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वार्षिक प्रतिवेदन
ANNUAL REPORT
2014-15

भाकृअनुप - काजू अनुसंधान निदेशालय
पुत्तूर - 574 202, कर्नाटक

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पुत्तूर-574 202, दक्षिण कन्नड़, कर्नाटक

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प्रस्तावना

मुझे काजू अनुसंधान निदेशालय, पुत्तूर का वार्षिक प्रतिवेदन 2014-15 प्रस्तुत करने में खुशी हो रही है। अनुमोदित कार्यक्रम के तहत फसल सुधार, फसल प्रबंधन, फसल संरक्षण, कटाई उपरान्त प्रौद्योगिकी तथा तकनीकी हस्तांतरण परियोजनाओं की प्रगति वार्षिक प्रतिवेदन में सम्मिलित की गई है।

राष्ट्रीय काजू जीन बैंक में सग्रहित 539 जननद्रव्यो में से 494 को आई.पी.जी.आर.आई वर्णक के आधार पर विवेचित किया जा चुका है। जननद्रव्य केटालॉग-IV में, 1991-1997 तक रोपित जननद्रव्यों के 108 लक्षणों की विवेचनाओ का प्रकाशन किया गया है। दक्षिण कन्नड़ जिले में सूक्ष्म पोषक तत्वों की मृदा में उपस्थिति का काजू फसल क्षेत्र के लिए मानचित्र तैयार किया गया है। जिससे पता चला है कि काजू उगाये जाने वाले क्षेत्र की मृदा में जिंक (75.8 प्रतिशत) और बोरान (87.9 प्रतिशत) की उपस्थित मृदा में सूक्ष्म तत्वों की कमी प्रदर्शित करती है। कीट रेड्वीड इरन्था अर्मीपस, पेन्थस बाइमाकुलेटस, स्फेडानोलेस्टस साइनस के जीवन चक्र अध्ययन से पता चला है इन कीटों का उपयोग चाय मच्छर बग के जैविक नियंत्रण में किया जा सकता है। काजू सेव एवं गुठली को सुखाने के लिए सौर उर्जा संग्रहित संहवन सयंन्त्र विकसित किया गया है। दक्षिण कन्नड़ जिले के आदिवासी किसानों की भूमि में जनजातीय उपयोजना के तहत 25 नये प्रदर्शन प्रक्षेत्रो का प्रचालन किया गया है। काजू अनुसंधान निदेशालय में रसायनिक उर्वरकों द्वारा दिये जाने वाली एन.पी.के. की मात्रा को कार्बनिक खादों द्वारा प्रतिस्थापन, काजू बागान स्थापन का अभिविन्यास, वार्षिक काजू दिवस एवं आदिवासी किसान संवाद समन्धित संगोष्ठियो का आयोजन सफलतापूर्वक किया गया। काजू पणधारियों के हित के लिए काजू उत्पादन तकनीक एवं काजू प्रसंस्करण पर आधारित प्रशिक्षण कार्यक्रमों का आयोजन किया गया। भा कृ अनु प-काजू अनुसंधान निदेशालय ने कृषि विश्व विद्यालय एवं भारतीय कृषि अनुसंधान संस्थानों द्वारा आयोजित विभिन्न प्रदर्शनियों में भी भाग लिया। निदेशालय ने काजू ग्राहकों के लिए उत्तम पौध सामग्री की उपलब्धता एवं वितरण में महत्वपूर्ण भूमिका निभाई है।

मै वर्ष 2014-15 के वार्षिक प्रतिवेदन के संकलन के लिए वैज्ञानिक और संपादकीय समिति के सदस्यों का आभार प्रकट करता हूँ।

स्थान : पुत्तूर, कर्नाटक
दिनांक : 18 जून, 2015

(पी. एल. सरोज)

ICAR-DIRECTORATE OF CASHEW RESEARCH

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PREFACE

I am happy to present the Annual Report 2014-15 of ICAR-Directorate of Cashew Research (DCR), Puttur (Karnataka). As per 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 539 accessions planted in National Cashew Field Gene Bank, 494 accessions have been evaluated as per IPGRI descriptors. Germplasm catalogue - IV: Minimum Descriptors of Cashew Germplasm Accessions has been published which represents 108 accessions characterized during 1991-1997 at NCFGB, Puttur. Soil micronutrient status maps with respect to cashew for Dakshina Kannada district of Karnataka have been prepared. It revealed that the available Zn (75.8% of the soil samples) and B (87.9% of the soil samples) were highly deficient in the soils. Of the different plant densities, plant density of 500 plants/ha resulted in the highest cumulative nut yield (six harvests) of 7.97 t/ha, closely followed by plant density of 384 plants/ha (7.59 t/ha). The biology of the reduviids *Irantha armipes, Panthous bimaculatus, Sphedanolestes signatus* and *Sycanus galbanus* (Heteroptera: Harpactorinae) has been worked out which can be attempted for biological control of tea mosquito bug. A natural convection solar tunnel dryer for drying raw cashewnuts and apples on a pilot scale has been designed and developed. Under Tribal Sub-Plan (TSP) programme, 25 new frontline demonstration plots were established in tribal farmer fields of Dakshina Kannada district, Karnataka. Brainstorming session on Substitution of NPK requirement using organic source, Foundation day of ICAR-DCR, Cashew farmers meet – 2014, Orientation on establishment of cashew orchards and, Cashew day and interaction meet with tribal farmers were organized at ICAR-DCR, Puttur. Training programmes on Cashew production technology and Cashewnut processing were organized for the benefit of the stakeholders. The Directorate participated in various exhibitions organized by SAUs and ICAR institutes. This Directorate has taken a prime 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 2014-15.

(P. L. Saroj)

Place : Puttur, Karnataka
Date : 18 June, 2015

CONTENTS

INTRODUCTION

Research on cashew was first initiated in the early 1950s. Indian Council of Agricultural Research (ICAR), sanctioned adhoc schemes for Research Centres located at Kottarakkara (Kerala), Ullal (Karnataka), Bapatla (Andhra Pradesh), Daregaon (Assam) and Vengurla (Maharashtra). In 1971, ICAR also sanctioned All India Coordinated Spices and Cashew Improvement Project (AICS and CIP) with its Headquarters located at ICAR-CPCRI, Kasaragod. The ICAR-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 ICAR-Directorate of Cashew Research (ICAR-DCR). Subsequent to the bifurcation of AICS and CIP, the Headquarters of All India Coordinated Research Project on Cashew was shifted to ICAR-DCR, Puttur. At present, this Coordinated Research Project is operating at 14 Centres distributed in major cashew growing areas of the country.

The main campus of ICAR-DCR is situated 5 km away from Puttur town at Kemminje (12.45° N latitude, 75.15° E longitude and 90 m above MSL). The main campus has an area of 68 ha with field experiments and Laboratory-cum-Administrative Block. Experimental Station at Shantigodu, which also forms part of the Directorate is 13 km away from the main campus and has an area of 80 ha. At main campus, the laboratories like Horticulture, Soil Science, Plant Breeding, Plant Physiology, Biotechnology, Plant Protection, Post Harvest Management and Audio-Visual 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 and 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 1750 books and 1601 back volumes of various journals. The library subscribes 35 National and 18 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 cashew-nut production and maintaining premier position as largest producer, processor and exporter at global level.

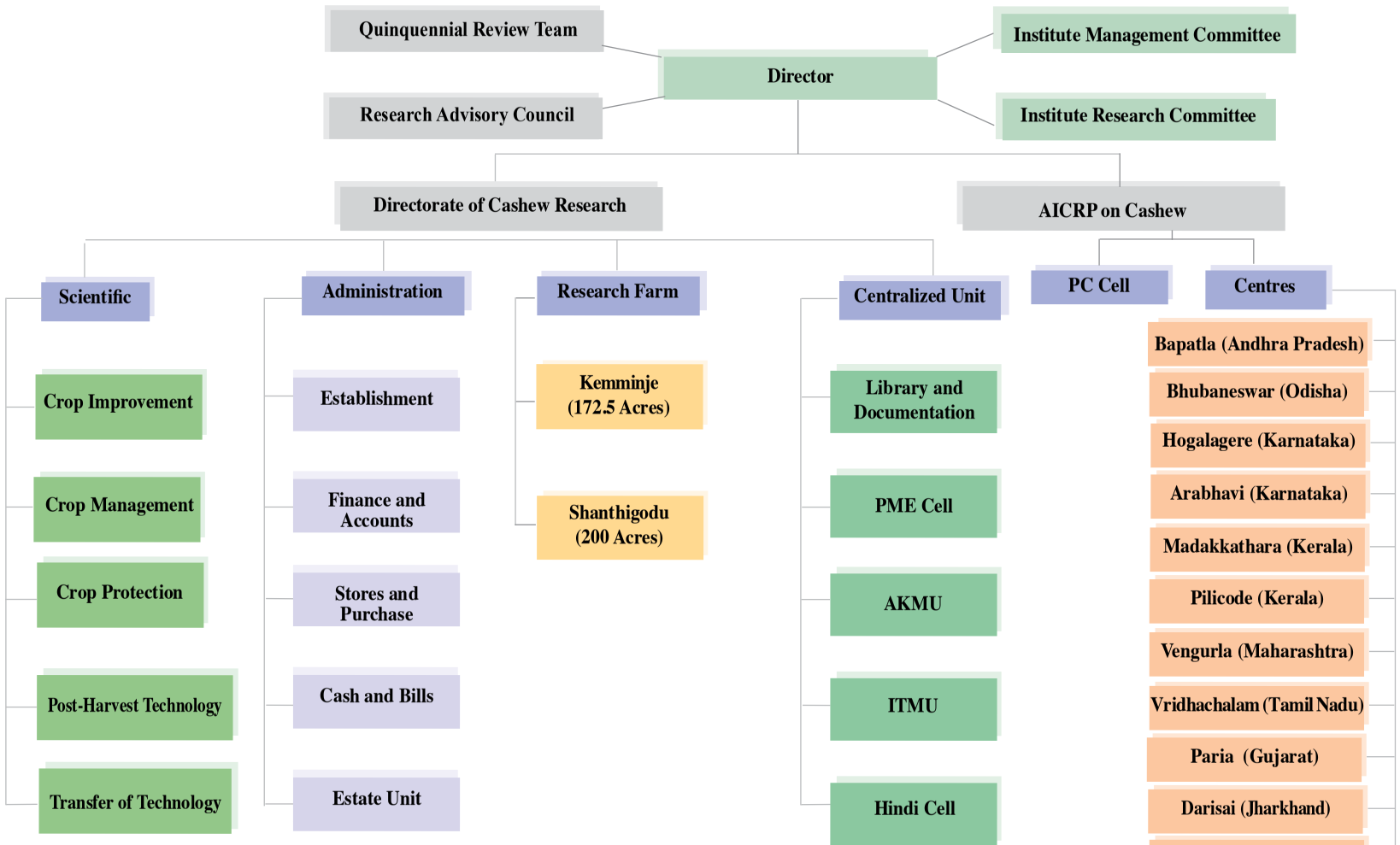
Mission

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

Mandate

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

ICAR - Directorate of Cashew Research



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

Organizational Structure

कार्यकारी सारांश

वर्ष 2014-15 में पी.पी.वी एवं एफ.आर.ए तथा 3 भा कृ अनु प नेटवर्क योजनाओं सहित 7 परियोजनाओं के अन्तर्गत कुल 26 परीक्षण भा कृ अनु प-काजू अनुसंधान निदेशालय, पुत्तूर, कर्नाटक में सतत प्रगति पथ पर अग्रसर हैं। भारतीय समन्वित काजू अनुसंधान परियोजना के भुवनेश्वर (उड़ीसा) केन्द्र से विकसित किस्मों का राष्ट्रीय काजू क्षेत्रीय जीन बैंक में संग्रहण से कुल 539 जननद्रव्यो का सग्रहण किया जा चुका है। वर्ष 2003-04 में रोपित 16 जननद्रव्यों सहित 494 एक्सेसनों की विवेचना आई.पी.जी.आर.आई मानक जैसे वृद्धी, उपज, गुठली लक्षणों के आधार पर किया जा चुका है। वर्ष 1991-1997 के दौरान रोपित 108 जननद्रव्यों की विवेचना को चतुर्थ केटालाग मे प्रकाशित किया गया है। दोहरान परीक्षण के अन्तर्गत रोपित आशाजनक किस्मों से हाइब्रीड - 126 को गुठली वजन (11-12 ग्राम) छिलकन प्रतिशत 29.1 एव गिरी वजन 3.3 ग्राम के आधार पर W-150 की श्रेणी मे रखा गया है। एक वंशज पौध संख्या 480 एवं VTH-30/4 को आनुवंशिक संग्रहण क्षेत्र से आशाजनक वंशज के रुप मे पहचाना गया है। आशाजनक हाइब्रिड किस्म से तीसरे वर्ष की उपज 6.9 किलो प्राप्त की जा सकती है। तथा इसको गिरी के वर्गीकरण के आधार पर मध्यम श्रेणी मे रखा गया है। कर्नाटक राज्य के दक्षिण कन्नड़ जिले की मृदा का पोषक तत्व विश्लेषण के आधार पर पोषक तत्वों की उपस्थिति का मानचित्र तैयार किया जा चुका है। जिसमे दर्शाया गया है कि जिंक उपलब्धता (75.8 प्रतिशत) एवं बोरान (87.9 प्रतिशत) मात्रा मृदा में पोषक तत्वों की कमी को दर्शाती है। इसके लिए 70-70 मृदा एवं पत्तियों के नमूनों का विश्लेषण किया है। काजू उगाये जाने वाले क्षेत्रो मे नाइट्रोजन उपलब्धता 30 से 94 प्रतिशत की उपलब्धता पोषक तत्व की कभी को दर्शाती है। एक परिक्षण में वृद्धी अवरोधक हार्मोन पेक्लोब्यूटराजोल (PBZ) को मिट्टी में पौध बेसिन क्षेत्र में डालने से फल लगाव में अधिकता किन्तु गुठली आकार में कमी तथा कुल उत्पादन मे वृद्धी देखी गई है। इस वृद्धी अवरोधक हार्मोन के (3 ग्राम a.i.) वार्षिक अनुप्रयोग से प्रति पौध उपज (2.89 कि.ग्रा.) एव गुठली आकार लम्बाई, चोड़ाई में कमी पायी गई है। उपचारित पौधो में गुठली लम्बई (29.2 मिली), चोडाई (22.7 मिली) और मोटाई (17.4 मिली) जबकि नियत्रण में लम्बाई (33.4 मिली) चोड़ाई (26.1 मिली) और मोटाई (19.6 मिली) पायी गयी। इस हार्मोन के प्रयोग से पौधों में फलत एवं फलन संख्या में नियत्रंण की तुलना अधिकता पायी गई है। विभिन्न पौध धनत्व परीक्षण में सामान्य दूरी पर रोपित पौधों (200 प्रति हैक्टयर) की संचय उपज (5.12 टन प्रति हैक्टयर) एवं उच्चतम धनत्व पौध संख्या 500 प्रति हैक्टयर से उच्चतम संजय उपज (7.97 टन/है) जबकि पौध संख्या 384 प्रति हैक्टयर मे कुल संचय उपज (7.59 टन प्रति हैक्टयर) पायी गई है। इससे ज्ञात होता है कि प्रारम्भिक वर्षों में उच्चतम पौध धनत्व के माध्यम से अधिक उपज प्राप्त की जा सकती है सभी किस्मों में भास्करा की संचय उपज (7.37 टन प्रति हैक्टयर) जबकि उल्लाल-3 (7.13 टन प्रति हैक्टयर) एवं धना (7.11 टन प्रति हैक्टयर) पायी गई।

एक प्रक्षेत्र सर्वेक्षण से पता चला है कि रोगजनक मेटराजियम एनीसोपली के कारण जुलाई से नवंबर महीने में काजू तना एवं जड़ छिद्रक कीट के प्यूपा का संक्रमण औसतन 6-34 प्रतिशत तक पाया गया। कई कीटों के जैविक अध्ययन मे रेडूवीड इरन्था, पेन्थस बीमाकुलेटस, सफेडोनोलेटस साइन्टकर साउन्स गालबेनस से चाय मच्छर बग का जैविक नियत्रण किया जा सकता है। काजू क्षेत्र में चाय मच्छर कीट के नर-मादा आर्कषण का समय 10-12 बजे के बीच अधिक पाया जाता है। यह फेरोमोन ट्रेप में फसे कीट संख्या के अध्ययन के आधार पर ज्ञात हुआ है। काजू क्षेत्रों में चींटीयों की 49 प्रजाती, 24 जेनेरा एव 7 उप-परिवार का प्रतिनिधित्व पाया गया है।

काजू क्षेत्र के सर्वेक्षण से पता चला है कि विश्व की सबसे खतरनाक चींटी प्रजाति अनाप्लोलेपीस एवं फलीडोल मेगासीफल पर अध्ययन की जरुरत है। निदेशालय में काजू

सेव एव गुठली सुखाने के लिए प्राकृतिक सौर उर्जा संहवन प्रणाली को विकसित किया है। इस प्रणाली का उपयोग करके सेव नमी 86-16 प्रतिशत एव गुठली नमी 17-8 प्रतिशत कम किया जा सकता है। इसके अलावा एक सेसंर पर आधारित वातावरण नियन्त्रण प्रणाली का विकास किया जिसमें सेव टूकड़ों को उर्ध्वाघर रखने से सुखाई समान मात्रा में की जा सकती है इस प्रणाली को काजू सेव के भौतिक गुणों को ध्यान मे रखकर विकसित किया गया है।

उप जनजातीय विकास योजना के अन्तर्गत 25 अग्रिम पक्ति प्रदर्शन आदिवासी किसानों के खेतो में लगाये गये है। पहले से प्रचालित पक्ति प्रदर्शनों का समय-समय पर निरीक्षण और तकनीकी सलाह वैज्ञानिक समूह द्वारा दी जा रही है। किसानों को लाभान्वित करने के लिए काजू अनुसंधान निदेशालय में रसायनिक उर्वरकों का प्रतिस्थापन पर विचार मंथन संगोष्ठी, काजू स्थापन तकनीक, काजू दिवस आदि कार्यक्रम आदिवासी किसानों के साथ आयोजित किये गये हैं। विभिन्न किसानों एवं कृषि विभाग के अधिकारियों को लाभान्वित करने के लिए काजू उत्पादन तकनीक एवं काजू प्रसंस्करण प्रणाली के प्रशिक्षण कार्यक्रमों का आयोजन किया गया। निदेशालय विभिन्न क्षेत्रों के किसानों को जाग्रत करने के लिए कृषि मेला, कृषि एवं बागवानी विश्वविद्यालय शिमोगा, केंद्रीय बागवानी प्रयोगिक क्षेत्र, चेट्टाली कर्नाटक के स्वर्ण जयन्ती समारोह एवं भारतीय कृषि अनुसंधान परिषद का भारतीय मसाला अनुसंधान केन्द्र कोझीकोड में रोपणी फसलों पर आयोजित अन्तराष्ट्रीय संगोष्ठी में भाग लिया। केन्द्रीय रोपणी फसल अनुसंधान उपक्षेत्र, विट्टुला, कृषि यंन्त्र मेला केन्द्रीय सुपारी और कोको विपणन एवं प्रसंस्करण सहकारी समिति लिमीटेड द्वारा आयोजित (विवेकानन्द, कालेज, पुत्तूर) में भाग लेकर किसानो को काजू उत्पादन तकनीक एवं प्रसंस्करण से सम्बन्धित सुझाव दिये।

वर्ष 2014-15 में लगभग 2 लाख काजू ग्राफ्टस का उत्पादन एवं वितरण किसानों तथा कृषि विभागों में किया गया। निदेशालय से 21 शोध पत्र (6 अन्तराष्ट्रीय एवं 16 राष्ट्रीय) 04 पुस्तक अध्याय, 4 तकनीक लेख, 1 तकनीक बुलेटीन, 3 प्रसार शिक्षा बुलेटिन एवं 7 तकनीक लेख प्रकाशित किये गये है। 21 शोध पत्र विभिन्न सेमिनार एवं संगोष्ठीयों में प्रस्तुत किये गये है। निदेशालय में शोध कार्यो की प्रभावी निगरानी के लिए RAC, IRC एवं IMC बैठकों का भी आयोजन किया गया है। निदेशालय में कर्मचारी सामाजिक कल्याण गतिविधियों से समन्धित बैठकों का भी आयोजन किया जाता है। हिन्दी भाषा का देशव्यापी उत्थान के लिए हिन्दी पाठशाला एवं राजभाषा कार्यन्वयन सिमिति की बैठकों का आयोजन किया गया। इस वार्षिक प्रतिवेदन 2014-15 में अनुसंधान परियोजनाओं के परिणाम का ब्योरा प्रस्तुत किया गया है।

EXECUTIVE SUMMARY

During 2014-15, a total of 7 projects having 26 experiments along with three ICAR-Network projects and one PPV and FRA project were in operation at ICAR-Directorate of Cashew Research, Puttur (Karnataka). Two released cashew varieties *viz.,* Jagannath and Balabhadra from AICRP-Cashew Centre Bhubaneswar (Odisha) have been added to the National Cashew Field Gene Bank (NCFGB) raising the total collections to 539. Sixteen germplasm accessions planted during 2003-04 were evaluated as per the IPGRI descriptors for their growth, yield and nut characters bringing the total number of accessions evaluated to 494. Germplasm Catalogue-IV: Minimum Descriptors of Cashew Germplasm Accessions has been published which represents 108 accessions characterized during 1991-1997 at NCFGB, Puttur. Among hybrids, under replicated trial, the hybrid, H-126 was found promising with a special character of jumbo nut (nut weight of 11-12 g), with a shelling percentage of 29.1 and kernel weight of 3.3 g which fits in to kernel grade of above W150. One seedling progeny *i.e.,* Tree No. 480 from VTH 30/4 was identified as a promising genetic stock as it recorded 6.9 kg nut yield in the third harvest itself and nuts of which fell under intermediate category.

Soil micronutrient status maps with respect to cashew for Dakshina Kannada district of Karnataka have been prepared. It revealed that the available Zn (75.8% of the soil samples) and B (87.9% of the soil samples) were highly deficient in the soils. In order to diagnose the nutrient constraints that limit cashew production, 70 soil and leaf samples each from Puttur (Karnataka) and Vengurla (Maharashtra) regions were collected. The available N content was low in 94 and 37 per cent of the cashew orchards in Puttur and Vengurla regions, respectively. Application of paclobutrazol (PBZ) @ 3 g a.i./plant annually was found significantly effective in reducing the nut length, width and thickness. The minimum length (29.2 mm), width (22.7 mm) and thickness (17.4 mm) of nut was recorded in PBZ treated plot as compared to control (length: 33.4 mm, width: 26.1 mm and thickness: 19.6 mm). The PBZ application increased the yield per plant but the nut weight got reduced. The highest nut yield (2.89 kg/plant) and minimum nut weight (6.2 g) was associated with annual application of PBZ @ 3 g a.i. per plant. This could be attributed to higher fruit set and fruit retention in the PBZ treated plants over untreated plants. Among different plant densities, plant density of 500 plants/ha resulted in the highest cumulative nut yield (six harvests) of 7.97 t/ha, closely followed by plant density of 384 plants/ha (7.59 t/ha). The plant density of 200 plants/ha was associated with the lowest cumulative nut yield of 5.12 t/ha. Increase in yield to the tune of 1.5 times under the plant density of 500 plants/ha over the normal plant density (200 plants/ha) indicates the potentiality of high density planting in cashew in the initial years of plantation. Among the varieties, Bhaskara had the highest cumulative nut yield of 7.37 t/ha, closely followed by Ullal-3 (7.18 t/ha) and Dhana (7.11 t/ha).

During the field surveys, natural mortality of Cashew Stem and Root Borer (CSRB) grubs and pre-pupae was noticed, during late July till November due to infection by the entomopathogenic fungus *Metarhizium anisopliae.* The infection percentage ranged between 6 and 34. The biology of the reduviids *Irantha armipes, Panthous bimaculatus, Sphedanolestes signatus* and *Sycanus galbanus* (Heteroptera: Harpactorinae) has been worked out which can be attempted for biological control of tea mosquito bug (TMB). The attraction of males

of TMB to virgin females has been confirmed which was maximum between 10 AM to 12 Noon under field conditions. This was evidenced by maximum catch of male TMB in the traps baited with virgin females during that period. Upon surveillance of cashew plantations, a total of 49 ant species representing 24 genera and 7 sub-families were recorded. Presence of world's worst invasive two ant species namely *Anaplolepis gracillipes* and *Phleidole megacephala* in cashew plantations of survey region needs attention.

Designed and developed a natural convection solar tunnel dryer for drying raw cashewnuts and apples on a pilot scale. This can effectively be used for reducing the moisture content of cashew apple from 85 to 16 per cent w.b. and that of raw cashewnut from 17 to 8 per cent d.b. In order to improve the efficiency of drying raw cashewnuts or cashew apple slices, sensor based environment control system has been designed. This sensor coupled microcontroller ensures uniform drying and enhance rate of drying irrespective of material exposed at different vertical spacing. A conceptual design of mechanized slicer for cashew apple is prepared based on the physical characteristics of cashew apples.

Under Tribal Sub-Plan (TSP) programme, 25 new frontline demonstration plots were established in tribal farmer fields of Dakshina Kannada district, Karnataka. The Frontline demonstration plots laid out earlier in the farmers' fields were monitored and technical advice was offered. Brainstorming session on Substitution of NPK requirement using organic source, Foundation day of ICAR-DCR, Cashew farmers meet – 2014, Orientation on establishment of cashew orchards and, Cashew day and interaction meet with tribal farmers were organized at ICAR-DCR, Puttur. Training programmes on Cashew production technology and Cashewnut processing were organized for the benefit of farmers and officials from line departments. The Directorate participated in Krishi Mela organized at University of Agricultural and Horticultural Sciences (UAHS), Shivamogga, Karnataka; ICAR-Central Horticultural Experiment Station (CHES) Golden Jubilee Exhibition at CHES, Chettalli, Karnataka; International Symposium on Plantation Crops (PLACROSYM XXI) organized at ICAR-Indian institute of Spices Research, Kozhikode, Kerala; Krishi Mela organized at ICAR-CPCRI Regional Station Vittal, Karnataka; Krishi Yantra Mela organized at Vivekananda Engineering College, Puttur, Karnataka by the Central Arecanut and Cocoa Marketing and Processing Co-operative Limited (CAMPCO) and exhibited various aspects of cashew production and processing technologies for the benefit of the stakeholders.

During the year, around 2.0 lakh cashew grafts were produced and distributed to farmers and development departments. During 2014-15; 21 research papers (6 International + 15 National), 4 book chapters, 4 technical reports, 1 technical bulletin, 3 extension bulletins and 7 popular articles were published. Besides, 28 papers were presented in different seminars and symposia. For effective monitoring of research and Directorate activities; RAC, IRC and IMC meetings were organized timely. 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) meetings were also organized. In this Annual Report, the details of results of the ongoing research projects are presented.

RESEARCH ACHIEVEMENTS

1. CROP IMPROVEMENT

1.1 Genetic Resources of Cashew

1.1.1 Germplasm survey and collection

A random survey was conducted in Siddapur and Sirsi taluks of Uttara Kannada district (Karnataka) and Thirthahalli, Sagar, Shivamogga and Sorabha taluks of Shivamogga district (Karnataka). A total of five accessions comprising of four accessions with bold nut size and one accession with compact canopy having slow growth habit and late flowering behaviour have been collected. Two released cashew varieties *viz.,* Jagannath and Balabhadra from AICRP-Cashew Centre Bhubaneswar (Odisha) have been added to the National Cashew Field Gene Bank (NCFGB) raising the total collections to 539.

1.1.2 Germplasm conservation

Eleven germplasm accessions made during the last fruiting season were multiplied and were planted at 6 m x 6 m distance @ 6 plants per accession for evaluation and characterization. In conservation block, 24 germplasm accessions evaluated previously were planted at a closer spacing of 4 m x 4 m @ 4 plants per accession.

1.1.3 Germplasm evaluation

Sixteen germplasm accessions planted during 2003-04 were evaluated as per the IPGRI descriptors (Table 1.1). Majority of the accessions (93.75%) had upright and open canopy with extensive branching habit. Most of them (93.75%) had obovate shaped yellow red coloured leaves at tender stage. The accessions were mostly mid season flowering types (87.5%). In these accessions, the apple colour was yellow (43.5%) in majority of the accessions followed by red (37.5%) and yellow red (18.75%) with cylindrical (56.25%) and conical (25%) shapes. Sizeable accessions (52.25%) had bold nut (>7 g) and 56.25 per cent

Table 1.1: Important features of germplasm accessions evaluated in 2014

Data Field	Descriptor		Descriptor state	No. of accessions
7	Tree habit	3	Upright and compact	1
		5	Upright and open	15
		7	Spreading	0
9	Leaf shape	1	Oblong	0
		2	Obovate (Club-shaped)	15
		3	Oval	1
16	Branching pattern	1	Extensive	15
		2	Intensive	1
19	Colour of young leaves	1	Red	2
		2	Yellow red	10
		3	Green red	4
		4	Purple	0

Data Field	Descriptor		Descriptor state	No. of accessions
28	Season of flowering	3	Early (Nov-Dec)	1
		5	Mid (Dec-Jan)	14
		7	Late (Jan-Feb)	1
31	Mature cashew apple colour	1	Yellow	7
		2	Red	6
		3	Yellow red	3
		4	Red purple	0
32	Shape of cashew apple	1	Cylindrical	9
		2	Conical-obovate	4
		3	Round	1
		4	Pyriform	2
50	Attachment of nut to cashew apple	3	Loose	6
		5	Intermediate	8
		7	Tight	2
35	Nut weight	3	Low (<5 g)	1
		5	Intermediate (5-7 g)	5
		7	High (>7 g)	10
43	Weight of cashew apple	3	Low (<27 g)	1
		5	Medium (27-52 g)	6
		7	High (>52 g)	9
60	Flowering duration	3	Short (<60 days)	4
		5	Medium (60-90 days)	12
		7	Long (>90 days)	0
62	Apple to nut ratio	3	Low (<6)	4
		5	Medium (6-12)	10
		7	High (>12)	2
63	Shelling percentage	3	Low (<18 %)	0
		5	Intermediate (18-28 %)	1
		7	High (>28%)	15
64	Kernel weight	3	Low (<1.2 g)	0
		5	Intermediate (1.2-2.5 g)	12
		7	High (>2.5 g)	4
57	Shell thickness	3	Thin (<2.5 mm)	0
		5	Intermediate (2.5-4.0 mm)	16
		7	Thick (>4.0 mm)	0
65	Attachment of peel to kernel	3	Loose	15
		7	Tight	1
68	Cumulative yield per plant (6 annual harvests)	3	Low (<9 kg)	2
		5	Medium (9-18 kg)	9
		7	High (>18 kg)	5

accessions had high weight of cashew apple (>52 g). The accessions were predominantly (56.25%) medium yielders while few accessions (31.25%) had higher cumulative yield.

1.1.4 Germplasm documentation

Germplasm Catalogue - IV: Minimum Descriptors of Cashew Germplasm Accessions has been published. The publication represents 108 accessions characterized during 1991-1997 at NCFGB, Puttur.

1.1.5 Genetic architecture of cashew germplasm

Genetic architecture of cashew germplasm was assessed using 13 important quantitative characters recorded on 478 accessions conserved in NCFGB. The mean, standard deviation, skewness and kurtosis were calculated and frequency distribution was arrived for 13 quantitative characters using Descriptive Statistics option of IBM SPSS Statistics Version 20. Further, correlation among these quantitative characters was worked out using the same software.

Considerable variability for all 13 characters was evident by the respective ranges and CVs. However, highest CV (52.21%) was observed for sex ratio followed by cumulative yield per plant (49.19%) and apple weight (37.81%). The lowest CV was observed for shelling percentage (15.15%) followed by shell thickness (16.83%). The frequency distribution patterns (Fig. 1.1) showed highly positive skewed distribution (Skewness value >1.0) for characters such as nut weight, sex ratio, apple weight and apple to nut ratio. Genetically, it is evident that decreasing alleles are in excess and dominant for these characters. Whereas characters such as tree spread, kernel weight and cumulative yield per plant showed moderately positively skewed distribution (Skewness >0.5 and <1.0) indicating decreasing alleles are in slight excess and dominant. Flowering intensity showed moderately negative skewed distribution (Skewness >-0.5 and <-1.0) indicating the presence of increasing alleles in slight excess and their dominant nature.

Different shapes of cashew apple

Tree height, shell thickness, flowering duration, shelling percentage and leaf area showed approximately symmetric distribution (Skewness between -0.5 and 0.5) indicating that increasing and decreasing alleles are in equal proportion and the dominance is ambi-directional. None of the characters showed highly negative skewed distribution. Positive kurtosis was observed for most characters except tree height, flowering duration and leaf area, which showed negative kurtosis. The kurtosis for flowering intensity was found to be zero.

Significant positive correlations with cumulative yield per plant were observed for tree height, tree spread, sex ratio, flowering duration, apple to nut ratio, shelling percentage and leaf area and significant negative correlation for shell thickness. The present germplasm collection represents sufficient number of accessions for both quantitative and qualitative characters in desired direction (Table 1.2). However based on the frequency distribution patterns, it is imperative to collect germplasm with dwarfness, less tree spread, high nut weight, apple weight and high yield.

Table 1.2: Number of accessions for desirable quantitative characters

Character	No. of accessions	Top accessions (Values in parenthesis)
Tree height (<2.5 m)	5	NRC-153 (1.5), NRC-128 (2.3), NRC-131 (2.4), NRC-100 (2.5), NRC-239 (2.5)
Tree spread (<3.0 m)	4	NRC-153 (1.5), NRC-121 (2.5), NRC-131 (2.7), NRC-190 (3.0)
Leaf area (>120 sq.m)	50	NRC-270 (168.3), NRC-291 (159.0), NRC-279 (156.0), NRC-277 (152.0), NRC-278 (150.3)
Nut weight (>7.0 g)	190	NRC-269 (16.78), NRC-183 (15.4), NRC-161 (15.0), NRC-402 (14.2), NRC-383 (13.4)
Sex ratio (>0.13)	74	NRC-60 (0.30), NRC-63 (0.29), NRC-68 (0.27), NRC-279 (0.27), NRC-278 (0.25)
Weight of cashew apple (>100 g)	29	NRC-385 (180.0), NRC-301 (169.8), NRC-140 (142.8), NRC-164 (141.0), NRC-333 (135.0)
Shell thickness (<2.5 mm)	40	NRC-152 (1.5), NRC-153 (1.5), NRC-285 (1.5), NRC-87 (1.7), NRC-281 (1.8)
Shell thickness (>4.0 mm)	16	NRC-160 (4.7), NRC-278 (4.6), NRC-166 (4.5), NRC -180 (4.5), NRC-270 (4.5)
Flowering duration (<60 days)	50	NRC-266 (42), NRC-246 (47), NRC-238 (48), NRC-265 (48), NRC-221 (50)
Flowering duration (>90 days)	161	NRC-24 (130), NRC-12 (128), NRC-11 (128), NRC-03 (121), NRC-20 (121)
Flowering intensity (>70%)	205	NRC-126 (96.8), NRC-175 (95.5), NRC-141 (95.2), NRC-148 (95.0), NRC-385 (93.7)
Apple to nut ratio (<6.0)	51	NRC-298 (2.0), NRC-156 (3.2), NRC-255 (3.3), NRC-238 (3.4), NRC-460 (3.6)
Apple to nut ratio (>12)	74	NRC-41 (28.1), NRC-385 (18.9), NRC-370 (18.6), NRC-115 (18.5), NRC-327 (18.1)
Shelling percentage (>28%)	265	NRC-406 (42.6), NRC-343(41.0), NRC-393 (40.5), NRC-405 (40.5), NRC-327 (40.3)
Kernel weight (>2.5 g)	62	NRC-183 (4.4), NRC-323 (4.0), NRC-333 (4.0), NRC-160 (3.7), NRC-409 (3.5)
Cumulative yield (6 years) (>18 kg/plant)	48	NRC-352 (Ullal-1; 27.53), NRC-457 (Estamol-1; 26.82), NRC-349 (NDR-2-1; 26.21), NRC-356 (Chintamani-1; 26.08), NRC-354 (Ullal-3; 25.95), NRC-465 (Banjha Kusum-1; 24.96), NRC-346 (Vengurla-4; 24.65), NRC-475 (Amritha; 24.42), NRC-452(Anakkayam-1; 24.06), NRC-434 (Petamalapalli-1; 23.70).

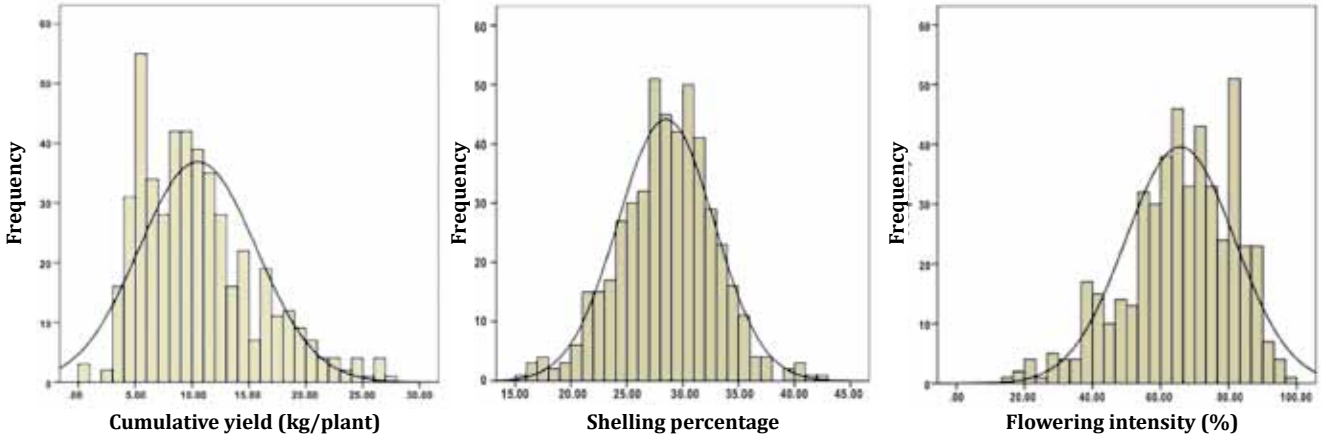


Fig. 1.1: Frequency distribution of cumulative yield, shelling percentage and flowering intensity

1.1.6 Genetic analysis of mapping population through molecular markers

Screening of mango and almond primers in parents of the mapping population *i.e.,* Ullal-3 x NRC-492 was initiated and so far initial screening of 15 mango and 24 almond primers has been completed. The phenotypic characters such as stem girth, plant height and canopy spread in east-west and north-south directions have been recorded on 93 hybrids of Ullal-3 x NRC-492 and descriptive statistics is represented in the Table 1.3.

Table 1.3: Descriptive Statistics of phenotypic characters

Character	Minimum	Maximum	Mean	SD
Stem girth (cm)	30.0	92.0	54.91	12.41
Plant height (m)	2.3	7.5	5.06	1.09
Canopy spread-EW	2.5	9.0	5.99	1.37
Canopy spread-NS	2.8	9.5	6.03	1.47

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

A total of 515 seeds of two back crosses *i.e.,* Ullal-3 x NRC-492 (Brazil dwarf) back crossed with Ullal-3 and, Bhaskara x NRC-492 back crossed with Bhaskara were sown. Plant height, girth and length of cotyledon to first leaf were recorded on the seedlings at one, two and three months after sowing. Descriptive statistics of three month old seedlings is given in the Tables 1.4 and 1.5. The data indicates that the frequency of dwarf plants is very low. These seedlings (472 back cross progenies and parents) were field planted.

Table 1.4: Descriptive statistics of (Ullal-3 x NRC-492: Tree Number 577) x Ullal-3

Parameters	LCFL (cm)	Plant height (cm)	Stem girth (cm)
Mean	5.72	31.25	0.78
SD	1.27	6.61	0.14
Skewness	0.92	-0.58	-0.49
SE of skewness	0.20	0.19	0.19
Kurtosis	2.28	0.67	0.32
SE of kurtosis	0.39	0.39	0.39
Range	2.6-11.0	8.0-46.0	0.4-1.0

LCFL: Length of cotyledon to first leaf

Table 1.5: Descriptive statistics of (Bhaskara x NRC-492 :Tree Number 626) x Bhaskara

Parameters	LCFL (cm)	Plant height (cm)	Stem girth (cm)
Mean	6.37	31.21	0.81
SD	1.22	6.99	0.12
Skewness	0.32	-0.25	-0.34
SE of skewness	0.23	0.23	0.23
Kurtosis	0.07	-0.27	0.26
SE of kurtosis	0.46	0.46	0.46
Range	4.0-10.0	14.0-47.5	0.5-1.1

LCFL: Length of cotyledon to first leaf

1.2 Genetic Improvement of Cashew

1.2.1 Performance of promising hybrids

Among hybrids, under replicated trial, the plant height ranged from 4.5 m (H-2452) to 6.4 m (Bhaskara), stem girth ranged from 46.9 cm (H-1250) to 62.4 cm (H-2473), while, the canopy spread in east to west direction ranged from 5.1 m (H-43) to 6.3 m (H-2473) and in north to south it ranged between 5.0 m (H-125) and 6.0 m (H-2452) (Table 1.6).

All the hybrids under evaluation were found to be less vigorous compared to Bhaskara (check variety) in terms of plant height.

The nut weight in hybrids varied significantly. Hybrid, H-125 recorded the highest nut weight (12.06 g), closely followed by H-126 (11.32 g). All the hybrids recorded high shelling percentage (>28%), except H-43 and H-68. Nut thickness and nut width were highest in H-125 (2.57 cm and 2.85 cm respectively) closely followed by H-126 (nut thickness of 2.41 cm and nut width of 2.73 cm). Nut length was highest with H-43 (3.98 cm) which also had lowest shelling percentage (26.05) (Table 1.7).

Table 1.6: Growth parameters

Hybrid/ variety	Cross combination	Plant height (m)	Stem girth (cm)	Canopy spread E-W (m)	N-S (m)
H-43	NRCC Sel-2 x Bhuthnath-II	4.9	49.7	5.1	5.6
H-66	NRCC Sel-2 x Bhuthnath-II	5.6	51.9	5.6	5.2
H-68	NRCC Sel-2 x Bhuthnath-II	5.7	58.3	6.6	5.6
H-125	NRCC Sel-2 x Bhedasi	4.8	51.3	5.2	5.0
H-126	NRCC Sel-2 x Bhedasi	5.3	57.2	5.5	5.3
H-1250	M 44/3 x VTH 40/1	4.7	46.9	5.2	5.2
H-2452	BLA-139-1 x VTH 711/4	4.5	50.1	5.8	6.0
H-2473	BLA-139-1 x VTH 711/4	5.3	62.4	6.3	5.7
NRCC Sel-2	Check	5.1	50.9	5.0	4.7
Bhaskara	Check	6.4	60.4	5.7	5.2

Table 1.7: Flowering and nut characters

Hybrid/ variety	Flowering laterals	Non-flowering laterals	Nut weight (g)	Shelling (%)	Nut thickness (cm)	Nut width (cm)	Nut length (cm)
H-43	5.43	16.7	10.05	26.05	1.84	2.9	3.98
H-66	4.7	13.1	9.46	29.70	1.76	2.64	3.59
H-68	5.9	16.6	10.35	27.93	1.83	2.70	3.66
H-125	4.3	32.6	12.06	29.13	2.57	2.85	3.65
H-126	5.06	14.63	11.32	29.10	2.41	2.73	3.66
H-1250	4.3	32.6	6.99	34.50	2.08	2.34	3.02
H-2452	5.06	8.815	5.07	30.20	1.68	2.28	3.06
H-2473	4.3	18.3	9.15	31.95	1.85	2.8	3.73
NRCC Sel-2 (check)	5.1	6.9	7.76	32.57	2.08	2.61	3.33
Bhaskara (check)	4.9	17.5	5.91	33.61	1.73	2.33	3.19
CD (p=0.05)	NS	NS	0.4	2.39	0.11	0.13	0.15

The apple characters of promising hybrids were compared with its parents and check. All the hybrids recorded higher apple weight (>100 g) compared to parents and check variety. The TSS content of apples of hybrids ranged from 12.5 to 14° Bx. The juice content of hybrids ranged from 70 to 81 per cent (Table 1.8).

Table 1.8: Apple characters

Hybrid	Apple colour	Apple weight (g)	TSS (° Bx)	Juice (%)
H-43	Orange red (33B)	100	13	81
H-66	Orange red (33B)	110	13	80
H-68	Orange red (33B)	108	12	70
H-125	Orange red (33B)	105	14	70
H-126	Orange red (33B)	102	13	72
NRCC Sel-2 (check)	Orange red (33B)	95	14	60
Bhuthnath-2 (parent)	Yellow orange (23A)	55	12	65
Bhedasi (parent)	Yellow (13A)	90	13	75

Among the hybrids under replicated trial, H-126 recorded the highest annual yield in the fourth harvest (2.91 kg/plant), cumulative yield (9.87 kg/plant) and average yield (2.47 kg/plant) as compared to other hybrids and check varieties (Table 1.9).

Table 1.9: Nut yield (kg/plant)

Hybrid/variety	Annual yield (2014)	Cumulative yield of 4 harvests	Average yield of 4 harvests
H-43	1.31	6.09	1.52
H-66	1.43	6.64	1.66
H-68	2.03	9.85	2.46
H-125	2.79	9.04	2.26
H-126	2.91	9.87	2.47
H-1250	1.70	6.99	1.75
H-2452	1.04	2.36	0.60
H-2473	1.86	6.33	1.58
NRCC Sel-2 (check)	1.69	7.09	1.77
Bhaskara (check)	2.72	9.20	2.30
CD (p=0.05)	1.42		

Among different hybrids, H-125 and H-126 recorded the highest per cent increment in nut and kernel weight over check varieties, Bhaskara and NRCC Sel-2 (Table 1.10).

Table 1.10: Nut and kernel weight

Hybrid/ variety	Per cent increase/decrease in nut weight over check		Per cent increase/decrease in kernel weight over check	
	Bhaskara	NRCC Sel-2	Bhaskara	NRCC Sel-2
H-43	70.05	29.51	27.62	-3.50
H-66	60.06	21.91	38.57	4.67
H-68	75.12	33.37	47.60	11.51
H-125	104.06	55.41	71.42	29.49
H-126	91.53	45.87	79.52	35.61
H-1250	18.27	-9.92	10.95	-16.18
H-2452	-14.21	-34.66	-24.76	-43.16
H-2473	54.82	17.91	44.29	8.99
NRCC Sel-2 (check)	31.30	-	32.38	-
Bhaskara (check)	-	-23.84	-	-24.46

The hybrid, H-126 was found promising with a special character of jumbo nut (nut weight of 11-12 g), with a shelling percentage of 29.1 and kernel weight of 3.3 g which fits in to kernel grade bigger than W150. So far no released hybrid has recorded kernel grade above W180. This hybrid recorded 91.50 per cent higher nut weight and 79.50 per cent higher kernel weight compared to popular variety Bhaskara. As compared to bold nut variety NRCC Sel-2, H-126 recorded 46 per cent higher nut weight and 36 per cent higher kernel weight. The hybrid also recorded an apple weight of 102 g with a juice content of 72 per cent with a TSS of 13° Bx. This hybrid is expected to fetch premium in export market because of jumbo nut size.

1.2.2 Performance of hybrids (selected from closely planted block)

Among the hybrids carried forward from closely planted block, the plant height varied significantly which ranged from 3.0 m (NRC-100 x NRC-276 (1007) to 4.9 m (NRC-239 x VTH 711/4 and NRCC-Sel-2 x NRC-271). The stem girth also varied significantly among hybrids with a range of 32.10 cm (NRC-99 x NRC-185) to 56.20 cm (NRC-103 x NRC-269). The canopy spread varied significantly among hybrids ranging from 3.50 m (NRC-99 x NRC-185) to 5.9 m (NRCC Sel-2 x NRC-271). The non-flowering laterals did not vary among hybrids, while the number of flowering laterals significantly varied among the hybrids. The lowest number of flowering laterals (3.5) were seen in a cross combination of NRCC Sel-2 x NRC-271, while the cross combination of NRC-100 x NRC-276 (1104) recorded the highest (15.30) number of flowering laterals per square metre of canopy (Table 1.11).

Table 1.11: Performance of hybrids

Cross combination	Plant height (m)	Stem girth (cm)	Canopy spread (m)	Non-flowering laterals	Flowering laterals
NRC-99 x NRC-185	3.3	32.1	3.5	11.7	13.8
NRC-100 x NRC-185	3.8	42.4	5.7	11.2	11.3
NRC-240 x NRC-194	3.6	41.0	5.0	14.3	5.6
NRC-222 x NRC-68	3.7	37.6	4.1	10.9	8.3
NRC-239 x VTH 711/4	4.9	44.3	5.0	15.4	5.5
NRC-103 x NRC-269	4.7	56.2	5.8	14.0	5.5
NRC-239 x NRC-276	3.6	44.2	5.4	12.2	6.6
NRC-100 x NRC-276 (1007)	3.0	33.2	4.3	10.5	6.0
NRC-100 x NRC-276 (1104)	3.3	33.9	3.7	6.5	15.3
NRCC Sel-2 x NRC-276 (1054)	3.8	42.7	5.4	14.4	7.2
NRCC Sel-2 x NRC-276 (1150)	3.5	38.4	4.8	12.6	5.6
NRCC Sel-1 x Bhuthnath-2	4.1	39.6	4.6	12.7	4.4
NRCC Sel-2 x NRC-271	4.9	53.0	5.9	15.1	3.5
NRCC Sel-2	3.4	32.1	4.4	11	7.5
Bhaskara	3.8	36.4	4.7	10.8	5.9
CD (p=0.05)	0.94	7.67	1.14	NS	4.36

1.2.3 Seedling selection in cashew

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 to find out the variability existing in cashew cultivars raised through seedlings. The nut yield significantly varied among seedling progenies (Table 1.12). The seedling progenies of VRI-3 recorded highest annual yield of 2.38 kg/plant in the third harvest. The cumulative yield was also highest (6.21 kg/plant) in the seedling progenies of VRI-3.

Table 1.12: Yield performance of seedling progenies: 2014

Variety	Yield (kg/plant) in 2014	Cumulative yield of 3 harvests	Average yield of 3 harvests
NRCC Sel-2	1.76	3.07	1.02
Vengurla-4	1.54	3.56	1.19
VRI-3	2.38	6.21	2.07
Bhaskara	1.75	4.26	1.42
VTH-174	1.83	4.24	1.41
VTH 30/4	1.78	4.16	1.39
CD (p=0.05)	0.41	-	-

One seedling progeny *i.e.,* Tree No. 480 from VTH 30/4 was identified as a promising genetic stock as it recorded 6.9 kg nut yield in the third harvest itself and nuts of which fell under intermediate category. The descriptive statistics for growth parameters and yield of six varieties exhibited wide variability for growth and yield among seedling progenies (Table 1.13).

Table 1.13: Descriptive statistics for growth parameters and yield of six varieties

Character/ Statistic	Stem girth (cm)	Plant height (m)	Canopy spread (m)	Yield (kg/plant)
Range	24-87	3.25-8.90	3.23-9.73	0.2-6.9
Mean	54.78	5.34	5.83	1.89
SD	13.56	1.13	1.35	0.67
SEm	1.38	0.12	0.14	0.03

The range for stem girth was wider in VTH-174 with a CV of 27.89 per cent and narrow in Bhaskara with a CV of 18.89 per cent. The highest average stem girth was recorded in Bhaskara while the lowest was in NRCC Sel-2. The wide range for plant height was observed in Bhaskara with a CV of 26.72 per cent whereas the range was narrow in VTH-174 with a CV of 10.25 per cent. The mean plant height was maximum in VTH-174 and minimum in VRI-3. The wider range for canopy spread was recorded in Vengurla-4 with a CV of 27.84 per cent and narrow range was in NRCC Sel-2 with a CV of 20.83%. The mean canopy spread was the lowest in NRCC Sel-2 while VTH-174 had the highest. The nut yield range was wider in VTH-30/4 with a CV of 66.18 per cent and narrower in NRCC Sel-2 with a CV of 17.84 per cent. The highest mean nut yield/tree (2.46 kg) was observed in VRI-3. The highest nut yield/tree (6.9 kg) was recorded in tree number 480, a seedling progeny of VTH-30/4.

The correlations between stem girth and nut yield per tree was highly significant while correlations between canopy spread and nut yield per tree was significant (Table 1.14). Correlation analysis among the growth parameters revealed highly significant positive association between stem girth and plant height, stem girth and canopy spread and plant height and canopy spread. This kind of relation among the growth characters suggests that selection for higher stem girth or canopy spread will lead to increased yield as there exists significant positive association between stem girth and canopy spread and both have significant positive correlation with yield.

Table 1.14: Correlation between growth parameters and yield

	Stem girth	Plant height	Canopy spread	Yield/ tree
Stem girth	1	0.455**	0.653**	0.295**
Plant height		1	0.641**	NS
Canopy spread			1	0.230*
Yield/tree				1

** Significant at 1%, * Significant at 5%, NS: non-significant

1.2.4 Development of dwarf and compact cashew hybrids

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 ICAR-DCR Experimental Station, Shantigodu. During the year, growth parameters such as girth (cm), plant height (m) (Table 1.15), canopy spread (m) and internodal length (cm) (Table 1.16) were recorded during the flowering season on all hybrid seedlings. The data was subjected to descriptive statistical analysis to understand the variability present in each cross for the above growth parameters. Plant height and canopy spread are the two important growth parameters to be considered for selection of dwarf and compact features of desirable genotype for suitability to high density planting system. In the present study among the cross combinations seedlings of Vengurle-4 x NRC-492 showed higher range, lowest mean and maximum coefficient of variation which was closely followed by combinations of Priyanka x NRC-492 and Dhana x NRC-492 for the plant height character among the direct crosses. The cross combinations Vengurle-4 x NRC-492 showed higher range, lowest mean and maximum coefficient of variation which was closely followed by combinations of Priyanka x NRC-492 and Dhana x NRC-492 for the average canopy spread feature among the direct crosses, whereas in reciprocal crosses, NRC-492 x Vengurle-4 exhibited higher range, lowest mean and maximum coefficient of variation for plant stature and it also recorded lowest canopy spread. But the cross combination NRC-492 x Priyanka manifested second lowest mean and the highest coefficient of variation for canopy spread feature. However, the

Table 1.15: Variability for stem girth and plant height in hybrid seedlings

S.No.	Cross	Stem girth (cm)				Plant height (m)			
		Range	Mean	SE	CV	Range	Mean	SE	CV
	Direct crosses								
1	Vengurla-4 x NRC-492	6-23	15.48	0.24	19.9	0.70-3.25	2.07	0.04	21.9
2	Vengurla-4 x Taliparamba-1	9-23	16.30	0.24	16.8	1.00-3.10	2.10	0.04	21.2
3	Priyanka x NRC-492	9-24	17.47	0.36	17.0	1.35-2.95	2.08	0.04	15.5
4	Priyanka x Taliparamba-1	16-25	19.33	0.98	15.3	1.75-3.20	2.42	0.18	22.3
5	Dhana x NRC-492	11-24	18.36	0.40	16.9	1.00-2.85	2.04	0.05	18.4
6	Dhana x Taliparamba-1	10-27	17.77	0.43	20.8	1.15-3.10	2.27	0.06	21.0
7	Madakkathara-2 x NRC-492	12-31	20.62	0.23	13.5	1.10-3.50	2.55	0.03	14.4
8	Madakkathara-2 x Taliparamba-1	14-29	21.68	0.04	14.4	1.25-3.75	2.67	0.08	16.5
	Reciprocal crosses								
9	NRC-492 x Vengurla-4	13-21	16.37	0.53	14.0	0.65-2.70	1.90	0.12	26.4
10	Taliparamba-1 x Vengurla-4	15-21	18.50	1.00	13.1	1.90-2.70	2.29	1.12	12.8
11	NRC-492 x Priyanka	11-22	17.92	0.81	16.3	1.20-2.60	2.02	0.10	18.0
12	Taliparamba-1 x Priyanka	17-24	21.00	0.82	10.3	2.15-3.20	2.56	0.14	14.3
13	NRC-492 x Dhana	17-23	19.58	0.66	10.5	1.75-2.65	2.28	0.01	13.6
14	Taliparamba-1 x Dhana	17-22	19.67	1.45	12.8	2.20-2.65	2.48	0.14	9.9
15	NRC-492 x Madakkathara-2	20-29	23.00	0.96	12.5	2.20-3.05	2.61	0.10	10.8

Table 1.16: Variability for internodal length and canopy spread in hybrid seedlings

S.No.	Cross	Internodal length (cm)				Canopy spread (m)			
		Range	Mean	SE	CV	Range	Mean	SE	CV
		Direct crosses							
1	Vengurle-4 x NRC-492	0.50-5.00	1.86	0.08	55.1	0.28-2.53	1.21	0.03	30.0
2	Vengurle-4 x Taliparamba-1	1.50-4.10	2.69	0.04	18.9	0.45-1.95	1.25	0.03	25.6
3	Priyanka x NRC-492	0.90-3.60	2.85	0.09	27.1	0.48-2.32	1.34	0.04	24.4
4	Priyanka x Taliparamba-1	1.60-3.50	3.03	0.24	24.1	1.18-2.25	1.67	0.11	20.2
5	Dhana x NRC-492	1.25-3.75	2.13	0.07	25.9	0.70-2.03	1.43	0.04	20.0
6	Dhana x Taliparamba-1	0.69-2.50	1.68	0.04	22.4	0.48-2.53	1.60	0.05	28.7
7	Madakkathara-2 x NRC-492	0.38-2.50	1.42	0.03	27.1	0.55-2.10	1.37	0.02	20.7
8	Madakkathara-2 x Taliparamba-1	0.75-2.50	1.47	0.06	29.2	0.60-2.32	1.59	0.05	24.1
		Reciprocal crosses							
9	NRC-492 x Vengurle-4	1.63-4.13	2.78	0.19	29.2	0.83-1.63	1.20	0.05	18.1
10	Taliparamba-1 x Vengurle-4	1.63-2.75	2.13	0.19	21.4	1.30-1.75	1.50	0.07	12.1
11	NRC-492 x Priyanka	2.25-3.50	3.27	0.09	10.1	0.70-1.90	1.35	0.09	23.9
12	Taliparamba-1 x Priyanka	2.75-3.25	3.11	0.06	5.4	1.40-2.20	1.83	0.11	15.3
13	NRC-492 x Dhana	1.25-2.13	1.71	0.07	14.8	1.33-2.38	1.71	0.10	18.0
14	Taliparamba-1 x Dhana	0.56-1.88	1.45	0.38	58.3	1.35-2.05	1.78	0.22	21.2
15	NRC-492 x Madakkathara-2	0.75-1.75	1.28	0.10	24.3	1.05-1.98	1.54	0.10	20.1

range was maximum in Taliparamba-1 x Vengurla-4 for canopy spread feature. Overall, there exists a good amount of variability for the traits studied in all the 15 crosses and there is a scope for selection of genotypes with desirable traits in ensuing years.

1.3 Evaluation of Cashew Germplasm for Cashew Apple Yield and Quality Traits

In order to evaluate cashew germplasm accessions for cashew apple yield and quality traits, 14 cashew germplasm accessions were planted at a spacing of 7.5 m x 7.5 m in RBD with three replications in 2013. Of different germplasm accessions, the maximum plant height was recorded in accession NRC-175 (2.0 m) and minimum in NRC-120 (1.3 m). The maximum canopy spread in N-S direction was recorded in accessions NRC-140 (1.8 m), NRC-270 (1.8 m), NRC-112 (1.8 m) and NRC-175 (1.8 m) while, minimum was in NRC-493 (1.3 m). The maximum canopy spread in E-W direction was found in accessions NRC-140 (2.0 m) and NRC-175 (2.0 m) while, minimum was in NRC-389 (1.4 m). The maximum stem girth was also recorded in NRC-140 and NRC-112, while number of primary and secondary branches were noticed in NRC-140 (Table 1.17). Flower panicles wherever observed have been removed for better growth of the plants.

Towards the end of South West monsoon season, incidence of *Phytophthora* root rot was noticed on the young plants of eight accessions (NRC-389, NRC-112, NRC-75, NRC-270, NRC-301, NRC-111, NRC-493 and NRC-189). The infected plants showed wilt

symptoms during the subsequent warm weather, dried and died within 10-12 days. Leaves appeared drought stressed, later turned yellow and fell down prematurely. The root system exhibited black discolouration and unidentified beetle grubs were also noticed feeding on the root system as a secondary infestation. Upon draining of water, drenching of Ridomil (metalaxyl-M + mancozeb) and subsequent application of *Trichoderma harzianum* enriched neem cake showed marked recovery of infected plants.

Cashew plants infested by *Phytophthora* root rot
a) cashew plant showing wilt symptoms and premature leaf fall and b) dead plant

Table 1.17: Growth parameters in different accessions

Accession	Plant height (m)	Canopy s pread (N-S) (m)	Canopy spread (E-W) (m)	Stem girth (cm)	No. of primary branches	No. of Secondary branches
NRC-301	1.9	1.6	1.6	20.4	3.9	11.9
NRC-493	1.8	1.3	1.5	18.6	4.1	11.3
NRC-140	1.9	1.8	2.0	21.7	5.2	17.0
NRC-120	1.3	1.4	1.5	18.6	4.8	11.5
NRC-389	1.5	1.4	1.4	20.0	3.8	11.9
NRC-75	1.8	1.5	1.5	18.4	4.0	11.7
NRC-111	1.8	1.7	1.7	19.5	4.6	14.4
NRC-176	1.6	1.4	1.5	16.5	5.3	15.0
NRC-270	1.8	1.8	1.6	18.6	3.1	10.8
NRC-112	1.9	1.8	1.8	21.7	5.1	18.8
NRC-144	1.7	1.5	1.6	19.4	4.8	13.3
NRC-189	1.4	1.5	1.6	21.0	4.1	13.7
NRC-175	2.0	1.8	2.0	19.8	3.9	11.8
NRC-183	1.6	1.6	1.5	19.2	3.8	12.4

2. CROP MANAGEMENT

2.1 Micronutrient Management in Horticultural Crops for Enhancing Yield and Quality – Cashew

2.1.1 Preparation of district wise (Dakshina Kannada district of Karnataka) soil micronutrient status maps for cashew

In India cashew is grown in many States and the prime cashew growing districts are depicted in Fig. 2.1. In order to characterize the available micronutrient status of cashew growing orchards of Dakshina Kannada district of Karnataka, 33 farmers' fields were selected. Soil sampling strategy was based on taking samples to represent the entire village, collected 10 to 12 samples to make one composite sample. The available Fe and Mn were sufficient in all the soils while, the available Zn was deficient in 75.8 per cent of the soil samples. The available Cu was deficient in 6.06 per cent soils and available B was deficient in majority of the soils (87.9%). The available micronutrients content of these soils were in the order of Fe > Mn > Cu > Zn > B. The available Fe, Mn, Zn, Cu and B status maps of cashew orchards of Dakshina Kannada district in Karnataka are shown in Figs. 2.2 to 2.6.

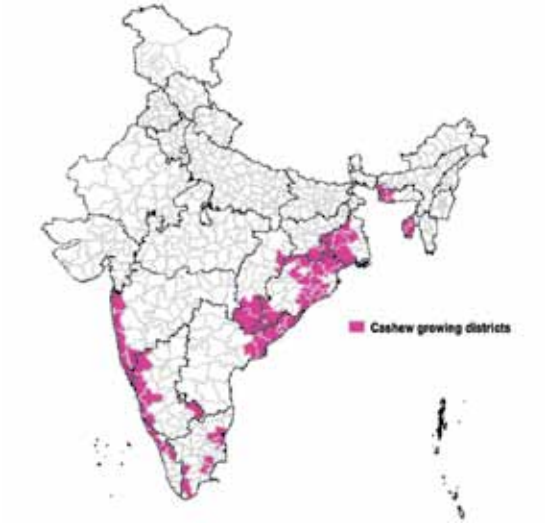


Fig. 2.1: Prime cashew growing districts in India

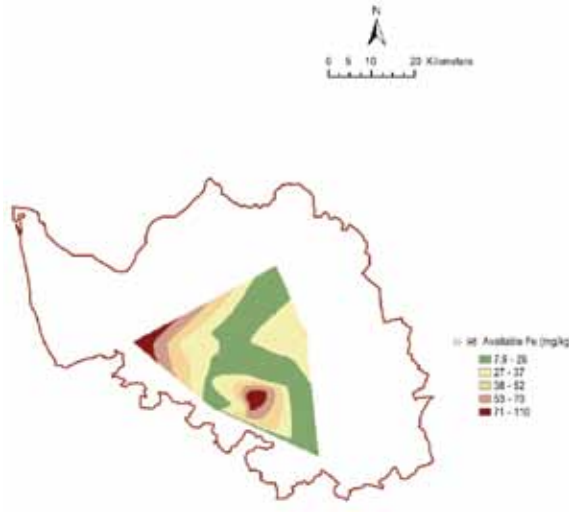


Fig. 2.2: Available Fe status map of cashew orchards

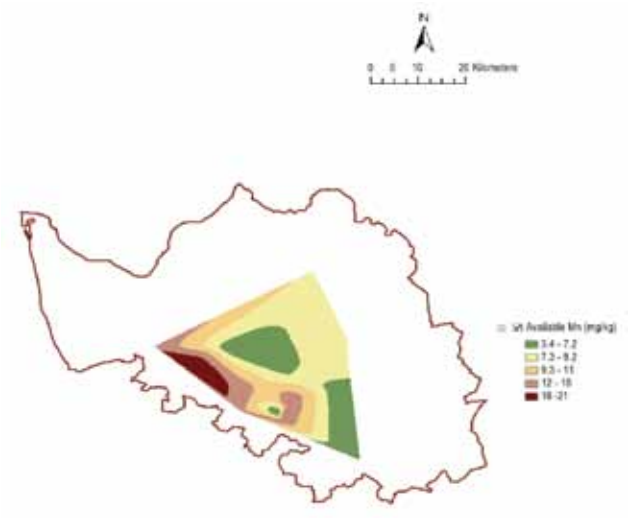


Fig. 2.3: Available Mn status map of cashew orchards

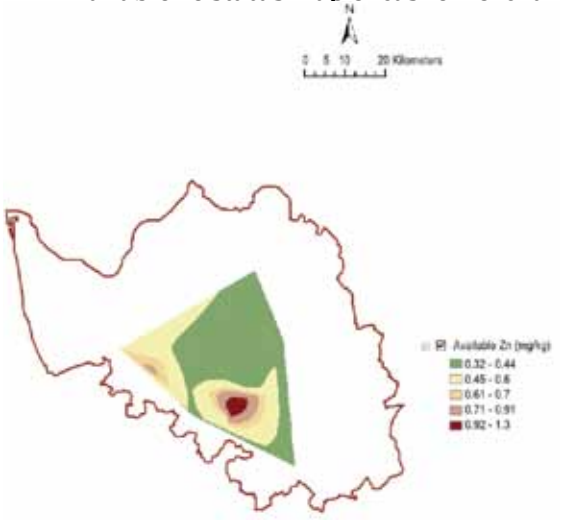


Fig. 2.4: Available Zn status map of cashew orchards

Fig. 2.5: Available Cu status map of cashew orchards

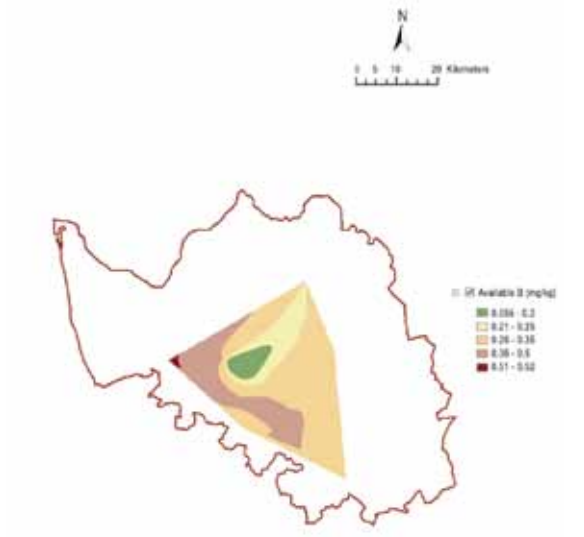


Fig. 2.6: Available B status map of cashew orchards

2.1.2 Effect of foliar spray of micronutrients on cashew

Micronutrient deficiencies were observed in cashew plantations. Foliar spray is useful for quick uptake in emergency situations when deficiencies are noted. Two field experiments have been initiated in 2014 at experimental farm of ICAR-Directorate of Cashew Research, Puttur to examine the effect of foliar spray of micronutrients on cashew. Study area is situated in a cashew growing belt, has typical lateritic soils of the west coast, located 87 m above mean sea level with a latitude of 12.77°N and longitude of 75.22°E. The climate is hot and humid throughout the year with an average annual rainfall of 3,500 mm, distributed mainly from June to September. The mean annual temperature is 27.6°C and mean maximum and minimum temperatures are 36°C and 20°C, respectively. The treatments were sole and different combinations of micronutrient fertilizers containing B, Zn, and Mo. Foliar nutrients were administered three times *viz.,* flushing, flowering and nut development of cashew. The experimental plants were 5 years (Expt. 1) and 14 years (Expt. 2) (During first year of study) old cashew plantations of Bhaskara variety spaced at 5 m x 5 m. The treatments were as follows:

T1: Solubor (0.1%)

T2: Zinc sulphate (0.5%)

T3: Ammonium molybdate (0.01%)

T4: Solubor (0.1%) + zinc sulphate (0.5%)

T5: Solubor (0.1%) + Ammonium molybdate (0.01%)

T6: Zinc sulphate (0.5%) + Ammonium molybdate (0.01%)

T7: Solubor (0.1%) + zinc sulphate (0.5) + Ammonium molybdate (0.01%)

T8: Control.

2.1.3 Initial soil properties of the experimental plots

Soil samples were collected at 0-0.30 m depth from base of the plant at 1.5 m radius before imposition of the foliar nutrition treatments. The soil fertility at the start of the experiment (Table 2.1) showed that the soils were acidic and non-saline in nature. The organic carbon content of the soils was high. The available N and K contents were medium while available P was low. The

exchangeable Ca content of the soils was higher than the critical value of 1.5 cmol(p+)kg^{-1} soil. Whereas, the exchangeable Mg content of the soils were lower than the critical value of 1.0 cmol(p+) kg^{-1} soil. The available Fe, Mn and Cu were sufficient, while available Zn and B were deficient.

Table 2.1: Initial soil properties of the experimental plots

Soil property	Expt. 1 (5 years old cashew)	Expt. 2 (14 years old cashew)
pH (1:2.5 soil:water)	5.58	5.61
EC (d Sm^{-1})	0.051	0.042
Organic carbon (g kg^{-1})	8.9	10.0
Available N (kg ha^{-1})	280.5	291.3
Available P (kg ha^{-1})	14.4	16.6
Available K (kg ha^{-1})	134.6	140.5
Exch. Ca [cmol(p+)kg^{-1}]	1.56	1.70
Exch. Mg [cmol(p+)kg^{-1}]	0.85	0.98
Available Fe (mg kg^{-1})	25.6	36.9
Available Mn (mg kg^{-1})	19.4	22.0
Available Zn (mg kg^{-1})	0.31	0.23
Available Cu (mg kg^{-1})	0.55	0.62
Available B (mg kg^{-1})	0.19	0.20

2.1.4 Enumeration of microbial population from the rhizosphere and non-rhizosphere soil samples

The rhizosphere and non-rhizosphere soil samples from healthy and un-healthy cashew plants (Ten sub-samples each site) were collected. Soil samples for microbiological analysis were stored at 4°C in a refrigerator until processed for analysis. For enumeration of microbial population, 10 g of moist soil was drawn from each sample and analysed for general microbial community, *viz*., bacteria, actinomycetes and fungi and function-specific microbial community, *viz*., free-living N-fixers, phosphate solubilizers and Fluorescent *Pseudomonas*. Enumeration was done by serial dilution and pour plate method. Nutrient agar medium for bacteria, Martin's Rose Bengal agar medium for fungi, Ken Knight and Munaier's agar medium for actinomycetes, Jensen's agar medium for free-living N-fixers, Pikovskaya agar medium for phosphate solubilizing bacteria and King's-B medium for Fluorescent *Pseudomonas* were used in this study and microbial population was expressed in terms of CFU per g of dry soil. Soil dehydrogenase activity was determined as per the procedure described by Tabatabai (1982) where TTC (2,3,5-triphenyl tetrazolium chloride) is used as terminal acceptor of protons and electrons from organic compounds being oxidized.

The population of bacteria, fungi, actinomycetes, N-fixers, P-solubilizers and Fluorescent *Pseudomonas* was more in the rhizosphere soil than in the non-rhizosphere soil. The microbial population was considerably higher in the rhizosphere soil of healthy plants than the rhizosphere soil of unhealthy plants except

fungal population. The bacterial population was higher in the rhizosphere soil of healthy cashew plants followed by actinomycetes, P-solubilizers, N-fixers, fungal and Fluorescent *Pseudomonas* population. Similar trend was observed in case of rhizosphere soil of unhealthy cashew plants except fungal whose population is higher than the N-fixers population. On an average, 2.83, 2.04, 2.24, 2.86 and 11.25 fold greater in the population of bacteria, actinomycetes, N-fixers, P-solubilizers and Fluorescent *Pseudomonas*, respectively in the rhizosphere soil of healthy cashew plants as compared to rhizosphere soil of unhealthy cashew plants. While, 24.1, 10.65, 6.28, 9.7, 8.82 and 5.42 fold greater in the population of bacteria, actinomycetes, fungi, N-fixers, P-solubilizers and Fluorescent *Pseudomonas*, respectively in the rhizosphere soil of healthy cashew plants as compared to non-rhizosphere soil of cashew plants (Table 2.2). Dehydrogenase activity, which is used as an indicator of microbial activity of soil appreciably higher in rhizosphere soil than in the non-rhizosphere soil. On an average the dehydrogenase activity in rhizosphere soil of healthy plants was 1.6 and 6.52 folds higher as compared to rhizosphere soil of unhealthy cashew plants and non-rhizosphere soils, respectively. The organic carbon content also followed a similar trend. The organic carbon content of rhizosphere soil of healthy plants was 1.38 and 1.68 folds higher than the rhizosphere soil of unhealthy cashew plants and non-rhizosphere soils, respectively (Table 2.3).

Table 2.2: Microbial population in the Rhizosphere and Non-rhizosphere soil of cashew plants

Microbial population	Rhizosphere soil		Non-rhizosphere soil
	Healthy plant	Unhealthy plant	
Bacteria (x 10^6 CFU/g dry soil)	105.63	37.35	4.38
Actinomycetes (x 10^6 CFU/g dry soil)	33.34	16.27	3.13
Fungi (x 10^4 CFU/g dry soil)	35.34	66.27	5.63
Free N-fixers (x 10^4 CFU/g dry soil)	60.64	27.11	6.25
P-solubilizers (x 10^5 CFU/g dry soil)	82.73	28.92	9.38
Fluorescent *Pseudomonas* (x10^3 CFU/g dry soil)	27.11	2.41	5.00

Table 2.3: Dehydrogenase activity and organic carbon in the rhizosphere and Non-rhizosphere soil of cashew plants

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

2.2 Establishment of Nutrient Diagnostic Norms in Cashew

Cashew growing soils are generally deficient in N, P, K, S, Mg, Zn, B and Mo. The yield gap analysis revealed that the optimum production potential of cashew is yet to be tapped. Poor nutrition is likely to be one of the major factors contributing to low nut yield and quality. Optimization of cashew

productivity and quality requires an understanding of the nutrient requirements of the tree, the factors that influence nutrient availability and the methods used to diagnose and correct deficiencies. Leaf analysis is a powerful tool in mineral nutrition research with perennial horticultural crops, not only to determine response to various nutrients but also as a diagnostic technique in assessing deficiency symptoms and making fertilizer recommendations. The critical nutrient norms for the agriculture and fruit crops have very well established, however, the information available on cashew is negligible. Absence of a suitable soil and plant test norms in relation to optimum nut yield further jeopardizes the timely diagnosis of causes for low productivity of cashew. Thus research on development of critical nutrient norms in soils and leaf of cashew is of paramount importance. The key objectives of the project include i) To diagnose the soil and plant nutritional factors limiting the productivity of cashew in major cashew growing regions of India, ii) To establish soil nutrient diagnostic norms for major cashew growing regions and iii) To establish leaf nutrient diagnostic norms for cashew.

2.2.1 Regional survey and sampling

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

2.2.2 Assessing soil properties of cashew orchards in Puttur and Vengurla regions

Seventy soil samples (0 to 30 cm depth) collected from different cashew orchards each in Puttur and Vengurla regions were analysed for selective physico-chemical characteristics. Soil pH varied from 4.7 to 6.9 with an average of 5.4 in Puttur region and 4.35 to 5.87 with a mean of 5.35 in Vengurla region. The pH values of all representative soils were mostly acidic to near neutral in reaction. The electrical conductivity of the soils varied from 0.01 to 0.233 dS m^{-1} with an average of 0.03 dS m^{-1} in Puttur region and 0.01 to 0.04 dS m^{-1} with a mean of 0.03 dS m^{-1} in Vengurla region, indicating non-saline in nature. The organic carbon content of the soils ranged from 0.46 to 1.88 per cent with a mean of 1.22 per cent in Puttur region and 0.18 to 2.85 per cent in Vengurla region. The organic carbon content was found to be high in 58 and 42 orchards in Puttur and Vengurla regions, respectively, medium in 10 and 4 orchards in Puttur and Vengurla regions, respectively, and low in remaining 2 and 14 orchards in Puttur and Vengurla regions, respectively.

The available N content of the soils varied from 63 to 376 kg/ha with a mean of 208 kg/ha in Puttur region. While, available N content in Vengurla region varied from 151 to 534 kg/ha with a mean of 324 kg/ha. Available N content was low in 66 orchards and medium in 4 orchards in Puttur region. In case of Vengurla region, 44 orchards were medium and 26 orchards were low in available N content. None of the soils fell under the category of high in available N content in both the regions. Available K content of the soils ranged from 45 to 373 kg/ha with a mean of 120 kg/ha, indicating 46 orchards were low, 20 were medium and 4 were high in available K content in Puttur region. In Vengurla region, the available K content varied from 35.5 to 484.2 kg/ha with a mean of 146.4 kg/ha, indicating 32 orchards were low, 33 were medium and 5 were high in available K content.

Exch. Ca content varied from 0.68 to 3.88 me/100 g with a mean of 1.51 me/100 g in Puttur region and it ranged from 0.30 to 1.58 me/100g with a mean value of 0.62 me/100 g in

Vengurla region. Majority of the soils (42 cashew orchards in Puttur region and 68 orchards in Vengurla region) were low in Exch. Ca content. Exch. Mg content of soils ranged from 0.12 to 1.92 me/100 g with a mean of 0.59 me/100 g in Puttur region and 0.1 to 0.70 me/100 g with a mean of 0.29 me/100 g in Vengurla region. Of 70 cashew orchards, 59 orchards in Puttur region and all samples in Vengurla region were low in Exch. Mg content.

2.2.3 Assessing leaf nutrient concentration of cashew orchards

Seventy leaf samples collected from 4th and 5th positions of non-flowering panicles from Vengurla region were analysed for N, P and K contents. The nutrient concentration of leaf exhibited a wide variation across the locations. The N concentration in cashew leaf varied from 0.54 to 1.60 per cent, P concentration in cashew leaf varied from 0.05 to 0.19 per cent while K concentration ranged from 0.36 to 1.03 per cent. Analysis of N concentration in leaf samples collected from different cashew orchards from Puttur region of Karnataka varied from 0.69 to 1.50 per cent. The micronutrients concentration in leaf samples of cashew varied greatly among orchards in Puttur region. Zinc varied from 2.5 to 25.0 mg/kg (mean 13.53 mg/kg), Cu 2.99 to 9.25 mg/kg (mean 5.07 mg/kg), Fe 36.25 to 275.62 mg/kg (mean 105.20 mg/kg) and Mn 66.10 to 593.58 mg/kg (mean 150.3 mg/kg).

2.3 Organic Farming in Cashew

A field experiment has been initiated in 2012 at ICAR-Directorate of Cashew Research, Puttur, Karnataka to develop organic nutrient management modules for sustainable cashew productivity. The objectives of the project include: i) to examine the influence of organic sources on growth, yield and quality of cashew and ii) to quantify the changes in soil physical, chemical and biological properties resulting from organic farming practices. The experiment was laid out in randomized block design with cashew variety 'Bhaskara'. The planting was done at a spacing of 7.5 m x 7.5 m. The details of the treatments are shown below:

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 P_2O_5/tree and woodash to supply 125 g K_2O/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 P_2O_5 and K_2O/tree/year.

2.3.1 Growth parameters and soil nutrient content

The Influence of organic and inorganic sources of nutrients on growth of cashew showed a wide variation. Growth parameters were the greatest in recommended NPK fertilizer + 10 kg FYM/tree followed by poultry manure to supply 500 g N/tree with minimum under control. The plant height and stem girth varied from 258 to 342 cm and

22.4 to 26.0 cm, respectively. The canopy spread in N-S direction ranged from 217 to 292 cm and in E-W direction varied from 218 to 308 cm (Table 2.4).

Organic carbon, available N, P, K, Exch. Ca and Mg content of surface samples after three years of experimentation were estimated. Organic manures caused increase in organic carbon content of soil over control. The percent increase in organic C in FYM to supply 500 g N/tree + biofertilizer consortia, FYM to supply 500 g N/tree + rock phosphate to supply 125 g P_2O_5/tree and wood ash to supply 125 g K_2O/tree and poultry manure to supply 500 g N /tree treatments over control was 10.5, 14.9 and 13.2, respectively. The application of recommended N, P, K fertilizer + 10 kg FYM/tree; FYM to supply 500 g N/tree + biofertilizer consortia; FYM to supply 500 g N/tree + rock phosphate to supply 125 g P_2O_5/tree and wood ash to supply 125 g K_2O/tree and poultry manure to supply 500 g N /tree treatments resulted in considerable increase in available N, P, K, Exch. Ca and Mg contents.

2.3.2 Leaf nutrient content

Analysis of leaf samples collected from 4th and 5th positions of non-flowering panicles from different treatments under organic farming in cashew indicated that there was no significant difference in N, P and K content of leaf with respect to treatments. The N, P and K concentration of index leaf varied from 1.18 to 1.27, 0.15 to 0.19 and 0.35 to 0.40 per cent, respectively.

Table 2.4: Effect of different organic and inorganic sources of nutrients on growth of cashew

Treatment	Plant height (cm)	Stem girth (cm)	Canopy spread (cm)	
			E-W	N-S
T1	280.9	25.00	235.1	255.67
T2	300.0	23.57	250.0	262.50
T3	304.17	24.92	279.17	258.33
T4	304.17	25.75	291.67	270.83
T5	283.33	23.50	229.17	216.67
T6	300.00	24.58	300.00	254.17
T7	279.17	24.17	250.00	245.83
T8	258.33	22.65	254.17	242.50
T9	287.50	23.50	241.67	275.00
T10	341.67	25.83	308.33	291.67
T11	288.89	22.39	218.06	216.67
CD (p=0.05)	38.8	NS	36.2	37.0

2.4 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)

2.4.1 Plant density and irrigation levels on growth parameters

The growth parameters *viz.,* plant height, stem girth and canopy spread of cashew plant were recorded under different plant densities and irrigation levels (Tables 2.5 and 2.6). The plant height ranged from 294.8 to 334.6 cm in different plant densities and 291.4 to 323.1 cm under different irrigation levels. Stem girth of the plant varied from 26.4 to 28.6 cm and 26.3 to 28.7 cm under different plant densities and irrigation levels, respectively. Canopy spread in N-S and E-W direction of the cashew plant varied from 249.0 to 280.4 cm and 263.6 to 296.4 cm, respectively, under different plant densities. Canopy spread with respect to different irrigation levels ranged from 249.2 to 274.2 cm in N-S direction and 265.3 to 286.0 cm under E-W direction. The stem girth of the plant in different plant densities and irrigation levels varied from 1.8 to 2.0 cm and 1.7 to 2.1 cm, respectively.

2.4.2 Plant density and irrigation levels on flowering parameters

The length of flower panicles varied from 16.7 to 17.4 cm and 15.9 to 18.9 cm under different plant densities and irrigation levels, respectively. The number of rachis per flower panicle under different plant densities ranged between 8.3 and 9.8 while, it was 8.0 to 10.7 under different irrigation levels (Tables 2.7 and 2.8).

Table 2.5: Effect of spacing and irrigation levels on plant height and stem girth

Irrigation (T)/ Spacing (M)	T1	T2	T3	T4	T5	T6	Mean
			Plant height (cm)				
M1	314.2	267.9	289.2	315.3	294.6	287.8	294.8
M2	315.8	335.8	347.5	282.2	347.1	271.7	316.7
M3	327.5	365.4	329.6	366.9	303.8	314.6	334.6
Mean	319.2	323.1	322.1	321.5	315.1	291.4	
Source	Main plot (M)	Sub plot (T)	Sub plot (T) x Main plot (M)			Main plot (M) x Sub plot (T)	
SE (d)	26.10	19.76	40.71			34.22	
LSD at 5%	NS	NS	NS			NS	
			Stem girth (cm)				
M1	28.4	24.8	26.8	25.4	28.8	27.4	26.9
M2	28.3	28.8	30.5	23.5	22.6	24.6	26.4
M3	26.4	30.0	28.6	30.8	28.9	26.9	28.6
Mean	27.7	27.8	28.7	26.6	26.8	26.3	
Source	Main plot (M)	Sub plot (T)	Sub plot (T) x Main plot (M)			Main plot (M) x Sub plot (T)	
SE (d)	2.35	1.85	3.76			3.21	
LSD at 5%	NS	NS	NS			NS	

Table 2.6: 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	269.2	218.8	242.5	278.6	238.3	246.7	249.0
M2	266.7	262.9	287.5	233.3	266.3	223.3	256.7
M3	249.6	300.8	285.0	310.6	259.2	277.5	280.4
Mean	261.8	260.8	271.7	274.2	254.6	249.2	
Source	Main plot (M)	Sub plot (T)	Sub plot (T) x Main plot (M)			Main plot (M) x Sub plot (T)	
SE (d)	29.32	20.51	43.72			35.53	
LSD at 5%	NS	NS	NS			NS	
			Canopy spread (E-W) (cm)				
M1	305.0	239.2	247.9	278.1	250.8	260.4	263.6
M2	277.5	304.6	301.7	236.3	306.7	248.8	279.2
M3	275.4	319.2	286.3	321.7	289.2	286.7	296.4
Mean	286.0	287.7	278.6	278.7	282.2	265.3	
Source	Main plot (M)	Sub plot (T)	Sub plot (T) x Main plot (M)			Main plot (M) x Sub plot (T)	
SE (d)	37.13	21.32	50.16			36.94	
LSD at 5%	NS	NS	NS			NS	

Table 2.7: Effect of spacing and irrigation on internodal length and rachis per panicle

Irrigation (T)/ Spacing (M)	T1	T2	T3	T4	T5	T6	Mean
			Internodal length (cm)				
M1	1.92	2.11	1.95	1.64	1.72	1.54	1.8
M2	2.14	1.91	2.11	1.52	2.50	2.03	2.0
M3	2.01	1.98	2.09	1.95	2.01	1.83	2.0
Mean	2.0	2.0	2.1	1.7	2.1	1.8	
Source	Main plot (M)	Sub plot (T)	Sub plot (T) x Main plot (M)			Main plot (M) x Sub plot (T)	
SE (d)	0.02	0.09	0.14			0.15	
LSD at 5%	0.05	0.18	0.29			0.31	
			Number of rachis per panicle				
M1	10.0	6.0	9.0	8.0	9.0	8.0	8.3
M2	11.0	11.0	9.0	9.0	10.0	9.0	9.8
M3	11.0	7.0	10.0	7.0	9.0	9.0	8.8
Mean	10.7	8.0	9.3	8.0	9.3	8.7	
Source	Main plot (M)	Sub plot (T)	Sub plot (T) x Main plot (M)			Main plot (M) x Sub plot (T)	
SE (d)	0.03	0.21	0.33			0.36	
LSD at 5%	0.07	0.42	0.67			0.73	

Table 2.8: Effect of spacing and irrigation on length and width of flower panicles

Irrigation (T)/ Spacing (M)	T1	T2	T3	T4	T5	T6	Mean
			Length of flower panicles (cm)				
M1	18.4	15.0	17.3	16.9	17.6	14.7	16.7
M2	18.7	19.6	17.8	16.4	14.8	16.9	17.4
M3	19.6	15.3	17.9	18.4	15.4	16.5	17.2
Mean	18.9	16.6	17.7	17.2	15.9	16.0	
Source	Main plot (M)	Sub plot (T)	Sub plot (T) x Main plot (M)			Main plot (M) x Sub plot (T)	
SE (d)	0.33	0.69	1.14			1.19	
LSD at 5%	NS	1.40	2.39			2.43	
			Width of flower panicles (cm)				
M1	25.5	21.2	23.5	24.5	23.0	21.9	23.3
M2	23.4	26.4	26.4	22.3	21.7	20.5	23.5
M3	29.5	26.0	24.8	23.8	19.7	40.7	27.4
Mean	26.1	24.5	24.9	23.5	21.5	27.7	
Source	Main plot (M)	Sub plot (T)	Sub plot (T) x Main plot (M)			Main plot (M) x Sub plot (T)	
SE (d)	0.56	0.93	1.57			1.61	
LSD at 5%	NS	1.90	3.36			3.29	

2.5 Effect of Paclobutrazol on Growth and Yield of Cashew

Paclobutrazol (PBZ) was applied to the plants @ 1.0, 2.0 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 effect of PBZ on plant height, stem girth, intermodal length, canopy spread and flowering parameters were recorded.

2.5.1 Growth parameters

The PBZ application reduced the growth of plants with respect to parameters like plant height, canopy spread and intermodal length while the number of flushes increased with the application of PBZ. The height of plant among PBZ treated plants ranged from 411 to 554 cm in different doses and frequency of application, while in untreated plants, plant height was found to be 558 to 562 cm. The stem girth among PBZ treated plants ranged from 38.13 to 40.80 cm, while the untreated plants had 40 to 42 cm. The internodal length of PBZ treated plants ranged from 12.9 to 16.0 cm, while the untreated plants recoded 18.1 to 18.6 cm indicating the role of PBZ in reducing the plant vigour (Table 2.9). The canopy spread in E-W direction among PBZ treated plants ranged from 366 to 416 cm, while the untreated plants it was 413 to 423 cm. The canopy spread in N-S direction among PBZ treated plants ranged from 387 to 429 cm, while in untreated plants it was 435 to 439 cm. The mean ground coverage among four directions among PBZ treated plants varied from 377 to 422 cm, while in untreated plants it was 424 to 431 cm (Table 2.10). The total number of new flushes among PBZ treated plants ranged from 186.0 to 199.3, while the untreated plants produced 155 to 174. The number of floral and non-floral lateral among PBZ treated plants ranged from 65.0 to 71.7 and 121.0 to 127.7, respectively while the untreated plants had 46 to 59 and 109 to 115 cm, respectively (Table 2.11).

Table 2.9: Effect of PBZ on plant height, stem girth and internodal length

Time of Application/	Plant height (cm)				Stem girth (cm)				Internodal length (cm)			
PBZ levels	Y1	Y2	Y3	Mean	Y1	Y2	Y3	Mean	Y1	Y2	Y3	Mean
PBZ@1g a.i./plant	500	530	554	527.8	39	41	43	40.8	14.8	15.8	17.6	16.0
PBZ@2g a.i./plant	461	497	511	489.3	37	41	41	39.7	11.7	13.2	16.4	13.8
PBZ@3g a.i./plant	411	464	508	460.9	35	39	40	38.1	10.8	11.6	16.4	12.9
Control	558	561	562	560.3	40	42	42	41.3	18.1	18.6	18.6	18.4
Mean	482	513	533		38	41	42		13.8	14.8	17.2	
Source	L	T	L x T		L	T	Lx T		L	T	L x T	
SEm±	22.17	26.29	48.32		1.94	1.39	2.99		0.58	0.62	0.12	
LSD (p<0.05)	48.31	NS	NS		NS	NS	NS		1.26	1.27	NS	

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

Table 2.10: Effect of PBZ on canopy spread

Time of Application/	E-W (cm)				N-S (cm)				Ground coverage (cm)			
PBZ levels	Y1	Y2	Y3	Mean	Y1	Y2	Y3	Mean	Y1	Y2	Y3	Mean
PBZ@1g a.i./plant	407	419	421	416	424	426	438	429	416	422	429	422
PBZ@2g a.i./plant	366	380	403	383	379	416	420	405	372	398	412	394
PBZ@3g a.i./plant	346	366	387	366	353	402	406	387	349	384	396	377
Control	413	423	423	420	435	438	439		424	431	431	429
Mean	383	397	409		424	426	438		390	409	417	
Source	L	T	L x T		L	T	Lx T		L	T	L x T	
SEm±	19.29	11.09	26.36		14.16	15.20	28.58		14.80	9.97	22.01	
LSD (p<0.05)	42.03	22.42	NS		30.86	NS	NS		32.26	20.31	NS	

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

Table 2.11: Effect of PBZ on number of flushes, flower laterals and non-flower laterals

Time of Application/	No. of flushes				Flower laterals				Non-flower laterals			
PBZ levels	Y1	Y2	Y3	Mean	Y1	Y2	Y3	Mean	Y1	Y2	Y3	Mean
PBZ@1g a.i./plant	192	187	179	186.0	68	66	61	65.0	124	121	118	121.0
PBZ@2g a.i./plant	208	192	186	195.3	76	73	65	71.3	132	119	121	124.0
PBZ@3g a.i./plant	212	196	190	199.3	78	72	65	71.7	134	124	125	127.7
Control	174	155	160	163.0	59	46	48	51.0	115	109	112	112.0
Mean	196.5	182.5	178.8		70.25	64.25	59.75		126.3	118.25	119	
Source	L	T	L x T		L	T	L x T		L	T	L x T	
SEm±	3.88	3.02	6.28		1.97	1.42	3.05		2.72	2.28	4.61	
LSD (p<0.05)	8.46	6.16	NS		4.29	2.9	NS		5.94	4.64	NS	

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

2.5.2 Flowering parameters

The PBZ application was found effective in increasing sex ratio, number of panicles per plant while, the length and width of panicles and flowering duration got reduced. The number of male and hermaphrodite flowers per panicle in PBZ treated plants varied from 316.4 to 348.2 and 44.6 to 58.4 respectively, while the untreated plants it varied from 326.0 to 332.4 and 43.8 to 47.2, respectively. The sex ratio ranged from 0.15 to 0.20 per cent in treated plants while in untreated plants it was 0.13 to 0.14 per cent (Table 2.12). The number of rachis per flower ranged from 7.30 to 7.95 in treated plants while in untreated plant it was 7.40 to 7.60. The length of flower panicles ranged from 14.0 to 15.7 cm and width 18.70 to 21.80 cm in treated plants while, in untreated plants the length and width varied from 18.40 to 21.60 cm and 25.80 to 27.20 cm, respectively (Table 2.13).

Table 2.12: Effect of PBZ on flower parameters

Time of Application/	No. of male flowers				No. of female flowers				Sex ratio			
PBZ levels	Y1	Y2	Y3	Mean	Y1	Y2	Y3	Mean	Y1	Y2	Y3	Mean
PBZ@1g a.i./plant	352.4	338.4	316.4	335.7	54.2	50.4	48.6	51.1	0.17	0.15	0.14	0.15
PBZ@2g a.i./plant	366.4	358.4	348.2	357.7	58.2	57.2	48.6	54.7	0.19	0.18	0.16	0.18
PBZ@3g a.i./plant	364.2	352.6	341.4	352.7	66.4	58.2	54.2	59.6	0.23	0.20	0.17	0.20
Control	332.4	328.4	326.0	328.9	47.2	43.8	44.6	45.2	0.14	0.13	0.14	0.14
Mean	353.9	344.5	333.0	64.8	56.5	52.4	49.0		0.18	0.17	0.15	
Source	L	T	L x T		L	T	L x T		L	T	L xT	
SEm±	15.78	9.97	22.01		4.63	3.81	7.75		0.02	0.01	0.03	
LSD (p<0.05)	NS	NS	NS		10.10	7.76	NS		0.03	NS	NS	

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

Table 2.13: Effect of PBZ on flower parameters

Time of Application/	No. of rachis per flower				Length of flower panicles (cm)				Width of flower panicles (cm)			
PBZ levels	Y1	Y2	Y3	Mean	Y1	Y2	Y3	Mean	Y1	Y2	Y3	Mean
PBZ@1g a.i./plant	7.2	7.40	7.40	7.30	13.20	16.2	17.8	15.7	21.6	21.80	22.00	21.80
PBZ@2g a.i./plant	8.2	7.80	7.60	7.95	13.10	15.6	16.0	14.9	18.6	19.40	19.60	19.00
PBZ@3g a.i./plant	8.0	7.80	7.00	7.60	12.60	13.8	15.6	14.0	16.8	19.20	20.20	18.70
Control	7.40	7.40	7.60	7.50	18.40	21.0	21.6	20.3	25.8	26.80	27.20	26.30
Mean	8.0	7.60	7.40		14.30	16.7	17.8		20.7	21.80	22.30	
Source	L	T	L x T		L	T	L x T		L	T	L x T	
SEm±	0.33	0.02	0.60		1.96	0.84	2.40		1.29	0.74	1.66	
LSD (p<0.05)	NS	NS	NS		4.27	NS	NS		2.46	1.51	NS	

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

2.5.3 Nut parameters

Of the frequency of PBZ application, annual application of PBZ was found significantly effective in reducing the nut length, width and thickness. The minimum length (29.2 mm), width (22.7 mm) and thickness (17.4 mm) of nut was recorded under the treatment @ 3 g a.i. per plant which was associated with annual application of PBZ as compared to control (length: 33.4 mm, width: 26.1 mm and thickness: 19.6 mm) (Table 2.14). The reduction of these parameters might be due to the increased percentage of flowered branches in PBZ-treated which intern lead to lower expenditure of tree reserves to the vegetative growth parameters leading consequently to no assimilate limitations.

2.5.4 Nut weight and yield

The PBZ application increased the yield per plant but the nut weight got reduced. The highest nut yield (2.89 kg/plant) and minimum nut weight (6.2 g) was associated with annual application of PBZ @ 3 g a.i. per plant. This could be attributed to higher fruit set and fruit retention in the PBZ treated plants over untreated plants (Table 2.15).

Table 2.14: Effect of PBZ on length, width and thickness of nut

Time of Application/	Nut length (mm)				Nut width (mm)				Nut thickness (mm)			
PBZ levels	Y1	Y2	Y3	Mean	Y1	Y2	Y3	Mean	Y1	Y2	Y3	Mean
PBZ@1g a.i./plant	31.5	31.6	32.1	31.7	24.3	24.0	24.3	24.2	18.8	18.4	18.8	7.6
PBZ@2g a.i./plant	29.3	29.9	32.0	30.4	23.7	23.9	25.4	24.3	17.1	17.5	18.5	6.5
PBZ@3g a.i./plant	28.7	28.9	30.2	29.2	22.5	22.1	23.5	22.7	17.0	17.2	18.0	6.2
Control	33.4	33.2	33.5	33.3	26.1	26.0	26.3	26.1	19.6	19.5	19.6	8.4
Mean	30.7	30.9	31.9		24.1	24.0	24.9		18.1	18.2	18.7	
Source	L	T	L x T		L	T	L x T		L	T	L x T	
SEm±	0.15	0.13	0.26		0.25	0.22	0.44		0.17	0.15	0.30	
LSD (p<0.05)	0.43	0.37	0.74		0.72	0.62	NS		0.72	0.62	1.24	

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 nut weight and yield

Time of Application/	Nut weight (g)				Yield (kg/plant)			
PBZ levels	Y1	Y2	Y3	Mean	Y1	Y2	Y3	Mean
PBZ@1g a.i./plant	7.4	7.6	7.7	18.7	2.78	2.57	2.50	2.62
PBZ@2g a.i./plant	6.3	6.4	6.7	17.7	3.01	2.86	2.53	2.80
PBZ@3g a.i./plant	6.0	6.0	6.5	17.4	3.08	2.96	2.63	2.89
Control	8.3	8.4	8.4	19.6	2.44	2.44	2.47	2.45
Mean	7.0	7.1	7.3		2.83	2.71	2.54	
Source	L	T	L x T		L	T	L x T	
SEm±	0.16	0.14	0.28		0.269	0.039	0.078	
LSD (p<0.05)	0.46	NS	NS		0.128	0.111	0.230	

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

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 value (5.63 m) for plant height, while lowest plant height (3.55 m) was associated with stionic combination of VRI-3/Taliparamba-1. The stem girth below the union ranged from 43.70 cm (VRI-3/Taliparamba-1) to 58.20 cm (Ullal-3/NRC-492). The stem girth above the union ranged from 36.60 cm (VRI-3/Taliparamba-1) to 49.10 cm (V-4/V-4). The stock:scion ratio ranged from 1.12 (NRCC Sel-2/NRC-492) to 1.20 (V-4/NRC-492 and NRCC Sel-2/Taliparamba-1). The canopy spread was lowest (4.98 m) in VRI-3/Taliparamba-1, while it was highest (5.86m) in Ullal-3/NRC-492. The internodal length was lowest (1.68 cm) in VRI-3/V-4 and highest (1.93 cm) in NRCC Sel-2/NRC-492 (Table 2.16).

Table 2.16: Growth parameters 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)	Internodal length (cm)
Ullal-3/ Vengurla-4	4.70	49.8	42.1	1.18	5.58	1.87
VRI-3/Vengurla-4	4.07	46.4	40.2	1.15	5.10	1.68
NRCC Sel-2/Vengurla-4	4.31	48.6	42.4	1.14	5.25	1.92
V-4/Vengurla-4	5.16	56.2	49.1	1.14	5.63	1.89
Ullal-3/ NRC-492	5.63	58.2	48.9	1.19	5.86	1.89
VRI-3/ NRC-492	4.16	55.7	46.7	1.19	5.54	1.70
NRCC Sel-2/ NRC-492	4.96	51.7	46.1	1.12	5.79	1.93
Vengurla-4/ NRC-492	4.76	52.6	43.8	1.20	5.62	1.90
Ullal-3/ Taliparamba-1	5.15	49.6	41.6	1.19	5.24	1.92
VRI-3/ Taliparamba-1	3.55	43.7	36.6	1.19	4.98	1.86
NRCC Sel-2/ Taliparamba-1	3.71	47.8	39.7	1.20	5.12	1.80
Vengurla-4/ Taliparamba-1	4.73	52.5	45.4	1.16	5.73	1.68

The flowering laterals and yield per plant varied significantly among stionic combinations (Table 2.17). The stionic combinations of VRI-3/Vengurla-4 and NRCC Sel-2/Vengurla-4 recorded the highest number of flowering laterals (12.7), closely followed by stionic combinations of Vengurla-4/Vengurla-4 and Ullal-3/ NRC-492 (12.3 each). The non-flowering laterals and sex ratio did not vary between different stionic combinations. The nut yield per plant significantly varied between different stionic combinations. The highest nut yield (3.28 kg/plant) was associated with a combination of VRI-3/NRC-492, closely followed by the stionic combination of Ullal-3/Taliparamba-1 (3.0 kg/plant). The stionic combination of VRI-3/NRC-492 was associated with highest cumulative nut yield (8.78 kg/plant) over 3 harvests.

Table 2.17: Flowering parameters and yield in different stionic combinations

Stionic combination (scion/rootstock)	Flowering laterals (m^{-2})	Non-Flowering laterals (m^{-2})	Sex ratio	Yield (kg/plant)	Cumulative yield (3 harvests)
Ullal-3/Vengurla-4	10.0	8.3	0.22	2.48	4.48
VRI-3/Vengurla-4	12.7	10.0	0.18	2.71	5.95
NRCC Sel-2/Vengurla-4	12.7	11.0	0.13	2.37	3.84
Vengurla-4/Vengurla-4	12.3	8.7	0.25	2.80	6.32
Ullal-3/NRC-492	12.3	8.0	0.26	2.73	7.34
VRI-3/NRC-492	11.3	14.0	0.11	3.28	8.78
NRCC Sel-2/NRC-492	9.0	12.0	0.04	2.58	5.64
Vengurla-4/NRC-492	8.3	9.0	0.17	2.64	6.16
Ullal-3/Taliparamba-1	7.5	10.5	0.77	3.00	5.81
VRI-3/Taliparamba-1	11.7	10.0	0.32	1.81	4.73
NRCC Sel-2/Taliparamba-1	7.0	9.0	0.12	2.01	2.59
Vengurla-4/Taliparamba-1	8.0	11.5	0.28	2.91	4.71
CD (p=0.05)	3.08	NS	NS	1.07	-

2.7 Performance of High Yielding Varieties of Cashew in different High Density Planting System

A field experiment was laid out in 2006 with 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 objectives of the experiment are to determine optimum plant density for achieving the highest yield and profits for the first ten years and to recommend suitable variety for achieving the highest yield and profit for the first ten years under high density planting system.

Main plot: Number of plants/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) and 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 and T9 - Bhaskara

Design: Split plot, Replications: 3

2.7.1 Growth parameters

The ground coverage of different varieties planted at different spacings indicated that the plant density of 384 plants/ha occupied the highest available space (62.0%), closely followed by the plant density of 500 plants/ha (59.8%). The ground coverage by plant canopy was the lowest (25.5%) under the plant density of 200 plants/ha. The ground coverage of canopy was also influenced by different varieties. The ground coverage was the highest with Ullal-1 (49.4%), while it was least with VRI-3 (35.7%) (Table 2.18).

Table 2.18: Effect of plant density and varieties on per cent ground coverage by canopy

Varieties / No. of plants/ha	VRI-3	NRCC Sel-2	Vengurla-7	Ullal-1	Dhana	Madakk-athara-2	Ullal-3	Vengurla-4	Bhaskara	Mean
S1-200	17.8	25.3	22.4	29.6	29.6	23.0	27.4	28.7	25.2	25.5
S2-236	20.4	21.4	25.6	30.5	31.8	21.7	28.0	31.2	31.6	26.9
S3-384	49.3	76.4	50.7	59.4	63.2	52.9	66.0	77.0	63.0	62.0
S4-500	55.2	60.6	56.5	78.1	68.5	53.4	59.7	53.2	52.8	59.8
Mean	35.7	45.9	38.8	49.4	48.3	37.7	45.3	47.5	43.1	
CD for main plot (p=0.05)										15.3
CD for sub plot (p=0.05)										8.2

2.7.2 Nut yield

The annual nut yield (2013-14) was not influenced by spacing. However, among plant densities, the plant density of 384 plants/ha was associated with highest annual yield of 3.50 t/ha. Among different varieties, Vengurla-4 (3.61 t/ha) and Ullal-1 (3.60 t/ha) recorded highest annual yield in the sixth harvest closely followed by NRCC Sel-2, Madakkathara-2, Vengurla-7 and Ullal-3 (Table 2.19).

Among different plant densities, plant density of 500 plants/ha recorded the highest cumulative nut yield of 7.97 t/ha, closely followed by plant density of 384 plants/ha (7.59 t/ha). Increase in yield to the tune of 1.5 times under the plant density of 500 plants/ha over the normal plant density (200 plants/ha). Among the varieties, Bhaskara recorded the highest cumulative nut yield of 7.37 t/ha, closely followed by Ullal-3 (7.18 t/ha) and Dhana (7.11 t/ha) (Table 2.20).

Table 2.19: Effect of plant densities and varieties on the nut yield (t/ha)

Varieties / No. of plants/ha	VRI-3	NRCC Sel-2	Vengurla-7	Ullal-1	Dhana	Madakk-athara-2	Ullal-3	Vengurla-4	Bhaskara	Mean
S1-200	2.42	3.58	3.58	3.75	2.42	3.58	3.58	3.75	2.42	3.23
S2-236	2.75	2.67	3.58	3.50	2.75	2.67	3.58	3.50	2.75	3.10
S3-384	3.17	4.25	3.30	3.42	3.17	4.25	3.30	3.42	3.17	3.50
S4-500	3.00	3.17	3.10	3.75	3.00	3.17	3.10	3.75	3.00	3.20
Mean	2.83	3.42	3.40	3.60	2.83	3.42	3.40	3.61	2.83	
CD for main plot (p=0.05)										NS
CD for sub plot (p=0.05)										0.49

Table 2.20: Effect of plant density and varieties on the cumulative nut yield (t/ha) (2008-14)

Varieties/ No. of plants/ha	VRI-3	NRCC Sel-2	Vengurla-7	Ullal-1	Dhana	Madakk-athara-2	Ullal-3	Vengurla-4	Bhaskara	Mean
S1-200	3.77	5.10	5.10	5.63	5.45	4.38	5.64	5.58	5.46	5.12
S2-236	4.50	4.63	5.32	5.81	6.63	4.29	5.80	7.22	5.79	5.55
S3-384	6.50	9.14	7.11	7.13	8.31	6.71	7.63	6.90	8.94	7.59
S4-500	6.63	7.91	7.04	8.04	8.04	7.42	9.65	7.74	9.27	7.97
Mean	5.34	6.69	6.14	6.65	7.11	5.70	7.18	6.86	7.37	

2.7.3 Leaf area index and light extinction coefficient

There was no significant difference in leaf area index (LAI) with respect to spacing. However, the highest LAI (1.62) was associated with a plant density of 384 plants/ha. The LAI was the highest in Vengurla-4 (1.80) which in turn was associated with highest annual nut yield (3.6 t/ha). The least LAI (1.07) was recorded in Vengurla-7. The Light extinction coefficient (K) was also not influenced by different densities of planting. However, the varieties varied significantly for K values. The highest K value was associated with Vengurla-4 (0.76), while it was least in Vengurla-7 (0.61) which was also associated with low LAI.

2.8 Morphological and Physiological Characterization of Cashew Varieties/Accessions

A study has been made to determine the variation in morphological and physiological characteristics of cashew in 21 different varieties/ accessions of 12 year old plants. Such studies are not only important for the identification of varieties but also to determine their genetic divergence.

2.8.1 Changes in leaf characters and plant growth analysis

The leaf length of different cashew varieties/ accessions varied from 12.33 to 17.93 cm. Maximum leaf length was recorded in VTH 30/4 (17.93 cm) followed by Ullal-3 (17.4 cm) whereas minimum leaf length was recorded in Madakkathara-2 (12.33 cm) followed by K 22-1 (12.36 cm). Maximum and minimum leaf ratio was observed in VRI-3 (1.90) and Madakkathara-2 (1.42), respectively. Bhaskara had maximum leaf width (10.6 cm) while it was minimum in Vengurla-1 (7.4 cm). Petiole length was longest in VTH 174 (2.10 cm) as compared to other varieties, while Madakkathara-1 (1.00 cm) recorded minimum petiole length. In Ullal-3 (28), maximum number of main veins was observed, while K 22-1 (21) recorded the minimum number of main veins originating from leaf blade (Table 2.21).

Table 2.21: Leaf characters of cashew varieties/accessions

Varieties/ Accessions	Leaf characters						
	Length (cm)	Width (cm)	Length: width	Petiole length (cm)	Length: petiole	Width: petiole	No. of main veins
Bhaskara	17.30	10.6	1.63	1.50	11.58	7.08	26
Dhana	13.26	7.83	1.69	1.30	10.25	6.05	27
H 32/4	14.13	8.00	1.77	1.33	10.61	6.01	24
Kanaka	14.23	7.93	1.79	1.33	10.69	5.95	25
K 22-1	12.36	8.36	1.48	1.57	7.90	5.35	21
Madakkathara-1	13.20	8.56	1.54	1.00	13.30	8.62	25
Madakkathara-2	12.33	8.66	1.42	1.77	6.99	4.92	26
Priyanka	16.53	9.10	1.82	1.77	9.36	5.16	24
NRCC Sel-1	13.43	7.56	1.77	1.33	10.08	5.68	23
NRCC Sel-2	16.60	9.16	1.81	1.43	11.60	6.40	25
Ullal-1	15.30	8.93	1.71	1.47	10.49	6.13	24
Ullal-2	13.73	8.00	1.72	1.27	10.87	6.32	25
Ullal-3	17.40	10.4	1.67	2.03	8.58	5.13	28
Ullal-4	16.43	9.56	1.71	2.03	8.08	4.71	23
VRI-3	15.13	7.93	1.90	1.47	10.35	5.41	27
VTH 30/4	17.93	9.83	1.82	1.83	9.79	5.37	27
VTH 174	14.33	8.33	1.72	2.10	6.84	3.97	22
Vengurla-1	12.96	7.40	1.75	1.43	9.07	5.18	23
Vengurla-3	14.63	8.40	1.74	1.53	9.55	5.48	22
Vengurla-4	16.46	10.5	1.56	1.63	10.10	6.43	23
Vengurla-7	14.73	8.86	1.66	1.60	9.23	5.55	25

Growth analysis can be used to account for growth in terms that have functional or structural significance. The final product yield or total crop dry matter is the spatial and temporal integration of all plant processes. The growth analysis requires measurement of plant biomass (dry weight) and assimilatory area (leaf area) to determine yield. The leaf area in different varieties/accessions ranged between 54.92 and 112.67 cm^2. The VTH 30/4 recorded the highest leaf area (112.67 cm^2) followed by Ullal-3 (110.98 cm^2). Lowest leaf area was recorded in Vengurla-7 (54.92 cm^2) followed by Vengurla-3 (59.98 cm^2). The maximum leaf fresh weight (3.85 g) and leaf dry weight (1.64 g) was recorded in Vengurla-4 whereas Ullal-4 recorded minimum leaf fresh weight (1.61 g) and leaf dry weight (0.54 g), respectively. The higher specific leaf weight (SLW) indicates the higher photosynthate production, translocation and accumulation in leaves due to higher photosynthetic rate and its influence on the development of reproductive organs and yield. In the present study, SLW showed significant variation among varieties. Vengurla-3 (17.43 mg/cm^2) recorded the maximum SLW followed by Vengurla-4 (16.21 mg/cm^2) and lowest SLW was recorded in NRCC Sel-2 (8.52 mg/cm^2) followed by Priyanka (9.15 mg/cm^2) (Table 2.22).

Table 2.22: Growth analysis of cashew varieties/accessions

Varieties/ Accessions	Leaf fresh weight (g/plant)	Leaf dry weight (g/plant)	Leaf area (cm^2)	Specific leaf area (cm^2/g dry weight)	Specific leaf weight (mg/cm^2 leaf area)
Bhaskara	2.95	1.07	98.50	91.88	10.88
Dhana	2.23	0.94	83.02	91.92	10.95
H 32/4	2.35	0.93	81.43	88.32	11.34
Kanaka	1.97	0.74	66.40	87.96	11.39
K 22-1	2.29	0.85	64.43	76.32	13.38
Madakkathara-1	1.98	0.88	67.50	80.78	12.50
Madakkathara-2	2.53	0.98	93.54	94.42	10.67
Priyanka	2.66	0.90	97.24	109.27	9.15
NRCC Sel-1	2.22	1.24	87.36	73.82	13.68
NRCC Sel-2	2.24	0.85	97.27	120.34	8.52
Ullal-1	2.23	0.86	78.68	92.58	10.80
Ullal-2	1.92	0.67	60.10	90.22	11.11
Ullal-3	3.81	1.36	110.98	85.43	11.74
Ullal-4	1.61	0.54	69.79	133.05	12.67
VRI-3	1.74	0.63	82.16	130.57	10.71
VTH 30/4	3.81	1.53	112.67	77.72	12.94
VTH 174	1.75	0.72	83.17	116.48	10.17
Vengurla-1	1.84	0.87	81.64	89.63	11.24
Vengurla-3	1.89	1.02	59.98	57.47	17.43
Vengurla-4	3.85	1.64	99.79	61.76	16.21
Vengurla-7	1.76	0.85	54.92	64.61	15.48

2.8.2 Relative water content and rate of water loss

Leaf water content is a useful indicator of plant water balance, since it expresses the relative amount of water present in the plant tissues. Plant metabolism is dependent on leaf water status as measured in terms of relative water content (RWC). Majority of the varieties / accessions had higher RWC which ranged from 71.2 per cent (H-32/4) to 91.5 per cent (Ullal-3). The rate of water loss was lowest in Ullal-3 (10.8%) and was highest in H-32/4 (22.7%).

2.8.3 Flowering characteristics

Flower bud differentiation was studied in selected two main branches of different cashew varieties / accessions during flowering season. During December to January, maximum flower bud differentiation into lateral bud and apical bud was observed in VTH-174 followed by Bhaskara. Priyanka showed minimum bud differentiation followed by Kanaka and Dhana. The number of leaves for total lateral shoots was more in VRI-3 followed by Madakkathara-2 whereas Kanaka, Priyanka and Ullal-4 showed minimum values. During January to February, maximum apical and lateral bud differentiation was observed in Ullal-3 and VTH 30/4. Minimum apical bud differentiation was recorded in Priyanka followed by Ullal-1. Maximum number of leaves for lateral shoots was recorded in VTH 30/4 followed by Bhaskara and VTH 174 whereas Priyanka, Dhana and Ullal-4 recorded lower leaves for lateral shoots.

2.8.4 Physiological changes during nut development

Studies on physiological maturity indexes of nut development with respect to 12 varieties / accessions showed that time taken from pollination to nut maturity varied from 50 to 70 days. Three weeks old nuts were tagged and subsequent growth changes in size (length, width and thickness) till nut maturity were studied. Approximate days required for apple development and days for final harvest were also recorded. Among selected varieties, Ullal-3, VTH 30/4, VTH 174 and Vengurla-1 showed consistency in maintaining relatively higher nut size (length, width and thickness) compared to other varieties till nut maturity. VTH-174 took less time for apple development (56 days) and days required for final harvest was also short (60 days). Seed or nut water content is very high shortly after fertilization and declines steadily during development until the seed reaches physiological maturation. After this point, the decrease in seed water content continues frequently at a faster rate, until the seed reaches a moisture level suitable for harvest. Rapid decline in the seed or nut moisture content when fruits mature indicates physiological maturity of the seeds or nuts. Same results correlate with the present study where VTH 174 (11.7%) had lowest total moisture in nut at matured stage indicating its early physiological maturity (Tables 2.23 and 2.24).

Table 2.23: Physiological changes during nut development

Varieties/ Accessions	Physiological maturity of cashew nut at different stages														
	3 weeks after pollination			4 weeks after pollination			5 weeks after pollination			6 weeks after pollination			7 weeks after pollination		
	Nut length (cm)	Nut width (cm)	Nut thickness (cm)	Nut length (cm)	Nut width (cm)	Nut thickness (cm)	Nut length (cm)	Nut width (cm)	Nut thickness (cm)	Nut length (cm)	Nut width (cm)	Nut thickness (cm)	Nut length (cm)	Nut width (cm)	Nut thickness (cm)
Bhaskara	2.9	2.3	1.7	3.3	2.6	1.9	3.4	2.7	2.0	3.5	2.7	2.2	3.6	2.7	2.3
Dhana	2.9	2.3	2.1	3.2	2.6	2.2	3.2	2.6	2.3	3.4	2.8	2.3	3.1	2.4	1.9
Kanaka	2.7	2.1	1.6	3.1	2.4	2.0	2.3	2.7	2.3	3.3	2.7	2.3	3.3	2.6	2.2
Ullal -1	2.9	2.4	1.5	3.3	2.6	1.9	3.5	2.7	2.0	3.6	2.6	2.1	3.5	2.7	2.1
Ullal-2	2.9	2.3	1.9	3.1	2.4	2.1	3.2	2.5	2.2	3.3	2.6	2.2	3.2	2.4	2.2
Ullal-3	3.0	2.4	1.7	3.5	2.7	2.0	3.7	2.9	2.3	3.7	2.8	2.4	3.8	3.0	2.4
VRI-3	2.9	2.4	1.7	3.2	2.7	2.0	3.3	2.7	2.3	3.3	2.8	2.4	3.4	2.8	2.2
VTH 30/4	3.0	2.5	1.8	3.2	2.5	1.9	3.3	2.7	2.0	3.4	2.8	2.3	3.4	2.6	2.3
VTH 174	3.1	2.3	1.7	3.3	2.4	1.7	3.4	2.5	1.8	3.4	2.6	1.9	3.3	2.4	1.9
Vengurla-1	3.2	2.4	1.8	3.4	2.5	2.2	3.6	2.5	2.2	3.6	2.6	2.3	3.6	2.6	2.3
Vengurla-3	2.9	2.6	1.8	3.2	2.8	2.2	3.5	2.9	2.4	3.5	3.0	2.4	3.6	3.1	2.5
Vengurla-4	3.0	2.4	1.8	3.3	2.5	1.9	3.3	2.6	2.0	3.4	2.8	2.1	3.5	2.7	2.1

Table 2.24: Physiological changes during nut development

Varieties/ Accessions	Physiological maturity of cashew nut at different stages									Days for apple development	Days for final harvest	Per cent total moisture content of nuts
	8 weeks after pollination			9 weeks after pollination			10 weeks after pollination					
	Nut length (cm)	Nut width (cm)	Nut thickness (cm)	Nut length (cm)	Nut width (cm)	Nut thickness (cm)	Nut length (cm)	Nut width (cm)	Nut thickness (cm)			
Bhaskara	3.5	2.7	2.0	3.3	2.4	1.8	2.5	2.3	1.7	60	66	12.4
Dhana	3.0	2.4	1.8	2.8	2.3	1.5	2.2	2.2	1.4	56	63	12.5
Kanaka	3.3	2.5	2.2	3.0	2.2	2.1	2.4	1.9	2.0	60	66	12.4
Ullal -1	3.3	2.4	1.7	3.0	2.4	1.7	2.4	2.3	1.6	63	65	13.3
Ullal-2	3.2	2.3	2.1	3.0	2.3	2.0	2.4	2.1	1.8	63	65	15.3
Ullal-3	3.6	2.7	2.0	3.0	2.2	1.8	0.0	0.0	0.0	56	63	13.7
VRI-3	3.2	2.5	2.1	3.1	2.3	1.9	2.4	2.2	1.8	60	65	13.8
VTH 30/4	2.9	2.3	1.7	2.7	2.2	1.7	0.0	0.0	0.0	56	63	13.1
VTH 174	3.1	2.2	1.6	2.8	2.0	1.4	0.0	0.0	0.0	56	60	11.7
Vengurla-1	3.4	2.6	1.9	3.0	2.2	1.7	0.0	0.0	0.0	56	63	12.2
Vengurla-3	3.3	2.5	2.3	3.3	2.3	2.1	2.6	2.3	1.9	60	65	13.6
Vengurla-4	3.4	2.5	2.0	3.3	2.4	1.9	2.5	2.2	1.7	60	65	14.5

2.8.5 Fruit characteristics

The study aimed to evaluate the fruit characters of cashew varieties and also to identify fruit attributes including size, volume and weight of fruit, fibre content, juice content and brix value as a selection criteria for superior cashew varieties. There was variation in fruit attributing characters among cashew varieties. Apple with nut weight, apple fresh weight and nut fresh weight and apple volume were recorded highest in Priyanka followed by VTH-30/4 while Vengurla-1 had the lowest values. Same trend was observed in case of apple dry weight and nut dry weight. The Brix value measured among selected cashew varieties, VTH 174 showed highest brix value (15°BX) and lowest value was in Dhana (7°BX). Apple: nut ratio calculated based on apple and nut fresh and dry weight ratio was highest in VTH 174 and was lowest in Madakkathara-1 and Ullal-3 (Table 2.25).

Table 2.25: Apple and nut characters of cashew varieties/accessions

Varieties	Apple and nut characters						Fibre content		Apple and nut characters			
	Apple with nut wt (g)	Apple fresh wt (g)	Nut fresh wt (g)	Apple dry wt (g)	Nut dry wt (g)	Apple volume (ml)	Fresh wt (g)	Dry wt (g)	Juice content (ml)	Brix value (°BX)	Apple : nut ratio (Fresh wt basis)	Apple : nut ratio (dry wt basis)
Bhaskara	80.3	72	8.7	8.4	6.9	81.7	23.3	4.7	57.3	10	8.3	1.2
Dhana	83.3	72	8.2	7.4	7.0	71.7	17.4	3.4	59.3	7	8.7	1.1
H 32/4	78.9	70	9.3	6.7	8.1	75.0	17.8	3.7	44.3	10	7.5	0.8
Kanaka	65.5	59	6.8	5.5	5.9	78.3	14.5	2.6	46.0	15	8.7	1.4
K 22-1	78.4	71	7.1	7.4	6.1	73.3	25.4	4.0	48.0	15	10.1	1.2
Madakkathara-1	67.5	59	9.0	6.0	7.4	65.0	15.4	4.1	49.7	12	6.6	0.8
Madakkathara-2	91.6	82	9.5	8.4	8.2	86.7	23.0	4.4	59.0	10	8.6	1.0
Priyanka	105.6	95	10.7	10.5	8.8	118.3	32.0	6.3	84.3	10	8.9	1.2
NRCC Sel-1	80.8	72	8.4	7.1	7.3	89.0	22.1	3.8	51.3	10	8.7	1.0
NRCC Sel-2	78.6	70	8.8	7.0	7.3	76.7	16.4	3.3	64.0	11	8.0	1.0
Ullal -1	67.4	58	9.0	7.0	7.6	65.0	15.5	3.8	41.3	10.4	6.6	0.9
Ullal-2	73.5	66	7.9	4.1	6.3	73.3	12.5	3.2	39.0	12	8.4	0.7
Ullal-3	75.5	66	9.5	3.5	7.8	81.7	17.3	3.8	56.0	10	7.1	0.4
Ullal-4	71.5	63	8.5	6.1	7.0	65.7	19.1	2.9	47.0	15	7.4	0.9
VRI-3	72.4	64	8.0	3.3	6.5	70.0	16.9	3.4	54.7	10	8.1	0.5
VTH 30/4	91.7	83	8.7	7.2	7.1	98.3	25.3	5.5	57.3	12	9.7	0.8
VTH 174	84.4	77	7.6	6.2	6.0	88.3	23.6	5.1	42.0	15	10.1	1.2
Vengurla-1	59.0	53	5.7	3.8	5.0	60.0	14.9	3.4	43.7	10	9.4	0.8
Vengurla -3	77.6	70	8.0	4.4	6.1	83.3	17.6	3.9	53.0	10.5	8.8	0.7
Vengurla -4	81.7	73	8.6	6.2	6.6	90.0	22.4	5.1	54.0	10	8.6	0.9
Vengurla -7	81.2	73	8.2	7.2	7.1	85.0	22.0	3.7	57.7	12	8.9	1.0

3. CROP PROTECTION

3.1 Cashew Stem and Root Borer (CSRB)

3.1.1 Virulence of entomopathogenic nematodes (EPN)

Three coleopteran infecting EPN strains of genus *Heterorhabditis* and *Steinernema viz., Heterorhabditis indica, Steinernema carpocapsae* and *S. abbasi* were multiplied on larvae of greater wax moth *(Galleria mellonella* Linnaeus) (Lepidoptera: Pyralidae). The emerging infective juveniles (IJs) were applied topically on to the test insect grubs; *Plocaederus* spp. at 0.5 ml suspension / 5 larvae containing approximately 10^3 IJs/ml., 10^4 IJs/ml and 10^5 IJs/ml. All these treatment concentrations were infective to the CSRB grubs under laboratory conditions and led to emergence of virulent infective juveniles.

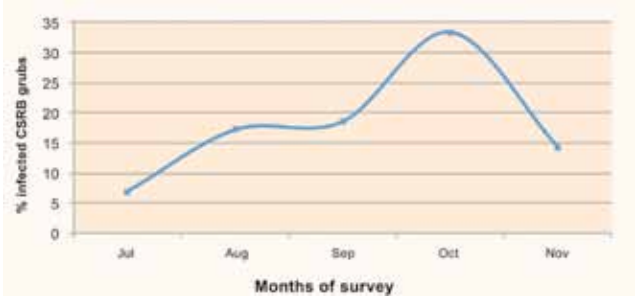


Fig. 3.1: Natural occurrence of entomo pathogenic fungus, *M. anisopliae* in CSRB infested trees

3.1.2 Survey for indigenous natural enemies

During the field surveys, natural mortality of CSRB grubs and pre-pupae was noticed during late July till November. Mortality of these CSRB stages was generally noticed in severely attacked cashew trees and was due to infection by the entomopathogenic fungus; *Metarhizium anisopliae*. The infection ranged between 6 and 34 per cent during different months of survey (Fig. 3.1). The cadavers were incubated and the aqueous spore suspension could induce 100 per cent mortality of CSRB grubs on topical application and through feed, under laboratory conditions.

Natural infection of pre-pupa of CSRB by indigenous entomopathogenic fungus, *M. anisopliae*

3.1.3 Survey for the determination of species composition

In order to estimate the species composition of borer species, the life stages of CSRB were collected from infested cashew trees in ICAR-DCR, Puttur, Madakkathara, Chalakudy and Munuvara in Kerala; representing the west coast and from Vridhachalam, Panruti, Ariyaloor and Aundimadam in Tamil Nadu; representing the east coast region. The collected grubs are being reared in laboratory for the determination of species.

It was noticed that CSRB infestation was predominantly in the root zone and was in significant in stem zone of infested cashew trees, in east coast locations surveyed, which had sandy/ sandy loam soils. However, incidence was observed in both root and stem zone in the west coast, though higher numbers of pest stages occurred in the root zone. Further, occurrence of *Batocera rufomaculata* the secondary borer pest on cashew was not observed in east coast regions surveyed.

3.2 Tea Mosquito Bug (TMB)

3.2.1 Field surveillance of TMB

The incidence of TMB *viz., Helopeltis antonii, H. bradyi, H. theivora* and *Pachypeltis maesarum* was assessed in the cashew plots of ICAR-DCR, Puttur during April 2014 - March 2015. *H. antonii* was the dominant species which accounted for 62.29 to 100 per cent of the TMB population during different months of observation (Table 3.1). The damage due to TMB ranged from 0 to 75 per cent during this period.

Table 3.1: Incidence of tea mosquito bug during different months of 2014-15

Month	*H. antonii* (No.)	*H. bradyi* (No.)	*H. theivora* (No.)	*P. maesarum* (No.)
April	86 (100)	0.00	0.00	0.00
May	106 (100)	0.00	0.00	0.00
June	98 (100)	0.00	0.00	0.00
July	41 (100)	0.00	0.00	0.00
August	48 (94.11)	0.00	0.00	3 (5.89)
September	38 (62.29)	0.00	7 (11.48)	16 (26.23)
October	83 (78.30)	11 (10.38)	10 (9.43)	2 (1.89)
November	107 (91.45)	2 (1.72)	8 (6.83)	0.00
December	178 (95.70)	0.00	8 (4.30)	0.00
January	110 (88.71)	2 (1.61)	12 (9.68)	0.00
February	110 (93.22)	0.00	8 (6.78)	0.00
March	114 (97.44)	0.00	3 (2.56)	0.00

Figures in the parentheses indicate the percentage values

3.2.2 Biology of natural enemies of TMB

At present, chemical control is the predominant measure followed to manage pests of cashew. There is a necessity to explore the possibility of employing biological control technique in the changing pest management scenario. Though, egg parasitoids are efficient in managing TMB under field conditions, they are not amenable for mass multiplication. Among the predators, besides spiders, reduviids and praying mantises were found to predate upon TMB under field conditions. An attempt was made to work out the biology and mass multiplication techniques for reduviids and praying mantises.

3.2.2.1 Biology of reduviids on TMB

During the year, *Irantha armipes Stal, Panthous bimaculatus* Distant, *Sphedanolestes signatus* Distant and *Sycanus galbanus* Distant (Heteroptera: Harpactorinae) are recorded as prospective predators of *Helopeltis* spp. These predators were reared in the laboratory on wax moth, *Galleria mellonella* larvae and their biology, mating and predatory behaviours were studied.

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 the species. Female laid a total of 88.04 ± 2.05 , 549.3 ± 5.5, 45 ± 0.37 and 208 ± 3.9 eggs in the case of *I. armipes, P. bimaculatus S. signatus and S. galbanus* respectively (Table 3.2). The hatchability of egg was highest in *P. bimaculatus* (99.1%).

Irantha armipes

Panthous bimaculatus

Sphedanolestes signatus

Sycanus galbanus

Eggs of different species of reduviids

Table 3.2: Oviposition pattern of reduviids

Reduviids	(Mean ± SE)			Per cent hatch
	No. of eggs/ batch	Total no .of eggs laid	Incubation period (days)	
Irantha armipes	12.6 ± 0.5	88.04 ± 2.05	14.4 ± 0.7	98.0
Panthous bimaculatus	109.8 ± 0.3	549.3 ± 5.5	21.0 ± 0.8	99.1
Sphedanolestes signatus	6.4 ± 0.1	45.0 ± 0.37	6.1 ± 0.1	84.7
Sycanus galbanus	96.6 ± 0.7	208 ± 3.9	17 ± 0.9	92.2

The total nymphal developmental periods were 52.3 ± 2.7, 52.3 ± 4.3, 45.0 ± 1.3 and 52.5 ± 4.4 days for *I. armipes, P. bimaculatus, S. signatus and S. galbanus* respectively (Table 3.3). 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 differed exceptionally in shape and size during their development. Preoviposition period of *S. signatus* was comparatively lower than *I. armipes, S. galbanus* and *P. bimaculatus* (Table 3.4).

Table 3.3: Nymphal developmental period of reduviids

Species	Stadial period (days) (Mean ± SE)					
	I	II	III	IV	V	Total
Irantha armipes	12.7 ± 0.8	9.7 ± 0.8	9.0 ± 0.4	8.3 ± 0.2	12.7 ± 0.6	52.3 ± 2.7
Panthous bimaculatus	8.6 ± 0.4	12.0 ± 2.0	11.2 ± 0.5	9.5 ± 0.3	11.2 ± 1.1	52.3 ± 4.3
Sphedanolestes signatus	9.0 ± 0.2	6.8 ± 0.8	8.7 ± 0.2	7.3 ± 0.2	13.3 ± 0.6	45.3 ± 1.3
Sycanus galbanus	17.0 ± 0.9	9.5 ± 0.8	7.5 ± 0.4	8.5 ± 0.4	10.0 ± 1.4	52.5 ± 4.4

Table 3.4: Oviposition periods and longevity of reduviids

Reduviids	Pre-oviposition	Oviposition	Post-oviposition	Longevity (days)	
	Period (Days) (Mean ± SE)			Male	Female
Irantha armipes	11.33 ± 0.3	31.6 ± 0.8	7.3 ± 1.7	57.8 ± 2.4	62.0 ± 1.8
Panthous bimaculatus	18.17 ± 0.3	52.17 ± 5.4	14.7 ± 1.5	93.5 ± 3.6	98.7 ± 1.4
Sphedanolestes signatus	8.60 ± 0.2	25.0 ± 0.4	6.6 ± 1.1	40.8 ± 3.3	42.2 ± 2.9
Sycanus galbanus	19.0 ± 2.5	5.0 ± 1.2	22.3 ± 3.1	43 ± 10.8	49 ± 12.2

The sequential acts of mating behaviour observed in the reduviids were arousal, approach, riding over and copulation. The aroused male has approached the females by chasing with extended antennal 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 and 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 included arousal, approach, capturing, rostral probing, paralysing, sucking and post predation.

3.2.2.2 Rearing success of purple boxer mantis, *Ephestiasula pictipes*

During recent surveys in cashew plantations, purple boxer mantis, *Ephestiasula pictipes* (Wood-Mason) (Mantodea: Hymenopodidae) was found to prey upon many cashew pests including tea mosquito bug, leaf beetles, caterpillars, grasshoppers, etc. Attempts were made to rear *E. pictipes* using wax moth larvae *Galleria mellonella* L. as prey to study the life history and rearing feasibility.

Whether mated or not, female mantises started laying their first ootheca generally after 10-14 days of emergence, but, oothecae laid before copulation were infertile. Each ootheca was laid at an interval of 3-5 days, with a maximum fecundity of 22 oothecae/female. Duration of oviposition lasted for 40-50 minutes/ootheca. Freshly laid ootheca was milky white, which turned into ivory white in 3-4 days. The length of oothecae ranged from 1.20 to 2.4 cm (mean 1.75 cm). But, the width of oothecae was uniformly 0.55 cm. The number of eggs/ootheca was variable, being as high as 22 and as low as 7, with 16-18 being most common. Oviposition period lasted even up to 82 days and post oviposition period lasted for 7-11 days. Newly hatched nymphs were fragile, reddish brown, and turned dark brown within 2-3 h. They preyed on small active wax moth larvae. Mortality of nymphs was very high during early stages, but at subsequent stages, it was less (2-3 %). The size of nymphs gradually increased as they grew, and the wing buds started developing during late instars and became prominently visible during pre-adult stage of both sexes. In general, female mantises were medium sized (2.3-2.5 cm), stout, having bulky abdomen and shorter antennae (0.6-0.8 cm) and the abdomen was not fully covered by wings.

But, males were slender, very active, smaller (1.9-2.1 cm), having longer antennae (1.3-1.5 cm) and wings extending beyond the abdomen. Sex ratio was male biased during all three seasons. Generally, the longevity of both mated and unmated female praying mantises was more than males and lived additional 20-25 days than male praying mantises. There was difference in duration of various life cycle parameters during two different seasons. Like other insects, the developmental duration was short during summer but more during rainy season. Incubation period was 15.22 days during Feb-May, while it was 16.89 days during Jun-Sep. The total nymphal developmental period of male and female *E. pictipes* were 64.89 and 66.4 days respectively during Februay-May. While it was 78.44 and 80.50 days during Jun-Sep. Sex ratio was male biased. Longevity of adults was more during Februay-May (Table 3.5).

Table 3.5: Developmental parameters, longevity and sex ratio of *E. pictipes* during two seasons

Parameters	Februay-May (Mean ± SE)		June-September (Mean ± SE)	
	Male	Female	Male	Female
Incubation period (days)	15.22 ± 0.15		16.89 ± 0.54	
1st instar (days)	8.22 ± 0.15	8.2 ± 0.13	9.56 ± 0.65	11.30 ± 1.01
2nd instar (days)	12.22 ± 0.43	12 ± 0.21	12.22 ± 0.81	13.10 ± 1.10
3rd instar (days)	14.67 ± 0.41	14.5 ± 0.45	11.89 ± 0.48	15.80 ± 0.95
4th instar (days)	9.22 ± 0.32	9.8 ± 0.53	13.44 ± 0.84	12.50 ± 0.64
5th instar (days)	7.44 ± 0.38	9.2 ± 0.25	13.67 ± 0.94	11.20 ± 0.57
6th instar (days)	13.11 ± 0.20	12.7 ± 0.21	17.67 ± 0.44	16.60 ± 0.58
Total Developmental Period (days)	64.89 ± 0.61	66.4 ± 1.01	78.44 ± 1.39	80.50 ± 1.67
Longevity (days)	74.62 ± 1.42	97.08 ± 0.97	68.23 ± 0.99	87.08 ± 1.43
Oviposition period (days)	77.54 ± 0.73		71.15 ± 1.72	
Sex ratio (male : female)	1:0.79		1:0.72	

Ootheca and a hatching nymph

Nymph - fourth instar

Nymphal stage of *E. pictipes*

Female mantis predating on a tea mosquito bug

Male and female at copulation

Adult stage of *E. pictipes*

3.2.3 Studies on semio-chemicals

The attraction of males of TMB to virgin females has been confirmed and the activity was seen between the ages of 4-14 days of emergence. The attraction was maximum between 10 AM to 12 Noon under field conditions. This was evidenced by maximum catch of male TMB in the traps caged with virgin females during that period.

3.2.4. Screening of cashew varieties against TMB

The screening of the varieties against the incidence of TMB was continued during the period of 2014-15. The damage due to the infestation of pest was recorded in 0-4 scale from first fortnight of November 2014 to March 2015 (Grade 0 = no damage, 1 = 1-3 necrotic lesions, 2 = 4-6 coalescing

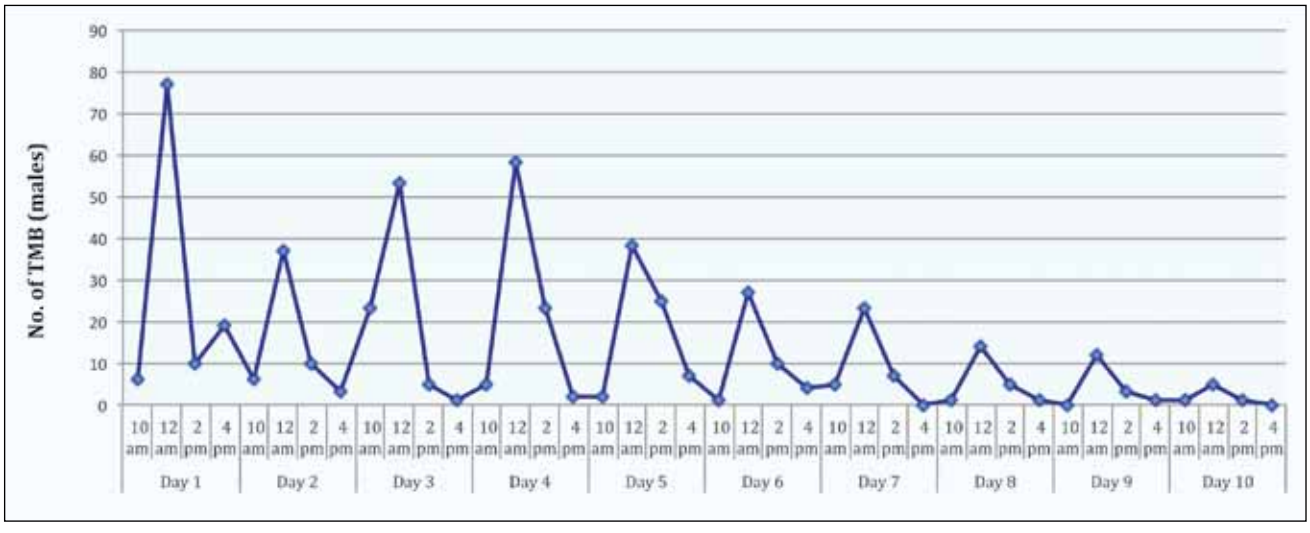


Fig.3.2: Attraction of males of TMB to virgin females

lesions, 3 = more than 6 coalescing lesions and 4 = complete drying). Field screening revealed that varieties such as Vengurla-1, Ullal-1, Ullal-2 and VRI-3 showed least damage scores (<1). The varieties Madakkathara-2, K-22-1 and Vengurla-7 had higher damage score (>3).

3.3 Biodiversity of Arthropod Fauna in Cashew Eco-System

3.3.1 Pest dynamics in cashew eco-system

The insect pest diversity was continuously monitored in various experimental cashew plots of this Directorate. The peak population of foliage pests occurred during November to January. The chronological order of pest incidence was; leaf miner (*Acrocercops syngramma*) > TMB (*Helopeltis antonii* ≥ *H.theivora*) along with sporadic incidence of *Pachypeltis mesaerum* > leaf and blossom webber (*Lamida* (= *Macalla*) *moncusalis*) and leaf rollers (*Sylepta* spp.). The localized and sporadic incidence of leaf beetles *Monolepta longitarsus* was restricted only to July – September months, which caused extensive leaf skeletonizing in top-worked trees during the year (Fig. 3.3).

Existence of tasar silk moth (*Antheraea mylitta*) was noticed during June to February in a few isolated cashew trees. Occurrence of apple and nut borers, *Thylocoptila paurosema, Nephopteryx* sp. *Hyalospila leuconeurella* and *Anarsia epotias,* leaf / inflorescence thrips (*Selenothrips rubrocinctus, Rhipiphorothirps cruentatus* and *Retithrips syriacus,* was moderate. However, leaf weevils (*Myllocerus* spp.), aphids (*Toxoptera odinae*) and mealy bugs (*Ferrisia virgata*) occurrence was very negligible.

3.3.2 Tasar silkworm in cashew

Tasar cocoons are the largest among all the silk-producing insects in the world and its silk fibre has its own distinctive colour, higher tensile strength, elongation and stress-relaxation values than the mulberry silk fibre. Under field conditions, occurrence of tasar silkworm, *Antheraea mylitta* was noticed initially on young cashew plants from June onwards and later noticed up to February on

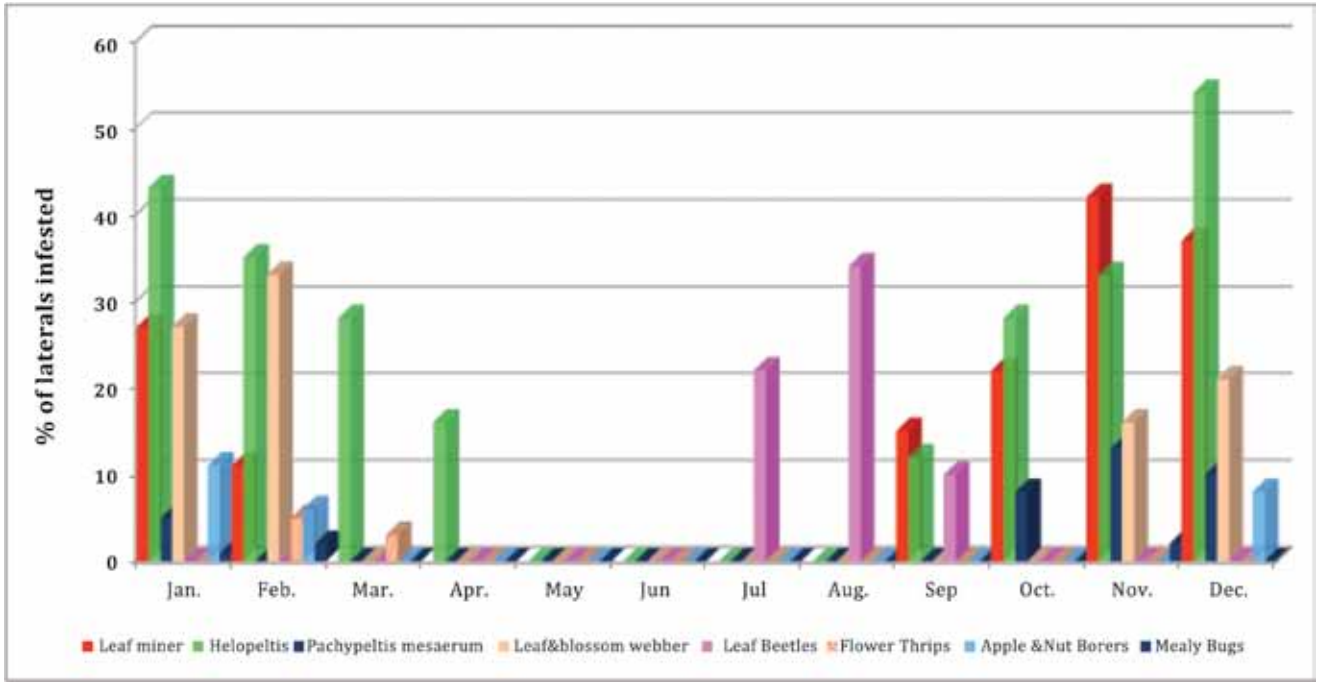


Fig. 3.3: Seasonal occurrence of various insect pests on cashew

old trees as well. Creamy flat-ellipsoidal eggs were laid singly on lower side of cashew leaves and a part of chorion was invariably eaten away by larvae upon hatching. In the infested trees, tender cashew leaves including midribs were eaten away by silkworms and a lot of faecal pellets were seen on the ground. Matured silkworms spinned cocoons by joining adjacent leaves and the creamy yellow oval cocoons with peduncles were seen on the cashew shoots.

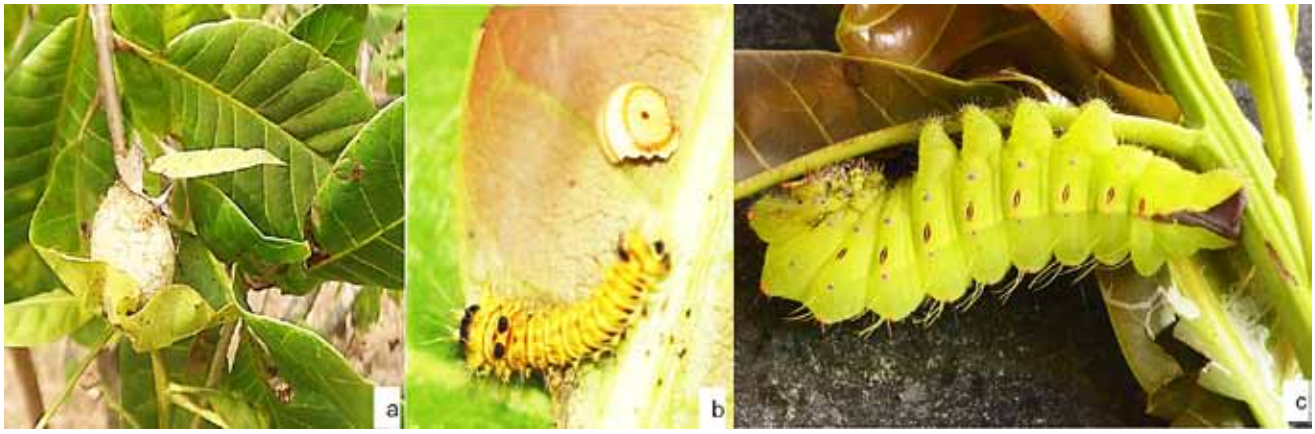
The ecorace of tasar silkworm occurred on cashew plantations of Puttur, Karnataka was identified as *A. mylitta* KE-02 by CTRTI, Ranchi and was reported for the first time in Karnataka. Previously, this ecorace has been reported on cashew in Kozhikode region of Kerala and presently distributed in Kannur and Palakkad regions of Kerala. The preliminary study revealed successful indoor rearing of tasar silkworm on cashew shoots. Under lab conditions, egg incubation period was 6.43 days. Egg mortality was observed at 3.22 per cent due to dryness and unknown reason. Mortality of 1st instar *A. mylitta* was very less (3.33%) and the larvae moulted in to second instar in 4.71 days. During pre-moulting and moulting, larvae remained without feeding for nearly 26 h. Each larva fed 35-41 tender cashew leaves of varying sizes before spinning, and feeding was voracious during fifth instar (24-29 leaves). Compared to all other instars, duration of fifth instar was longer (10.43 days). Mortality of larvae was 9.20, 10.13, 29.58 and 28 per cent during 2nd, 3rd, 4th and 5th instars and the cumulative larval mortality was 60 per cent. Larval mortality was mainly due to Nucleo Polyhedrosis Virus (NPV). The larvae could complete all five instars successfully in 26-31 days (Table 3.6). Fully grown tasar silkworm weighed 17 to 18 g and measured 8 to 9 cm in length. During the present study, effective rate of rearing (ERR) on cashew was 40 per cent and the average cocoon weight was 6.24 g (Table 3.7).

Table 3.6: Developmental duration and mortality at different stages of *A. mylitta* on cashew (X = 143)

Developmental stage	Duration (days) Mean ± SEM	Mortality at each stage (%)
Egg	6.43 ± 0.17	3.23
1st instar	4.71 ± 0.19	3.33
2nd instar	3.50 ± 0.17	9.20
3rd instar	5.14 ± 0.21	10.13
4th instar	6.07 ± 0.20	29.58
5th instar	10.43 ± 0.18	28.00
Pupa	25.36 ± 0.68	0.00

Table 3.7: Larval weight, adult longevity and grainage parameters of *A. mylitta* on cashew

Parameters	Mean ± SEM
Matured fifth instar larval weight (g)	17.1 ± 0.21
Total larval developmental period (days)	28.69 ± 0.60
Female longevity (days)	7.79 ± 0.19
Male longevity (days)	3.21 ± 0.11
Pre-oviposition period (days)	1.06 ± 0.07
Oviposition period (days)	3.68 ± 0.13
Post-oviposition period (days)	2.75 ± 0.12
Fecundity (No.)	182.8 ± 6.19
Hatchability (%)	96.78
Cocoon weight (g)	6.24 ± 0.39
Cocoon length (cm)	3.58 ± 0.06
Cocoon breadth (cm)	2.05 ± 0.04
Peduncle length (cm)	2.88 ± 0.40



a) Cocoon of tasar silkworm spun on cashew shoot in field, b) just hatched larva and fed chorion and c) Fifth instar larva

3.3.3 Species composition of ants in cashew plantations

Upon surveillance of cashew plantations, a total of 49 ant species representing 24 genera and 7 subfamilies were recorded. The study found that cashew trees were consistently visited by ants during all the seasons of the year. Though foraging activity of same ant species was seen throughout the day, activity was generally more during morning hours. Most of ant species were attracted for the extra floral nectarines present on young leaves, developing inflorescences and young fruits. Species belonging to Myrmicinae were most dominant comprising 22 species (44.9% of total species). Formicinae with 13 species was the immediate successor, while, Aenictinae and Dorylinae were represented by only one species (Fig. 3.4). *Camponotus* was found as the most species-rich genus represented by seven species followed by *Monomorium* by six species. But, 15 other genera were represented by only one species. Among the ant species, *Camponotus compressus, Camponotus sericeus, Oecophylla smaragdina* and *Anaplolepis gracillipes* were considered as abundant and very common. Upon survey, seven species were considered as common, 15 as moderate, 12 as less common, while, 10 as rare. However, the jumping ant *Harpognathous saltator*, an endemic species to the Western Ghats was not recorded in the study region. Presence of two world's worst invasive ant species namely *A. gracillipes and Phleidole megacephala* in cashew plantations of survey region attracts attention and warrants regular monitoring.

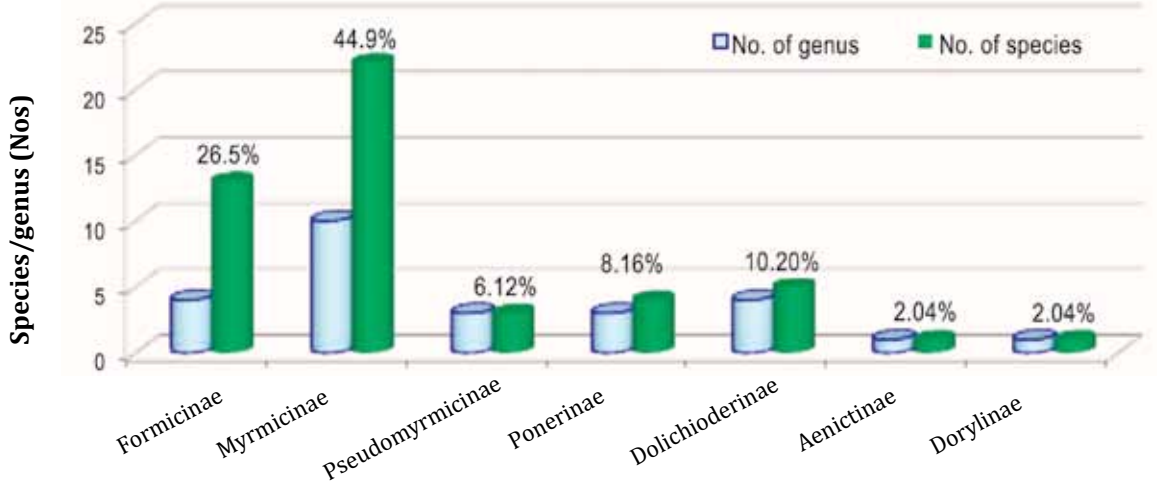
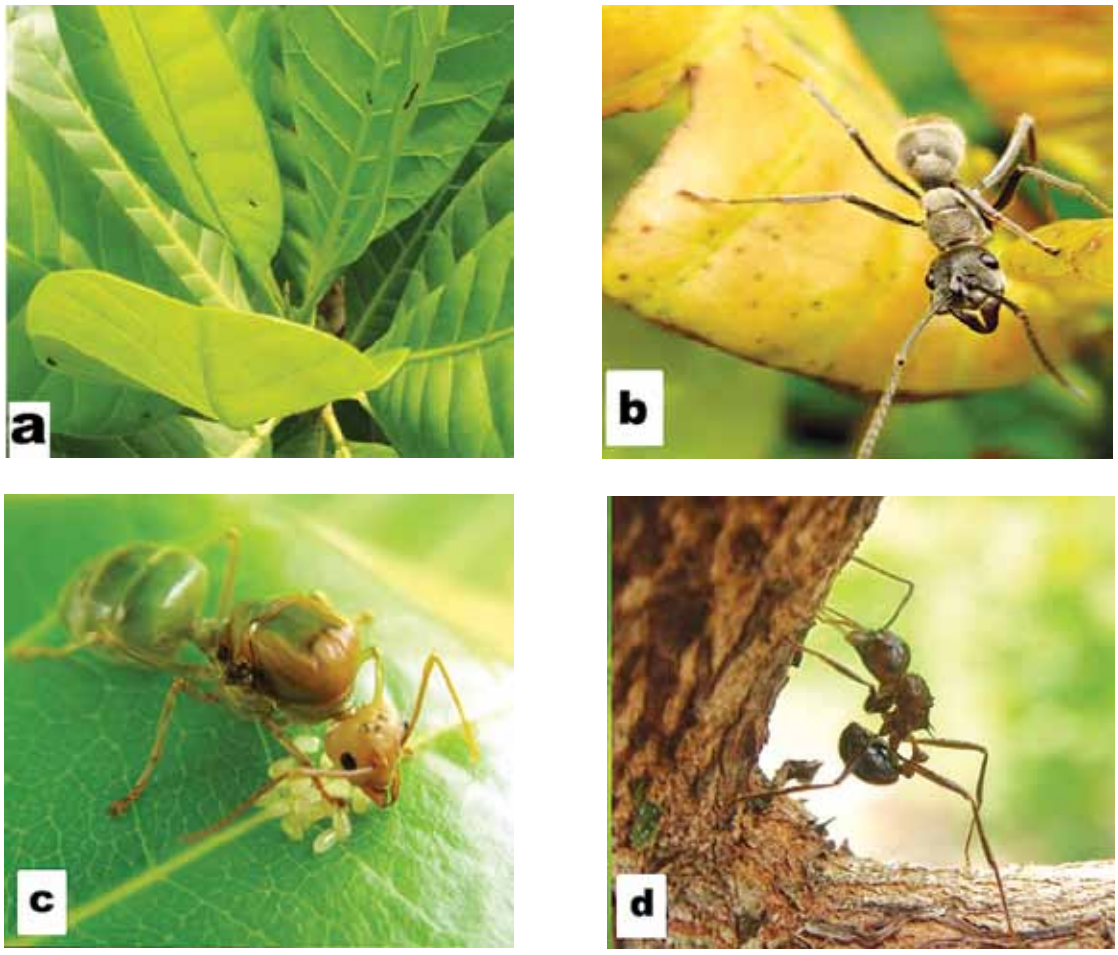


Fig. 3.4: Species composition of ants in cashew plantations

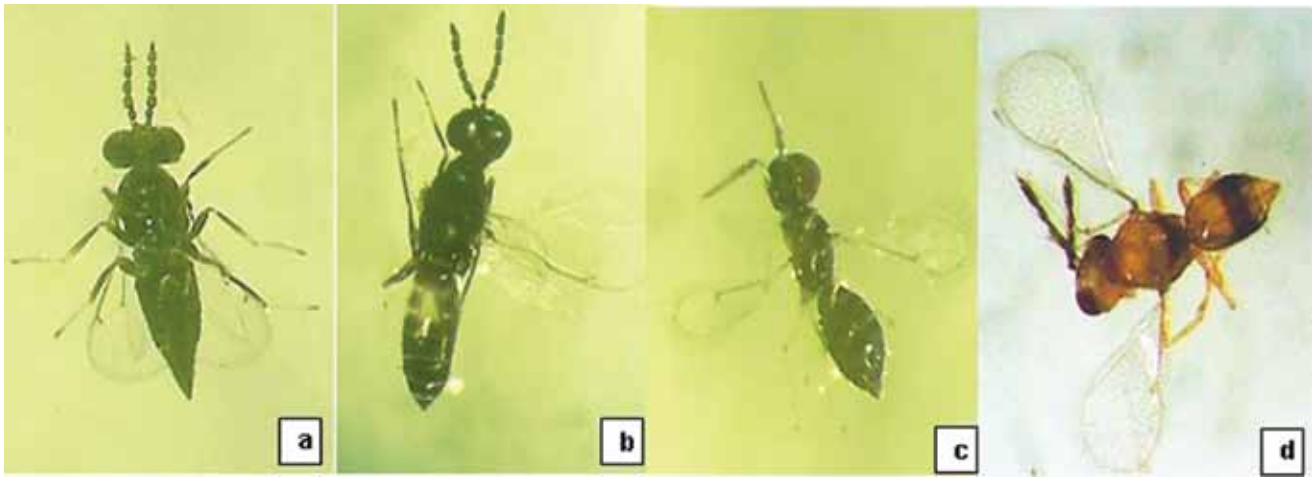


a) Ants foraging on a cashew shoot b) *Diacamma* sp., c) Queen ant of *Oecophylla smaragdina* and its eggs and d) *Myrmicaria brunnea*

3.3.4 Documentation of parasitoids of cashew leaf miner

Leaf miner, *Acrocercops syngramma* M. (Lepidoptera: Gracillariidae) is a defoliating pest of cashew, occurring in almost all the cashew growing regions of the country as well as the world. In India, it causes serious damage to the tender leaves of cashew attacking 2-80 per cent of the young leaves. Nearly three decades back, *Chelonus* sp. (Braconidae), *Cirrophilus* sp. and *Sympiesis* sp. (Eulophidae) were reported as larval parasitoids of cashew leaf miners. Upon recent surveys at ICAR-DCR, it was found that, there are other parasitoids, which are unreported earlier, parasitize the cashew leaf miner. During the present investigation, three larval parasitoids namely, *Chrysocharis* sp., *Closterocerus* sp. and *Aprostocetus* sp. all belonging to Eulophidae were recorded on cashew leaf miner larvae. Among these three parasitoids, *Chrysocharis* sp. was the dominant (99%) during last four years. While, *Closterocerus* sp. and *Aprostocetus* sp. were recorded only during 2011 at 0.5 per cent level. Leaf miner larvae parasitized by *Chrysocharis* sp. appeared brownish black in colour and the inner contents were sucked up. Fully matured parasitoid larvae came out of miner larvae for pupation but pupated within the mines. Pupae transformed in to pre-adult and emerged as adults from mines by making way out as a tiny hole. Among the instars, the 1st and 2nd instar leaf miner larvae were not

parasitized but 3rd and 4th instar larvae were generally parasitized. Up to 58 per cent parasitism of leaf miner larvae has been recorded in field conditions. Hence, except in nursery and very young cashew plants, there is no need of insecticidal spray unless required. Further, adult parasitoids of *Chrysocharis* sp. could successfully emerge from pupae even from the leaf mines collected from insecticide sprayed plots indicating that there was no effect of insecticides like lambda cyhalothrin on pupal stage of this parasitoid.



Parasitoids of cashew leaf miner a) *Chrysocharis* sp. female, b) *Chrysocharis* sp. male c) *Closterocerus* sp. and d) *Aprostocetus* sp.

3.4 Pollinators of Cashew

The diversity of pollinators of cashew was assessed preliminarily using bee bowls and hand net collection. The bees like *Apis cerana indica*, *Braunsapis* sp., *Pseudapis oxybeloides, Ceratina* sp. and *Lasioglossum* sp., were noticed as frequent visitors of cashew flowers. These bees mainly visited fresh and a day-old cashew flowers for nectar as well as pollen. Among the bees, pollen load was heavy on hind femur of *Pseudapis* sp. and *Braunsapis* sp. Foraging activity started from 9.30 AM onwards and noticed even up to 6.00 PM in the evening. But maximum activity was seen between 11.00 AM to 1.00 PM. The other bee flora recorded include *Alternanthera* sp., *Antigonon leptopus, Blumea* sp., *Tridox procumbens, Melastoma malabathricum, Ocimum* sp., *Leucas aspera* and *Mimosa pudica.* Specificity of certain bees to specific group of flowers was also noticed.

***Apis cerana indica* busy in collecting nectar and pollen**

Position of collecting pollen from a fresh flower by *Braunsapis* sp.

4. POST-HARVEST TECHNOLOGY

4.1 Design, Development and Evaluation of Solar Tunnel Dryer for Cashew Apple and Nut

4.1.1 Solar tunnel dryer: Design and development

Solar drying is often differentiated from sun drying by the use of equipment to collect the sun's radiation in order to harness the insolation for drying applications. Based on the preliminary investigations under controlled conditions of drying, a direct natural convection solar tunnel dryer is designed and developed for raw cashewnuts and apples on a pilot scale. It is a batch type dryer developed for the purpose of reducing the moisture content of cashew apple from 85 per cent to 16 per cent w.b. and in the case of raw cashewnuts from 17 per cent to 8 per cent d.b. It consisted of a hemi-cylindrical walk in type metallic frame structure covered with UV-stabilized semi - transparent polyethylene sheet of 200 µm thickness and had a base area of 3.75 m x 6.00 m for drying around 0.4 t/batch. The structural components of solar tunnel drier are suitably designed to dismantle and to shift to any location. Two chimneys are placed at equidistance apart on the top of tunnel to remove moisture during drying. Make shift solar tunnel dryer is fabricated and installed in the premises of ICAR - Directorate of Cashew Research, Puttur. The system is oriented in such a way that maximum insolation received by the dryer.

Basic mechanisms involved in the drying process are, migration of moisture from the interior of a food matrix to the surface and the evaporation of moisture from the surface to the surrounding air. The drying of a product is a complex heat and mass transfer process which depends on external variables such as temperature, humidity and velocity of the air stream and internal variables which depend on parameters like surface characteristics, chemical composition, physical structure and size and shape of the product. Due to insolation, air inside the dryer is heated up and instigates moisture transfer from the material to be dried. Simultaneously, buoyancy stimulates air flow to drive out humid air depending on the prevailing air velocity. Cashew apple being high moisture fruit, drying trays of size (0.60 x 0.40 m) to accommodate 5 to 7 kg of slices (2-3 mm thickness) in thin layer *i.e.* < 100 mm bed depth are fabricated with stainless steel wire mesh, provided at the bottom to allow dry air to pass through the slices. Design detail of the solar dryer developed is given below and the specifications are presented in Table 4.1.

Make shift poly house solar tunnel dryer

Table 4.1: Design details of poly house solar tunnel dryer

Components	Specification
Length of solar poly house dryer (cm)	600
Width of solar poly house dryer (cm)	375
Height of solar poly house dryer (cm)	200
Floor area of solar poly house dryer (cm^2)	225000
Area of solar radiation receiving area (cm^2)	353250
Tray size (cm)	60 x 90
Number of trays	5
Number of trolleys	8
Door size (cm)	175 x 90
Initial moisture content (% w.b.)	86.76
Final moisture content (% w.b.)	16.27
Capacity of solar poly house dryer (kg)	350-400
Orientation of tunnel	E-W direction
Collector material	UC polythene 200 µm sheet
Global solar radiation (Kcal cm^{-2}) - Mangalore	5.4

4.1.1.1 Quantity of water to be removed

Mass of initial water content was calculated using following equation: $M = \frac{(m_1 * x)}{100}$ ...(1)

Where M: Mass of initial water content (kg); m_1: Initial moisture content of cashew apple %w.b.; x: Mass of selected product taken for drying, kg

Mass of bone dry product was calculated as: $M_d = x - M$... (2)

M_d: Mass of bone dry product (kg)

Initial moisture content (d.b.) was calculated as:

$$M_1 = \frac{m_1}{(100 - m_1)} x\ 100 \quad \text{... (3)}$$

Final moisture content (d.b.) was calculated as:

$$M_1 = \frac{m_2}{(100 - m_2)} x\ 100 \quad \text{... (4)}$$

The mass of water to be removed during drying was calculated using following equation:

$$M_w = \frac{(m_1 - m_2)}{100} * x \text{ ... (5)}$$

M_w: Mass of water to be removed (kg)

4.1.1.2 Total energy (Q) required for drying

Total energy required for drying was calculated using following equation:

$$Q = M_d x C_d x (T_2 - T_1) + M x C_p x (T_2 - T_1) + M_w x \lambda \text{ ... (6)}$$

C_d: Specific heat of product (kJ kg^{-1} $^oC^{-1}$); C_p: Specific heat of water (kJ kg^{-1} $^oC^{-1}$); T^1: Ambient air temperature (^oC); T^2: Temperature inside the solar tunnel dryer (^oC); λ: Latent heat of vaporization of water (kJ kg^{-1})

Energy required (Q) per hour for drying was calculated using the equation:

$$Q = \frac{Q}{t} \text{ ... (7)}$$

t: Total drying time (h)

Drying rate (k) is calculated as:

$$k = \frac{M_w}{t} \quad \ldots (8)$$

4.1.1.3 Collector area of solar tunnel dryer required for drying

Based on the assumption that about 68 per cent area of hemispherical shaped solar tunnel dryer towards south is able to receive sunlight whereas remaining 32 per cent area towards north is from the sun, the collector area (A_c) of solar tunnel dryer required for drying is calculated using the equation:

$$A_c = \frac{Q_t}{I x \eta x 0.68} \quad \ldots (9)$$

I: Global solar radiation for Mangalore region (5.4 kJ $h^{-1}m^{-2}$); η: Overall thermal efficiency of solar tunnel dryer.

4.1.1.4 Dimensions of solar tunnel dryer

Area of semi-cylindrical shape of solar tunnel dryer (a) is calculated as:

$a = \pi \times r \times rx (r+L)$ ... (10)

r: Radius of dryer (m); L: Length of dryer (m)

Diameter (d) of solar tunnel dryer 3.75 m is kept as constant for easy entry and other convenience. Radius of solar tunnel dryer (r) is calculated as:

$$r = \frac{d}{2} \quad \ldots (11)$$

Length of solar tunnel dryer (L) is calculated as:

$$L = \frac{(a - \pi r^2)}{\pi r} \quad \ldots (12)$$

Floor area (drying area) of solar tunnel dryer (A) is calculated as:

$A = Lxd$ ... (13)

Perimeter of solar tunnel dryer (p) is calculated as:

$p = \pi xr$ ... (14)

4.1.1.5 Design of chimney

Since airflow in the dryer takes places due to the draft caused by the density difference between outside cold air and inside hot air, a natural draft uses the basic law that warm air rises. Air as it is warmed expands and becomes lighter in mass. Colder, heavier air pushes in under it and forces it up. This causes a draft. Mass of air needed for removing M_w kg of water was calculated using the following equation:

$$q_a = \frac{(M_w x \lambda)}{C_a x (T_3 - T_1)} \quad \ldots (15)$$

M_w: Mass of water to be removed (kg); C_a: Specific heat of air (kJ kg^{-1} $^oC^{-1}$); T^3: Temperature inside the chimney of dryer (^oC)

Mass of exit air (q) is calculated as:

$q = M_w + q_a$ ... (16)

Density of inlet air is calculated as:

$$\rho_1 = \rho_o x \frac{T_0}{T_1} \ldots (17)$$

ρ_i: Density of inlet air (kgm^{-3}); ρ_e: Density of exit air (kgm^{-3}); ρ_o: Density of air at 0°C (kg m^{-3}); T_0: Temperature of air at 0°C (^oK)

Produced draft in chimney:

$D_p = Hxgx (\rho_1 - \rho_e) \ldots (18)$

D_p: Produced draft (kg $m^{-1}s^{-2}$); g: gravity constant (m s^{-2})

But actual draft is calculated as:

$D_a = 0.75xD_p \ldots (19)$

Velocity of exit air (V) is calculated as:

$$V = \sqrt{\frac{2D_a}{\rho_e}} \quad \ldots (20)$$

D_a: Actual draft (kg m^{-1} s^{-2})

Volume of exit air (Ve) is calculated as:

$$V_e = \frac{q}{\rho_e} \quad \ldots (21)$$

Rate of exit air is (Q_s) calculated as follows:

$$Q_a = \frac{V_e}{t} \ldots (22)$$

Thus if assumed this exit air is being carried by n number of chimney. Rate of exit air for single chimney (Q_c) was calculated as follows:

$$Q_c = \frac{Q_a}{n} \ldots (23)$$

Q_a: Rate of air required ($m^3\ s^{-1}$)

Area of chimney (a_e) was calculated using the equation: $a_c = \frac{Q_c}{V} \ldots (24)$

V: Velocity of exit air ($m^3\ s^{-1}$)

Diameter of chimney (dc) is calculated as:

$$d_c = \sqrt{\frac{4xa_c}{\pi}} \ldots (25)$$

4.1.2 Performance of the dryer

In order to understand the performance of dryer, no load test is conducted to understand the hourly variation in the solar dryer in comparison to ambient temperature. Essentially temperature profile, relative humidity and air flow rate at different location of the solar tunnel dryer can be studied in relation to performance of the dryer. Variation in the average temperature inside poly house tunnel dryer is depicted in Fig. 4.1. Air temperature of the solar dryer is observed to be highest between 11 AM to 2 PM when the Sun is usually overhead. Rise in temperature inside the drying chamber is up to 18°C compared to ambient environment during bright sunshine days assuring better performance than open – air sun drying. In addition to that, diurnal variation of relative humidity of the ambient air and drying chamber indicated enhanced performance of drying at low humidity *i.e.* < 2- 5 per cent.

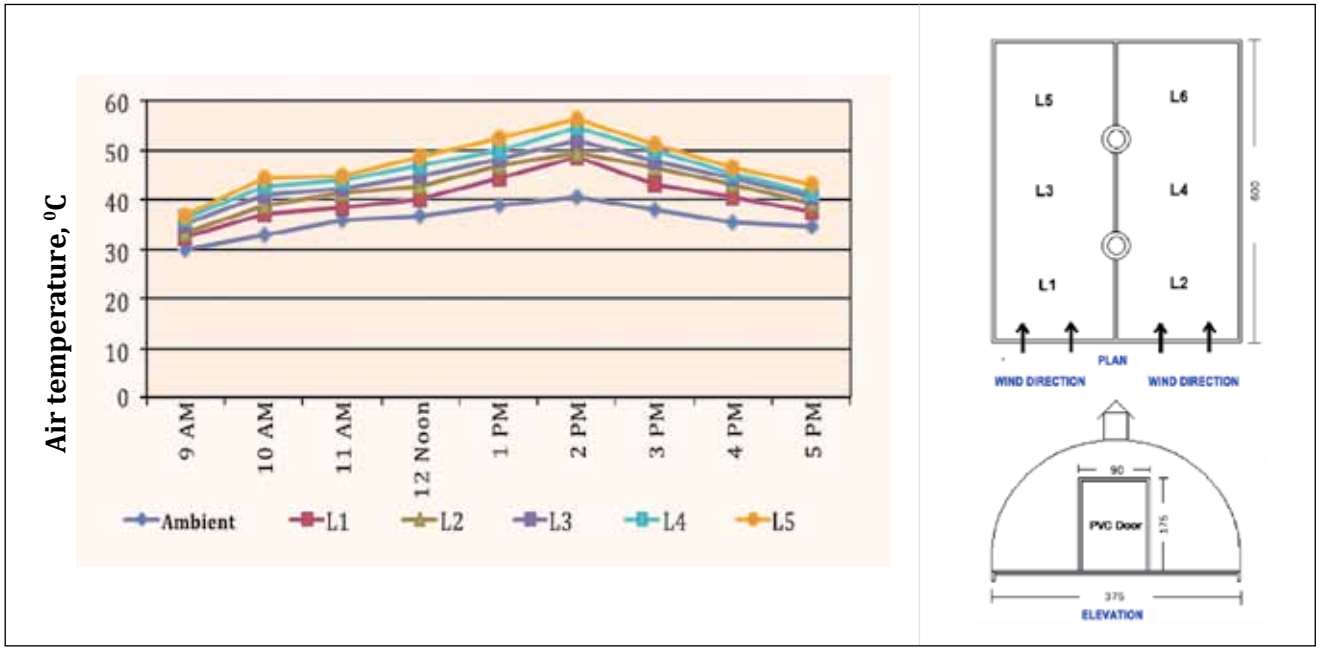


Fig. 4.1: Variation in the average air temperature inside poly house solar tunnel dryer

4.1.3 Technique for drying cashew apple slices or raw cashewnuts under solar dryer

Freshly harvested cashew apples of given variety were washed with water to remove adhering dirt or sand. Later, surface moisture was wiped off using tissue paper and carefully sliced across the length of the fruit manually using stainless steel knife *i.e.* to obtain circular c/s slices. Weighed quantity of slices were transferred to the wire mesh bottom tray and loaded in the trolley. Two such trolleys were moved in to the drying chamber of the solar dryer and weight loss of slices at regular interval *i.e.* every 1 h was recorded. Partially dried samples were packed in polythene bags in the evening and transferred to desiccators. Weight of the apple slices were noted before transferring in to drying chamber of the solar dryer on the following day. It was observed that loss or gain due to moisture, cashew apples being hygroscopic, was negligible. Simultaneously, samples of cashew apples were cut in to pieces and dried under convective dryer maintained at temperature of 80°C for 3 h to determine its initial moisture content. This initial moisture content was used to compute the time required to reduce the moisture content of cashew apple slices being dried under solar dryer to pre-determined level *i.e.* 16 per cent w.b. After drying under solar dryer, slices were transferred to electrically operated convective dryer maintained at temperature of 60°C for 1 h to make it amenable for pulverization to transform in to powder form. Cashew apple powder (CAP), thus made were packaged using polythene sachets for further investigations.

In the case of drying raw cashewnuts, freshly harvested nuts were cleaned for the adhering pulpy material. Later, it was sorted based on the major axis dimension *viz.*, small (<23 mm), medium (23-27mm) and large (>27mm). About 5 kg of such graded nuts were transferred to wire mesh tray and loaded on to the trolley. These trolleys were placed inside in appropriate location and moisture loss was recorded at definite interval of 1 h till 5 PM of the day. Later, these partially dried nuts were transferred to polythene bags and placed inside desiccators. Drying continued on the following day till the moisture content of the raw cashewnuts reduced to 8 per cent d.b. Initial moisture content of the freshly harvested nuts were determined following chemical distillation method to compute the drying rate during solar drying.

4.1.4 Drying characteristics of cashew apple slices under natural convection solar tunnel dryer

4.1.4.1 Effect of varieties on the rate of drying

Cashew apple slices of different varieties *viz.,* Dhana, Bhaskara, K 22-1, Ullal-3 and Madakkathara-2 were dried under poly house solar dryer. Moisture ratio of cashew apple slices was computed and plotted against drying time (Fig. 4.2). Drying of cashew apple showed falling rate period of drying and the time required to reduce its moisture to desired level followed the same trend irrespective of varieties. Depending on the initial moisture content of the cashew apple, total time required to 16 per cent w.b. ranged from 7-11 h. Only in the case of Maddakkathara-2, influence of rainfall and selection of site topography experienced. Increase in the relative humidity due

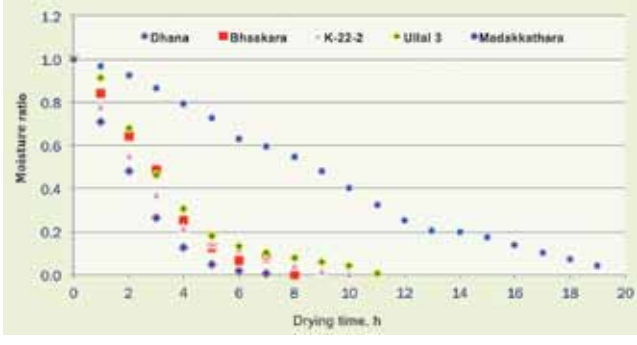


Fig. 4.2: Effect of cashew apple varieties on drying its slices in poly house solar tunnel dryer

to accumulation of moisture extended the time required for drying slices. Therefore, selection of the site and preventing the dryer from moisture accumulation are of paramount importance.

4.1.4.2 Effect of size reduction on the rate of drying

Investigation on size reduction of cashew apples in to various sizes *viz.,* slices (circular c/s), cubes and vertical segments (radial cut along major axis) under natural convection solar dryer indicated that faster drying due to increased surface area exposed for drying media (Fig. 4.3). In the case of cubes or radial cut, as discussed earlier, migration of moisture from core of the material to surface needed more time for moisture transfer in to drying media. Besides, practically it is easier to slice cashew apple in to slice rather than cube or segment with minimal loss of juice content. Further, cashew apple attains stable position and convenient to cut across major axis, while mechanizing slicing of the fruit towards bulk production.

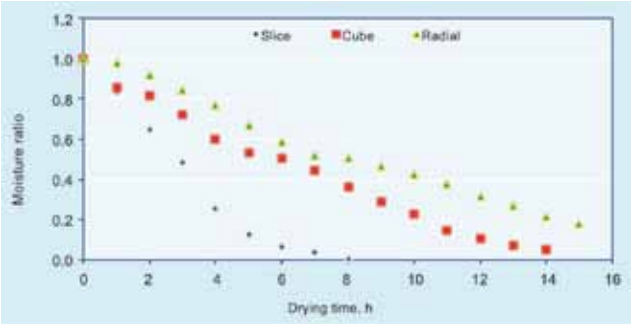
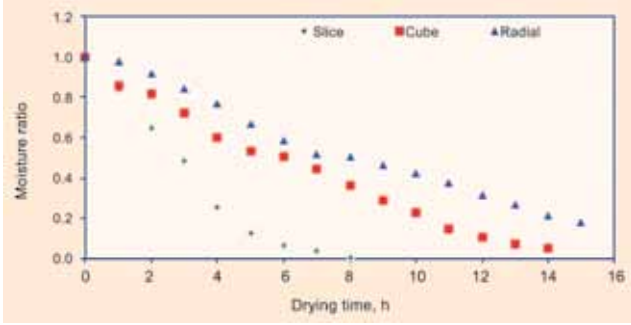


Fig. 4.3: Effect of size reduction on drying of cashew apple slices in poly house solar tunnel dryer

4.1.4.3 Effect of juice extracted cashew apple on the rate of drying

Experiments were conducted to study the drying characteristics of partially juice extracted cashew apple pomace which can be used for the preparation of admixture for animal, poultry, fish and piggery feed after converting in to powder. Cashew apples were subjected to static pressure using 2 t load hydraulic juice extracting machine to reduce the moisture content (juice content) of the fruit and later exposed to solar drying. Initially squeezed cashew apple samples were prepared by compressing the fruits once to remove juice content up to 42 per cent and twice to remove the juice content up to (58%). Moisture ratio of both squeezed cashew sample (Fig. 4.4) showed slower with respect to time primarily due to limited surface area opened while applying compressive force during juice extraction and paraffin layer restricting the moisture diffusion.



1-pass cashew apple

2-pass cashew apple

Fig. 4.4: Drying characteristics of squeezed cashew apple slices in poly house solar tunnel dryer

4.1.4.4 Drying characteristics of raw cashewnuts under poly house solar tunnel dryer

Comparison of drying raw cashewnuts of three different sizes *viz.,* small, medium and large under natural convection solar dryer is shown in Fig 4.5 and 4.6. It is evident that time required for drying raw cashewnuts of sizes small, medium and large to safer level of 8 per cent d.b. was 10, 12 and 16 h respectively under solar dryer which is 29, 25 and 16 per cent respectively lower than the time required for drying directly under Sun. Amount of moisture in the nuts and quantity of raw cashewnuts loaded completely on a tray in a single layer contributed for the varied results. Therefore, raw cashewnuts could be dried in solar dryer which is safer, faster, more efficient and cost effective.

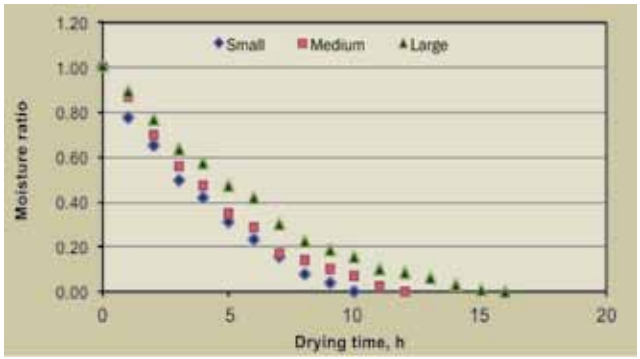


Fig. 4.5: Drying rate of raw cashewnuts in Poly house solar tunnel dryer

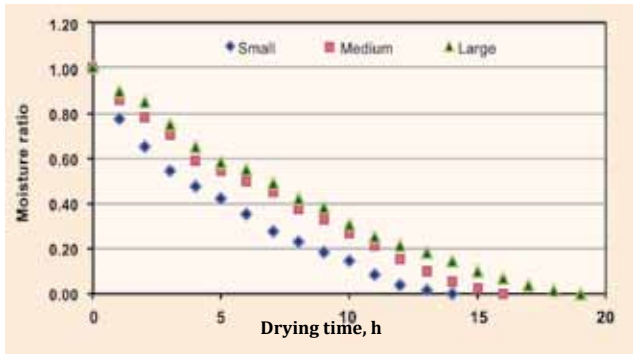


Fig. 4.6: Drying rate of raw cashewnuts in Open sun drying

4.1.5 Improving the performance of poly house solar tunnel dryer

In order to improve the efficiency of drying raw cashewnuts or cashew apple slices, sensor based environment control system has been designed. This sensor coupled microcontroller ensures uniform drying and enhance rate of drying irrespective of material exposed at different vertical spacing. Embedding the sensor based micro controller operating system and incorporation of exhaust air vent is underway.

4.2 Developing quality standards for raw cashewnuts

4.2.1 Developing questionnaire on quality standards for raw cashewnuts and pre-testing

A technical questionnaire with 37 fields is prepared to gather information pertaining to quality standards for raw cashewnuts in India. This questionnaire is prepared for the target group involved in handling raw cashewnuts *viz.,* farmers, traders and processors. Personal information, quantity of nuts handled, mode of assessing the quality, sampling, parameters considered, drying of nuts, assessing the infestation of the nuts, pricing etc., are covered in the questionnaire. The questionnaire has been pre-tested with farmers, traders and processors and refined. Farmers are concerned about price at one end and processors on the other end showed interest for quality as end product decides profitability. A private partner is identified and necessary official formalities are underway to initiate the action oriented research to develop a moisture meter for raw cashewnuts.

4.3 Design and development of mechanized slicer for cashew apple

A conceptual design of mechanized slicer for cashew apple is prepared based on the physical characteristics of cashew apples. Comparing the rotational disc type blade and vertical reciprocating serrated blade employed for cutting or shearing food products, former one with specific bevel angle found to be appropriate mechanism for slicing high

moisture pulpy fruit like cashew apple. Engineering drawing of the aforesaid slicer is prepared and the cost of fabrication is worked out.

4.4 Value Added Products from Cashew Apple

Keeping in view the market demand, an attempt has been made to standardize methodology for the preparation of value added products namely cashew apple cider (2-6% alcohol) and Juice blend ready to serve (RTS) beverages using cashew apple.

4.4.1 Cashew apple cider

For the preparation of cashew apple cider (2-6% alcohol), four varieties/accession namely Dhana, Madakkathara-2, Vengurla-4 and germplasm collection-301 were selected. In addition to that, cashew apples from different varieties / accessions (mixed) were also collected. The juice extracted from each variety/accession and juice extracted from mixed varieties/accessions have been used for the preparation of value added products.

Cashew apple cider

The sugar content of the of the apple juice varied from 8.5 to 10.5 °Bx while the alcohol was in the range of 3.5 to 5.5 per cent v/v. Based on the preliminary sensory evaluation, juice extracted from mixed varieties/accessions was better as compared to the juice extracted from each variety/ accession.

4.4.2 Blended RTS

In order to prepare ready to serve (RTS) beverages, five different varieties/accession *viz.,* Vengurla-3, Dhana, Bhaskara, Ullal-3 and germplasm collection-301 were chosen. The RTS drinks have been prepared using the cashew apple juice alone and cashew apple juice mixed with different proportion of lime juice, maintaining the

Blended RTS

concentration of apple juice uniform in all cases. Sensory evalution of different preparation of have been done using nine point hedonic scale. Of the different preparations, the RTS drink containing cashew apple juice blended with 3 per cent lime juice was the best on the basis of organoleptic evaluation (Table 4.2).

Table 4.2: Sensory analysis of cashew apple – lime blended RTS

Cashew apple	Sensory attribute				Overall
Juice: lime juice (%)	Colour	Flavour	Taste	Body	acceptability
20:10	6.22	4.33	5.0	5.0	5.13
20:08	6.11	4.00	4.4	4.77	4.82
20:06	6.55	5.11	5.88	5.77	5.82
20:04	6.88	6.00	6.5	6.22	6.4
20:03	6.88	6.55	8.11	6.55	6.77
20:02	6.77	5.88	7.00	6.44	6.55
20:01	6.55	5.44	5.77	6.00	5.94
CD (p=0.01)	1.58	2.1	1.71	1.55	1.75

5. TRANSFER OF TECHNOLOGY

5.1 Transfer of Technology Programme in Cashew

5.1.1 Socio-economic impact of cashew cultivation in Dakshina Kannada

Ten major social and economic indicators were studied to arrive at the socio-economic impact of cashew farming among the respondents in Dakshina Kannada district of Karnataka. The data indicated that Impact on labour engagement was low with only 20 per cent farmers hiring labour for cashew. The hiring of labour was mainly for plant protection and harvesting operations. Majority of the farmers (85%) reported no change in farm expenditure due to cashew cultivation. However, 43 per cent of farmers reported an increase in farm income due to cashew cultivation. On an average there was an increase of ₹ 2272/- per year in farm expenditure and ₹ 4188/- per year in farm income due to cashew cultivation. The data also revealed that social factors has greater role to play on cashew cultivation over economic factors (Table 5.1).

Table 5.1: Socio-economic impact of cashew cultivation (n=75)

Sl. No.	Impact Indicators	Increase		No change		Mean*
		f	%	f	%	
1	**Impact on cropping pattern**					
	Area under cashew cultivation over the years	13	17	62	83	1.5 acre
	Purchase of new land and cashew cultivation	2	3	73	97	2.0 acres
2	**Impact on labour engagement**					
	Hired labour engagement	15	20	60	80	1-2 Nos
	Family labour engagement	8	11	67	89	1 No.
3	**Impact on farm expenditure**					
	Cashew cultivation and farm expenditure	11	15	64	85	₹ 2272/-
4	**Impact on farm income**					
	Cashew cultivation and farm income	32	43	43	57	₹ 4188/-
5	**Impact on family income**					
	Cashew cultivation and family income	27	36	48	64	₹ 4259/-
6	**Impact on family expenditure**					
	Profit from cashew cultivation and family expenses	15	20	60	80	₹ 2666/-
7	**Impact on social participation**					
	Cashew cultivation and participation in social events	46	61	29	39	-
8	**Impact on extension contact**					
	Contacts with extension agency and research institutes	50	67	25	33	-
9	**Impact on mass media exposure**					
	Cashew cultivation and mass media exposure	42	56	33	44	-
10	**Impact on opinion leadership**					
	Cashew cultivation and opinion leadership in his/her area	47	63	28	37	-

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

Classification of cashew farmers based on the social and economic benefits accrued showed that nearly half of the cashew farmers (47%) belong to high social impact category while in case of economic impact, majority (80%) belonged to low benefits category. Overall, nearly half of the cashew farmers (47%) recorded medium level of socio-economic impact (Table 5.2).

Table 5.2: Classification of farmers based on social and economic impact (n=75)

Categories	Social Impact			Economic Impact			Socio-economic Impact		
	f	%	Range	f	%	Range	f	%	Range
Low	23	31	<0.715	60	80	<0.101	24	32	<0.493
Medium	17	22	0.715-1.445	2	3	0.101-1.329	35	47	0.493-1.299
High	35	47	>1.445	13	17	>1.329	16	21	>1.299
Mean		1.080			0.715			0.896	
SD		0.731			1.228			0.806	

5.1.2 Determinants of socio-economic impact

The correlation analysis identified that three personal variables *viz.*, years of experience in farming, extension participation and cosmopoliteness of cashew farmers had a significant relationship with socio economic impact. The regression analysis revealed that four variables *viz.*, the age of cashew farmer, years of experience in farming, cosmopoliteness and distance of cashew plot from home had a significant positive contribution towards socio economic impact (Table 5.3).

Table 5.3: Relationship and contribution of personal variables towards socio-economic impact (n=75)

Sl. No.	Socio-personal variables	'r' value	'b' value
1	Age	0.061	-0.321*
2	Level of education	0.087	0.127
3	Primary occupation	0.038	-0.030
4	Experience in farming	0.251*	0.516**
5	Experience in cashew farming	-0.013	-0.066
6	Extension contact	0.195	-0.067
7	Extension participation	0.263*	0.318
8	ICT usage	0.055	-0.101
9	Cosmopoliteness	0.331**	0.215*
10	Land used for cashew	-0.172	-0.107
11	Land used for other crops	0.017	-0.147
12	Distance of cashew plot from home	-0.203	-0.273*

**Significant at 5% level, *Significant at 10% level

The study identified six economic variables *viz.*, importance given to cashew, cultivable land available, number of yielding cashew trees, expenditure in agriculture, net income from agriculture and expenditure in cashew farming as having significant relationship with socio-economic impact. The regression analysis revealed that one variable *i.e.* importance given to cashew exerts a significant positive contribution towards explaining the variability in socio-economic impact. The socio-personal and economic variables used in the study could together explain up to 60 per cent variability in socio economic impact (R^2 = 0.670) (Table 5.4).

Table 5.4: Relationship and contribution of economic variables towards socio-economic impact (n=75)

Sl. No.	Economic variables	'r' value	'b' value
1	No. of crops grown	-0.186	0.054
2	Importance given to cashew	0.522**	0.297**
3	Farm size	0.089	-0.102
4	Cultivable land available	0.256*	0.143
5	No. of yielding cashew trees	0.519**	0.106
6	Yield of cashew/tree	0.025	-0.028
7	Expenditure in agriculture	0.415**	0.014
8	Net income from agriculture	0.451**	0.137
9	Expenditure in cashew farming	0.326**	0.232
10	Net income from cashew farming	0.205	-0.039
** Significant at 5% level, *Significant at 10% level			

Model Summary

Model	R	R^2	Adjusted R^2	S.E. of the Estimate
1	0.880[a]	0.774	0.670	0.4698

5.1.3 Predicting socio-economic impact: Step- wise regression models

Stepwise regression was used to check the extent to which the selected models explained the variation in socio-economic impact. Of the seven models tested to examine the variation in socio-economic impact among the respondents, the Model 7 explained up to 68 per cent of the variation in socio-economic impact using the predictors *viz.,* importance given to cashew (X1), years of experience in farming (X2), cosmopoliteness (X3), distance of cashew plot from home (X4), extension participation (X5), land used for other crops (X6) and net income from cashew farming (X7) (Table 5.5). The model 7 also had the lowest standard error of the estimate (0.462) thus making it the best model suited to predict adoption of pest management technologies by farmers. The model is fitted as: SEI=-0.125+ 0.484X1+ 0.301X2+ 0.210X3-0.277X4 + 0.214X5-0.168X6 + 0.179X7. The model can be used to measure socio-economic impact of cashew cultivation under similar agro-ecological situations.

Table 5.5: Models predicting socio-economic Impact: Step-wise regression analysis

Model		Unstandardized coefficients		Standardized coefficients	t	Significance
		B	S.E.	Beta		
7	(Constant)	-0.125	0.248		-0.504	0.616
	IMPCSW	0.378	0.062	0.484	6.115	0.000
	FRMNGEXP	0.018	0.004	0.301	4.529	0.000
	CSMPLTNS	0.033	0.012	0.210	2.880	0.005
	PLOTDIST	0.000	0.000	-0.277	-3.736	0.000
	EXTNPRTPN	0.024	0.008	0.214	2.831	0.006
	OTHCRPLND	-0.174	0.072	-0.168	-2.425	0.018
	INCM	6.273E-007	0.000	0.179	2.215	0.030
SEI = -0.125 + 0.484X1 + 0.301X2 + 0.210X3 - 0.277X4 + 0.214X5 - 0.168X6 + 0.179X7						
Model Summary						
Model	R	R^2	Adjusted R^2	S.E. of the Estimate		
7	0.843[g]	0.711	0.680	0.4622		
Predictors: (constant), IMPCSW, FRMNGEXP, CSMPLTNS, PLOTDIST, EXTNPRTPN, OTHCRPLND, INCM						

5.1.4 Constraints faced by farmers in cashew cultivation

The technical, management, economic/ marketing and processing constrains as faced by cashew farmers of Dakshina Kannada district are listed in Table 5.6. The data revealed that poor price and the high price fluctuations in market for raw cashewnut (83%) is the major constraint followed by low availability of hired labour (71%) in cashew cultivation.

Table 5.6: Constraints faced by farmers in cashew cultivation (n=75)

Sl. No.	Constraints	Rank	f	%
I	**Technical constraints**			
1	Attack of Tea Mosquito Bug and resultant yield loss	3	31	41
2	Death of yielding trees due to Cashew Stem and Root Borer attack	4	26	35
3	Flower drying in certain varieties	5	15	20
4	Poor yield of certain varieties	6	13	17
5	Poor soils in cashew orchards	12	3	4
II	**Management constraints**			
6	Collection of nuts from large plantations / theft	7	10	13
7	Monkey menace during fruiting	10	4	5
III	**Economic/marketing constraints**			
8	Poor price/ price fluctuation	1	62	83
9	Low availability of hired labour	2	53	71
10	Price control/manipulation by processors	8	9	12
11	Lack of cashew farmer associations/groups	9	9	12
IV	**Processing constraints**			
12	No value for cashew apple/wastage of cashew apple	11	3	4

5.1.5 Technology adoption and socio-economic determinants of cashew farming in North Kerala

5.1.5.1 Socio-personal and economic profile of cashew farmers

Of the 12 socio-personal variables, cashew farmers were equally distributed as far as their age was concerned with mean age of 59 years. Majority had low level of education (7th standard pass) (53%) and 90 per cent had agriculture as their primary occupation. Cashew farmers were equally distributed with respect to their experience in cashew farming with an average experience of 27.7 years. Contact with extension agencies was medium among majority (60%) of the cashew farmers while participation in extension programmes was low for almost half of the farmers. Cashew farmers of 46% exhibited medium level of ICT usage while majority (50%) had low level of cosmopoliteness. Cashew cultivation by most of the farmers (69%) is under rainfed conditions. Majority (59%) of farmers have their cashew plantations away from their homes at an average distance of 1350 m.

The study on economic profile of cashew farmers indicated that each household has on an average 117 number of cashew trees in an area of 1.71 acres with a mean yield of 6.90 kg/tree. The nut yield levels obtained by majority (40%) of the farmers were moderate with an average net income of ₹ 32,000/- per year.

5.1.5.2 Technology utilization status and Socio-economic determinants of farm level adoption of cashew production technologies

The overall adoption of cashew production technologies (CPTs) was very poor in North Kerala with an index score of 29.5 (Table 5.7). The correlation between adoption and socio-personal variables revealed that four socio personal variables *viz.,* extension contact, extension participation of cashew farmers, ICT usage and cosmopoliteness had a significant relationship with farmers' adoption of cashew production technologies. It may be noted that majority of the farmers recorded low levels of extension participation and cosmopoliteness and medium levels of extension contact and ICT usage (Table 5.8).

Table 5.7: Adoption levels of recommended cashew production technologies (n=68)

Cashew Production Technologies	Adoption Index	Rank	S.D.	% farmers under various levels of adoption		
				Low	Medium	High
Planting and Initial care	57.8	1	22.95	29	28	43
Soil and water conservation	22.0	5	24.60	28	51	21
Manures and fertilizers	35.0	2	38.28	51	6	43
Pruning and training	12.3	7	17.76	51	32	16
Plant protection	30.7	3	16.21	32	40	28
Intercropping	20.8	6	40.25	78	1	21
Harvesting and post-harvest	27.6	4	12.60	34	44	22
Overall adoption of CPTs	29.5	-	15.27	43	29	28

Table 5.8: Relationship between adoption and socio-personal variables (n=68)

Sl. No.	Socio-personal variables	'r' value
1	Age	-0.073
2	Level of education	0.113
3	Primary occupation	0.039
4	Experience in farming	0.073
5	Experience in cashew farming	0.003
6	Extension contact	0.298*
7	Extension participation	0.449**
8	ICT usage	0.301*
9	Cosmopoliteness	0.461**
10	Land used for cashew	0.167
11	Land used for other crops	0.037
12	Distance of cashew plot from home	0.169

**Significant at 1% level, *Significant at 5% level

The study on relationship between adoption and economic variables showed that seven economic variables *viz.,* farm size, area under cashew, number of yielding cashew trees, expenditure in agriculture, net income from agriculture, expenditure in cashew farming and net income from cashew farming had significant relationship with adoption of cashew production technologies (Table 5.9).

Table 5.9: Relationship between adoption and economic variables (n=68)

Sl. No.	Economic variables	'r' value
1	Importance given to cashew	0.032
2	Farm size	0.355**
3	Area under cashew	0.354**
4	Cultivable land available	-0.208
5	No. of yielding cashew trees	0.576**
6	Yield of cashew/tree	0.135
7	Expenditure in agriculture	0.439**
8	Net income from agriculture	0.443**
9	Expenditure in cashew farming	0.463**
10	Net income from cashew farming	0.277**

**Significant at 1 % level, *Significant at 5 % level

5.1.5.3 Identifying predictors of adoption of cashew production technologies

Stepwise regression was used to identify predictors and select models explained the variation in adoption of cashew production technologies. In this analysis, four models were tested to examine the variation in adoption among the respondents. Model 4 was found explaining up to 47.5 per cent of the variation in adoption using the predictors (Table 5.10).

Table 5.10: Identifying predictors for adoption of cashew production technologies

Model		Unstandardized Coefficients		Standardized Coefficients	t	Significance
		B	S.E.	Beta		
1	(Constant)	19.199	2.367		8.111	0.000
	CSWTR	0.088	0.015	0.576	5.719	0.000
2	(Constant)	18.743	2.285	8.202	0.000	
	CSWTR	0.072	0.016	0.472	4.482	0.000
	EXTNPTN	0.641	0.256	0.264	2.504	0.015
3	(Constant)	16.846	2.361	7.136	0.000	
	CSWTR	0.052	0.018	0.341	2.922	0.005
	EXTNPTN	0.705	0.249	0.290	2.827	0.006
	AGRINC	3.385	1.467	0.249	2.307	0.024
4	(Constant)	18.948	2.498	7.586	0.000	
	CSWTR	0.076	0.021	0.493	3.683	0.000
	EXTNPTN	0.651	0.244	0.268	2.670	0.010
	AGRINC	6.014	1.882	0.442	3.195	0.002
	FRMSZ	-1.779	0.830	-.353	-2.143	0.036

a. Dependent variable: AI

Model Summary

Model	R	R^2	Adjusted R^2	S.E. of the Estimate
4	0.689[d]	0.475	0.442	11.407

d. Predictors: (Constant), CSWTR, EXTNPTN, AGRINC, FRMSZ

5.1.5.4 Adoption and Impact of different varieties on cashew area, production and productivity

Study on impact of recommended varieties on total cashew area showed that highest area is covered by Priyanka (41%) followed by Madakkathara-2 (18%). The adoption pattern also showed similar trend with respect to varieties (Table 5.11). Analysis of variety-wise impact on cashew production showed that farmers realized the highest yield from variety Sulabha (13.0 kg/tree) followed by Madakkathara-2 (8.0 kg/tree) and Priyanka (7.6 kg/tree), Ullal-3 (6.75 kg/tree) and Vengurla-4 (6.35 kg/tree). The productivity under

normal density planting (8 m x 8 m) was higher for Sulabha (2096 kg/ha) and Madakkathara-2 (1402 kg/ha) which was followed by Priyanka (1215 kg/ha), Ullal-3 (1080 kg/ha) and Vengurla-4 (1016 kg/ha). Plantations under seedling origin reported on an average yield of 5.2 kg/tree with a productivity of 518 kg/ha.

Table 5.11: Varietal adoption and impact on cashew area (n=68)

Variety	Adopted by (% farmers)	Area covered* (%)
Priyanka	44	40.72
Kanaka	7	3.01
Dhana	3	1.24
Bhaskara	4	0.83
Raghav	4	2.05
Madakkathara-2	18	17.76
Sulabha	6	3.32
Amrutha	1	0.64
Vengurla-4	3	0.64
Ullal-3	3	0.71
Total (under recommended varieties)	68**	70.94
Seedling origin	43	29.06

* the percentages won't add up to 100 due to adoption of multiple varieties by a single farmer
** represents total percentage of farmers who have adopted released varieties

5.1.5.5 Contribution of cashew production technologies towards variability in cashew productivity

Regression analysis indicated that the three technologies *viz.,* planting and initial care, plant protection and manures and fertilizers had significant relationship with cashew productivity (Table 5.12).

Table 5.12: Contribution of cashew production technologies towards variability in cashew productivity

Technology	Productivity 'b' value
Varieties	0.274
Planting and initial care	0.385*
Soil and water conservation	-0.038
Manures and fertilizers	0.286*
Pruning and training	-0.196
Plant protection	0.331*
Intercropping	-0.287
Harvesting and post-harvest	0.271
R^2 =0.346	

*Significant at 5% level

5.2 Development of an Interactive and Dynamic Web-space for Cashew Information Management

Under this project, plug-ins like cashew weather advisory and cashew grafts 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. The database on cashew germplasm has been fine tuned with respect to fields such as apple colour and cumulative yield.

ADDITIONAL INFORMATION
6. PROGRAMMES ORGANIZED

6.1 Brainstorming Session on Substitution of NPK requirement using Organic Sources

As part of the orientation training for newly joined scientists of AICRP on Cashew, a brainstorming session on Substitution of NPK requirement using organic sources was organized on 19 May, 2014 at ICAR-DCR, Puttur. Dr. M. Gangadhara Nayak, Principal Scientist and Director In-charge while welcoming experts and delegates mentioned the importance of organic cashew production, which gets a premium price in the global and domestic markets. Dr. T.N. Raviprasad, Principal Scientist (Agrl. Ento.) and Scientist In-charge, PC Cell briefed about the purpose of this session. The session was chaired by Dr. N.P. Singh, Director, Central Coastal Agricultural Research Institute, Goa.

He elaborated the techniques of *in situ* composting and benefits of organic cultivation in terms of soil biota, environmental safety and human health. Dr. A.N. Ganeshamurthy, Principal Scientist (Soil Science), ICAR-IIHR, Bengaluru, Dr. R.A. Ram, Principal Scientist (Hort.), ICAR-CISH, Lucknow, Dr. P. Subramanian, Principal Scientist (Agronomy), ICAR-CPCRI, Kasaragod and Dr. T.R. Rupa, Principal Scientist (Soil Science), ICAR-DCR were the experts for this session.

Brainstorming session in progress

Dr. T.N. Raviprasad, Scientist In-charge, PC Cell moderated the session. During the discussions, the following decisions emerged: 1) The N requirement needs to be met with the locally available cheapest organic source *viz.*, neem cake, pongamia cake, castor cake, sal cake, FYM, vermicompost, sheep/ goat manure etc.; 2) Use of various green leaf manuring crops to provide the N requirement based on the local situations and recycling of residues; 3) Evaluating the microbial consortium having *Pseudomonous* spp., *Bacillus* spp. etc. and dolomite addition and 4) Evaluating biodynamic compost, need based herbal pesticides derived from calotropis and neem may be done.

6.2 Foundation Day of ICAR-DCR: Cashew Farmers Meet - 2014

The ICAR-Directorate of Cashew Research, Puttur celebrated its Foundation day on 18 June, 2014. Cashew Farmers Meet - 2014 was organized to mark the occasion in which more than 150 cashew farmers participated besides nursery men, representatives of KVK, development departments, NGOs and scientists. Dr. M.G. Nayak, Principal Scientist and Director In-charge, ICAR-DCR, in his welcome address explained about the technology transfer activities carried out at this Directorate. Chief Guest of the function Shri. A.B. Ibrahim, IAS, Deputy Commissioner, D.K. District, Karnataka, appreciated the efforts being made by the Directorate in demonstrating the technologies at farmers' fields in order to enhance the productivity of cashew. He emphasized that the cashew apple needs to be utilized more efficiently. He also addressed some of the issues like marketing and subsidy for cashew cultivation which were

raised by cashew farmers. Dr. George V. Thomas, Director, ICAR-CPCRI, Kasaragod was the Guests of Honour. Prof. R.K. Pathak, Former Director, ICAR-CISH, Lucknow in his Foundation Day Lecture on 'Jaivik Cashew for Export Promotion and Domestic Consumption' explained about the various basic and applied aspects of input and crop health management under organic farming. Prof. P.L. Saroj, Director, ICAR-DCR, Puttur, highlighted the technologies developed by the Directorate and urged farmers to adopt technologies for better

Shri A.B. Ibrahim, IAS, Deputy Commissioner, D.K. District, Karnataka, addressing the gathering

Smt. Thulasi Maddineni, IAS, Chief Executive Officer of Dakshina Kannada Zilla Panchayat, Karnataka distributing cashew grafts to tribal farmers

profit. Innovative cashew farmers from Karnataka were felicitated on this occasion. Technical bulletins on 'Rejuvenation Techniques in Cashew' and 'Geru Maragala Punaschethana Tantrikathe' (Kannada) were released. This was followed by a farmer - scientist interaction session.

6.3 Orientation Training on Establishment of Cashew Orchard

Orientation training on Establishment of cashew orchards under Tribal Sub Plan (TSP) was organized at ICAR-DCR, Puttur on 5 September, 2014. A total of 30 tribal farmer participants attended the programme. Dr. M.G. Nayak, Principal Scientist (Hort.), ICAR-DCR welcomed the gathering and presented the objectives of the TSP and expected outcome. The programme was inaugurated by the Chief Guest Smt. Thulasi Maddineni, IAS, Chief Executive Officer of Dakshina Kannada Zilla Panchayat, Karnataka. Smt. Thulasi Maddineni said those who have taken the benefit under the tribal sub-plan of the Central Government can make use of the national rural employment guarantee scheme to grow mixed crops in their cashew plantations. Added to this, they can also consider taking up bee-keeping activities in their areas. All these measures will help improve their income levels, she said. She assured of her full support and cooperation for cashew farmers of D.K. district. Smt. Meenakshi Manjunath, Member, Zilla Panchayat, D.K. District, Karnataka suggested the tribal farmers to make the best use of the training and support provided by ICAR-DCR under TSP. She further suggested the farmers to take up cashew cultivation for their own economic and livelihood upliftment and not for the sake of subsidy.

Prof. P.L. Saroj, Director, ICAR-DCR, gave an overview of cashew research and development in India. He urged the beneficiaries to make use of the opportunities to improve the productivity of their orchards. He expressed his view on different research strategies and technologies

developed to enhance productivity of cashew. He felt the need of adoption of improved technologies and varietal replacement for sustained cashew production in farmers fields. Sri. K. Subash Rai, a pogressive cashew farmer shared his experiences in cashew cultivation. Field visits were arranged at this Directorate and in a demonstration plot at Kadamajalu village of Puttur taluk, Karnataka. On this occasion, cashew grafts of high yielding varieties were distributed to the tribal farmers. Dr. P.S. Bhat, Principal Scientist, ICAR-DCR proposed the vote of thanks.

6.4 Cashew Day and Interaction Meet with Tribal Farmers

The ICAR-Directorate of Cashew Research, Puttur organized Annual cashew day and Interaction meet with Tribal farmers under ICAR Tribal Sub Plan on 20 February, 2015. More than 150 cashew farmers participated besides nursery men, representatives of KVK, development departments, NGOs and scientists. The Hon'ble member of parliament, Dakshina Kannada district, Shri. Nalin Kumar Kateel was the Chief Guest and Dr. C. Vasudevappa, Vice Chancellor, University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka was the Guest of Honour. Prof. P.L. Saroj, Director ICAR-DCR presided over the meeting. Dr. M.G. Nayak, Principal Scientist (Hort.), ICAR-DCR welcomed the dignitaries and participants and gave an account of efforts being made under the tribal sub plan including NEH region.

Shri. Nalin Kumar Kateel, stressed upon the need of elevating the status of cashew cultivation and better income from cashew farming. He appreciated the research efforts made by ICAR-DCR, in developing improved technologies for cashew production and called for wider outreach of the technologies in collaboration with development departments. Prof. P.L. Saroj, in his presidential address, suggested the farmers to adopt cashew production technologies developed by this

Shri. Nalin Kumar Kateel, Hon'ble member of parliament, D.K. District, Karnataka inaugurating the meet

Directorate for obtaining better income. This was followed by a farmer – scientist interaction session.

6.5 Training Programmes

6.5.1 Training on cashew production technology

A three days training programme on Cashew production technology was organized at ICAR-DCR during 7-9 January, 2015 for the officials of BAIF, Pune in which eleven participants from Maharashtra, Gujarat and Madhya Pradesh attended. Various aspects of cashew improvement, production, protection, processing and transfer

Group photo of the participants with resource persons

of technology efforts were explained to the participants during this programme.

6.5.2 Training on cashewnut processing

A three days training programme on Cashewnut processing was organized at ICAR-DCR during 26-

28 March, 2015. The major focus of the training was on grading of raw cashewnuts, maintenance of processing machineries and preparation of value added products from cashewnut and apple. Fifteen women from Self Help Group (SHG) Saphalam Cashew Processors Society under Kudumbashree, Kasaragod attended the training programme.

6.6 Exhibitions

- 18-20 October, 2014 - Krishi Mela organized at University of Agricultural and Horticultural Sciences (UAHS), Shivamogga, Karnataka. This Directorate put up stall to display various cashew production and processing technologies to the farmers.
- 1-3 December, 2014 - ICAR-Central Horticultural Experiment Station (CHES) Golden Jubilee Exhibition at ICAR-CHES, Chettalli. This Directorate put up stall to display various cashew production and processing technologies to the farmers.

Delegates in ICAR-DCR stall

- 10-12 December, 2014 - International Symposium on Plantation Crops (PLACROSYM XXI) organized at ICAR-Indian institute of Spices Research, Kozhikode, Kerala. This Directorate put up stall to display various cashew production and processing technologies to the farmers.
- 10 January, 2015 - Krishi Mela organized at ICAR-CPCRI Regional Station Vittal, Karnataka. This Directorate put up stall to display various cashew production and processing technologies to the farmers.
- 24-26 January, 2015 - Krishi Yantra Mela organized at Vivekananda Engineering College, Puttur, Karnataka by The Central Arecanut and Cocoa Marketing and Processing Co-operative Limited (CAMPCO). On-farm Cashewnut Processing was highlighted in this stall wherein machineries required for on-farm processing were exhibited.
- 14-15 March, 2015 - Kaju Summit organized at TMA Pai International Convention Centre, Mangalore by Karnataka Cashew Manufacturers Association. cashew apple processing was highlighted in this stall wherein products made out of cashew apple were exhibited.

6.7 Establishment of Demonstration Plots

The demonstration plots established in farmers' fields at Puttur, Sullia and Bantwal taluks of Dakshina Kannada district of Karnataka with the financial support of NHM programme of DCCD, Kochi were monitored regularly by the Scientists of this Directorate during the period and technical advice was given as and when required.

6.8 Area Expansion under TSP

Under TSP programme, 25 new Frontline demonstration plots were established in tribal farmer fields of Dakshina Kannada district, Karnataka. The plots were monitored regularly by the team of Scientists of this Directorate during the period and technical advice was given as and when required. A subsidy of ₹ 3,72,000/- has been distributed to the farmers as first year installment.

6.9 Advisory Visits / Consultancy

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

7. LINKAGES AND COLLABORATIONS

Organization	Area of collaboration
ICAR-National Bureau of Agriculturally Important Insects (NBAII), Bengaluru	Identification of kairomones/ pheromones of major pests of cashew.
ICAR-Indian Institute of Horticultural Research (IIHR), Bengaluru	Biosystematics of tea mosquito bug and natural enemies.
University of Agricultural Sciences (UAS), GKVK, Bengaluru ICAR-Indian Agricultural Research Institute (IARI), New Delhi	Identification of arthropod fauna associated with cashew.
Directorate of Cashewnut and Cocoa Development (DCCD), Kochi	Training programmes for farmers and frontline demonstrations.
• Department of Horticulture, Karnataka • Horticultural Research Station, Ullal, Mangalore • Zonal Agricultural Research Station, Brahmavar, Udupi district, Karnataka	Training programmes for farmers and Krishi melas.
KVK, Mangaluru	Transfer of technology
AICRP-Cashew Centres located in SAUs / ICAR Institutes material.	Multilocational testing, exchange of research findings / germplasm / planting

8. TRAINING AND CAPACITY BUILDING

Deputation abroad		
Nayak, M.G.	Visited Russia in the delegation sponsored by DBT, New Delhi under the programme exposure visit of Indian scientists of F and G level.	13-20 September, 2014
Other training programmes		
Rajkumar Arjun Dagadkhair	Professional attachment training in the discipline of Food Technology at ICAR-NRC for Grapes, Pune, Maharashtra.	12 May – 11 August, 2014
Babli Mog	Professional attachment training in the discipline of Plant Physiology at ICAR-IARI, New Delhi.	16 May – 16 August, 2014
Sajeev, M.V.	Workshop on open access to agricultural knowledge for inclusive growth and development at ICAR-NAARM, Hyderabad.	29-30 October, 2014
Vanitha, K.	ICAR sponsored winter school on advances in pest forecast models and decision support systems for crop protection in changing climate scenario conducted at ICAR-CRIDA, Hyderabad.	29 October - 18 November, 2014
Eradasappa, E.	CAFT training on modern tools and techniques for plant breeding in the era of genomics at TNAU, Coimbatore, Tamil Nadu.	12 November - 2 December, 2014
Nayak, M.G.	Training on emotional intelligence for self and organisation development at ICAR-NAARM Hyderabad.	23-28 November, 2014
Vanitha, K.	Training programme on taxonomy of bees and other insect pollinators under niche area of excellence project on capacity building in taxonomy of insects and mites at University of Agricultural Sciences, GKVK, Bengaluru.	29 December, 2014 to 3 January, 2015

Budget (2014-15)

Allocation : ₹ 2,00,000.00 Utilisation : ₹ 2,01,938.00

Budget (Approx.) proposed for trainings : 2015-16 : ₹ 3,00,000.00

Subject area of Training

- Physiological and hormonal basis of flowering, fruiting and biomass partitioning in perennial trees and fruit crops
- Designing and analysis of experiments
- Rootstock studies
- Stress management
- Management development programme
- D-space/Koha open access software/e-book
- Competency enhancement programme for technical officers
- Recruitment rules and maintenance of roster
- Office automation and office management
- Oracle ERP/MIS FMS
- Income tax related issues

9. PUBLICATIONS

9.1 Research Publications

9.1.1 International

Adiga, J.D., Kalaivanan, D., Meena, R.K., Mohana, G.S. and Lakshmipathi 2014. Performance of vigorous cashew cultivars as Influenced by dwarf rootstocks. *Vegetos,* 27(2): 233-239.

Balasubramanian, D. and Sandeep, T.N. 2014. Drying behaviour of unpeeled cashew kernels in steam assisted cross flow dryer. *International Journal of Agricultural Engineering,* 7(2): 307-312.

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

Srikumar, K.K., Bhat, P.S., Raviprasad, T.N., Vanitha, K., Saroj, P.L. and Ambrose, D.P. 2014. Biology and behavior of six species of reduviids (Hemiptera: Reduviidae: Harpactorinae) in cashew ecosystem. *Journal of Agricultural Urban Entomology,* 30: 65-81.

Srikumar, K.K., Bhat, P.S., Vanitha, K., Rajmohana, K. and Raviprasad, T.N. 2014. Phenology and parasitization behaviour of *Telenomus cuspis* egg parasitoid of *Helopeltis antonii* (Hemiptera: Miridae) on cashew. Proceedings of National Academy of Sciences, India, Section B: Biological Sciences DOI 10.1007/s 40011-0-14-0365-0.

Vanitha, K., Srikumar, K.K. and Bhat, P.S. 2014. Record of weed flora of cashew plantations as hosts of tea mosquito bug. *The Ecoscan,* 8(3&4): 221-224.

9.1.2 National

Balasubramanian, D. and Joycy, R.L.K. 2014. Performance evaluation of mechanized shelling machine for steam treated raw cashewnuts. *Journal of Plantation Crops,* 42(2): 185-190.

Bhat, P.S. and Srikumar, K.K. 2013. Genitalia structure examination for inter-specific mating of *Helopeltis antonii* and *H. theivora. Current Science,* 105(1): 23-25.

Bhat, P.S. and Srikumar, K.K. 2014. Occurrence of parasitoid *Leiphron* sp. (Hymenopterra: Braconidae) on adults of *Helopeltis antonii* Signoret in cashew. *Journal of Horticultural Sciences,* 9(1): 103-105.

Eradasappa, E., Mohana, G.S., Thimmappaiah and Saroj, P.L. 2014. Pollen fertility in cultivated and wild species of cashew. *Journal of Plantation Crops*, 42(2): 268-271.

Lakshmipathi., Dinakara Adiga, J., Kalaivanan, D., Mohana, G.S. and Ramkesh Meena 2015. Effect of growth regulators on leaf area and yield of cashew (*Anacardium occidentale* L.) var. Bhaskara. *Ecology Environment and Conservation,* Suppl. 20, pp. 21-23.

Lakshmipathi., Dinakara Adiga, J., Kalaivanan, D., Mohana, G.S. and Ramkesh Meena, 2015. Effect of foliar application of certain micronutrients on photosynthesis and yield of cashew (*Anacardium occidentale* L.) var. Bhaskara under South West Coast region of Karnataka. *Ecology Environment and Conservation,* 21(1): 1-4.

Lakshmipathi., Dinakara Adiga, J., Kalaivanan, D., Mohana, G.S. and Ramkesh Meena 2015. Effect of plant growth regulators, quadrants and time of the day on photosynthetic activity in cashew (*Anacardium occidentale* L.) var. Bhaskara. *Ecology Environment and Conservation,* Suppl. 20, pp. 25-28.

Lakshmipathi, Dinakara Adiga, J, Kalaivanan, D., Mohana, G.S. and Meena, R.K. 2015. Effect of foliar application of micronutrients on reproductive growth of cashew (*Anacardium occidentale* L.) under south west coast region of Karnataka, India. *Trends in Biosciences*, 8(2): 447-449.

Sajeev, M.V. and Saroj, P.L. 2014. Technology utilization and its socio-economic determinants among cashew farmers of Karnataka. *Indian Research Journal of Extension Education,* 14(3): 59-65.

Sajeev, M.V., Saroj, P.L. and Lakshmisha, R. 2014. Technology impacts on area, production and productivity of cashew in Dakshina Kannada district, Karnataka. *Journal of Plantation Crops,* 42(1): 62-69.

Sajeev, M.V., Saroj, P.L. and Lakshmisha, R. 2014. Socio-economic correlates and determinants of cashew productivity: An analysis of Dakshina Kannada District. *Journal of Plantation Crops,* 42(2): 215-222.

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

Saroj, P.L., Mohana, G.S., Adiga, J.D. and Eradasappa, E. 2014. New vistas in cashew breeding. *Agrotechnology* Open Access Journal 2014, 2:4 http://omicsgroup.org/journals/agrotechnology.php.

Saroj, P.L. and Rupa, T.R. 2014. Cashew research in India: Achievements and strategies. *Progressive Horticulture,* 46(1): 1-17.

Srikumar, K.K., Bhat, P.S., Raviprasad, T.N. and Vanitha, K. 2014. Biology, behaviour and functional response of *Cydnocoris gilvus* Brum. (Heteroptera: Reduviidae: Harpactorinae) a predator of Tea Mosquito Bug (*Helopeltis antoni*i Sign.) on cashew in India. *Journal of Threatened Taxa,* 6(6): 5864-5870.

9.2 Papers presented in Symposia/Workshops/ Seminars

Adiga, J.D., Mohana, G.S. and Eradasappa, E. 2015. Inter-specific hybridization in cashew. In: National Meet on Distant Hybridization in Horticultural Crop Improvement. ICAR-IIHR, Bengaluru, 22-23 January, 2015, pp.269.

Balasubramanian, D. 2014. Moisture sorption characteristics of cashew kernels. International Symposium on Plantation Crops (PLACROSYM XXI), ICAR-IISR, Kozhikode, Kerala, 10-12 December, 2014.

Balasubramanian, D. 2014. Achievements of ICAR-DCR in intellectual property and technology management. Annual Meet cum Workshop jointly conducted by Zonal Technology Management Unit, ICAR-Central Institute of Fisheries Technology, Cochin and ICAR-Indian Institute of Horticulture Research Institute, Bengaluru at ICAR-IIHR, Bengaluru, 9 October, 2014.

Balasubramanian, D. 2015. DCR-Technologies for commercialization. In: Horticulture Institute Industry Institute Meet conducted by ICAR-IIHR, Bengaluru, 10 February, 2015.

Balasubramanian, D., Saroj, P.L., Meena, R.K. and Vanitha, K. 2014. Research status of technological development of cashew in India. In: National Conference on Cashew - Strategies for cashew development in non-traditional areas, jointly organized by DCCD, Kochi and Department of Horticulture, State Horticulture Department, Jharkhand, pp. 195-204.

Kalaivanan, D. and Meena, R.K. 2014. High density planting system for higher production and productivity in cashew. In: International conference on Bioscience - State of the art Advancement, 11-12 September, Kottayam, Kerala, pp. 83.

Dinakara Adiga, J., Mohana, G.S. and Eradasappa, E. 2015. Interspecific hybridization in cashew. Souvenir of lead papers and abstracts-National Meet on Distant Hybridization in Horticultural Crop Improvement, 22-23 January, 2015, ICAR-IIHR, Bengaluru, pp. 269.

Dinakara Adiga, J., Eradasappa, E., Mohana, G.S., Meena, R.K. and Nayak, M.G. 2014. Seedling selection in cashew. In: International Symposium on Plantation Crops (PLACROSYM XXI), ICAR-IISR, Kozhikode, Kerala, 10-12 December, 2014, pp. 41.

Ganga Visalakshy, P.N., Swathi, C., Bhat, P.S., Babu, A., Srikumar, K.K. and Darshana, C.N. 2014. Cross infectivity and bioassay studies of entomopathogens *Beauveria bassiana* isolates against *Helopeltis* spp infesting plantation crops In: International Symposium on Plantation Crops (PLACROSYM XXI), ICAR-IISR, Kozhikode, Kerala, 10-12 December, 2014.

Nayak, M.G. 2015. Problem and prospects of cashew cultivation in India. In: National Seminar on Sustainable Horticulture organized by North East Horticultural Society at Medziphema, Nagaland, 26-29 February, 2015.

Nayak, M.G. 2015. Techniques for rejuvenation of senile cashew orchards. In: National Seminar: The Cashew Prospective Future Crop at Panjim, Goa by DCCD, Kochi, 13-14 March, 2015.

Lakshmipathi., Dinakara Adiga, J., Kalaivanan, D., Mohana, G.S. and Meena, R.K. 2014. Effect of foliar application of micronutrients on reproductive growth of cashew (*Anacardium occidentale* L.) under south west coast region of Karnataka, India. In: International Symposium on Plantation Crops (PLACROSYM XXI), ICAR-IISR, Kozhikode, Kerala, 10-12 December, 2014, pp. 81.

Lakshmipathi., Adiga, J.D., Kalaivanan, D., Mohana, G.S. and Meena, R.K., 2014. Effect of foliar application of certain micronutrients on photosynthesis and yield of cashew (*Anacardium occidentale* L.) var. Bhaskara under south west coast region of Karnataka. In: International Symposium on Plantation Crops (PLACROSYM XXI), ICAR-IISR, Kozhikode, Kerala, 10-12 December, 2014, pp. 84.

Lakshmipathi., Adiga, J.D., Mohana, G.S. and Meena, R.K. 2015, Effect of post germination treatment with GA3 and NAA on growth of cashew (*Anacardium occidentale* L.) seedlings. In: National Biodiversity Congress, Thiruvananthapuram, 23-27 February, 2015, pp. 443-453.

Lakshmipathi., Dinakara Adiga, J., Kalaivanan, D., Mohana, G.S. and Meena, R.K. 2014. Effect of foliar application of certain micronutrients on photosynthesis and yield of cashew (*Anacardium occidentale* L.) var. Bhaskara under south west coast region of Karnataka. International Conference on Bioscience - State of the art Advancement, 11-12 September, 2014, Kottayam, Kerala, pp. 84.

Meena, R.K., Nayak M.G, Adiga, J.D. and Saroj, P.L. 2014. Effect of paclobutrazol on flowering, fruiting and yield of cashew in west coast region of Karnataka, India. In: International Symposium on Plantation Crops (PLACROSYM XXI), ICAR-IISR, Kozhikode, Kerala, 10-12 December, 2014, pp. 82.

Mohana, G.S., Nayak, M.G. and Eradasappa, E. 2014. Genetic architecture of cashew germplasm. In: International Symposium on Plantation Crops (PLACROSYM XXI), ICAR-IISR, Kozhikode, Kerala, 10-12 December, 2014, pp. 24.

Raviprasad, T.N. and Bhat, P.S. 2014. Efficacy of certain food grade repellents against *Ephestia cautella* Wlk infesting stored cashew kernels. In: International Symposium on Plantation Crops (PLACROSYM XXI), ICAR-IISR, Kozhikode, Kerala, 10-12 December, 2014, pp. 84.

Rupa, T.R. and Kalaivanan, D. 2014. Soil N, P and K fractions in response to nutrient management strategies under mature cashew plantation. In: National Seminar on Developments in Soil Science - 2014: 79th Annual Convention of the Indian Society of Soil Science, Acharya N.G. Ranga Agricultural University, Hyderabad, 24-27 November, 2014.

Sajeev, M.V. and Saroj, P.L. 2014. Impact of technology on cashew production: An analysis. In: 7th National Extension Education Congress, ICAR Research Complex for NEH Region, Umiam, Meghalaya, 8-11 November, 2014.

Saroj, P.L. 2015. Present status and strategies for enhancing cashewnut production. In: Souvenir of National Seminar on Sustainable Horticulture vis-à-vis Changing Environment, SASRD, Nagaland University, Medziphema, 26-28 February, 2015, pp. 62-72.

Saroj, P.L. and Nayak, M.G. 2014. Advances in production technology of ber and karonda. In: Souvenir of National Seminar on Strategies for Conservation, Improvement and Utilization of Underutilized Fruits, ICAR-CHES, Chettali, 1-3 December, 2014, pp. 166-174.

Saroj, P.L., Nayak, M.G. and Meena, R.K. 2014. Physiology of flowering, fruit and nut development in cashew. In: Souvenir of National Seminar-cum-Workshop on Physiology of Flowering in Perennial Fruit Crops, ICAR-CISH, Lucknow, 24-26 May, 2014, pp. 105-114.

Saroj, P.L., Mohana, G.S., Adiga, J.D. and Eradasappa, E. 2014, New vistas in cashew breeding. Proceedings of the 3rd International Conference on Agriculture and Horticulture, HICC, Hyderabad, India. P. 91.

Saroj, P.L., Adiga, J.D. and Balasubramanian, D. 2014. Research and development in cashew-world scenario. In: Souvenir of International Symposium on Plantation Crops, 10-12 December, 2014, pp. 49-71.

Srikumar, K.K. and Bhat, P.S. 2014. Effects of seven host plants on biology of tea mosquito bug. International Symposium on Plantation Crops (PLACROSYM XXI), ICAR-IISR, Kozhikode, Kerala, 10-12 December, 2014.

Vasanthi, P. and Raviprasad, T.N. 2014. Species composition of cashew stem and root borers in cashew plantations in India. In: 3rd Indian Bio-diversity Congress, 12-15 December, 2014. SRM University, Chennai, Tamil Nadu, India.

9.3 Book Chapters

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

Saroj. P.L., Adiga, J.D. and Balasubramanian, D. 2015. Research and development in cashew-world scenario. In: Souvenir, International Symposium on Plantation Crops (Eds: R. Dinesh, J.E. Santhosh, C.M. Senthil Kumar, K. Prathapan, R Ramakrishnan Nair, T.J. Zohn Zachariah and M. Ananada Raj), ICAR-IISR, Kozhikode, Kerala, pp. 49-71.

Saroj, P.L. and Rupa, T.R. 2014. Prospects of cashew cultivation under changing climatic conditions. In: Climate Dynamics in Horticultural Science: Principles and Applications, Vol. I. (Eds. Choudhary, M.L. *et al.*); Pub. Apple Academic Press Inc. Canada, pp. 85-104.

9.4 Technical Reports / Compendia

Annual Report 2013-14. ICAR-Directorate of Cashew Research, Puttur, pp. 112 (Eds: P.S. Bhat and T.R. Rupa).

Annual Report 2013-14. All India Co-ordinated Research Project on Cashew. ICAR-Directorate of Cashew Research, Puttur, pp. 137 (Eds: T.N. Raviprasad and P.L. Saroj).

Cashew News, 2014. ICAR-Directorate of Cashew Research, Puttur, Vol.19 (1), pp. 12 (Eds: T.R. Rupa and M.V. Sajeev).

Cashew News, 2014. ICAR-Directorate of Cashew Research, Puttur, Vol.19 (2), pp. 12 (Eds: T.R. Rupa and M.V. Sajeev).

9.5 Extension Bulletins / Pamphlets

Kalaivanan, D. and Vanitha, K. 2014. Mundiri sagupadi thozhilnutpangal (Tamil). ICAR– Directorate of Cashew Research, Puttur, pp. 6.

Nayak, M.G., Bhat, P.S. and Raviprasad, T.N. 2014. Rejuvenation techniques in cashew. ICAR-Directorate of Cashew Research, Puttur, pp. 6.

Nayak, M.G., Bhat, P.S., Raviprasad, T.N. and Eradasappa, E. 2014. Geru Maragala Punashetana Tantrikate - Rejuvenation techniques in cashew (Kannada). ICAR–Directorate of Cashew Research, Puttur, pp. 6.

9.6 Technical Bulletin

Nayak, M.G., Mohana, G.S., Bhat, P.S., Saroj, P.L. and Swamy, K.R.M. 2015. Minimum descriptors of cashew germplasm accessions: catalogue-IV. ICAR-Directorate of Cashew Research, Puttur, pp. 15.

9.7 Technical / Popular Articles

Balasubramaniam, D. and Saroj, P.L. 2014. Exploring untapped potential of cashew apple for masses. *Indian Horticulture,* 59(6): 42-49.

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

Bhat, P.S. and Krishna Kumar, N.K. 2014. Reaping cashew free from pests infestations. *Indian Horticulture,* 59(6): 61-62.

Mohana, G.S., Nayak, M.G. and Eradasappa, E. and Meena, R.K. 2014. Study of cashew germplasm: A genetic approach. *Cashew News,* 19(2): 3-5.

Rupa, T.R. and Pandey, V. 2014. Feeding cashew trees the high-tech way. *Indian Horticulture,* 59(6): 57-60.

Saroj, P.L., Bhat, P.S. and Rupa, T.R. 2014. Advances in improving cashew productivity (in Marathi). *Caju Phal Vikash Vrita Patrika,* April-June, 2014, pp. 13-21.

Saroj, P.L., Krishna Kumar, N.K. and Janakiram, T. 2014. Converting wasteland into goldmine by cashew cultivation. *Indian Horticulture*, 59(6): 49-56.

10. राजभाषा कार्यान्वयन एवं प्रगति

राजभाषा कार्यान्वयन समिति

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

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

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

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

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

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

राजभाषा के प्रति जागरुकता पैदा कराने हेतु राजभाषा विभाग की ओर से जारी किए गए वार्षिक कार्यक्रम के अनुसार इस निदेशालय में 14 सितंबर से हिंदी पखवाड़ा समारोह विभिन्न प्रतियोगिताओं जैसे, हिंदी निबंध लेखन, प्रारूप, टिप्पण एवं मसौदा लेखन प्रतियोगिता, स्मरण परीक्षा प्रतियोगिता के साथ आयोजित की गई है। प्रतियोगिताओं के विजेताओं को पुरस्कार भी वितरण किया जाता है। इसके अतिरिक्त सरकारी काम काज में हिंदी का अधिकाधिक प्रयोग करने वाले अधिकारियों एवं कर्मचारियों को इस अवसर पर मुख्य अतिथि द्वारा प्रोत्साहन योजना के अधीन नकद पुरस्कार वितरण किया जाता है।

मुख्य अतिथि द्वारा दीप प्रज्वलन

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

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

वेबसाइट का प्रदर्शन

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

हिंदी कार्यशाला

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

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

पुत्तूर नगर राजभाषा कार्यान्वयन समिति (नराकास)

पुत्तूर और विट्टल में स्थित केंद्रीय सरकार के कार्यालय, उपक्रम, बैंक सहित 22 सदस्य कार्यालय सम्मिलित कर नगर राजभाषा कार्यान्वयन समिति, पुत्तूर की पच्चीसवीं अर्धवार्षिक बैठक दिनांक 25.07.2014 को और दिनांक 22.01.2015 को छब्बीसवीं अर्धवार्षिक बैठक निदेशक महोदय की अध्यक्षता में आयोजित की गई।

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

निदेशालय में निम्नलिखित रिपोर्ट हिंदी में प्रकाशित किया गया

1. निदेशालय के वार्षिक प्रतिवेदन (वर्ष 2013-14) पूर्ण रूप से हिंदी में।
2. अखिल भारतीय समन्वित काजू अनुसंधान परियोजना, वार्षिक प्रतिवेदन सारांश (वर्ष 2013-14)।
3. काजू समाचार में हिंदी समिती की गतिविधियों के बारे में प्रतिवेदन।
4. नित्यप्रति प्रयोग में आने वाले फार्मों का हिंदी रुपान्तरण।

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

11. AWARDS / RECOGNITIONS

- Prof. P.L. Saroj: Nominated as Executive Councellor, Horticulture Society of India for second consecutive term.
- Prof. P.L. Saroj: Chairman for a Technical Session 'Post harvest management of underutilized fruits' in the National Seminar on Strategies for Conservation, Improvement and Utilization of Underutilized Fruits at ICAR-CHES, Chettalli, 1-3 December, 2014.
- Prof. P.L. Saroj: Chairman, Technical Session 'Varietal wealth and genetic resources' in the International Symposium on Plantation Crops at ICAR-IISR, Kozhikode, Kerala, 10-12 December, 2014.
- Prof. P.L. Saroj: Co-Chairman, Technical Session 'Production technology of fruits and plantation crops' in the National Seminar on Sustainable Horticulture vis-à-vis Changing Environment at SASRD, Nagaland University, Medziphema, 26-28 February, 2015.
- Prof. P.L. Saroj: Chairman, 'Interface Meeting with Line Departments and Cashew Farmers' on 27 February, 2015 at Nagaland University, Medziphema (Nagaland).
- Dr. P.S. Bhat: Guided Mr. K.K. Srikumar, Research Scholar, for award of degree of Doctor of Philosophy at Mangaluru University, Mangaluru for his thesis entitled 'Bio-systematics, comparative biology and management of tea mosquito bug (*Helopelt*is spp) in cashew (*Anacardium occidentale* L.).
- Dr. J.D. Adiga: Best participant award in International Conference on Biosciences, Kumarakom, Kottayam, Kerala, 11-12 September, 2014.
- Dr. M.V. Sajeev: Best paper award for the paper entitled 'Impact of Technology on Cashew Production: An Analysis' in the 7th National Extension Education Congress, ICAR Research Complex for NEH Region, Umiam, Meghalaya, 8-11, November, 2014.
- Dr. K. Vanitha: Recognized as one of the outstanding participants in the ICAR sponsored winter school on Advances in Pest Forecast Models and Decision Support Systems for Crop Protection in Changing Climate Scenario' during 29 October to 18 November, 2014 at ICAR-Central Research Institute for Dryland Agriculture, Hyderabad.

12. RAC / IRC / IMC / IJSC METINGS

12.1 Research Advisory Committee

Dr. P. Rethinam, Former Executive Director (APCC), Bhagireth, 18, Lakshmi Nagar, S.N. Palayam, Sugarcane Breeding Institute P.O., Coimbatore - 641 007, Tamil Nadu.	Chairman
Dr. K.U.K. Nampoothiri, Former Director, ICAR-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, ICAR-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, ICAR-Directorate of Cashew Research, Puttur - 574 202, Karnataka.	Member Secretary

The third meeting of the VIth RAC (18th meeting) of the Directorate was held during 7-8 May, 2014 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. Dr. K.U.K. Nampoothiri, Former Director, ICAR-CPCRI and M.S. Swaminathan Research Foundation, Jeypore, Odisha; Dr. S. Chandrasekharan, Professor, Centre of Plant

RAC meeting in progress

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 Committee made field visits to various experimental plots in Kemminje as well as Shantigodu campuses of the Directorate. The Chairman and members appreciated the approaches in conserving wide ranging types of cashew germplasm, evaluation of cashew varieties suitable for apple characteristics, developing hybrids for dwarfness, multiplication of uniform root stocks. Later, the progress made under various research projects were discussed. After detailed discussion, recommendations were finalized for submission to the Council. The Committee laid stress on identifying germplasm from nontraditional areas, developing methods for multiplication of uniform root stocks, standardizing fertigation to enhance yields, usage of micronutrients, developing semio-chemical based pest management practices with additional efforts on evaluation and conservation of bio-control agents. The Committee also opined that the technologies developed by the Directorate need to be demonstrated in the farmers' plots in the vicinity of the Directorate. The meeting came to an end with vote of thanks by Dr. T.N. Raviprasad, Member Secretary, RAC.

12.2 Institute Research Committee

The 27th IRC meeting of ICAR-DCR was held during 4-5 July, 2014 and 20 October, 2014 under the Chairmanship of Prof. P.L. Saroj, Director, ICAR-DCR. Dr. G.S. Mohana, Senior Scientist and Member Secretary welcomed the experts and scientists. Prof. P.L. Saroj, in his introductory remarks denoted the importance of IRC meeting and the need for in detail discussions to be made in research projects. Dr. G.S. Mohana presented the general recommendations and Action Taken Report of 5th QRT, 17th RAC and 26th IRC meetings. There were technical sessions on Crop Improvement chaired by Dr. P.C. Tripathi, Principal Scientist & Head, ICAR-Central Horticultural Experiment Station (IIHR), Chettalli, Kodagu district, Karnataka; Crop Management chaired by Dr. Reju M. Kurian, Principal Scientist, Division of Fruit Crops, ICAR-IIHR, Bengaluru; Crop Protection chaired by Dr. A. K. Chakravarthy, Head, Division of Entomology and Nematology, ICAR-IIHR, Bengaluru; Post Harvest Technology Chaired by Dr. C.K. Narayana, Principal Scientist, Division of Post Harvest Technology, ICAR-IIHR, Bengaluru and, Transfer of Technology chaired by Prof. M.S. Nataraju, Professor and Head (Agricultural Extension), Regional Centre, NAEB,

IRC meeting in progress

University of Agricultural Sciences, GKVK, Bengaluru. The scientists of the Directorate presented progress made under various projects and technical programme of all the projects was finalized.

12.3 Institute Management Committee

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

The Institute Management Committee (IMC) met twice on 12 August, 2014 and 17 March, 2015. The activities of the Directorate were appraised to the IMC during the meetings. The IMC strongly recommended for the filling of the vacant posts for smooth functioning of the activities of the Directorate.

12.4 Institute Joint Staff Council

Official side	Status
Prof. PL. Saroj	Chairman
Dr. T.R. Rupa	Member
Dr. G.S. Mohana	Member
Shri. K.M. Lingaraja	Member
Shri. R. Arulmony	Member
Dr. K. Vanitha	Member Secretary
Staff side	
Smt. K. Padminikutty	Member
Smt. K. Reshma	Member
Shri. Ravishankar Prasad	Member Secretary
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. All issues related to staff welfare were addressed.

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, 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, E. Eradasappa and P.L. Saroj).
1.2.1	Development of dwarf and compact cashew hybrids suitable for high density planting (E. Eradasappa, G.S. Mohana and J.D. Adiga).
1.8.1	Genetic analysis of mapping population through molecular markers for important traits in cashew (G.S. Mohana, 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 Babli Mog).
2.15	Root stock studies in cashew (J.D. Adiga, M.G. Nayak).
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 , J.D. Adiga and Babli Mog).
2.19	Irrigation requirement for cashew under high density planting system (Ramkesh Meena and T.R. Rupa).
2.20	Organic farming in cashew (T.R. Rupa and P.S. Bhat).
2.21	Establishment of nutrient diagnostic norms in cashew (T.R. Rupa).
2.22	Physiological Responses of cashew to salt and drought stresses (Babli Mog and T.R. Rupa).
3.	**CROP PROTECTION**
3.17	Biodiversity of arthropod fauna in cashew eco-system (P.S. Bhat, T.N. Raviprasad and K. Vanitha).

3.19	Evaluation of indigenously occurring natural enemies for their efficacy in managing cashew a and b stem and root borers and tea mosquito bug (T.N. Raviprasad and K. Vanitha).
3.20	Investigations on semio-chemicals for management of TMB and CSRB (T.N. Raviprasad, P.S. Bhat and N. Bhaktavatsalam).
3.21	Diversity and bio-ecology of insect pollinators and their efficiency in increasing yield of cashew (K. Vanitha and T.N. Raviprasad).
4.	**POST- HARVEST TECHNOLOGY**
4.15	Design, development and evaluation of solar tunnel dryer for cashew apple (D. Balasubramanian and Rajkumar Arjun Dagadkhair).
4.16	Developing quality standards for raw cashew nuts (D. Balasubramanian and K. Vanitha).
4.17	Design and development of mechanical slicer for cashew apple (D. Balasubramanian).
4.18	Reduction of tannins from cashew apple juice by using low cost food grade materials (Rajkumar Arjun Dagadkhair and Babli Mog).
4.19	Screening of cashew varieties to specify use of cashew apple in value added products (Rajkumar Arjun Dagadkhair and Ramkesh Meena).
5.	**TRANSFER OF TECHNOLOGY**
5.1	Transfer of technology programmes in cashew (M.V. Sajeev, M.G. Nayak, P.S. Bhat and D. Balasubramanian).
5.2	Impact of cashew production technologies on area, production and productivity of cashew (M.V. Sajeev).
5.3	Development of an interactive and dynamic for cashew information management at DCR (G.S. Mohana and. M.V Sajeev).

ICAR Consortia / Network Partner

- Micronutrient management in horticultural crops for enhancing yield and quality.
- Consortium Research Project on borers in network mode.
- Out Reach Programme in network mode on management of sucking pests in horticultural crops.

Externally Funded Projects

- DBT: Evaluation of indigenous strain of fungal pathogen *Beauveria bassiana* against *Helopeltis* spp on guava, cashew and tea.
- PPV and FRA: Development of morphological descriptors and DUS test guidelines for cashew (*Anacardium occidentale* L.).

Annexure-II

Participation in Seminars / Symposia / Meetings

Saroj, P.L.	Brainstorming session on coastal agricultural research held under the chairmanship of Secretary, DAER & DG, ICAR at Central Coastal Agricultural Research Institute, Goa.	9 April, 2014
Saroj, P.L.	National level training of cashew organized by Directorate of Cashewnut and Cocoa Development, Kochi under NHM Programme at Central Coastal Agricultural Research Institute, Goa	22 April, 2014
Saroj, P.L	Interactive conference of the Vice Chancellors of the SAUs/ DU/ CAUs/ Project Coordinators held at AP Shinde Hall, NASC Complex, New Delhi.	28 April, 2014
Saroj, P.L.	24th Meeting of ICAR Regional Committee No. VIII at ICAR-CTCRI, Trivandrum, Kerala.	2-3 May, 2014
Saroj, P.L.	National seminar-cum-workshop on Physiology of flowering in perennial fruit crops at ICAR-CISH, Lucknow.	24-25 May, 2014
Eradasappa, E.	Global Conference on Technological challenges and human resources for climate smart horticulture – issues and strategies at NAU, Navsari, Gujarat.	28-31 May 2014
Saroj, P.L.	Foundation day lecture of NAAS at NASC complex, New Delhi.	5 June, 2014
Saroj, P.L	NAIP workshop on Impact of capacity building programmes at NASC complex, New Delhi.	6-7 June, 2014
Rupa,T.R.	National seminar on Sustainability and profitability of coconut, arecanut and cocoa farming – technological advances and way forward at ICAR-CPCRI, Kasaragod, Kerala.	22-23 August, 2014
Saroj, P.L.	Interaction meeting with Dr. Jose Graziano da Silva, Director General, FAO at NASC, New Delhi.	8 September, 2014
Bhat, P.S.	Launching workshop of ORP on Sucking pests of horticultural crops at ICAR-IIHR, Bengaluru, Karnataka.	8 September, 2014
Rupa,T.R.	Launching workshop of Micronutrient management in horticultural crops for enhancing yield and quality' at ICAR-IIHR, Bengaluru, Karnataka.	8 September, 2014
Adiga, J.D.	International conference on biosciences held at Kumarakom, Kottayam, Kerala.	11-12 September, 2014
Sajeev, M.V.	Workshop on Open access to agricultural knowledge for inclusive growth and development at ICAR-NAARM, Hyderabad	29 - 30 October, 2014
Saroj, P.L. Nayak, M.G. Ramkesh Meena	Indian horticulture congress – an international event organized by Horticultural Society of India at TNAU, Coimbatore, Tamil Nadu.	6-9 November, 2014

Sajeev, M.V.	Seventh national extension education congress: ICAR Research Complex for NEH Region, Umiam, Meghalaya.	8-11 November, 2014
Rupa, T.R.	National seminar on Developments in Soil Science: 2014, 79th Annual convention of the Indian Society of Soil Science at ANGRAU, Hyderabad, Telangana.	24-27 November, 2014
Saroj, P.L.	National seminar on Strategies for conservation, improvement and utilization of underutilized fruits held at ICAR-CHES, Chettalli, Karnataka.	1-3 December, 2014
Saroj, P.L Raviprasad, T.N. Balasubramanian, D. Adiga, J.D. Mohana, G.S. Sajeev, M.V.	International symposium on Plantation crops (PLACROSYM XXI) - Converging technologies for sustainability, organized by ICAR-IISR, Kozhikode, Kerala.	10-12 December, 2014
Saroj, P.L. Bhat ,P.S. Raviprasad, T.N. Balasubramanian,D., Muralikrishna, K.	Annual Group Meeting of Scientists of AICRP on Cashew at Agricultural College, (ANAGRAU) Bapatla, organized by Cashew Research Station, Bapatla, Dr. YSR Horticultural University Andhra Pradesh.	18-20 December, 2014
Nayak, M.G.	Programme on Farmers Right and Variety Registration sponsored by PPV and FRA - organized by KVK, Kankanady, Mangalore at Belthangadi, Karnataka.	19 December, 2014
Saroj, P.L.	Silver Jubilee Symposium of NAAS with theme Strategic Approaches for Horticulture Research, Education and Development – Way Forward at NAAS Complex, New Delhi.	26 - 27 December, 2014
Vanitha, K.	District level training programme on cashew at Keechanur Village, Kundapura, Karnataka.	9 January, 2015
Rupa,T.R.	Training workshop with all the HRD Nodal Officers at ICAR-NAARM, Hyderabad.	26 February, 2015
Nayak, M.G.	National symposium on cashew: The cashew prospective crop of future at Institute Menenzes Braganza, Panjim, Goa, organized by DCCD, Kochi.	13-14 March, 2015
Saroj, P.L. Sajeev, M.V.	Caju Summit: 2015 organized by Karnataka Cashew Manufacturers Association at T M A Pai Auditorium Mangalore, Karnataka.	14-15 March, 2015
Saroj, P.L. Nayak, M.G. Raviprasad, T.N.	National Seminar on Sustainable horticulture vis-a-vis Changing environment at SASRD, Nagaland University at Medziphema, Nagaland.	26-28 March, 2015
Saroj, P.L. Nayak, M.G. Raviprasad, T.N.	Group meeting of Researchers and development agencies for cashew area expansion in NEH Region, College of Horticulture, SASARD, Medziphema, Nagaland.	27 March, 2015

Annexure-III

Radio Talks / TV Programmes

Name	Topic	Recorded/Telecast
Saroj, P.L.	Overview of cashew production – Farmers perspective (English) by Doordarshan -1, Chandana TV channel.	15 October , 2014
Nayak, M.G.	Nursery management and cashew grafts production (Kannada) by Doordarshan -1, Chandana TV channel.	15 October, 2014
Nayak, M.G.	Pruning and canopy management in high density planting cashew orchards (Kannada) by Doordarshan -1, Chandana TV channel.	15 October, 2014
Bhat, P.S.	Foliage pests of cashew (Kannada) by Doordarshan-1, Chandana TV channel.	15 October, 2014
Raviprasad, T.N.	Management of major pests: Cashew stem and root borer in cashew orchards (Kannada) by Doordarshan-1, Chandana TV channel.	15 October, 2014
Nayak, M.G.	Agro techniques to enhance cashew yield (Kannada) by Doordarshan -1, Chandana TV channel.	27 October, 2014
Sajeev, M.V.	Cashew production technologies as a part of coverage of PLACROSYM XXI exhibition by All India Radio, Kozhikode, Kerala.	12 December, 2014
Mohana, G.S.	Uses of internet for agriculture information and development - All India Radio, Mangalore.	5 February, 2015

Annexure-IV

Services to Farmers

Sale of cashew grafts: ICAR-DCR has a cashew nursery accredited by National Horticulture Board (NHB) to cater the need of planting materials. Softwood grafts of varieties like Bhaskara, 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, brouchers, media and other publications.

Field demonstration on cashew cultivation

Advisory service on pest management in cashew

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

Annexure-V

Distinguished Visitors

Name and designation	Address	Date of visit
Dr. K.E. Lawande	Vice Chancellor, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri post, Maharashtra	11 April, 2014
Dr. N.P. Singh	Director, Central Coastal Agricultural Research Institute, Goa	19 May, 2014
Shri. Venkatesh N. Hubballi	Director, Directorate of Cashewnut and Cocoa Development, Kochi	21 May, 2014
Shri. Nagaraja, IFS	Managing Director, Karnataka Cashew Development Corporation, Mangalore, Karnataka	29 May, 2014
Shri. A.B. Ibrahim, IAS	Deputy Commissioner, Dakshina Kannada, Karnataka	18 June, 2014
Prof. R.K. Pathak	Ex-Director, Central Institute of Sub-tropical Horticulture, Lucknow, Uttar Pradesh	18 June, 2014
Dr. N.K. Krishna Kumar	Deputy Director General (HS), Indian Council of Agricultural Research, New Delhi	17 August, 2014
Shri. V.P. Kothiyal	Director (Works), Indian Council of Agricultural Research, New Delhi	28 August, 2014
Smt. Thulasi Maddineni, IAS	Chief Executive Officer of Dakshina Kannada Zilla Panchayat, Karnataka.	5 September, 2014
Shri. V.V. Bhat, IAS	Former Secretary to Government of India and Member (Financial) of Atomic Energy, Space and Earth Commission	19 December, 2014
Dr. M.G. Bhat	Former Director, ICAR-Directorate of Cashew Research, Puttur – 574 202, Dakshina Kannada, Karnataka	19 December, 2014
G. Ravindra Chary	Project Coordinator In–charge AICRP on Dryland Agriculture, Central Research Institute for Dryland Agriculture Hyderabad	20 January, 2015
Dr. Brahma Singh	Former Director, Life Sciences, Defense Research Development Organization, New Delhi	12 February, 2015
Dr. Subhash, N.	Professor and Head, Plant tissue culture Anand Agricultural University, Gujarat	12 February, 2015
Dr. V.S. Korikanthimath	Former Director, ICAR-Central Coastal Agricultural Research Institute, Goa	12 February, 2015
Shri. Nalin Kumar Kateel	The Hon'ble Member of Parliament, Dakshina Kannada district, Karnataka	20 February, 2015

Annexure-VI

Personnel

Staff Position as on 31.3.2015

Category	Sanctioned	Filled	Vacant
Director (RMP)	1	1	-
Scientific	17	13	4
Technical	19	15	4
Administrative	15	10	5
Canteen staff	1	1	-
Skilled Support Staff	37	25	12
Total	**90**	**65**	**25**

Research Management Position	
Prof. P.L. Saroj, Director	
Scientific	
1. Dr. Thimmappaiah	Principal Scientist (Genetics and Cytogentics) upto 31.7.2014
2. Dr. M. Gangadhara Nayak	Principal Scientist (Horticulture)
3. Dr. P. Shivarama 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. Dinakara Adiga	Senior Scientist (Horticulture)
8. Dr. G.S. Mohana	Senior Scientist (Genetics and Cytogenetics)
9. Dr. M.V. Sajeev	Scientist (Agricultural Extension)
10. Dr. Ramkesh Meena	Scientist (Horticulture)
11. Shri. E. Eradasappa	Scientist (Plant Breeding)
12. Dr. (Mrs.) K. Vanitha	Scientist (Agricultural Entomology)
13. Dr. D. Kalaivanan	Scientist (Soil Science) upto 15.11.2014
14. Shri. Rajkumar Arjun Dagadkhair	Scientist (Food Technology)
15. Dr. Babli Mog	Scientist (Plant Physiology)

Technical		
1.	Shri. K. Muralikrishna	Chief Technical Officer
2.	Shri. P. Abdulla	Chief Technical Officer
3.	Shri. Arulmony	Assistant Chief Technical Officer
4.	Shri. Prakash G. Bhat	Assistant Chief Technical Officer
5.	Shri. A. Padmanabha Hebbar	Senior Technical Officer
6.	Shri. Lakshmipathi	Senior Technical Officer
7.	Shri. Lakshmisha	Senior Technical Officer (upto 10.6.2014)
8.	Shri. K.V. Ramesh Babu	Senior Technical Officer
9.	Shri. N. Manikandan	Senior Technical Officer
10.	Shri. R. Muthuraju	Technical Officer
11.	Shri. K. Seetharama	Technical Officer
12.	Shri. M. Bhojappa Gowda	Technical Officer
13.	Shri. Vijay Singh	Technical Assistant
14.	Shri. Ravishankar Prasad	Technical Assistant
15.	Shri. K. Babu Poojari	Technical Assistant
16.	Shri. Bejmi Veigas	Senior Technician (upto 30.4.2014)
17.	Shri. Honnappa Naik, P.	Senior Technician
Administration		
1.	Shri. K.M. Lingaraja	Assistant Administrative Officer (Establishment)
2.	Smt. M. Rathna Ranjini	Assistant Administrative Officer (Stores)
3.	Shri. O.G. Varghese	Private Secretary
4.	Smt. B. Jayashri	Personal Assistant
5.	Smt. Reshma, K.	Personal Assistant
6.	Ms. Winnie Lobo	Assistant
7.	Smt. M. Leela	Assistant
8.	Shri. Umashankar	Upper Division Clerk
9.	Smt. K. Padminikutty	Upper Division Clerk
10.	Shri. K. Balappa Gowda	Gestetner Operator

Annexure-VII

Results-Framework Document (RFD) : 2013–2014

ICAR - Directorate of Cashew Research, Puttur, Karnataka

Section 1
Vision, Mission, Objectives and Functions

Vision

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

Mission

Increasing the production and productivity of cashew.

Objectives

1) Conservation of genetic resources/ germplasm for sustainable use

2) Production management and value addition.

3) Transfer of technology through various media.

Functions

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

Section 2

Inter-se Priorities among Key Objectives, Success Indicators and Targets

Sl.No.	Objective(s)	Weight	Action(s)	Success indicator(s)	Unit	Weight	Target/Criteria values				
							Excellent 100%	Very good 90%	Good 80%	Fair 70%	Poor 60%
1	Conservation of genetic resourc germplasm for sustainable use	20	Collection, characterization and conservation of Germplasm	Accessions added / characterized in Germplasm	Number	10.00	5	4	3	2	1
			Breeding of varieties for good traits and tolerance to biotic and abiotic stress	Hybrids and selections under process of development and evaluation	Number	10.00	5	4	3	2	1
2	Production management and value addition	50	Production of elite and disease free planting material	Number of grafts produced	Number (in lakhs)	14.00	1.8	1.5	1.4	1.3	1.0
			Development of improved production and protection technologies	Improved production and protection technologies in process of development	Number	24.00	4	3	2	1	0
			Postharvest technology	Postharvest technologies under process of development for better utilization of harvested produce	Number	12.00	2	1	0	0	0

Sl.No.	Objective(s)	Weight	Action(s)	Success indicator(s)	Unit	Weight	Target/Criteria Values				
							Excellent 100%	Very good 90%	Good 80%	Fair 70%	Poor 60%
3	Transfer of technology through various media	19	Effective dissemination of scientific and technical knowhow	TOT programmes conducted	Number	12.00	5	4	3	2	1
				Publication of extension literature, radio talks and TV programmes.	Number	7.00	6	5	4	2	1
	Efficient functioning of the RFD System	3	Timely submission of Draft RFD (2013-14) for approval	On-time submission	Date	2.00	15/05/2013	16/05/2013	17/05/2013	20/05/2013	21/05/2013
			Timely submission of Results for RFD (2012-13)	On-time submission	Date	1.00	01/05/2013	02/05/2013	05/05/2013	06/05/2013	07/05/2013
	Administrative reforms	4	Implement ISO 9001 as per approved action plan	% Implementation	%	2.00	100	95	90	85	80
			Prepare an action plan for implementation	On-time submission	Date	2.00	30/07/2013	10/08/2013	20/08/2013	30/08/2013	10/09/2013
	Improving internal efficiency / responsiveness / service delivery of Ministry / Department	4	Implementation of Sevottam	Independent audit of implementation of citizen's charter	%	2.00	100	95	90	85	80
				Independent audit of implementation of public grievance redressal system	%	2.00	100	9	90	85	80

Section 3

Trend Values of the Success Indicators

Sl.No.	Objectives	Actions	Success indicator	Unit	Actual value for FY 2011-2012	Actual value for FY 2012-2013	Target value for FY 2013-2014	Projected values for FY 2014-2015	Projected values for FY 2015-2016
1	Conservation of genetic resources/ germplasm for sustainable use	Collection, characterization and conservation of germplasm	Accessions added / characterized in germplasm	Number	15	15	4	4	4
		Breeding of varieties for good traits and tolerance to biotic and abiotic stress	Hybrids and selections under process of development and evaluation	Number	4	4	4	4	4
2	Production management and value addition	Production of elite and disease free planting material	Number of grafts produced	Number (in lakhs)	1.6	1.5	1.5	1.7	1.8
		Development of improved production and protection technologies	Improved production and protection technologies in process of development	Number	5	6	3	4	4
		Postharvest technology	Postharvest technologies under process of development for better utilization of harvested produce	Number	Not Available in RFD document	Not Available in RFD document			

Sl.No.	Objectives	Actions	Success indicator	Unit	Actual value for FY 2011-2012	Actual value for FY 2012-2013	Target value for FY 2013-2014	Projected values for FY 2014-2015	Projected values for FY 2015-2016
3	Transfer of technology through various media	Effective dissemination of scientific and technical knowhow	TOT programmes conducted	Number	5	5	4	7	7
			Publication of extension literature, radio talks and TV programme.	Number	Not available in RFD document	Not Available in RFD document	5	7	8
	Efficient functioning of the RFD system	Timely submission of Draft RFD (2013-14) for approval	On-time submission	Date			16/05/2013		
		Timely submission of Results for RFD (2012-13)	On-time submission	Date			02/05/2013		
	Administrative reforms	Implement ISO 9001as per approved action plan	% Implementation	%			95		
		Prepare an action plan for implementation	On-time submission	Date			10/08/2013		

	Improving internal efficiency / responsiveness / service delivery of Ministry / Department	Implementation of sevottam	Independent audit of implementation of citizen's charter	%	95
			Independent audit of implementation of public grievance redressal system	%	95

Section 4

Description and Definition of Success Indicators and Proposed Measurement Methodology

Sl. No.	Success indicator	Description	Definition	Measurement	General comments
1	Accessions added / characterized in germplasm	Germplasm are genetic resources of cashew which are source of genetic variability	Germplasm is collection of all cultivars, wild species etc for conservation and utilization	Number of accessions added/characterized	--
2	Hybrids and selections under process of development and evaluation	Source materials for improved varieties to be evaluated	Best performing hybrids/ selections will be identified for their evaluation before release	Number of hybrids, selections under process of development and evaluation	--
3	Number of grafts produced	Production of planting material through soft wood grafting	It is an asexual method of propagation by which new planting material is produced	Number (in lakhs)	In cashew planting material mainly consists of soft wood grafts
4	Improved production and protection technologies in process of development	Developing production technologies to improve input use efficiency and increase Benefit: cost ratio of growers	Input use efficiency refers to judicious use of agricultural inputs to increase cashew production per unit of inputs used.	Developing packages related to foliar nutrition, INM, spacing for high yielding varieties, plant protection schedules etc.	Improving nutrient use efficiency, productivity and pest management are most important factors to increase productivity of cashew.
5	Postharvest technologies under process of development for better utilization of harvested produce	Technologies to carry out post harvest handling in cashew.	Development of new technologies to improve post harvest utilization of cashew.	Number of technologies developed or in the process of development.	There is a need to develop advanced technologies for processing of cashew for better quality products.

Sl. No.	Success indicator	Description	Definition	Measurement	General comments
6	TOT programmes conducted	Capacity building activities to improve knowledge and skill of cashew growers, extension workers etc.	Training is a process of acquiring new skill, attitude and knowledge through various means	Number	–
7	Publication of extension literature, radio talks and TV programme	Creating awareness through print and mass media methods	Dissemination of knowledge through popular articles, pamphlets ,radio talk and TV programme	Number	–

Section 5

Specific Performance Requirements from other Departments

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

Section 6

Outcome/Impact of Activities of Organisation/Ministry

S. No.	Outcome/Impact of organisation	Jointly responsible for influencing this out-come/impact with the following organisation(s)/ departments/ministry(s)	Success indicators	Unit	2011-12	2012-13	2013-14	2014-15	2015-16
1	Production of quality planting materials of cashew, awareness of stakeholders & capacity building	State departments of horticulture/National Horticulture Mission/ AICRP-Cashew	Production / distribution of quality and disease-free planting materials	Number (in lakhs)	1.6	1.45	1.5	1.7	1.8
			Awareness of stakeholders & capacity building through training/ demonstrations	Per cent increase in awareness among stakeholders	70	70	70	70	75

Annual (April 1, 2013 to March 31, 2014) Performance Evaluation Report of RFD 2013-2014 of RSCs i.e. Institutes

Name of the Division : Horticulture
Name of the Institution : ICAR - Directorate of Cashew Research
RFD Nodal Officer : J. Dinakara Adiga

S.No.	Objectives	Weight	Actions	Success indicators	Unit	Weight	Target / criteria value					Consolidated achievements	Performance per cent		achievements against target values of 90% Col.	Reasons for shortfalls or excessive achievements, if applicable
							Excellent 100%	Very Good 90%	Good 80%	Fair 70%	Poor 60%		Raw score	Weighted raw score		
1	Production management and value addition	50	Development of improved production and protection technologies	Improved production and protection technologies in process of development	Number	24.00	4	3	2	1	0	4	100	24	133.3	Achievement falls under excellent category which is desirable
			Production of elite and disease free planting material	Number of grafts produced (in lakhs)	Number in lakhs	14.00	1.8	1.5	1.4	1.3	1.0	1.5	90	12.6	100	NA
			Postharvest technology	Postharvest technologies under process of development for better utilization of harvested produce	Number	12.00	2	1	0	0	0	2	100	12	200	Achievement falls under excellent category which is desirable
2	Conservation of genetic resources/ germplasm for sustainable use	20	Collection, characterization and conservation of germplasm	Accessions added/ characterized in germplasm	Number	10.00	5	4	3	2	1	5	100	10	125	Achievement falls under excellent category which is desirable

S.No.	Objectives	Weight	Actions	Success indicators	Unit	Weight	Target / criteria value					Consolidated achievements	Performance per cent		Achievements against target values of 90% Col.	Reasons for shortfalls or excessive achievements, if applicable
							Excellent 100%	Very Good 90%	Good 80%	Fair 70%	Poor 60%		Raw score	Weighted raw score		
			Breeding of varieties for good traits and tolerance to biotic and abiotic stress	Hybrids and selections under process of development and evaluation	Number	10.00	5	4	3	2	1	5	100	10	125	Achievement falls under excellent category which is desirable
3	Transfer of technology through various media	19	Effective dissemination of scientific and technic knowhow	TOT programmes conducted	Number	12.00	5	4	3	2	1	6	100	12	150	Due to implementation of TSP, number of programmes got increased
				Publication of extension literature, radio talks and TV programme.	Number	7.00	6	5	4	2	1	4	80	5.6	80	Publication is need based
	Efficient functioning of the RFD system	3	Timely submission of Draft RFD (2013-14) for approval	On-time submission	Date	2.00	15/05/ 2013	16/05/ 2013	17/05/ 2013	20/05/ 2013	21/05/ 2013	14/5/ 2013	100	2	100	
			Timely submission of RFD(2012-13	On-time submission	Date	1.00	01/05/ 2013	02/05/ 2013	05/05/ 2013	06/05/ 2013	07/05/ 2013	30/4/ 2013	100	1	100	
	Administrative reforms	4	Implement ISO 9001 as per approved action plan	% Implementation	%	2.00	100	95	90	85	80	0	0	0	0	
			Prepare an action plan for Innovation	On-time submission	Date	2.00	30/07/	10/08/	20/08/	30/08/	10/09/	30/7/	100	2	100	

S.No.	Objectives	Weight	Actions	Success indicators	Unit	Weight	Target / criteria value					Consolidated achievements	Performance per cent		achievements against target values of 90% Col.	Reasons for shortfalls or excessive achievements, if applicable
							Excellent 100%	Very Good 90%	Good 80%	Fair 70%	Poor 60%		Raw score	Weighted raw score		
	Improving internal efficiency / responsiveness / service delivery of Ministry / Department	4	Implementation of Sevottam	Independent audit of implementation of citizen's charter	%	2.00	100	95	90	85	80	100	100	2	105	
				Independent audit of implementation of public grievance redressal system	%	2.00	100	95	90	85	80	100	100	2	105	

Total Composite Score : 95.20

Rating : Very good

Procedure for computing the Weighted and Composite Score

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

"Approved by RFD committee"
(Sd/-)
Director

Annexure-VIII

Budget 2014-15

Head of Account		₹ in lakhs
	Allocation	**Expenditure**
Non plan	514.00	449.36
Plan including Network Projects, NEH and TSP	184.35	178.70
Pension & Retirement	103.00	102.87
P-Loans & Advance	5.00	3.15
R-Deposit scheme	-	0.15
Total	**806.35**	**734.23**
Revenue (Main centre)	**Taget**	**Achievement**
Receipts from sale of farm produce	75.10	42.04
Other revenue receipts	-	3.53
Revenue (RFS)		
Receipts from sale of farm produce	-	16.03
Other revenue receipts	-	-
Total	**75.10**	**61.60**

Annexure-IX

Meteorological Data at ICAR-DCR, Puttur (2014-15)

Month	Temperature (°C)		Relative humidity (%)		Rainy days	Rainfall (mm)	Wind velocity (km/h)	Sunshine (h)	Pan evoporation (mm)
	Max.	Min.	7.28 h	14.28 h					
April	37.2	22.3	88.2	52.1	-	-	2.7	7.4	6.2
May	33.9	24.0	90.4	58.2	5	210.0	2.1	4.5	4.7
June	31.2	24.5	90.6	75.4	16	500.0	2.6	3.6	2.8
July	37.9	28.5	43.0	107.6	30	1261.7	3.6	1.6	2.1
August	31.1	22.2	89.9	82.0	26	715.1	2.0	1.1	2.4
September	32.6	22.8	85.6	75.2	17	1374.6	2.0	3.7	2.5
October	42.8	28.7	100.5	83.5	14	219.8	2.5	5.7	3.8
November	34.5	14.8	72.6	52.8	3	88.0	3.6	7.8	4.6
December	34.7	10.1	75.6	51.2	3	83.0	1.7	19.4	2.7
January	43.1	60.7	88.6	52.5	1	1.6	2.5	9.7	4.7
February	37.3	19.7	77.3	37.5	0	0.0	2.7	8.9	4.5
March	35.4	20.6	86.3	33.6	2	20.0	2.7	8.0	5.0
				Total rainfall :		**4473.8**			

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

Annexure-X

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	Database on cashewnut processing in India (2003)	100.00
6	Directory of cashewnut processing industries in India (2003)	100.00
7	Process catalogue on development of economically viable on-farm cashewnut processing	45.00
8	Annotated bibliography on cashew (1995-2007)	205.00
9	Soil and water management in cashew plantations	30.00
10	Biochemical characterization of released varieties of cashew	85.00
11	Pruning and canopy architecturing in cashew	40.00
12	Development of dual mode dryer for raw cashewnuts	90.00
13	Alternate energy utilization of cashew shell cake for thermal application	90.00
14	Status of cashew germplasm collection in India (Booklet)	*
15	Compendium of concluded research projects (1986 -2001)	*
16	Cashew nutritive value (Revised) (Brochure)	*
17	Cashew cultivation practices (Pamphlet)	*

Price indicated above does not include postage.

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

* Free of cost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