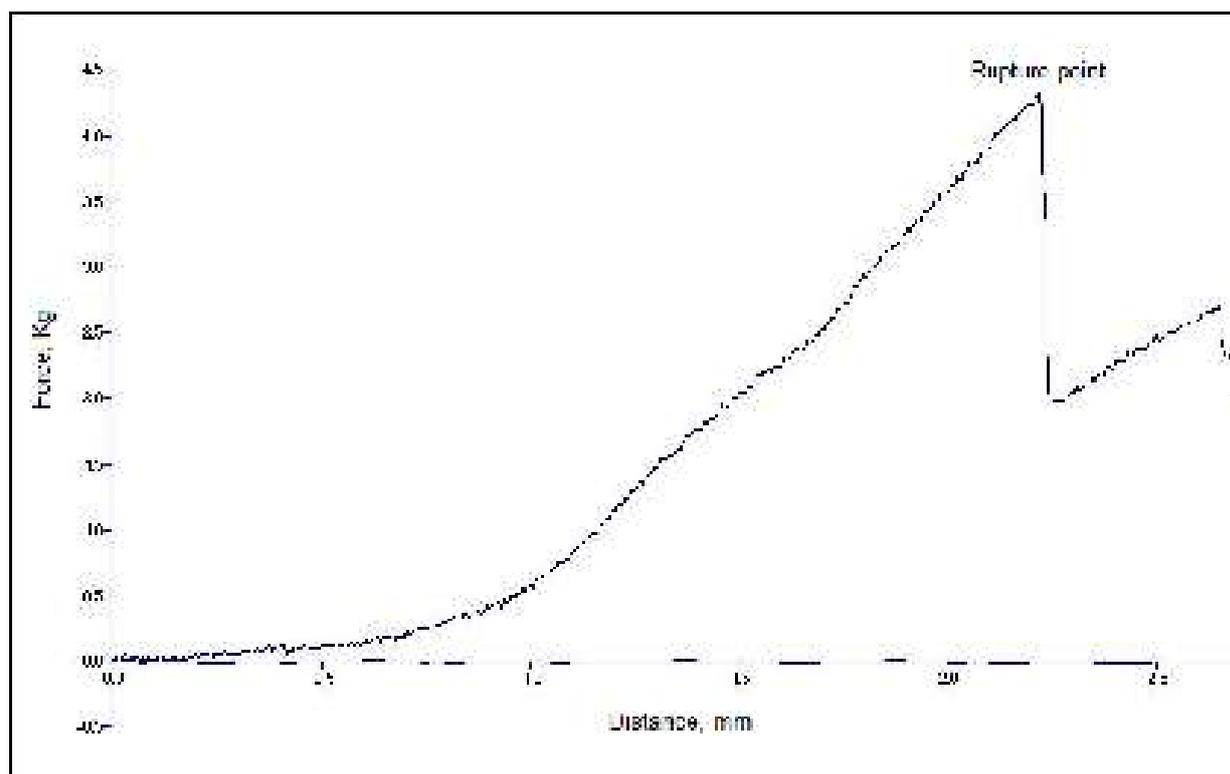


Fig. 4.3: Rupture force of cashew kernels under uni axial compression load

4.2.8 Coefficient of internal friction

Influence of moisture on coefficient of internal friction of cashew kernels against various surfaces viz., cardboard, glass, galvanized iron and mild

steel are represented in Fig. 4.4. Coefficient of internal friction was found to increase for all base surfaces with the increase in moisture content from 3 to 7 per cent d.b. Mean values

of coefficient of internal friction ranged from 0.40 to 0.72 for glass, 0.39 to 0.68 for plywood, 0.39 to 0.66 for mild steel and 0.32 to 0.63 for

galvanized iron. Coefficient of internal friction was found to be the highest for kernels on glass, while galvanized iron recorded a minimum.

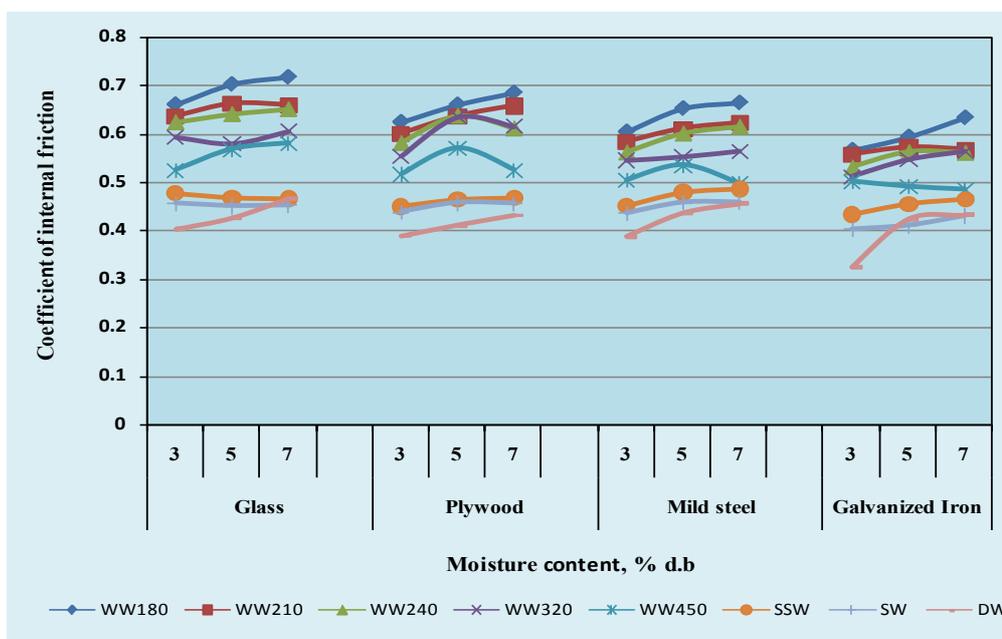


Fig 4.4: Coefficient of friction of cashew kernels

4.2.9 Surface colour characteristics of cashew kernels

Presently, wholesomeness, size and surface colour are considered as major criteria while grading cashew kernels manually. As per the standards prescribed by Export Act, 1983, white whole kernels are expected to have ivory white surface colour and accordingly skilled labourers are trained for the sorting process. This continuous grading process develops eye fatigue for the women engaged in this operation lowering grading efficiency. Accounting the problem of scarcity of skilled work force and improper segregation of cashew kernels, surface colour of cashew kernels determined to serve as basic data for refinement of cashew colour sorters.

4.2.9.1 Changes in surface colour of various

grades of cashew kernels

Surface colour showed superior values for L, hue and WI for the white whole cashew kernels and it ranged from 78.1 to 76.4, 84.2 to 83.9 and 64.6 to 63.4 respectively. Other grades considered for the investigation i.e. SW, SSW and DW found to be inferior to standard value (Unprocessed cashew kernel) in terms of L, hue and WI due to darkening or surface roughness. As the marked difference was observed among the various grades, surface colour characteristics of cashew kernels could serve as quality indicator.

4.2.9.2 Changes in surface colour of cashew kernels of different origin

In order to examine the influence of locale or origin of raw cashewnuts and processing stages

(steaming) on the final quality of cashew kernels in terms of light reflectance values, experiments were conducted. Whiteness index worked out for the certain grades of cashew kernels obtained from various origins of raw nuts viz., Nigeria, Benin, Ivory coast, Karnataka and Kerala are presented in Table 4.2. Change in the surface colour of kernels was quiet evident from declining trend of

whiteness index in the order of WW, SW, SSW and DW. WI Values ranged from 65.85 to 60.98 for WW, from 64.84 to 60.26 for SW, from 63.85 to 60.30 for SSW and from 60.86 to 52.37 for DW irrespective of the origin confirming location of raw nut and mode of processing become decisive factors on quality of end product.

Table 4.2: Surface colour of cashew kernels from different destinations

Origin	WW			SW			SSW	DW
	210	320	400	210	320	400		
Nigeria	64.28	62.98	60.98	63.10	62.51	61.77	62.36	57.55
Benin	65.85	63.94	64.08	64.57	64.43	62.13	61.25	59.65
Ivory coast	65.25	64.77	64.10	64.84	61.39	60.26	63.85	60.06
Karnataka	64.19	65.17	64.23	62.27	64.82	63.58	61.10	60.86
Kerala	64.09	64.40	63.86	60.26	61.50	60.53	60.30	52.37

WW-White wholes; SW-Scorched whole; SSW-Scorched wholes seconds; DW-Dessert wholes

4.2.9.3 Changes in surface colour of kernels at various stages of processing

In a secondary level experiments conducted, it was observed that the surface colour of cashew kernels obtained after different stages of processing (subjected to steaming process) showed minimal changes for the indigenous nuts i.e. Karnataka and Kerala compared to imported nuts viz., Nigeria, Benin and Ivory coast. Change in the whiteness index of cashew kernel indicates that environmental factors or handling methods needs to be controlled towards obtaining better quality at packaging stage. Therefore, it is recommended to develop a database on surface colour characteristics of cashew kernels obtained from various origins with optimum processing

parameters. Nevertheless, the data generated will assist processor to follow the protocols to maximize the profit.

4.2.10 Summary

A technical report on NAIP entitled “A value chain on cashew for domestic and export market” was prepared and forwarded to PIU-NAIP, New Delhi through Consortium Leader (Cashew Export Promotion Council of India, Kollam). Major achievements through this project at this Directorate as consortium partner are listed as under:

- Based on the inherent characteristics of raw cashewnuts, heterogeneity confirmed and basic data generated utilized for designing rotary grader.



- Measurable parameters and its contribution to quality of raw cashewnuts are identified.
- A concentric drum type rotary grader for raw cashewnuts is developed and pertinent processing parameters are optimized.
- Moisture sorption isotherms of raw cashewnuts were investigated in relation to shelf life and safe level moisture was worked out to be 8.14 per cent d.b.
- Energy requirement at various stages of processing for different regions irrespective of mode of operations worked out. Based on the data collected, optimum energy demand was worked out to identify problems and probable measures were suggested.
- In view of growing problem of labour shortage, machinery in the line of processing viz., mechanized sheller, steam assisted cross flow kernel dryer, Peeling machinery and colour sorter were evaluated for its performance.
- Free and bound moisture in cashew kernels were demarcated in order to improve its shelf life.
- Physical, mechanical and textural properties of cashew kernel were determined to design cashew kernel related machinery.
- Surface colour characteristics of various grades of industrially processed cashew kernel of different origins were determined towards refinement of existing colour sorter.

5. TRANSFER OF TECHNOLOGY

5.1 Transfer of Technology Programme in Cashew

5.1.1 Impact of cashew production technologies on area, production and productivity of cashew

In order to find out the socio-economic determinants of farm level adoption of cashew production technologies, socio-personal variables and their contribution towards adoption, data has been collected and analysed using step-wise regression models. The contribution of cashew production technologies towards variability in cashew production and productivity were also studied.

The study indicated the level of adoption of recommended pest management practices by farmers, relationship and contribution of socio-personal/economic factors towards adoption of pest management practices. Regression models have been developed to predict extent of adoption of pest management practices.

5.1.2 Socio-personal variables and their contribution towards adoption

The regression analysis revealed that three variables *viz.*, the age of cashew farmer, years of experience in farming and extension participation have a significant positive contribution towards adoption, while two factors *viz.*, type of land used for cashew cultivation and distance of cashew plot from home had a significant negative contribution towards adoption of cashew production technologies (Table 5.1).

Table 5.1: Socio-personal variables and their contribution in explaining the variability in adoption

Socio-personal variables	'b' value
Age	-0.0628***
Level of education	0.073 ns
Primary occupation	-0.068 ns
Experience in farming	0.660***
Experience in cashew farming	0.143 ns
Extension contact	-0.159 ns
Extension participation	0.339*
ICT usage	0.112 ns
Cosmopolitaness	-0.037 ns
Land used for cashew	-0.172**
Land used for other crops	0.066 ns
Distance of cashew plot from home	-0.266***

$R^2 = 0.786$, ns = Non significant, ***Significant at 1% level, **Significant at 5% level, *Significant at 10% level, n = 75

5.1.3 Economic variables and their contribution towards adoption

Four variables *viz.*, the number of crops grown, farm size, number of yielding cashew trees and expenditure incurred in cashew farming were the economic factors which had a significant positive contribution towards explaining the variability in adoption of cashew production technologies. The socio-personal and economic variables used in the study could together explain up to 78 per cent variability in adoption of cashew production technologies (Table 5.2).

Table 5.2: Economic variables and their contribution in adoption

Economic variables	'b' value
No. of crops grown	0.262***
Importance given to cashew	-0.075 NS
Farm size	0.174**
Cultivable land available	0.161 NS
No. of yielding cashew trees	0.297*
Yield of Cashew/tree	-0.082 NS
Expenditure in agriculture	-0.197 NS
Net income from agriculture	-0.120 NS
Expenditure in cashew farming	0.219*
Net income from cashew farming	0.280 NS

$R^2 = 0.786$, ns = Non significant, ***Significant at 1% level, **Significant at 5% level, *Significant at 10% level, n = 75

5.1.4 Predicting adoption of cashew production technologies

Stepwise regression was used to explain the variation in adoption of cashew production technologies among the respondents. Of the eight models, model eight explained up to 69.7 per cent of the variation in adoption using the predictors viz., number of cashew trees (X1), other crops grown (X2), cultivable land available (X3), years of experience in farming (X4), age of the farmer (X5), extension participation (X6), distance of cashew plot from the farmers home (X7) and expenditure in cashew farming (X8). This model also had the lowest standard error of the estimate (9.351) thus making it the best model suited to predict adoption of cashew production technologies by farmers. The model is fitted as: $CPT AI = 30.543 + 0.400 X1 + 0.247 X2 + 0.261 X3 + 0.443 X4 - 0.426 X5 + 0.234 X6 - 0.202 X7 + 0.173 X8$ (Table 5.3). The model can be used to predict adoption of cashew production technologies by farmers under similar agro-ecological situations.

Table 5.3: Models predicting adoption of cashew production technologies

Sl. No	Model		Coefficients ^a			t	Significance
			Un-standardized Coefficients		Standardized Coefficients		
			B	Std. Error	Beta		
	(Constant)		30.543	5.073		6.021	0.000
1	CSHWTRS	X1	0.029	0.005	0.400	5.383	0.000
2	CRPSGRWN	X2	2.472	0.755	0.247	3.274	0.002
3	NONCLTV	X3	3.207	0.869	0.261	3.691	0.000
4	FRMNGEXP	X4	0.531	0.126	0.443	4.222	0.000
5	AGE	X5	-0.531	0.133	0.426	-4.007	0.000
6	EXTNPRTPN	X6	0.508	0.174	0.234	2.917	0.005
7	PLOTDIST	X7	-0.004	0.001	0.202	-2.615	0.011
8	CSHWEXP	X8	0.384	0.166	0.173	2.310	0.024



a. Dependent variable: CPT AI; b. $CPT AI = 30.543 + 0.400 X1 + 0.247 X2 + 0.261 X3 + 0.443 X4 - 0.426 X5 + 0.234 X6 - 0.202 X7 + 0.173 X8$

Model Summary				
Model	R	R ²	Adjusted R ²	S.E. of the Estimate
8	0.835 ^h	0.697	0.660	9.351

Predictors: (Constant), CSHWTRS, CRPSGRWN, NONCLTV, FRMNGEXP, AGE, EXTNPRTPN, PLOTDIST, CSHWEXP

5.1.5 Production and productivity profile of cashew farmers

The production and productivity profile of cashew farmers showed that farmers achieved a mean production of 425 kg and productivity of 2.92 kg/tree. In case of production, majority fell in to medium (40%) and low (43%) producer categories while they were almost equally

divided into high (33%), medium (36%) and low (31%) categories with respect to productivity achieved. As far as their operational holdings are concerned, majority (41%) belonged to small farmer group while the rest were almost equally divided between medium (31%) and large holder (28%) groups with an average holding size of 1.9 ha (Table 5.4).

Table 5.4: Classification of farmers based on production and productivity of cashew

Categories	Production			Productivity		
	f	%	Range	f	%	Range
High	13	17	>674	25	33	>3.96
Medium	30	40	674-177	27	36	3.96-1.87
Low	32	43	<177	23	31	<1.87
Mean	425			2.92		
SD	497			2.09		
n = 75						

5.1.6 Relationship of socio-personal factors

Twelve socio-personal variables were studied for their relationship with cashew productivity. The correlation analysis revealed that extension contact and extension participation along with primary occupation showed a significant relationship with cashew productivity. It may be noted that contact with extension agencies was found to be low among majority of cashew farmers while participation in extension

programmes was found to be medium for almost two-third of the farmers. Majority had high school education while, 15 per cent of them had acquired a degree and 93 per cent had agriculture itself as their primary occupation (Table 5.5). The relationship carries importance in light of the fact that extension contact and participation is on a downward trajectory while better educated farmers were found to be shifting from cashew due to perceived high benefits from alternative crops like rubber.

Table 5.5: Relationship of socio-personal factors with productivity of cashew

Variables	'r' value
Age	-0.067
Level of education	0.075
Primary occupation	0.244*
Experience in farming	-0.058
Experience in cashew farming	0.134
Extension contact	0.229*
Extension participation	0.292*
ICT usage	0.067
Cosmopolitaness	-0.194
Land used for cashew	-0.198
Land used for other crops	0.065
Distance of cashew plot from home	-0.001
*Significant at the 0.05 level (2-tailed)	
**Significant at the 0.01 level (2-tailed)	
n = 75	

5.1.7 Relationship of economic factors with productivity of cashew

Ten economic variables were studied for their relationship with cashew productivity. The correlation analysis revealed that the economic factors have a higher relationship with cashew productivity. of the economic variables, five variables *viz.*, importance given to cashew crop, number of yielding cashew trees, yield of cashew/tree, expenditure incurred in agriculture and net income from agriculture showed a significant relationship with productivity of cashew (Table 5.6). More than half of the cashew farmers realized only moderate yields with an average net income of ₹ 29,664/ha/year against an average

expenditure of ₹ 9293/ha/year which was on a very lower side.

Table 5.6 : Relationship of economic factors with productivity of cashew

Variables	'r' value
No: of crops grown	-0.052
Importance given to cashew	0.378**
Farm size	0.077
Cultivable land available	0.011
No. of yielding cashew trees	0.090
Yield of cashew/tree	0.351**
Expenditure in agriculture	0.310**
Net income from agriculture	0.467**
Expenditure in cashew farming	0.284*
Net income from cashew farming	0.186
*Significant at the 0.05 level (2-tailed)	
**Significant at the 0.01 level (2-tailed)	
n = 75	

5.1.8 Contribution of socio-personal and economic variables

Regression analysis revealed that seven variables *viz.*, age of the farmer, primary occupation, years of experience in farming, cosmopolitaness, number of yielding cashew trees, yearly expenditure made in cashew farming and net income from cashew farming were found to contribute significantly to the productivity achieved by cashew farmers (Table 5.7). The variables selected for the study could explain up to 50 percent of the variability ($R^2=0.495$) in cashew productivity.

Table 5.7: Contribution of socio-economic variables towards variability in cashew productivity

Variables	Standardized coefficients		t	Significance
	Beta			
(Constant)			0.343	0.733
Age	-0.613**		-3.590	0.001
Level of education	-0.168		-1.334	0.188
Primary occupation	0.370**		3.491	0.001
Experience in farming	0.192		1.210	0.232
Experience in cashew farming	0.242*		2.276	0.027
Extension contact	-0.025		-0.145	0.885
Extension participation	0.374		1.731	0.089
ICT usage	0.000		-0.003	0.997
Cosmopolitaness	-0.370**		-3.292	0.002
Land used for cashew	-0.030		-0.282	0.779
Land used for other crops	-0.049		-.476	0.636
Distance of cashew plot from home	-0.019		-0.146	0.885
Number of crops grown	-0.007		-0.049	0.961
Importance given to cashew	-0.022		-0.165	0.869
Farm size	0.183		1.677	0.100
Cultivable land available	-0.012		-0.079	0.938
Number of yielding cashew trees	-0.517*		-2.402	0.020
Expenditure in agriculture	-0.148		-0.853	0.397
Net income from agriculture	0.136		0.923	0.361
Expenditure in cashew farming	0.545**		3.818	0.000
Net income from cashew farming	0.684**		2.835	0.007
*Significant at 0.05 level (2-tailed) **Significant at 0.01 level (2-tailed)				
Model summary				
R	R ²	Adjusted R ²	S.E. of the Estimate	
0.800 ^a	0.640	0.495	1.48	

5.1.9 Contribution of cashew production technologies

Regression analysis revealed the extent of contribution of each production technology towards variability found in levels of cashew production and productivity in the district. Plant protection component which scored the lowest

adoption index emerged as the most significant contributor towards cashew production ($b=0.339^{**}$). Soil and water conservation technology which showed a significant relationship ($r=0.344^{**}$) with cashew production was also found to have a significant contribution towards explaining the variability in cashew production

($b=0.326^*$). Intercropping, another poorly adopted technology was also found to have a significant contribution towards explaining the variability in cashew production ($b=0.243^*$)

(Table 5.8). All the recommended production technologies together could explain only up to 40 per cent of variability in cashew production ($R^2 = 0.406$).

Table 5.8: Contribution of cashew production technologies towards variability in cashew production and productivity

Technology	Production	Productivity
	'b' value	'b' value
Varieties	-0.131 NS	-0.077 NS
Planting and initial care	0.037 NS	-0.159 NS
Soil and water conservation	0.326*	0.208 NS
Manures and fertilizers	-0.195 NS	-0.184 NS
Pruning and training	0.178 NS	0.313*
Plant protection	0.339**	0.139 NS
Intercropping	0.243*	-0.097 NS
Harvesting and post harvest	-0.012 NS	0.024 NS
	$R^2 = 0.406$	$R^2 = 0.149$
NS = Non significant, **Significant at 1 % level, *Significant at 5 % level		

5.1.10 Adoption status of recommended pest management technologies

The adoption of pest management technologies was quantified by measuring the farmer's ability to identify the symptoms of tea mosquito bug (TMB) and cashew stem and root borer (CSRB) attack, status of TMB and CSRB attack in farmers' fields, application of recommended chemical in correct dose, adoption of phyto-sanitation measures and adoption of other recommended management measures. Pest management, which is one of the most important components in cashew

production, scored a low adoption index (20).

In the case of TMB, 30 per cent of the farmers could identify initial attack symptoms while 26 percent of the farmers took up spraying. In the case of management of CSRB, 35 per cent of the farmers could identify initial symptoms of CSRB attack in their orchards while 60 per cent were unable to do so. However, 90 per cent of the farmers never attempted removing grubs from CSRB affected trees. The adoption level for other pest management measures is presented in Table 5.9.

Table 5.9: Adoption of pest management measures in cashew

Recommended pest management measures	Adoption by cashew farmers					
	Always/ Fully		Sometimes/ Partially		Never/ Non adoption	
	f	%	f	%	f	%
Identifying initial symptoms of TMB attack	23	30	5	7	47	63
Spraying against TMB at recommended time	19	26	7	9	49	65
Spraying of recommended chemical	23	30	4	5	48	65
Spraying of pesticide in recommended dose	18	24	2	3	55	73
Monitoring for renewed TMB attack	24	32	4	5	47	63
Identifying initial symptoms of CSRB attack	26	35	4	5	45	60
Removal of grubs from CSRB affected trees	2	3	5	7	68	90
Chiseling out the affected bark	6	8	10	13	59	79
Application of recommended pesticide	7	9	9	12	59	79
Application of pesticide in recommended dose	7	9	9	12	59	79
n = 75						

5.1.11 Relationship between adoption and socio-personal variables

The correlation analysis identified that two socio personal variables *viz.*, years of experience in farming and extension participation of cashew farmers had a significant relationship with farmers' adoption of pest management technologies. The regression analysis revealed that two variables *viz.*, the age of cashew farmer and their primary occupation have a significant positive contribution towards adoption (Table 5.10).

5.1.12 Relationship between adoption and economic variables

The study identified five economic variables

viz., importance given to cashew, number of yielding cashew trees, expenditure in agriculture, net income from agriculture net income from cashew farming had significant relationship with adoption of pest management technologies. The regression analysis revealed that the variable farm size exerts a significant positive contribution towards explaining the variability in adoption of pest management technologies. The socio-personal and economic variables used in the study could together explain up to 60 per cent variability in adoption of pest management technologies ($R^2 = 0.600$) (Table 5.11).

Table 5.10: Relationship between adoption and socio-personal variables and their contribution in explaining the variability in adoption

Socio-personal variables	'r' value	'b' value
Age	0.146 NS	-0.609**
Level of education	-0.096NS	-0.154 NS
Primary occupation	-0.155 NS	-0.305 *
Experience in farming	0.356**	0.779NS
Experience in cashew farming	0.180NS	-0.074 NS
Extension contact	0.189 NS	0.217 NS
Extension participation	0.248*	-0.018NS
ICT usage	0.217 NS	0.209 NS
Cosmopolitaness	0.158 NS	0.009 NS
Land used for cashew	0.001 NS	-0.129NS
Land used for other crops	0.066 NS	0.002 NS
Distance of cashew plot from home	-0.135 NS	-0.036NS
R ² = 0.600 NS = Non significant, **Significant at 1 % level, *Significant at 5 % level, n = 75		

Table 5.11: Relationship between adoption and economic variables and their contribution in explaining the variability in adoption

Economic variables	'r' value	'b' value
No. of crops grown	-0.180NS	-0.029 NS
Importance given to cashew	0.246*	-0.273 NS
Farm size	0.123 NS	0.259*
Area under cashew	-0.023NS	-0.254 NS
No. of yielding cashew trees	0.433**	0.198NS
Yield of cashew/tree	0.146 NS	0.052 NS
Expenditure in agriculture	0.377**	-0.081 NS
Net income from agriculture	0.340**	0.237 NS
Expenditure in cashew farming	0.183 NS	0.387 NS
Net income from cashew farming	0.333*	0.227 NS
R ² = 0.600 NS = Non significant, **Significant at 1 % level, *Significant at 5 % level, n = 75		

5.1.13 Predicting adoption of pest management technologies: Step-wise regression models

Stepwise regression was used to find out the extent to which the selected models explained

the variation in adoption of pest management technologies. Of the six models tested, model six explained up to 46.4 per cent of the variation in adoption of pest management technologies using

the predictors such as number of cashew trees (X1), years of experience in farming (X2), ICT usage (X3), primary occupation of farmer(X4), income from agriculture (X5) and age of the farmer (X6). This model also had the lowest standard error of the estimate (14.717) thus making it the best model suited to predict adoption of pest

management technologies by farmers. The model is fitted as: $PPT AI: 40.579 + 0.028 X1 + 0.808 X2 + 0.737 X3 - 19.167 X4 + 1.916E-005 X5 - 0.412 X6$. The model can be used to predict adoption of pest management technologies by farmers under similar agro-ecological situations (Table 5.12).

Table 5.12: Models predicting adoption of pest management technologies

Coefficients ^a						
Sl. No.	Model	Unstandardized coefficients		Standardized coefficients	t	Significance
		B	S.E.	Beta		
	(Constant)	40.579	15.104		2.687	0.009
1	CSHWTRS (X1)	0.028	0.009	0.323	3.247	0.002
2	FRMNGEXP (X2)	0.808	0.190	0.562	4.262	0.000
3	ICTU (X3)	0.737	0.297	0.227	2.478	0.016
4	OCCPN (X4)	-19.167	7.078	-0.251	-2.708	0.009
5	INCM (X5)	1.916E-005	0.000	0.232	2.392	0.020
6	AGE (X6)	-0.412	0.200	-0.275	-2.064	0.043
a. Dependent Variable: PPT AI						
b. $PPT AI: 40.579 + 0.028 X1 + 0.808 X2 + 0.737 X3 - 19.167 X4 + 1.916E-005 X5 - 0.412 X6$						
Model Summary						
Model	R ²	Adjusted R ²	S.E. of the Estimate			
6	0.464	0.416	14.71760			
f. Predictors: (Constant), CSHWTRS, FRMNGEXP, ICTU, OCCPN, INCM, AGE						

5.2 Development of an interactive and dynamic web-space for cashew information management at DCR

The existing site www.cashew.res.in has been revamped and updated with new information. Plug-ins like archives, quick links, facebook page of DCR, cashew weather advisory, flash banner,

photo slide show, latest news and image crawler have been implemented. Various fields such as about us, research, extension, facilities, staff, library, AICRP, for farmers, reports, FAQ, tender, RTI, office orders, RFD documents etc. have been updated. Images of all field and field visits have been collated into a database.

6. PROGRAMMES ORGANIZED

6.1 Foundation Day Celebration of DCR : Innovative Cashew Farmers Meet - 2013

The Directorate of Cashew Research, Puttur celebrated its foundation day on 18 June, 2013. Innovative Cashew Farmers Meet - 2013 was organized to mark the occasion. More than 150 participants including innovative farmers, progressive farmers, nursery men, representatives of development departments, NGOs and scientists participated and shared their experiences.



Dignitaries on the dias

Dr. M.G. Nayak, Principal Scientist (Hort.), DCR welcomed the gathering. He advocated that the adoption of scientific management practices along with high yielding cashew varieties to increase production and productivity of cashew. Innovative farmers from Karnataka, Kerala and Tamil Nadu presented their innovations. Shri. Badanaje Shankar Bhat, innovative farmer from Karnataka explained about bio-pesticides prepared from cashew nut shell liquid (CNSL). Shri. Baby Jacob from Kerala presented the method of multiple rooting system of old cashew orchard rejuvenation while Shri. S. Thangarasu shared his experiences on high density planting in cashew under organic management practices.

Chief Guest of the function Shri. N. Kumar, Member, ICAR Governing Body, stressed on the need for increasing profitability in cashew farming. He observed that cashew farmers are focusing on cost reduction in order to achieve better income. He appreciated the low cost techniques used by innovative farmers. Shri. V.L. Meena, MD, KFDC, Mangalore appreciated the technologies of DCR and observed that large scale area expansion under cashew brought about by Karnataka Cashew Development Corporation was possible only due to the technological support provided by DCR, Puttur. These technologies have in turn benefitted cashew farmers in the region. During his presidential address, Prof. P.L. Saroj, Director, DCR gave an overview of the present status of cashew research in India. He emphasized upon adoption of improved technologies developed by the DCR and urged to follow the scientific method of cashew cultivation in order to get higher returns. He further emphasized that production of non-alcoholic beverage using cashew apple needs a special focus. Farmers were taken to the cashew museum and laboratories and were appraised of the research achievements. On this occasion, a technical bulletin on 'Development of concentric drum type rotary sieve grader for raw cashew nut' was released. This was followed by a farmer - scientist interaction session.

6.2 Interactive Meeting on Quality Standards for Raw Cashewnuts

An Interactive meeting on 'Quality standards for raw cashewnuts' was organized at DCR on 28 August, 2013 in collaboration with Directorate of Cashewnut and Cocoa Development (DCCD), Kochi. Representatives of cashew processing industry, officials from DCCD, scientists of DCR

and various AICRP-Cashew centres participated in the meeting. Prof. P.L. Saroj, Director, DCR in his opening remarks highlighted the urgent need for developing quality standards for raw cashewnuts which helps both producers and processors alike. He briefed about the present status of cashew cultivation and processing standards in India. He extended research support from the Directorate towards a project for finalizing the quality standards. Shri. Venkatesh N. Hubballi, Director, DCCD extended monetary support for a project to standardize the quality standards. He requested the house to have an interaction based on the concept note prepared by Dr. D. Balasubramanian, Principal Scientist, DCR.



Interactive meeting in progress

Dr. D. Balasubramanian, Principal Scientist, DCR presented the concept note on 'Quality standards for raw cashew nuts'. In the beginning, the rationale for the development of quality standards for raw cashewnuts was explained by him. Besides, the role of various stakeholders in the value chain of cashew viz., cashew growers, traders and processors in assessing the quality and current methodology being followed were also described by him. The applicability of 'Agmark Standards' in the present scenario and its drawbacks were also outlined. As a part of

research project to be taken up at this Directorate, factors influencing quality of raw cashewnuts, importance of sampling technique to be adopted, process suitability of raw cashewnuts, objectives of the project, role of moisture content of raw cashewnuts, development of price structure for raw cashewnuts were delineated by him.

Shri. K. Sudhakar Kamath, President, Karnataka Cashew Manufacturers Association; Shri. G. Giridhar Prabhu, Ex-President, Karnataka Cashew Manufacturers Association and Shri. P. Subraya Pai interacted on the concept note and shared concerns and expectations of the cashew industry. Shri. G. Giridhar Prabhu informed that industry needs 170-190 nut counts which will yield 24-25 per cent. There should be a maximum of only 10-15 per cent immature nuts. The nuts for industry purpose should have proper drying of three days which provides perfect white colour to the kernels during processing. They also highlighted on a framework for future action in this project and extended support of industry.

Dr. Jnanadevan, Joint Director, DCCD and scientists from DCR and AICRP-Cashew Centres also interacted along with the industrialists and provided valuable suggestions towards refining the concept note. Issues related to instrumentation, awareness among producers, preparation of literature on harvesting and post harvest techniques and need for analyzing farmers' opinion on quality standards were also discussed during the meeting. It was decided that Dr. D. Balasubramanian will prepare a project proposal based on the concept note and submit the same to DCCD for funding.

6.3 Agricultural Education Day - 2014

Agricultural Education Day 2014 was organized on 28 February, 2014 on the theme "Scope

of Agricultural Education”. More than 250 students and teachers from various schools of Puttur participated in the programme.



Children visiting experimental field

The students were exposed to the research and extension activities of the Directorate through field visits, visit to cashew museum and different laboratories. The theme lecture of the programme was delivered by Dr. G.S. Mohana, Senior Scientist, DCR where the scope of Agricultural Education was dealt in detail. The students were introduced to the importance of agriculture and various opportunities by the Chief Guest Shri. Sathish Kumar Rai, Head Master, Vivekananda English Medium High School, Puttur. The programme was presided over by Dr. P.S. Bhat, Director-in-Charge, DCR who appraised the students about the role of agriculture in the development of the country and the importance of the services rendered by agricultural scientists in achieving food and nutritional security of the people. Earlier a quiz programme on ‘General Agriculture’ was conducted for the students in which 12 teams from various schools participated. The programme generated immense curiosity and wide appreciation among the students and teachers.

6.4 Training Programmes

6.4.1 Training programmes on integrated pest management in cashew

A two days training programme on Integrated Pest Management in Cashew was organized at DCR under sponsorship of KVK, Kasaragod for project staff of State Planning Board, Kerala during 18-19 November, 2013. Prof. P.L. Saroj, Director, DCR inaugurated the programme. He highlighted the importance of integrated pest management in cashew in the context of eco-friendly soil and plant health management. Dr. P.S. Bhat, Principal scientist (Agril. Entomology), DCR briefed about the objectives of the programme and said that the purpose of the training programme is to enlighten the cashew farmers about non-chemical pest management. Experts from Agril. Entomology of DCR delivered lectures / practical demonstrations on various topics such as ‘Management of tea mosquito bug’, ‘cashew stem and root borer, minor pests and diseases in cashew’ in the training programme.



Participants with resource persons

6.4.2 Awareness cum training programme on protection of plant varieties and farmers' rights act.

Awareness cum Training Programme on 'Protection of Plant Varieties and Farmers' Rights Act' (PPV&FRA) was organized at DCR, Puttur on 21 December, 2013 under sponsorship of PPV&FRA, New Delhi. About 100 cashew farmers from Dakshina Kannada district of Karnataka participated in the programme. The programme was inaugurated by the Chief Guest Dr. George V. Thomas, Director, CPCRI, Kasaragod. In his inaugural address, Dr. George V. Thomas explained in detail the role of Protection of Plant Varieties and Farmer's Rights Authority, overview of PPV&FRA and importance of the act for farming communities and plant breeders. On this occasion, DCR Calendar 2014 was released by the Chief Gust. Prof. P.L. Saroj, Director, DCR delivered the presidential address. In his presidential address, Prof. Saroj appraised farmers about various aspects of biodiversity and importance of its conservation. He urged the farmers to understand and make full use of their rights under the PPV&FRA, which protect the right of farmers, breeders and promote them to develop new varieties. Dr. M.G. Nayak, Principal Scientist, DCR delivered lecture on 'Farmers rights and DUS testing guidelines in Cashew'. He stressed on access to seed, benefit sharing, compensation and other rights under the act. He also dwelt on DUS testing guidelines for cashew along with major 23 characters and how to compare new varieties with the existing ones.

Dr. M.R. Dinesh, Principal Scientist, IIHR, Bengaluru briefed about the 'Guidelines for DUS testing and Plant variety development in mango, guava, papaya and custard apple'. He

also explained the role of farmers and breeders in conservation, improving and developing plant varieties, registration of plant varieties and benefits of registration. Dr. V. Niral, Principal Scientist, CPCRI, Kasaragod presented the guidelines for DUS testing in coconut. She explained about onsite DUS testing facility for coconut farmers and various characters used for testing. A farmer-scientist interaction



A view of the inaugural programme

followed where various aspects of DUS testing, registration of plant varieties, breeders rights and farmers rights, procedures in PPV&FRA etc. were discussed.

6.4.3 Training on pest management in cashew

A training on pest management in cashew was organized in association with Shri Kshetra Dharmasthala Rural Development Programme (SKDRDP), Puttur for tribal farmers at Perlampady village, Kolthige, Puttur on 23 February, 2014. Shri. Achutha Mudithaya, progressive cashew farmer inaugurated the training programme and shared his experiences in cashew farming. More than 100 farmers participated in the programme.



Meeting in progress

Dr. M.G. Nayak, Principal Scientist, DCR advocated that the adoption of scientific management practices along with high yielding cashew varieties is the need of the hour for realizing the quantum jump in production and productivity of cashew. Further he also informed the participants about the financial support available for tribal farmers for cashew cultivation under Tribal Sub Plan. Dr. P.S. Bhat, Principal Scientist, DCR stressed on the various aspects for the management of tea mosquito bug and cashew stem and root borer, the two major pests of cashew. Field visit to demonstration plot of DCR was arranged in which various aspects of ultra high density planting including incidence of tea mosquito bug was shown to the farmers. The training cum field visit resulted in large interest among the tribal farmers and more than 25 farmers expressed their willingness to take up cashew cultivation.

6.4.4 Training on cashew production technology

A training on cashew production technology was organized for tribal farmers at Bettampady village, Irde, Puttur on 25 February, 2014 in association with SKDRDP, Puttur. Dr. P.K.S. Bhat,

progressive cashew farmer and Ex-President of All India Arecanut Growers' Association inaugurated the training programme and shared his experiences in cashew farming. More than 100 farmers participated in the programme.



A section of the participants

Dr. M.G. Nayak, Principal Scientist, DCR emphasized to follow scientific management practices along with high yielding cashew varieties for increasing the productivity. Dr. T.N. Raviprasad, Principal Scientist, DCR spoke in detail on various aspects of pest management in cashew. He stressed the need of maintenance of weed free orchards and timely plant protection measures. Farmers were taken to experimental field and explained about the ultra high density planting system in cashew.

6.4.5 Training on cashew apple utilization

Training on cashew apple utilisation was organized in association with SKDRDP, Puttur for tribal women at DCR, Puttur on 28 March, 2014. Dr. M.G. Bhat, former Director, DCR inaugurated the training programme and stressed on the health benefits of cashew apple products. He highlighted the importance of public-private partnership for popularizing cashew apple preparation. More than 100 tribal women participated in the programme.



Cashew apple utilization - Hands on training

Shri. M.N. Venkata Krishna, Progressive cashew farmer and entrepreneur shared his experiences in cashew processing and marketing. Smt. Meenakshi, Group Leader, SKDRDP spoke on the occasion and requested the tribal women to make the best use of recipes discussed in the training for the nutritional benefit of their families. Dr. M.G. Nayak, Principal Scientist, DCR informed the participants about the financial support available for tribal farmers and thanked SKDRDP for extending the support in organizing Tribal Sub Plan programmes. Prof. P.L. Saroj, Director, DCR in his presidential remark informed the gathering about the immense nutritional benefits and vast scope for cashew apple utilization in the country. He opined that food security is meaningless without nutritional security and stressed upon the increased utilization of all locally available fruits in the coastal region. Dr. D. Balasubramanian, Principal Scientist, DCR conducted practical demonstrations on preparation of juice, squash, jam and pickle. Later the trainees were given hands on training on the preparation of these products.

6.5 Exhibitions

6.5.1 CTCRI golden jubilee international conference and exhibition

DCR participated in CTCRI Golden Jubilee International Conference and Exhibition held at CTCRI, Thiruvananthapuram during 09-12 July, 2013. Around 150 delegates representing 14 countries visited the stall. The Hon'ble DG, ICAR



Delegates in DCR stall

and DDG (Hort.) visited the stall and enquired about progress of research work at DCR.

6.5.2 Horticulture mela

DCR participated in Horticulture Mela organized by University of Horticultural Sciences, Bagalkot, Karnataka during 21-24 November, 2013. A large number of farmers and scientific staff from various organizations visited the stall and necessary information was provided to them.

6.5.3 Symposium on medicinal, spices and aromatic crops (SYMSAC-VII)

DCR participated in exhibition organized as a part of SYMSAC-VII at Madikeri during 27-29 November, 2013. More than 300 farmers and delegates visited the stall. Since cashew is not



Participation of students in the exhibition

cultivated in Madikeri, a lot of queries were made by them regarding this crop. Scientists from various organizations who were participating in the SYMSAC-VII also visited the stall and necessary information was provided.

6.5.4 Exhibition on bio-diversity

DCR participated in exhibition at St. Philomena College, Puttur, Karnataka during 16-17, December, 2013. More than 500 delegates and students benefitted from this exhibition organized as a part of national seminar on bio-diversity.

6.5.5 Establishment of demonstration plots



Demonstration plot on high density planting

The demonstration plots established on farmers' fields at Puttur, Sullia and Bantwal taluks of Dakshina Kannada district of Karnataka with the financial support of National Horticulture Mission (NHM) programme of DCCD, Kochi were monitored regularly by the Scientists of this Directorate and technical advice was given as and when required. Some new demonstration plots were also established on high density planting of cashew.

6.5.6 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.

6.5.7 Supply of planting material

Around 1,50,000 cashew grafts of high yielding and recommended varieties produced under two different revolving fund schemes viz., Mega Seed Project and DCCD Revolving Fund besides the graft production under Institute Revenue Generation programme. Cashew grafts have been supplied to the farmers and developmental agencies.



Cashew Nursery

6.5.8 Visitors

Visitors were taken to various experimental plots, cashew nurseries, cashew museum

and laboratories and were appraised of the achievements and technologies developed by the Directorate (Table 5.1).

Table 5.1: Exposure visit to DCR during 2013-14

Visitors category	Organization	Number of participants	Date of visit
Farmers/Officials	KVK, Belagavi, Karnataka	12	27 April, 2013
Farmers	Different districts of Karnataka, Kerala and Tamil Nadu	132	18 June, 2013
Farmers/Officials	Dept of Horticulture, Uttara Kannada, Karnataka	32	20 June, 2012
Farmers/Officials	Dept of Agriculture, Baghmara, Meghalaya	12	22 June, 2013
Farmers	Kadamba Service Co-op Society, Sirsi, Karnataka	20	19 October, 2013
Students	University of Agricultural Sciences, Raichur, Karnataka	100	11 November, 2013
Project staff	State Planning Board, Kerala	08	18 November, 2013
Students	University of Agricultural Sciences, Bengaluru	50	10 December, 2013
Students	Mangalore University, Mangalore	10	11 December, 2013
Students	College of Horticulture, Udayanagiri	50	02 January, 2014
Students	College of Horticulture, Kolar, Karnataka	50	03 January, 2014
Students	College of Horticulture, Yelavala, Karnataka	50	04 January, 2014
Farmers/Officials	Moodbidri, Karnataka	22	10 March, 2014
Others	From different organizations / farmers / officials	54	
	Total	602	

ADDITIONAL INFORMATION

7. LINKAGES / COLLABORATION

Organization	Area of collaboration
National Bureau of Agriculturally Important Insects (NBAII), Bengaluru	Identification of kairomones/ pheromones of major pests of cashew.
Indian Institute of Horticultural Research (IIHR), Bengaluru	Biosystematics of tea mosquito bug and natural enemies.
University of Agricultural Sciences (UAS), GKVK, Bengaluru Indian Agricultural Research Institute (IARI), New Delhi	Identification of arthropod fauna associated with cashew.
Central Institute for Agricultural Engineering (CIAE), Bhopal	Development of improved cashew processing machinery.
Directorate of Cashewnut and Cocoa Development (DCCD), Kochi	Training programmes for farmers and frontline demonstrations.
<ul style="list-style-type: none"> • 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	Transfer of technology
AICRP-Cashew Centres located in SAUs / ICAR institutes	Multilocational testing, exchange of research findings / germplasm / planting material.

8. HUMAN RESOURCE DEVELOPMENT

Deputation abroad / Executive development programme		
Saroj, P.L.	Advanced Training on Leadership Development at College of Agriculture and Life Sciences, Cornell University, Ithaca, NY 14853, USA.	23 February - 8 March, 2014
Other training programmes		
Kalaivanan, D.	ICAR Sponsored CAFTA Training Programme on Recent Advances in Micro Irrigation and Fertigation organized by Department of Agronomy, TNAU, Coimbatore.	4-24 September, 2013
Mohana, G.S.	SAS for NARS at PDADMAS (ICAR), Bengaluru.	24-28 September, 2013
Raviprasad, T.N.	Advanced Hindi Translation Training Course, Central Translation Bureau (CTB), Govt. of India, New Delhi.	21-25 October, 2013
Sajeev, M.V.	CAFT Training Programme on Innovative Approaches for Agricultural Knowledge Management conducted by Division of Agricultural Extension, IARI, New Delhi.	14 January - 3 February, 2014
Mohana, G.S.	Refresher Course on Agricultural Research Management, NAARM, Hyderabad.	3-15 February, 2014

9. PUBLICATIONS

9.1 Research publications

9.1.1 International

Balasubramanian, D. 2014. Optimizing processing parameters of concentric type rotary sieve grader using dimensional analysis. *Journal of Agricultural Mechanization in Asia, Africa and Latin America*. 45(1): 84-90.

Balasubramanian, D. and Joycy, R.L.K. 2013. Performance evaluation of high speed colour sorter for cashew kernels. *Acta Agrophysic*, 20(4): 543-553.

Bhat, P.S. and Srikumar, K.K. 2013. Record of egg parasitoids *Telenomus* sp. laricis group (Hymenoptera: Platygasteridae) and *Chaetostricha* sp. (Hym: Trichogrammatidae) from *Helopeltis theivora* Waterhouse (Heteroptera: Miridae) infesting cocoa. *International Journal of Agricultural Sciences*, 3 (5): 510-512.

Bhat, P.S., Srikumar, K.K., Raviprasad, T.N., Vanitha, K., Rebijith, K.B. and Asokan, R. 2013. Biology, behaviour, functional response and molecular characterization of *R. trochantericus* Stal var. luteous (Hemiptera: Reduviidae: Harpactorinae) a potential predator of *Helopeltis* spp. (Hemiptera: Miridae). *Entomological News*, 123(4): 264-277.

Bhat, P.S., Srikumar, K.K. and Raviprasad, T.N. 2013. Seasonal Diversity and Status of Spiders (Arachnida: Araneae) in Cashew Ecosystem. *World Applied Sciences Journal*, 22(6): 763-770.

Srikumar, K.K., Bhat, P.S., Raviprasad, T.N., Vanitha, K., Krishna Kumar, N.K., Rebijith, K.B.

and Asokan, R. 2013. Distribution of major sucking pest, *Helopeltis* spp. (Hemiptera: Miridae) of cashew in India. *Proceedings of Zoological Society of India*, DOI 10.1007/s:12595-013-0091-2.

Srikumar, K.K. and Bhat, P.S. 2013. Demographic parameters of *Helopeltis antonii* Signoret (Heteroptera: Miridae) on neem, cocoa and henna. *African Journal of Agricultural Research*, 8(35): 4466-4473.

Vasanthi, P. and Raviprasad, T.N. 2013. Biology and morphometrics of cashew stem and root borers (CSRB); *Plocaederus ferrugineus* and *Plocaederus obesus* (Coleoptera: Cembycidae) *International Journal of Scientific and Research Publications*, 3(1): 1-7.

Vasanthi, P. and Raviprasad, T.N. 2013. Antennal sensilla of cashew stem and root borers (CSRB); *Plocaederus ferrugineus* and *Plocaederus obesus* (Coleoptera: Cembycidae). *International Journal of Science and Research*, 2(4): 62-69.

9.1.2 National

Bhat, P.S. and Srikumar, K.K. 2013. Occurrence of man-faced stink bug, *Catacanthus incarnatus* Drury on cashew in Puttur region of Karnataka. *Insect Environment*, 19(1): 32-34.

Bhat, P.S., Srikumar, K.K. and Raviprasad, T.N. 2013. Spider (Arachnida: Araneae) diversity, seasonality and status in cashew agroecosystem. *Indian Journal of Arachnology*, 2: 30-42.

Dinakara Adiga, J. and Kalaivanan, D. 2013. Influence of dwarf rootstocks on growth and

- vigour of popular cashew cultivars. *Journal of Plantation Crops*, 41(3): 428-432.
- Lakshmipathi., Dinakara Adiga, J., Kalaivanan, D. and Saroj, P.L. 2013. Response of cashew (*Anacardium occidentale* L.) to osmopriming with gibberellic acid (GA3). *Journal of Plantation Crops*, 41(3): 455-459.
- Rejani, R., Adiga, J.D. and Yadukumar, N. 2013. Performance of different varieties of cashew under high density planting system. *Journal of Plantation Crops*, 41(1): 28-33.
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- Saroj, P.L. and Balasubramanian, D. 2013. Cashew Industry in India - a sustainable road map. *Indian Horticulture*, 58(1): 9-15.
- Shobha, D., Thimmappaiah and Jose, C.T. 2013. Molecular characterization and association analysis in cashew using RAPD and ISSR markers. *Journal of Plantation Crops*, 41(3): 292-299.
- Srinivasan, R., Natarajan, A., Anil Kumar, K.S. and Kalaivanan, D., 2013. Distribution of available macro and micronutrients in cashew growing soils of Dakshina Kannada district of coastal Karnataka. *Madras Agric. J.*, 100 (1-3): 747-750.
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- Vasanthi, P. and Raviprasad, T.N. 2013. Laboratory evaluations of oviposition, egg mortality and feeding deterrence of cashew stem and root borer (CSRB); *Plocaederus ferrugineus*. (Coleoptera:Cembycidae). *Journal of Plantation Crops*, 41(2): 227-232.
- Yadukumar, N. and Rejani, R., Nandan, S.L. and Prabhakar, B. 2013. Nutrient budgeting and nutrient balance studies under high density planting system in cashew. *Indian Journal of Agricultural Sciences*, 83(1): 14-21.

9.2 Papers presented in Symposia/Workshops/Seminars

Balsubramanian, D., Saroj, P.L., Meena, R.K. and Vanitha, K. 2014. Research status for technological development of cashew in India. In: National Conference on Cashew - Strategies for Cashew Development - Non Traditional States. Jointly conducted by Directorate of Cashewnut and Cocoa Development, Kochi, Kerala and Department of Horticulture, Jharkand on 20-21 November, 2013 at Ranchi, Jharkand (Souvenir - Strategies for Cashew Development - Non Traditional States. Published by Directorate of Cashewnut and Cocoa Development, Kochi, Kerala. pp. 32-37)

Balasubramanian, D. and Saroj, P.L. 2014. Changing scenario of cashewnuts processing in Karnataka - System of processing and

- its economies. In: National Conference on “Horticulture Industry in India with specific reference to Karnataka: Challenges and Opportunities” organized jointly by University of Agricultural Sciences, Dharwad and Indian Society of Agricultural Economics, Mumbai from 12-14 February, 2014 at College of Agriculture, Bijapur (Eds: V.R. Kiresur, G.N. Kulkarni and S.S. Patil), University of Agricultural Sciences, Dharwad. pp. 61).
- Balasubramanian, D. 2013. Processing of Cashew. In: State Level Seminar on Cashew Production. Jointly conducted by Regional Research Station, Tamil Nadu Agricultural University, Vridhachalam, Tamil Nadu and Directorate of Cashewnut and Cocoa Development, Kochi, Kerala on 23-24 March, 2014.
- Lakshmi pathi., Dinakara Adiga, J., Kalaivanan, D. and Saroj, P.L. 2013. Influence of osmopriming with gibberellic acid (GA3) on emergence, vigour and growth of seedling in cashew (*Anacardium occidentale* L.) under nursery conditions. In: National Seed Seminar on Innovations in Seed Research and Development.” (Eds: Monika A Joshi, S.K. Jain, Kalyani Srinivasan, P.C. Nautiyal and V.A. Tonapi), Seed Tech New (Spl. Vol., June 2013) ISST, New Delhi, pp. 114.
- Mohana, G.S. and Nayak, M.G. 2014. DUS testing guidelines for cashew. In: Workshop on PPV& FRA, CPCRI, Kidu station, Dakshina Kannada, Karnataka on 25 March, 2014.
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- Srikumar, K.K., Bhat, P.S., Raviprasad, T.N., Rajmohana, K. and Vanitha, K. 2013. Species diversity, population dynamics and behaviour of egg parasitoids of *Helopeltis* spp. (Hemiptera, Miridae). In: 4th Biopesticide International Conference: Eco-friendly plant protection and production for food security and food safety and the role of biopesticides in the global economy. Organized by Crop Protection Research Centre (CPRC), Department of Zoology, St. Xavier’s College, Palayamkottai-627002, Tamil Nadu during 28-30 November, 2013, pp. 208.
- Srikumar, K.K., Bhat, P.S., Raviprasad, T.N. and Vanitha, K. 2014. Field screening of cashew varieties / accessions against tea mosquito bug (*Helopeltis antonii*) In: Applied Zoologists Research Association Silver Jubilee International Conference: Probing Biosciences for Food Security and Environmental Safety at CRRI, Cuttack (Odisha) during 16-18 February, 2014, pp. 42.
- Vanitha, K., Bhat, P.S., Raviprasad, T.N. and Srikumar, K.K. 2013. Ants species composition, seasonal diversity and their role in cashew

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- Vanitha, K., Srikumar, K.K., Bhat, P.S. and Raviprasad, T.N. 2014 Species spectrum and seasonal abundance of predatory arthropod fauna in cashew ecosystem In: Applied Zoologists Research Association (AZRA) Silver Jubilee International Conference : Probing Biosciences for Food Security and Environmental Safety at CRRI, Cuttack (Odisha) during 16-18 February, 2014, pp. 39.
- Vasanthi, P. and Raviprasad, T.N. 2013. Life tables of cashew stem and root borers (CSRB); *Plocaederus ferrugineus* and *Plocaederus obesus* (Coleoptera : Cembycidae) on cashew. PLACROSYM XX, UPASI Tea Research Foundation, Coimbatore, Tamil Nadu, 12-15 December 2013, pp. 110.
- Vasanthi, P. Raviprasad, T.N. Nagesh, M. and Nikhita, K. 2013. Entomopathogenic nematodes and entomopathogenic fungus in cashew ecosystem. BIOCICON: 4th Biopesticide International Conference organized by Crop Protection Research Centre, Department of Zoology, St. Xavier's College, Palayamkotta, Tamil Nadu during 28-30 November, 2013, pp. 117.
- 9.3 Book Chapters**
- Adiga, J.D. and D. Kalaivanan. 2013. Cashew. In: Fruit Production in India (Ed: W.S. Dhillon) Narendra Publishing House, 1417 Kishan Dutt Street, New Delhi 110 006, India, pp. 145-166.
- Nayak, M.G. 2013. Prospects and problems of cashew cultivation and cashew based entrepreneurship in North Eastern Hill (NEH) Region. In: Developing the potential of underutilized Horticultural Crops of Hill Region (Eds: N. Prakash, S. S. Roy, P.K. Sharma and S.V. Ngchan), Today and Tomorrow Printers and Publishers, New Delhi pp. 387-403.
- Nayak, M.G., Saroj, P.L. and Bhat, P.S. 2013 Indigenous traditional knowledge in horticulture documentation, validation and replicability issues. In: Indigenous traditional knowledge for promotion of sustainable agriculture (Eds: Sureshbabu *et al.*). Pub. NIRD, Rajendranagar, Hyderabad (AP), pp. 1-164.
- Raviprasad, T.N., Bhat, P.S. and Vanitha, K. 2013. Pest and disease management in cashew including biological control. In: National Symposium on Cashew at University of Agricultural and Horticultural Sciences, Shimoga (Eds: B. Sathyanarayana Reddy, C. Sunil, P. Sridhar Herle and H.D. Mohan Kumar), pp. 64-72.
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9.4 Technical Reports / Compendia / Articles

Annual Report 2012-13. Directorate of Cashew Research, Puttur, pp. 86 (Eds: P.S. Bhat and T.R. Rupa).

Annual Report 2012-13. All India Co-ordinated Research Project on Cashew, Directorate of Cashew Research, Puttur, pp. 106. (Eds: T.N. Raviprasad and P.L. Saroj).

Cashew News 2013. Directorate of Cashew Research, Puttur. Vol. 18 (1), pp. 12 (Eds: T.R. Rupa, and J.D. Adiga).

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DCR at a Glance - 2014. Directorate of Cashew Research, Puttur, Karnataka, pp.12 (Eds: P.L. Saroj, D. Balasubramanian, P.S. Bhat and T.R. Rupa).

9.5 Extension Bulletins / Pamphlets

Balasubramanian, D. 2014. Post Harvest Technologies for Commercialization, Directorate of Cashew Research, Puttur, Karnataka, India, pp. 4.

Mohana, G.S, and Muthuraju, R. 2014, Calender, Directorate of Cashew Research, Puttur.

9.6 Technical Bulletins

Balasubramanian, D. 2014. Alternate energy utilization of cashew shell cake for thermal application. Directorate of Cashew Research, Puttur, Karnataka, India, pp. 15.

Balasubramanian, D. 2014. Development of dual mode dryer for raw cashewnuts. Directorate of Cashew Research, Puttur, Karnataka, India, pp. 15.

9.7 Technical / Popular Articles

Mohana, G.S., 2013. Plant Germplasm information in PGR Portal of NBPGR, Adike Patrike, May, 2013, pp. 21.

9.8 Scientific/ Teaching Reviews

Sajeev, M.V and Nayak, M.G. 2013. Participatory Technology Development and Transfer: A model based on experiences in Cashew. In: Compendium of lectures, Model Training Course on Agricultural Extension, CPCRI, Kasaragod.

Sajeev, M.V. and Thamban, C. 2013. Farming system research / extension approach for technology transfer in plantation crops, In: Compendium of lectures, Model Training Course on Agricultural Extension, CPCRI, Kasaragod.

10. राजभाषा कार्यान्वयन एवं प्रगति

1.	डॉ पी एल सरोज	अध्यक्ष
2.	डॉ टी एन रविप्रसाद	सदस्य
3.	डॉ टी आर रूपा	सदस्य
4.	श्री टी एस पोन्नय्या	सदस्य
5.	डॉ रामकेश मीणा	सदस्य
6.	श्री लक्ष्मीपती	सदस्य
7.	श्री के सीताराम	सदस्य
8.	श्रीमति के रेश्मा	सदस्य
9.	श्री रविशंकर प्रसाद	सदस्य
10.	श्रीमती पद्मिनि कुट्टी	सदस्य
11.	श्री प्रकाश जी भट्ट	प्रभारी अधिकारी

राजभाषा विभाग गृह मंत्रालय के आदेश अनुसार इस निदेशालय में हिन्दी समिति घटित किया गया है और राजभाषा के विकास के लिए जरूरी कदम उठाया जा रहा है। वर्ष २०१३-१४ में राजभाषा कार्यान्वयन समिति की बैठकें नियमित रूप से आयोजित हुईं। हर बैठक में निदेशालय में हो रही हिन्दी कार्यान्वयन के संबंध में चर्चा की गयी। केंद्र से आए पत्रों एवं सूचना के बारे में भी चर्चा की गयी। वार्षिक कार्यक्रम में दी गयी लक्ष्य प्राप्ति के लिए कदम उठाने के बारे में चर्चा की गयी एवं अनेक निर्णय भी लिए गए।

हिन्दी में कार्यालयीन कार्य करने के लिए कर्मचारियों को प्रोत्साह देने के लिए पुरस्कार योजना जरी है। प्रशासन अनुभाग में हिन्दी में काम करनेवालों में उत्साह बड़ा है। निदेशालय के बहुसंख्यक कर्मचारी हिन्दी में कार्यसाधक ज्ञान प्राप्त कर चुके हैं। अन्य कर्मचारियों को प्रशिक्षण दिलाने का कोशिश जारी है। निदेशालय के ग्रंथालय में अनेक उपयुक्त हिन्दी पुस्तकों को खरीदा गया था। इन में प्रशासनिक शब्दावली, तकनीकी एवं वैज्ञानिक शब्द कोश, अनेक महामहिमों का व्यक्ति चित्रण, कृषि अनुसंधान और बागवानी से संबंधित प्रकाशन और कुछ हिन्दी साहित्यकारों का लोकप्रिय उपन्यास भी शामिल हैं।

कार्यालय में सभी नामफलक, प्रपत्र, मोहरे आदियों को द्विभाषी में बनवाया गया है। कर्मचारियों में हिन्दी में

काम करने की झिझक दूर करने के लिए समय समय पर हिन्दी कार्यशालाओं का आयोजन किया जा रहा है। इस वर्ष ऐसे चार कार्यशालाओं का आयोजन किया गया था। इस वर्ष विशेष रूप से इस निदेशालय का वार्षिक प्रतिवेदन को हिन्दी में अनुवाद करके प्रकाशन करने का प्रायास भी किया गया।

पुत्तूर नगर राजभाषा कार्यान्वयन समिति (नराकास)

काजू अनुसंधान निदेशालय, पुत्तूर नगर राजभाषा कार्यान्वयन समिति (नराकास) का संयोजक कार्यालय है। इस निदेशालय पुत्तूर नराकास के २३ सदस्य कार्यालयों के राजभाषा से संबंधित गतिविधियों समीक्षा करता है। उनके विकास के लिए जरूरी कार्यक्रमों को आयोजन करता है।

वर्ष २०१३-१४ में जून और जनवरी में, पुत्तूर नराकास की अर्धवार्षिक बैठकों आयोजित हुईं। इन बैठकों में पुत्तूर और विट्टल के सभी केन्द्र सरकारी कार्यालयों के प्रधान / अधिकारियों ने भाग लिया। हर सदस्य कार्यालय में हो रही गतिविधियों का समीक्षा करना और उन्हें आगे बढ़ाने के लिए जरूरी सूचना एवं मार्गदर्शन देना इन बैठकों का उद्देश्य था।

सभी सदस्य संघटनों के कर्मचारियों के सुविधा के लिए हिन्दी कार्यशाला आयोजन किया गया। अनेक विद्वानों ने कार्यशाला में कर्मचारियों को मार्गदर्शन किया। सभी कर्मचारी इन कार्यशालाओं के समुचित लाभ उठाया।

सितंबर १४-२८ तक बहुत उत्साहपूर्ण वातावरण में संयुक्त हिन्दी पखवाडा मनाया गया। इस अवसर पर कर्मचारियों और विद्यार्थियों के लिए अनेक प्रतियोगिताओं का आयोजन किया गया। विद्यार्थियों को, हिन्दी सीखने के लिए प्रेरणा देने के लिए हिन्दी परीक्षाओं में उत्तम अंक पाने वालों को नकद पुरस्कार से सम्मनित किया गया। हिन्दी की प्रसरण को विस्तृत रूप देने की दृष्टि से हिन्दी अद्यापकओं और विद्यार्थियों के माता पिताओं को भी कार्यक्रमों में शामिल किया गया।

11. AWARDS / RECOGNITIONS

- Prof. P.L. Saroj : Chief Guest and inaugurated 'National Symposium on Cashew: Cashew Promotion in India-Challenges and Opportunities' held at University of Agriculture and Horticulture Sciences, Shimoga, Karnataka from 29-30 October, 2013.
- Prof. P.L. Saroj : Chairperson in a Technical Session of National Seminar on 'Climate Change' held at Bihar Agricultural University, Sabour on 25 May, 2013.
- Prof. P.L. Saroj : Co-chairman for Technical Session 'Scientist-Industry Interface' during the 'International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-Climate' held at CTCRI, Thiruvananthapuram on 12 July, 2013.
- Prof. P.L. Saroj : Co-chairman in Technical Session on 'Crop Management' during National Citrus Meet (Theme: Citrus Varieties, their Protection, Climate Change and Citrus Production) at NRC Citrus, Nagpur during 12-13 August, 2013.
- Prof. P.L. Saroj : Chairman, Poster Evaluation Committee during National Citrus Meet (Theme: Citrus Varieties, their Protection, Climate Change and Citrus Production) at NRC Citrus, Nagpur during 12-13 August, 2013.
- Prof. P.L. Saroj : Chairman for Technical Session 'New Proposals' during the Annual Group Meeting of Scientists of AICRP Cashew (AGM-2013) at Bidhan Chandra Krishi Viswavidyalaya, Kalyani, West Bengal during 5-7 January, 2014.
- Prof. P.L. Saroj : Nominated as Patron of 'Society for Horticultural Research and Development', Ghaziabad (UP).
- Dr. M.G. Nayak : Nominated as Member of Editorial Board of Progressive Horticulture by Indian Society of Horticulture for Research and Development, Uttarakhand.
- Dr. Adiga, J.D. : Nominated as Assistant Editor of Corm, The Journal of Floriculture.

12. QRT / RAC / IRC / IMC / IJSC MEETINGS

12.1 Quinquennial Review Team (QRT) Meeting

The QRT meeting under the Chairmanship of Dr. Kirti Singh, Former Chairman, Agricultural Scientists' Recruitment Board, New Delhi and other members held during 9-10 April, 2013 at DCR, Puttur. Dr. V.A. Parthasarathy, Former Director, Indian Institute of Spices Research,

Kozhikode; Dr. S.P. Singh, Former Director, PDDB (Presently NBAll), Bengaluru; Dr. V.B. Singh, Professor of Horticulture, SASARD, Nagaland University; Dr. S.I. Hanamashetti, Dean, KRC College of Horticulture, Arabhavi, Karnataka (Members of QRT) participated in this meeting. The team had interaction with the scientists and the IMC members also. The QRT finalized the report and submitted to ICAR.

12.2 Research Advisory Committee

Dr. P. Rethinam, Former Executive Director (APCC), Bhagireth, 8, Lakshmi Nagar, S.N. Palayam, Sugarcane Breeding Institute P.O., Coimbatore - 641 007, Tamil Nadu.	Chairman
Dr. K.U.K. Nampoothiri, Former Director, CPCRI, Kasaragod, Director, M.S. Swaminathan Research Foundation, Biju Patnaik Medicinal Plant Garden and Research Centre, Village: Makaput (Telliguda), Jeypore P.O., Koraput district, Odisha - 764 002.	Member
Dr. S. Chandrasekaran, Professor of Agricultural Entomology, Centre for Plant Protection Studies, Tamil Nadu Agricultural University, Coimbatore - 641 003 Tamil Nadu.	Member
Dr. K.V. Ramana, Former ADG (Hort.), Door No. 86-2-21/2, Sangeetam Venkatareddy Street, Jawaharlal Nehru Road Rajahmundry - 533 103, East Godavari District, Andhra Pradesh.	Member
Prof. M. Udayakumar, Emeritus Scientist, Department of Crop Physiology, University of Agricultural Sciences, GKVK, Bengaluru - 560 065, Karnataka.	Member
Prof. P.L. Saroj, Director, Directorate of Cashew Research, Puttur - 574 202, Dakshina Kannada district, Karnataka.	Member
Assistant Director General (Hort.I), Indian Council of Agricultural Research, Krishi Anusandhan Bhavan-II, Pusa Gate, New Delhi - 110 012.	Member
Dr. P.M. Haldankar, Professor and Head, Department of Horticulture, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli - 415 712, Ratnagiri district, Maharashtra.	Member
Dr. T.N. Raviprasad, Principal Scientist, Directorate of Cashew Research, Puttur - 574 202, Karnataka.	Member Secretary



The second meeting of the VI RAC (17th meeting) of the Directorate was held during 11-12 June, 2013 under the chairmanship of Dr. P. Rethinam, Former Executive Director, APCC and Former ADG (Plantation Crops), ICAR. Prof. P.L. Saroj, Director, DCR welcomed the RAC and made introductory remarks about research activities of DCR. Later, the chairman of the VI RAC made his opening remarks opined that research work should be intensified based on the research findings of the DCR. He also informed that certain aspects of cashew cultivation such as hybrid development, canopy management, micronutrient application and efficient pest management should be given priority to realize the full potential of cashew to meet domestic raw nut requirement. He stressed that partnership approach for evaluation and level of adoption of recommended technologies in the farmers' fields and further impact studies need to be initiated. Dr. K.U.K. Nampoothiri, Former Director, CPCRI and M.S. Swaminathan Research Foundation, Jeypore, Odisha; Dr. S. Chandrasekaran, Professor, Centre of Plant Protection Studies, Tamil Nadu Agricultural University, Coimbatore; Dr. M. Udayakumar, Emeritus Scientist, University of Agricultural Sciences, Bengaluru and Dr. S.K. Malhotra, ADG (Hort.-I), Member (ICAR representative) participated in the meeting.

The progress made under various research projects were discussed and recommendations were made. The Chairman and members along with the Director and scientists of DCR also visited the experimental plots at Kemminje and Shantigodu Farms. After detailed discussion,

recommendations were finalized for submission to the Council. The meeting came to an end with vote of thanks by Dr. T.N. Raviprasad, Member Secretary, RAC.

12.3 Institute Research Committee

The 26th IRC meeting of DCR was held during 23-24 July, 2013 under the Chairmanship of Prof. P.L. Saroj, Director, DCR. Dr. Mohana, G.S. Senior Scientist and Member Secretary welcomed the experts and scientists. Prof. P.L. Saroj, in his introductory remarks indicated the importance of IRC meeting and the need for in-depth deliberations to be made in research projects. Dr. Mohana, G.S., presented the general recommendations and Action Taken Report of 16th RAC and 25th IRC meetings. There were technical sessions on "Crop Improvement" chaired by Dr. K. Nirmal Babu, Project Coordinator, All India Coordinated Research Project on Spices, Indian Institute of Spices Research, Kozhikode, Kerala; "Crop Management" chaired by Dr. R. Chithirachelvan, Principal Scientist & Head, Division of Fruit Crops, IIHR, Bengaluru; "Crop Protection" chaired by Dr. R. Asokan, Principal Scientist, Division of Biotechnology, IIHR, Bengaluru; "Post Harvest Technology" Chaired by Dr. Nayansingh Thakor, Professor and Head, Department of Agril. Engineering, Dr. Balasaheb Sawanath Konkan Krishi Vidyapeeth (Dr. BSKKV), Dapoli, Maharashtra and, "Transfer of Technology chaired by Prof. P.L. Saroj, Director, DCR. The scientists of the Directorate presented progress made under various projects and technical programme of all the projects was finalized.

12.4 Institute Management Committee

Name and Address	Status
Prof. P.L. Saroj, Director, DCR, Puttur – 574 202, Karnataka	Chairman
Assistant Director General (Hort.-I), ICAR, Krishi Anusandhan Bhavan-II, New Delhi - 110 012	Member
The Joint Director of Horticulture, (Plantation Crops and Plant Protection), Directorate of Horticulture, Govt. of Karnataka, Lalbagh, Bengaluru-4, Karnataka	Member
Dr. Mahabaleshwar Hegde, Professor of Horticulture, College of Agriculture, Hassan, Hassan District, Karnataka	Member
Dr. K.V. Bhat, Head, DNA Fingerprinting, National Bureau of Plant Genetic Resources, Pusa Campus, New Delhi 110 012	Member
The Special Officer (Cashew), Aravind Chambers, Mundakkal West, Near DCC Office, Kollam - 691 001, Kerala State	Member
Dr. Sudha Mysore, Principal Scientist, Indian Institute of Horticultural Research, Hesaraghatta Lake post, Bengaluru - 560 089.	Member
Dr. Ramanathan, Principal Scientist, Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala-695 017	Member
Dr. T.N. Raviprasad, Principal Scientist, DCR, Puttur - 574 202, Karnataka.	Member
The Finance and Accounts Officer, Central Plantation Crops Research Institute, Kasaragod - 671 124, Kerala	Member
Sri. K.M. Lingaraja, Asst. Administrative Officer (E) & Administrative Officer in-charge, DCR, Puttur - 574 202, Karnataka	Member Secretary

The Institute Management Committee (IMC) met twice on 23 December, 2013 and 22 March, 2014. The activities of the Directorate were

appraised to the IMC during the meetings. The equipments to be purchased during 2013-14 were also discussed during the meeting.



12.5 Institute Joint Staff Council

Official side	
Prof. PL. Saroj	Chairman
Dr. T.R. Rupa	Member
Dr. Mohana, G.S.	Member
Shri. K.M. Lingaraja	Member
Shri. R. Arulmony	Member
Dr. K. Vanitha	Member Secretary
Staff side	
Smt. K. Padminikutty	Member Secretary
Smt. Reshma, K.	Member
Sri. Ravishankar Prasad	Member
Shri. K. Babu Poojary	Member (CJSC)
Shri H. Veerappa Gowda	Member

The Institute Joint Staff Council met four times at quarterly intervals during the year to discuss about staff welfare activities.

ANNEXURES

Annexure-I

Ongoing Research Programmes

Project No.	Title
1. CROP IMPROVEMENT	
1.1	Collection, conservation, evaluation and documentation of cashew germplasm (M.G. Nayak, G.S. Mohana, E. Eradasappa and Ramkesh Meena, P.L. Saroj and P.S. Bhat).
1.2	Genetic improvement of cashew for yield and quality traits (J.D. Adiga, G.S. Mohana, M.G. Nayak, Ramkesh Meena and P.L. Saroj).
1.2.1	Development of dwarf and compact cashew hybrids suitable for high density planting (E. Eradasappa, G.S. Mohana, J.D. Adiga, M.G. Nayak).
1.8	Application of molecular markers in cashew (Thimmappaiah, and J.D. Adiga).
1.8.1	Genetic analysis of mapping population through molecular markers for important traits in cashew (G.S. Mohana, Thimmappaiah, J.D. Adiga and E. Eradasappa).
1.9	Development and evaluation of back cross progenies of promising hybrids for dwarf stature and high yield (G.S. Mohana, J.D. Adiga and E. Eradasappa).
1.10	Evaluation of cashew apple germplasm for cashew apple yield and quality traits (P.L. Saroj, Ramkesh Meena, E. Eradasappa, M.G.Nayak and K. Vanitha).
2. CROP MANAGEMENT	
2.11	Performance of high yielding varieties of cashew in different high density planting system (J.D. Adiga, Ramkesh Meena and D. Kalaivanan).
2.15	Root stock studies in cashew (J.D. Adiga, M.G. Nayak and D. Kalaivanan).
2.16	Effect of foliar application of nutrients on growth, fruit set, yield and quality of cashew (T.R. Rupa).
2.17	Maximization of yield in irrigated cashew and sustaining soil productivity through integrated nutrient management (T.R. Rupa and D. Kalaivanan).
2.18	Effect of Paclobutrazol on growth and yield of cashew (Ramkesh Meena , M.G. Nayak and J.D. Adiga).
2.19	Irrigation requirement for cashew under high density planting system (D. Kalaivanan and Ramkesh Meena).
2.20	Organic farming in cashew (D. Kalaivanan, T.R. Rupa and P.S. Bhat).

2.21	Establishment of nutrient diagnostic norms in cashew (T.R. Rupa and P.L. Saroj).
3. CROP PROTECTION	
3.15	Evaluation of alternate techniques for the management of cashew stem and root borer (T.N. Raviprasad and P.S. Bhat).
3.16	Studies on causes of black spot formation on cashew kernels (T.N. Raviprasad).
3.17	Biodiversity of arthropod fauna in cashew eco-system (P.S. Bhat, T.N. Raviprasad and K. Vanitha).
3.18	Evaluation of certain repellents against storage insect pest (<i>Ephestia cautella</i> - Pyralidae : Lepidoptera) infesting stored cashew kernels (T.N. Raviprasad and P.S. Bhat).
3.19	Evaluation of indigenously occurring natural enemies for their efficacy in managing cashew stem and root borers (CSRB) and tea mosquito bug (TMB) (T.N. Raviprasad, K. Vanitha and P.S. Bhat).
4. POST HARVEST TECHNOLOGY	
4.12	Studies on alternate energy utilization of cashewnut shell cake (D. Balasubramanian).
4.14	Development of compact type drum roasting machine for raw cashewnuts (D. Balasubramanian and S.D. Deshpande).
4.15	Design, development and evaluation of solar tunnel dryer for cashew apple (D. Balasubramanian).
	NAIP : A value chain on cashew for domestic and export market (Consortium partner: D. Balasubramanian).
5. TRANSFER OF TECHNOLOGY	
5.1	Transfer of technology programmes in cashew (Sajeev, M.V., M.G. Nayak, P.S. Bhat and J.D. Adiga).
5.2	Impact of cashew production technologies on area, production and productivity of cashew (Sajeev, M.V.).
5.3	Development of an interactive and dynamic for cashew information management at DCR (G.S. Mohana and Sajeev, M.V.).

ICAR Consortia / Network Partner

- Production of quality seeds and planting materials of horticultural crops.
- Micronutrient management in horticultural crops.
- Organic farming in horticultural crops.
- Management of borers in horticultural crops.
- ORP on Management of sucking pests in Horticultural Crops (ICAR funded through IIHR, Bengaluru).

Externally Funded Project

- DBT: Evaluation of indigenous strain of fungal pathogen *Beauveria bassiana* against *Helopeltis* spp.

Annexure-II

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

Kalaivanan, D.	Group meeting on Net Work Project on Organic Horticulture at IISR, Calicut, Kerala.	2 April, 2013
Saroj, P.L.	Visit to AICRP on Cashew Centre, Darisai for reviewing the ongoing research programmes.	23 May, 2013
Saroj, P.L.	National Seminar on Climate Change at Bihar Agricultural University, Sabour and presented a lead paper on Climate Change on Productivity and Quality of Cashew.	23 May, 2013
Kalaivanan, D.	International Conference on Water Quality and Management for Climate Resilient Agriculture at Jain Hills, Jalgaon, Maharashtra, India.	28-31 May, 2013
Saroj, P.L. Mohana, G.S.	Participated in the National Seminar on Horticulture Biotechnology held on at IIHR, Bengaluru.	14 June, 2013
Sajeev, M.V.	Golden Jubilee International Conference and Exhibition, CTCRI, Thiruvananthapuram, Kerala.	9-12 July, 2013
Saroj, P.L.	International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-Climatic and to Co-chair a Session on Scientist-Industry Interface at CTCRI, Thiruvananthapuram.	12 July, 2013
Saroj, P.L. Bhat, P.S.	Discussion on Performance Indicators at National Centre for Agricultural Economics and Policy Research (NCAP), New Delhi.	15 July, 2013
Saroj, P.L. Bhat, P.S.	Interaction Meeting with Director, PDFSR, Modipuram at NASC Complex, Pusa, New Delhi.	15 July, 2013
Saroj, P.L.	Participated in the 85 th ICAR Foundation Day Celebrations at AP Shinde Symposium Hall, NASC Complex, Pusa, New Delhi.	16 July, 2013
Nayak, M.G.	District Level Seminar on Rejuvenation of Cashew Orchards – Organized by ZP Mangalore and NHM.	12 August, 2013
Saroj, P.L.	National Citrus Meet (Theme : Citrus Varieties, their Protection, Climate Change and Citrus Production) at NRC for Citrus, Nagpur.	12-13 August, 2013
Nayak, M.G.	Review meeting of Cashew Development Programmes organized by DCCD, Kochi.	25 August, 2013

Saroj, P.L.	Meeting of Project Coordinators of AICRPs/AINPs and the Leaders of the CRPs held under the Chairmanship of Secretary, DARE and DG, ICAR at NASC Complex, Pusa, New Delhi.	29-31 August, 2013
Saroj, P.L.	National Meet on Fruit Crops : Farmers, Traders and Researchers Interface at NBAII, Bengaluru under the Chairmanship of Secretary, DARE & DG, ICAR, New Delhi.	22 October, 2013
Saroj, P.L.	Visit to AICRP Cashew Centre at Horticulture Research Station, Hogalagere under University of Horticultural Sciences, Bagalkot for reviewing the ongoing research programmes.	22 October, 2013
Saroj, P.L. Rupa, T.R. Raviprasad, T.N.	National Symposium on Cashew Promotion in India, Challenges and Opportunities, University of Agricultural and Horticultural Sciences, Shimoga.	29-30 October, 2013
Bhat, P.S.	Discussion on Issues pertaining to Agriculture and Allied Sector in Karnataka at National Institute of Animal Nutrition and Physiology (NIANP), Bengaluru under the Chairmanship of Secretary, DARE & DG, ICAR, New Delhi.	21 November, 2013
Sajeev, M.V.	Horticulture Mela, UHS, Bagalkot, Karnataka.	22-24 November, 2013
Sajeev, M.V.	SYMSAC-VII and Farmers Meet, IISR, Madikeri, Karnataka.	27-29 November, 2013
Kalaivanan, D.	4 th Workshop Cum Installation of SAS training programme for nodal officers held at UAS, Bengaluru.	15-16 November, 2013
Balsubramanian, D.	National Conference on Cashew - Strategies for Cashew development – Non Traditional States. Jointly conducted by Directorate of Cashewnut and Cocoa Development, Cochin, Kerala and Department of Horticulture, Jharkand.	21 November, 2013
Nayak, M.G.	Review Meeting of Status of Germplasm in Horticulture. Organized at NRC-Grapes, Pune.	29 November, 2013
Vanitha, K.	4 th Biopesticide International Conference: Eco-friendly Plant Protection and Production for Food Security and Food Safety and the Role of Biopesticides in the Global Economy.	November 28-30, 2013
Sajeev, M.V.	International Conference on Extension Educational Strategies for Sustainable Agricultural Development – A Global Perspective: UAS, GKVK, Bengaluru, Karnataka.	5-8 December, 2013



Saroj, P.L.	Interactive Workshop on Administrative and Financial matters for the ICAR Institutes located in Southern Region at NAARM, Hyderabad.	5-8 December, 2013
Sajeev, M.V. Vanitha, K.	National Conference and Exhibition on Biodiversity, St. Philomena College, Puttur, Karnataka.	16-17 December, 2013
Saroj, P.L. Raviprasad, T.N. Adiga, J.D. Eradasappa, E.	Annual Group Meeting of Scientists of AICRP-Cashew-2013, Bidhan Chandra Krishi Viswavidyalaya, Kalyani, West Bengal.	5-7 January, 2014
Saroj, P.L.	Visit to AICRP Cashew Centre at ICAR Research Complex for Goa, for reviewing the experiments.	17 January, 2014
Saroj, P.L.	Joint Conference of Vice Chancellors and ICAR Directors Conference at Baramati, Pune, Maharashtra.	19-20 January, 2014
Balsubramanian, D.	National Conference on horticulture Industry in India with specific reference to Karnataka: Challenges and Opportunities organized jointly by University of Agricultural Sciences, Dharwad and Indian Society of Agricultural Economics, Mumbai at College of Agriculture, Bijapur.	12-14 February, 2014
Vanitha, K.	AZRA Silver Jubilee International Conference: Probing biosciences for food security and environmental safety.	16-18 February, 2014
Eradasappa, E.	Brainstorming Meet and Training Cum Demonstration on Cryopreservation and In Vitro conservation in Horticultural Crops at IIHR, Bengaluru.	21-22 February, 2014
Kalaivanan, D.	One day Hindi Workshop held at CPCRI, Regional Station, Vittal, Karnataka,	18 February, 2014
Saroj, P.L.	Custodian farmers meet at CARI Port Blair organized as part of ICAR-Bio-diversity International Project on 'Conservation and Sustainable Use of Cultivated and Wild Tropical Fruit Diversity: Promoting Sustainable Livelihood, Food Security and Ecosystem Services.	19 March, 2014
Nayak, M.G. Balsubramanian, D.	State Level Seminar on Cashew Production. Jointly conducted by Regional Research Station (RRS), Tamil Nadu Agricultural University, Vridhachalam, Tamil Nadu and Directorate of Cashew and Cocoa Development, Kochi, Kerala at RRS, Vridhachalam, Tamil Nadu.	23-24 March, 2014

Annexure-III

Radio Talk

Adiga, J.D.	Processing of cashewnut and apple at All India Radio, Mangalore.	29 April, 2013
Nayak, M.G.	Planting and establishment of cashew orchards at All India Radio, Mangalore.	18 July, 2013
Raviprasad, T.N.	Pest management in cashew cultivation at All India Radio, Mangalore.	20 February, 2014

Annexure-IV

Services to Farmers

Sale of cashew grafts: DCR has a cashew nursery accredited by National Horticulture Board (NHB) to cater the need of planting materials. Soft wood grafts of varieties like Bhaskara, 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.

Advisory service: Advisory service on all aspects of cashew cultivation and processing is given to growers and stakeholders through pamphlets, brochures, 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. H.P. Singh Former Director	Central Research Institute for Dryland Agriculture (CRIDA) Hyderabad.	16 May, 2013
Dr. S.K. Malhotra Assistant Director General (Hort.)-II	Krishi Anusandhan Bhavan -II Pusa, New Delhi 110 012.	11 June, 2013
Dr. P. Rethinam Former Executive Director (APCC)	Bhagireth, 18, Lakshmi Nagar, S.N. Palayam, Sugarcane Breeding Institute P.O., Coimbatore - 641 007, Tamil Nadu.	11 June, 2013
Dr. K.U.K. Nampoothiri Former Director, CPCRI, Kasaragod, Director, M.S. Swaminathan Research Foundation	Biju Patnaik Medicinal Plant Garden and Research Centre, Village: Makaput (Telliguda), Jeypore P.O., Koraput district, Odisha - 764 002.	11 June, 2013
Mr. N. Kumar Member, General Body, ICAR	Indian Council of Agricultural Research, New Delhi.	16 June, 2013
Dr. R. Chithiraichelvan Principal Scientist and Head	Division of Fruit Crops, Indian Institute of Horticultural Research, Bengaluru, Karnataka	23 July, 2013
Dr. George V. Thomas Director	Central Plantation Crops Research Institute, Kasaragod, Kerala	21 December, 2013
Sh. Suresh Kumar, Chief Administrative Officer	Central Plantation Crops Research Institute, Kasaragod, Kerala	23 February, 2014
Dr. S. Ayyappan Secretary, DARE and Director General, ICAR	Indian Council of Agricultural Research, Krishi Bhavan, New Delhi 110 114.	9 March, 2014
Dr. N.K. Krishna Kumar, Deputy Director General (Hort.), ICAR	Indian Council of Agricultural Research, Krishi Anusandhan Bhavan –II, Pusa, New Delhi 110 012.	9 March, 2014
Dr. C. Vasudevappa Vice Chancellor	University of Agricultural and Horticultural Sciences, Shimoga , Karnataka	28 March, 2014

Annexure-VI

Personnel

Staff position as on 31.3.2014

Category	Sanctioned	Filled	Vacant
Director (RMP)	1	1	-
Scientific	17	13	4
Technical	19	16	3
Administrative	15	10	5
Canteen staff	1	1	-
Supporting	37	27	10
Total	90	68	22

Research management position Managerial

Prof. P.L. Saroj, Director

Scientific

1	Dr. Thimmappaiah	Principal Scientist (Genetics and Cytogenetics)
2	Dr. M.G. Nayak	Principal Scientist (Horticulture)
3	Dr. P.S. Bhat	Principal Scientist (Agricultural Entomology)
4	Dr. T.R. Rupa	Principal Scientist (Soil Science - Soil Physics and Soil and Water Conservation)
5	Dr. T.N. Raviprasad	Principal Scientist (Agricultural Entomology)
6	Dr. D. Balasubramanian	Principal Scientist (Agricultural Structures and Processing Engineering)
7	Dr. J.D. Adiga	Senior Scientist (Horticulture)
8	Dr. Mohana, G.S.	Senior Scientist (Genetics and Cytogenetics)
9	Dr. Sajeev, M.V.	Scientist (Agricultural Extension)
10	Dr. Ramkesh Meena	Scientist (Horticulture)
11	Dr. K. Vanitha	Scientist (Agricultural Entomology)
12	Dr. D. Kalaivanan	Scientist (Soil Science)
13	Mr. Eradasappa, E.	Scientist (Plant Breeding)

Technical		
1	Sri. K. Muralikrishna	Chief Technical Officer
2	Sri. P. Adbulla	Chief Technical Officer
3	Sri. R. Arulmony	Assistant Chief Technical Officer
4	Sri. A. Padmanabha Hebbar	Senior Technical Officer
5	Sri. Prakash G. Bhat	Senior Technical Officer
6	Sri. Lakshmipathi	Senior Technical Officer
7	Sri. R. Lakshmisha	Senior Technical Officer
8	Sri. K.V. Ramesh Babu	Senior Technical Officer
9	Sri. N. Manikandan	Technical Officer
10	Sri. R. Muthuraju	Technical Officer
11	Sri. K. Seetharama	Technical Officer
12	Sri. A. Poovappa Gowda	Technical Officer (Upto 31 st August, 2013)
13	Sri. K. Babu Poojary	Technical Assistant
14	Sri. Ravishankar Prasad	Technical Assistant
15	Sri. Vijay Singh	Technical Assistant
16	Sri. Bejmi Veigus	Senior Technician
17	Sri. P. Honappa Naik	Technician
Administration		
1	Sri. T.S. Ponnaiah	Administrative Officer (Upto 31 st May, 2013)
2	Sri. K.M. Lingaraja	Assistant Administrative Officer (Establishment)
3	Ms. M. Ratna Ranjani	Assistant Administrative Officer (Stores)
4	Sri. O.G. Varghese	Private Secretary
5	Ms. B. Jayashree	Personal Assistant
6	Ms. K. Reshma	Personal Assistant
7	Ms. Winne Lobo	Assistant
8	Ms. M. Leela	Assistant
9	Sri. Uma Shankar	Upper Division Clerk
10	Ms. Padmini Kutty	Upper Division Clerk
11	Sri. K. Balappa Gowda	Gestetner Operator

Annexure-VII

Budget (2013-14)

(₹ in lakhs)

Budget	Plan	Non-Plan	External	Total
Allocation	200.00	598.00	32.20	830.20
Utilization	179.63	510.83	28.98	719.44

Annexure-VIII

Meteorological Data (2013-14)

Month	Temperature (°C)		Relative humidity (%)		Rainy days	Rainfall (mm)	Wind velocity (km/h)	Sun-shine (h)	Pan Evaporation (mm)	
	Max.	Min.	7.28 h	14.28 h						
Apr.13	36.2	24.1	90	46	3	52.6	1.9	7.4	5.4	
May 13	34.2	24.5	90	59	8	145.4	2.0	4.6	4.3	
Jun.13	29.2	22.4	94	83	28	1061	2.3	0.4	3.8	
Jul.13	27.9	22.0	93	86	31	1473.8	3.0	0.2	3.9	
Aug.13	29.5	21.8	93	76	26	376.4	2.0	2.5	3.7	
Sep.13	29.8	22.0	92	74	18	245.5	2.0	2.8	3.7	
Oct.13	31.3	22.4	93	66	16	178.8	1.8	4.2	3.3	
Nov.13	33.4	21.4	89	47	6	41.4	1.5	7.8	3.6	
Dec.13	33.6	17.7	87	38	0	0	1.6	8.9	3.8	
Jan.14	34.1	19.2	88	37	0	0	2.1	8.5	4.4	
Feb.14	34.7	20.3	90	38	0	0	2.3	8.0	4.9	
Mar.14	37.2	22.4	88	33	0	0	2.7	7.4	6.2	
Total rainfall						3574.9				

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

Annexure-IX

Publications for Sale

Sl. No.	Publication	Price (₹)
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
5	Status of cashew germplasm collection in India (Booklet)	*
6	Compendium of concluded research projects (1986 -2001)	*
7	Sudharitha geru besaya kramagalu (Booklet in Kannada)	15.00
8	Cashew nutritive value (Revised) (Brochure)	*
9	Database on cashewnut processing in India (2003)	100.00
10	Directory of cashewnut processing industries in India (2003)	100.00
11	Process catalogue on development of economically viable on-farm cashewnut processing	45.00
12	Cashew cultivation practices (Pamphlet)	*
13	Annotated bibliography on cashew (1995-2007)	205.00
14	Soil and water management in cashew plantations	30.00
15	Biochemical characterization of released varieties of cashew	85.00
16	Pruning and canopy architecturing in cashew	40.00
17	Development of dual mode dryer for raw cashewnuts	90.00
18	Alternate energy utilization of cashew shell cake for thermal application	90.00

Price indicated above does not include postage.

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

* Free of cost